

Effectiveness of a Neuro-Play Therapy-Based Intervention on Working Memory, Self-Control, and Cognitive Flexibility in Children with Learning Disabilities

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ABSTRACT

This study aimed to determine the effectiveness of a neuro-play therapy-based intervention in improving working memory, self-control, and cognitive flexibility among children with learning disabilities. This applied quasi-experimental study employed a pretest-posttest design with a one-month follow-up and a control group. The statistical population consisted of children aged 7–11 years with diagnosed learning disabilities who attended counseling centers in District 10 of Tehran during the first semester of the 2025–2026 academic year. Using purposive sampling, 60 eligible children were selected and assigned to an experimental group ($n = 30$) and a control group ($n = 30$). The experimental group received a structured neuro-play therapy intervention in 11 two-hour group sessions conducted twice weekly, whereas the control group received no intervention. Data were collected using the Daneman and Carpenter Working Memory Capacity Test, Tangney et al.'s Self-Control Scale, and Dennis and Vander Wal's Cognitive Flexibility Inventory. Data were analyzed using mixed repeated-measures analysis of variance in SPSS version 26. Mixed ANOVA indicated significant time effects for cognitive flexibility, $F(2,114) = 70.11$, $p < .001$, $\eta^2 = .55$; self-control, $F(2,114) = 35.32$, $p < .001$, $\eta^2 = .38$; and working memory, $F(2,114) = 107.42$, $p < .001$, $\eta^2 = .65$. Significant time $\times$ group interactions were also found for cognitive flexibility, $F(4,114) = 21.56$, $p < .001$, $\eta^2 = .43$; self-control, $F(4,114) = 7.61$, $p < .001$, $\eta^2 = .21$; and working memory, $F(4,114) = 14.67$, $p < .001$, $\eta^2 = .34$. Between-group effects were significant for cognitive flexibility, $F(2,57) = 3.03$, $p = .050$, $\eta^2 = .10$; self-control, $F(2,57) = 3.10$, $p = .050$, $\eta^2 = .10$; and working memory, $F(2,57) = 3.65$, $p = .032$, $\eta^2 = .12$. Neuro-play therapy appears to be an effective intervention for enhancing executive functions in children with learning disabilities, particularly working memory, self-control, and cognitive flexibility. The persistence of improvement through the follow-up assessment suggests that structured, neuroscience-informed play activities may produce relatively stable cognitive and behavioral benefits. Accordingly, neuro-play therapy may be incorporated into psychological, counseling, and educational rehabilitation programs designed for children with learning disabilities.

Keywords: Neuro-Play Therapy, Working Memory, Self-Control, Cognitive Flexibility, Learning Disabilities, Executive Functions

1. Introduction

Specific learning disabilities are among the most consequential neurodevelopmental difficulties encountered during childhood because their effects extend beyond academic achievement and influence cognitive functioning, emotional adjustment, self-perception, interpersonal experiences, and participation in educational activities. Children with learning disabilities may demonstrate persistent difficulties in acquiring and applying fundamental academic skills such as reading, written expression, or mathematics despite access to conventional education and adequate opportunities for learning. These difficulties frequently create a discrepancy between children's intellectual potential and their actual academic performance and may expose them to repeated experiences of failure, frustration, negative feedback, and reduced academic engagement. Importantly, the effects of learning disabilities are not restricted to formal academic tasks. Children experiencing substantial learning difficulties may also encounter barriers to full participation in school-based social and physical activities, and their educational experiences can be shaped considerably by the extent to which their individual needs, preferences, and voices are recognized within the school environment (Allen et al., 2024). Consequently, contemporary approaches to learning disabilities increasingly emphasize not only remediation of academic skills but also the enhancement of underlying cognitive processes that enable children to regulate their behavior, maintain task-relevant information, adapt to changing demands, and participate effectively in learning situations.

A particularly important theoretical framework for understanding the cognitive difficulties associated with learning disabilities is the concept of executive functions. Executive functions constitute a family of higher-order cognitive processes that enable goal-directed behavior, deliberate problem-solving, planning, regulation of attention and emotion, inhibition of inappropriate responses, maintenance and manipulation of information, and flexible adjustment to changing environmental demands. Among the most influential conceptualizations of executive functioning, three core processes have received substantial attention: working memory, inhibitory control or self-control, and cognitive flexibility. These processes are distinguishable but closely interconnected and jointly contribute to complex reasoning, learning, decision-making, and adaptive behavior (Diamond, 2013). Their developmental importance is

especially pronounced during childhood, when children must increasingly control immediate behavioral impulses, remember and integrate multiple instructions, shift between different rules, organize academic information, and generate alternative solutions to problems. Deficits in one or more of these executive processes can therefore interfere with the acquisition and application of academic skills and may help explain why some children with learning disabilities continue to experience difficulties even when conventional instructional support is available.

Working memory is one of the central components of executive functioning and refers to the limited-capacity system responsible for temporarily maintaining information while simultaneously processing, manipulating, or integrating it. Rather than functioning as passive short-term storage, working memory supports the active coordination of information required for comprehension, reasoning, problem-solving, and the completion of multistep activities. Contemporary working-memory research highlights the interaction between temporary storage systems and attentional mechanisms that bind information into coherent representations during complex cognitive activities (Baddeley et al., 2021). In educational settings, working memory enables a child to retain the beginning of a sentence while processing its conclusion, remember instructions while carrying them out, maintain intermediate results during mathematical calculations, connect newly presented information with previously learned material, and organize several pieces of information simultaneously. Accordingly, limitations in working memory can adversely affect reading comprehension, written expression, mathematical performance, classroom participation, and the ability to follow increasingly complex instructional sequences.

The importance of working memory for students with specific learning disabilities has also been demonstrated through intervention research. Children with learning disabilities frequently require greater cognitive effort to perform academic tasks, meaning that limited working-memory resources may be rapidly exhausted when they must simultaneously decode, comprehend, calculate, monitor accuracy, and maintain task instructions. Recent intervention evidence indicates that systematic and targeted working-memory training can improve working-memory performance among primary school students with specific learning disabilities, supporting the proposition that these cognitive limitations are potentially modifiable rather than fixed characteristics (Okur & Aksoy, 2025). This finding is particularly relevant for cognitive rehabilitation because it

suggests that interventions should not focus exclusively on observable academic outcomes. Instead, strengthening the cognitive mechanisms underlying academic performance may increase children's capacity to benefit from instruction and cope more effectively with cognitively demanding tasks.

Working memory also interacts with other higher-order cognitive abilities that influence learning. For instance, metacognition—the capacity to monitor, evaluate, and regulate one's own cognitive processes—has been shown to explain important aspects of critical thinking beyond the contribution of working memory alone (Li et al., 2024). This distinction demonstrates that successful learning requires coordinated functioning across several levels of cognitive regulation. Children must not only retain information but also recognize when a strategy is ineffective, evaluate alternative approaches, modify behavior, and monitor progress toward a goal. Such processes depend on a broader executive-function network in which working memory is integrated with inhibition, self-regulation, and cognitive flexibility. Thus, an intervention capable of stimulating several executive components concurrently may provide broader benefits than training directed toward a single isolated cognitive process.

Self-control represents another fundamental dimension of executive functioning and generally refers to the capacity to regulate impulses, inhibit immediate but inappropriate responses, resist distraction, delay gratification, and organize behavior in accordance with longer-term goals. In classroom contexts, self-control allows children to remain engaged in tasks despite competing stimuli, wait for appropriate opportunities to respond, follow instructional rules, regulate frustration when confronted with difficult material, and persist when immediate success is not achieved. From a dual-system perspective, self-control is especially important when immediate impulses compete with reflective, goal-directed behavior. Evidence from behavioral research has demonstrated that inadequate self-control can contribute to excessive engagement with immediately rewarding activities and difficulty regulating behavior in the presence of salient environmental cues (Zahrai et al., 2022). Although such findings have been examined in contexts beyond childhood learning disabilities, they illustrate the broader importance of inhibitory regulation in balancing short-term impulses against longer-term objectives.

The role of self-control in learning and psychological adjustment is also supported by research linking self-regulation to educational and mental-health-related

outcomes. Self-control can influence how individuals manage attention, establish priorities, cope with emotional demands, and sustain behavior directed toward academic objectives. Research examining learning and mental health has identified self-control as an important construct associated with academic functioning and adaptive engagement with educational demands (Zhang et al., 2024). Likewise, contemporary studies of technology-related behavior have continued to emphasize relationships between self-control, self-evaluation, and perceived behavioral competence (Rodríguez et al., 2025). For children with learning disabilities, self-control may assume even greater importance because repeated academic difficulties can increase frustration, avoidance, impulsive responding, or disengagement. Consequently, interventions that allow children to practice behavioral inhibition, waiting, turn-taking, rule following, and emotional regulation within a motivating environment may contribute meaningfully to adaptive functioning.

The third key executive component, cognitive flexibility, refers to the capacity to shift efficiently between mental sets, rules, perspectives, strategies, or behavioral responses when environmental circumstances change. Cognitive flexibility allows individuals to recognize when an established approach is ineffective, abandon an unsuccessful strategy, generate alternative solutions, and adapt behavior according to newly emerging information. During childhood, cognitive flexibility supports problem-solving, classroom adjustment, reading comprehension, mathematical reasoning, social understanding, and adaptation to unexpected situations. Research involving children with developmental language difficulties has demonstrated the relevance of cognitive flexibility to their ability to produce novel responses and reorganize representations when conventional patterns are insufficient (Blom et al., 2021). These findings underscore the importance of flexibility as a cognitive resource that enables children to move beyond rigid response patterns.

The combined contribution of working memory, inhibition, and cognitive flexibility becomes particularly evident in complex problem-solving tasks. Effective problem-solving requires children to maintain relevant information, suppress ineffective or distracting responses, and shift toward alternative strategies when necessary. Evidence from elementary school students indicates that inhibition, working memory, and cognitive flexibility each contribute to successful science problem-solving performance, demonstrating that executive functions operate as fundamental cognitive supports for educational reasoning

(Schäfer et al., 2024). Consequently, deficits in these executive domains may have cumulative effects in children with learning disabilities. A child who struggles to retain information, inhibit impulsive responses, and change strategy when confronted with failure is likely to experience greater difficulty completing multistep tasks and may become increasingly dependent on external guidance.

Executive-function development is also sensitive to children's linguistic, social, and environmental experiences. Contemporary research indicates that children's executive functioning can vary as a function of complex developmental experiences, including multilingual exposure and broader patterns of cognitive engagement (Romero et al., 2025). Such findings reinforce the principle of neurocognitive plasticity, according to which executive processes are not entirely static but can respond to sustained environmental stimulation and structured practice. This principle provides an important theoretical foundation for cognitive and neuropsychological interventions targeting children with learning disabilities. If repeated experiences requiring active memory maintenance, inhibition, attention switching, and adaptive problem-solving systematically recruit executive networks, then structured training may gradually strengthen children's ability to use these processes in both therapeutic and educational settings.

Existing research has therefore increasingly focused on cognitive rehabilitation and other targeted interventions designed to improve executive functioning among children with learning disabilities. For example, non-motor cognitive rehabilitation has been shown to improve working memory and cognitive flexibility in children with reading-related learning disabilities (Soltani et al., 2023). These interventions typically involve repeated exercises that progressively challenge cognitive capacities while allowing children to practice specific executive skills under controlled conditions. Similarly, cognitive games have been used to address cognitive flexibility among children with mathematics disorders, providing preliminary support for the therapeutic value of structured game-based activities (Hassanvand & Arjmandnia, 2019). Collectively, these studies suggest that executive deficits associated with learning disabilities may be responsive to systematic cognitive stimulation.

The use of play is especially promising because play provides a developmentally appropriate medium through which children can repeatedly exercise cognitive skills without experiencing the activities as conventional academic remediation. Structured games can require children to

remember rules, inhibit dominant responses, switch between competing instructions, anticipate consequences, solve problems, monitor errors, and regulate emotions. In contrast to repetitive paper-and-pencil exercises, play-based interventions may also increase intrinsic motivation and reduce the psychological burden associated with situations that resemble the academic tasks in which children have previously experienced failure. Neuropsychological play therapy extends this principle by combining structured therapeutic play with assumptions derived from neuropsychology and cognitive rehabilitation. Recent evidence has shown that neuropsychological play therapy can improve executive functioning and working memory in children with learning disorders, providing direct support for the potential of this approach in the target population (Ghanbari & Talebi, 2025).

The value of child-centered and developmentally appropriate intervention is also consistent with the broader literature on support for children with specific learning disabilities. A systematic review of parent-involved interventions has shown that interventions for children with specific learning disabilities increasingly incorporate the child's broader developmental and family context rather than treating academic impairment as an isolated educational problem (Guo & Keles, 2025). Although parent involvement and neuro-play therapy represent different intervention modalities, both approaches reflect a movement toward multidimensional support that recognizes the interaction among cognition, behavior, environment, and relationships. Similarly, the lived experiences of children with substantial learning difficulties indicate that meaningful educational participation requires sensitivity to children's individual experiences and opportunities for engagement rather than reliance exclusively on standardized instructional expectations (Allen et al., 2024).

The psychological consequences accompanying learning disabilities further strengthen the need for interventions that are engaging, supportive, and capable of influencing more than academic performance alone. Individuals with learning disabilities may experience anxiety and related emotional difficulties, and contemporary intervention reviews have emphasized the need for targeted approaches capable of addressing psychological vulnerability within this population (Beaudoin et al., 2025). A child who repeatedly encounters tasks perceived as excessively difficult may develop anticipatory anxiety, avoid challenging activities, or exhibit emotional and behavioral dysregulation. Interventions delivered through safe and structured play may

reduce the threatening character of cognitive practice while simultaneously creating opportunities to experience mastery, receive immediate feedback, tolerate mistakes, and practice emotional regulation. These characteristics may be particularly relevant for children whose prior learning experiences have been dominated by correction and failure.

Taken together, the available evidence supports several conclusions. First, executive functions—including working memory, self-control, and cognitive flexibility—are fundamental to learning, problem-solving, behavioral regulation, and adaptive functioning (Diamond, 2013; Schäfer et al., 2024). Second, children with learning disabilities may experience impairments in cognitive processes that extend beyond the specific academic skill in which the disability is manifested. Third, working memory and cognitive flexibility appear amenable to targeted cognitive rehabilitation and structured training (Okur & Aksoy, 2025; Soltani et al., 2023). Fourth, cognitive games and neuropsychologically informed play interventions provide developmentally appropriate mechanisms for engaging children in repeated executive-function practice (Ghanbari & Talebi, 2025; Hassanvand & Arjmandnia, 2019). Finally, the broader literature indicates that effective interventions for children with learning disabilities should recognize the interaction of cognitive, behavioral, emotional, social, and contextual factors rather than narrowly focusing on academic deficits (Beaudoin et al., 2025; Guo & Keles, 2025).

Nevertheless, important empirical questions remain. Much of the existing intervention literature has examined individual components of executive functioning separately, such as working memory or cognitive flexibility, rather than evaluating whether an integrated play-based neurocognitive program can simultaneously improve several executive domains. This limitation is important because working memory, inhibitory control, and cognitive flexibility operate interdependently during real-world academic activities. Moreover, determining whether intervention-related improvements persist after treatment is essential because immediate post-intervention gains do not necessarily indicate stable cognitive change. Follow-up assessment can therefore clarify whether newly strengthened skills are maintained after structured therapeutic practice has ended. There is also a need for additional evidence in children with different manifestations of specific learning disabilities, including reading, writing, and mathematics difficulties, because cognitive demands and patterns of executive weakness may differ across diagnostic presentations. Given

the theoretical basis of executive-function plasticity, the encouraging findings of cognitive rehabilitation research, and emerging evidence regarding neuropsychological play therapy, evaluating an integrated neuro-play therapy intervention across multiple executive outcomes and across repeated measurement occasions represents an important extension of existing research.

Accordingly, the aim of the present study was to determine the effectiveness of a neuro-play therapy-based intervention in improving working memory, self-control, and cognitive flexibility in children with learning disabilities.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed an applied, quantitative, quasi-experimental design with a pretest–posttest, one-month follow-up, and control group. The statistical population consisted of all children aged 7–11 years with learning disabilities who attended counseling centers located in District 10 of Tehran, Iran, during the first semester of the 2025–2026 academic year. From this population, 60 eligible children were selected through nonprobability purposive sampling, with the initial sample size determined by considering the possibility of participant attrition during the intervention and follow-up stages. After obtaining written informed consent from the children's parents, the participants were assigned to two groups of 30 participants each: an experimental group receiving the neuro-play therapy intervention and a control group receiving no cognitive or psychological intervention during the study period. The inclusion criteria were being between 7 and 11 years of age; having a confirmed diagnosis of a specific learning disability involving reading, writing, or mathematics as determined by a qualified psychologist; willingness and ability to participate actively in the intervention sessions; and provision of written informed consent by a parent or legal guardian. The exclusion criteria included the presence of severe psychiatric disorders such as autism spectrum disorder, schizophrenia, or bipolar disorder; serious neurological disorders such as uncontrolled epilepsy; simultaneous participation in another specialized psychological, educational, or cognitive rehabilitation intervention; absence from more than two consecutive sessions or three nonconsecutive sessions during the intervention; and unwillingness to complete the assessment instruments at any of the pretest, posttest, or follow-up

stages. Outcome variables were assessed at three time points: before the intervention, five days after completion of the intervention, and one month after the posttest. Throughout the research process, ethical principles were observed by providing parents and children with clear information regarding the objectives and procedures of the study, obtaining written informed consent from parents, ensuring participants' right to withdraw from the study at any stage without educational or therapeutic consequences, protecting the confidentiality of personal and performance-related information, and conducting all play-based activities in a safe and nonjudgmental environment designed to prevent excessive fatigue, psychological pressure, embarrassment, or humiliation.

2.2. Measures

Daneman and Carpenter Working Memory Capacity Test. Working memory was assessed using the Working Memory Capacity Test developed by Daneman and Carpenter in 1980. The instrument consists of 27 sentences organized into six progressively demanding sections containing sets of two to seven sentences. Its central feature is the simultaneous assessment of two components of working memory, namely processing and storage. During administration, participants listen carefully to a series of relatively complex sentences and are required to perform two mental operations concurrently. First, they determine whether the meaning or content of each sentence is correct, representing the processing component; second, they retain and subsequently recall the final word of each sentence, representing the storage component. For example, after listening to the two sentences presented in the first section, the participant determines whether each sentence is correct and records the final word of each sentence. The number of sentences gradually increases across subsequent sections until the seven-sentence condition is reached, with additional time allowed as task complexity increases. Each correct response receives one point, whereas incorrect or omitted responses receive no points. Each sentence therefore contributes separate processing and storage scores. Because the test contains 27 sentences, scores for each component range from 0 to 27, and the overall working memory score is calculated from the average performance across processing and storage components and may be expressed as a percentage. Previous Iranian psychometric evaluations have provided evidence supporting the reliability and validity of this instrument. Asadzadeh reported a validity

coefficient of .88 and a split-half reliability coefficient of .85, while Mojtabazadeh reported a Kuder–Richardson reliability coefficient of .87 among secondary-school students. These coefficients indicate satisfactory psychometric properties for the assessment of working memory capacity.

Tangney Self-Control Scale. Self-control was measured using the Self-Control Scale developed by Tangney and colleagues in 2004. The instrument was originally developed as a 36-item self-report measure based on previous approaches to the assessment of self-regulation and self-control and was subsequently refined into a shorter 13-item version. The scale is intended to assess an individual's general capacity to control impulses, regulate behavior, resist inappropriate responses, and direct behavior toward longer-term goals. Responses are provided on a five-point Likert scale, with higher overall scores indicating greater self-control. Evidence for the construct validity of the original instrument was obtained through its associations with indicators such as academic achievement, adjustment, positive interpersonal relationships, and interpersonal skills. In the original psychometric evaluations, Cronbach's alpha coefficients of .83 and .85 were obtained across two samples. The psychometric properties of the instrument have also been examined in Iranian populations. Studies conducted with Iranian participants reported Cronbach's alpha coefficients as high as .89, while another investigation obtained a test–retest reliability coefficient of .88 and a Cronbach's alpha coefficient of .80. Expert evaluations have additionally supported the content and face validity of the Persian version. These findings indicate that the scale possesses acceptable internal consistency, temporal stability, and validity for assessing self-control.

Dennis and Vander Wal Cognitive Flexibility Inventory. Cognitive flexibility was assessed using the Cognitive Flexibility Inventory developed by Dennis and Vander Wal in 2010. This brief 20-item self-report instrument was designed to assess the cognitive flexibility required to challenge maladaptive thoughts and replace them with more adaptive interpretations and responses. The instrument evaluates cognitive flexibility through dimensions related to perceiving difficult situations as controllable, generating alternative explanations for life events and human behavior, and producing multiple alternative solutions when confronting challenging circumstances. Items are rated on a seven-point Likert scale ranging from 1, indicating strong disagreement, to 7, indicating strong agreement. Item scores are summed to generate an overall cognitive flexibility score

ranging from 20 to 140, with higher scores reflecting greater cognitive flexibility. In the original psychometric study, Dennis and Vander Wal provided evidence supporting the factorial structure, convergent validity, and concurrent validity of the instrument. The control dimension demonstrated an inverse association of approximately $-.39$ with the Beck Depression Inventory, while convergent validity with the Martin and Rubin measure of cognitive flexibility was reported at $.75$. Cronbach's alpha coefficients of $.81$ for the total scale, $.75$ for perceived controllability, and $.77$ for the alternatives-related dimension were reported in the original study. Psychometric investigations of the Persian version have also demonstrated acceptable reliability. Test-retest reliability coefficients were reported as $.71$ for the total scale and $.55$, $.72$, and $.57$ for its respective dimensions, while Cronbach's alpha coefficients were $.90$ for the total scale and $.87$, $.89$, and $.55$ for the corresponding subscales. Collectively, these findings support the use of the instrument for evaluating cognitive flexibility in the present study.

2.3. Interventions

The experimental group participated in a structured neuro-play therapy program derived from the neuro-play therapy framework developed by Hasavand and Arjmandnia. Neuro-play therapy integrates principles from neuroscience, cognitive rehabilitation, psychology, and therapeutic play and uses purposeful play-based activities to stimulate neural plasticity, strengthen neural connections, and improve cognitive, behavioral, emotional, and social functioning. The intervention was specifically structured to enhance executive functions by engaging children in progressively challenging activities requiring attention, response inhibition, working memory, behavioral regulation, cognitive shifting, sequencing, and adaptive problem-solving. The intervention was administered in group format twice weekly, with each session lasting approximately two hours. The protocol consisted of 11 active therapeutic-training sessions followed by a final consolidation and termination session. The control group received no neuro-play therapy, cognitive rehabilitation, or comparable psychological intervention during the corresponding period. The first session focused on familiarizing the children with the therapist and other group members, establishing group rules, creating a safe therapeutic environment, and strengthening rapport. The second session used animal and geometric puzzles of

progressively increasing difficulty, in which children observed a model and reconstructed the corresponding puzzle, with the primary purpose of strengthening executive functioning, organization, sustained attention, and problem-solving. The third session involved direct and reverse versions of the "sit down and stand up" game, requiring children first to execute sudden verbal commands and subsequently perform the opposite response; this activity primarily targeted response inhibition, attentional control, behavioral regulation, and cognitive flexibility. During the fourth session, sequential skill cards were used to teach a multistep activity, after which children were required to arrange the cards according to the correct sequence of actions, thereby strengthening sequencing, planning, organization, and executive control. The fifth session employed colored cards, word cards, object displacement activities, and tasks requiring the temporary retention of words, numbers, and shapes within specified time intervals to reinforce executive functioning, inhibitory control, mental organization, and flexible processing.

The later sessions placed greater emphasis on the direct strengthening of working memory and the active maintenance and manipulation of information. During the sixth session, number-balloon activities and matching exercises involving letters and numbers were implemented to enhance working memory capacity and attentional maintenance. The seventh session consisted of letter-based games in which children searched for, identified, and manipulated target letters within letter matrices, thereby strengthening visual attention and working memory. The eighth session incorporated coded games and dual-task activities, including locating numbers in coded matrices, rule-based verbal games, moving a bowl of water along a designated line while maintaining balance, and reaching a specified destination by following the researcher's instructions. These exercises were designed to simultaneously engage information retention, divided attention, working memory, behavioral regulation, and executive coordination. During the ninth session, children performed object-memory games together with progressive forward and backward counting and auditory techniques intended to reinforce active information storage and retrieval. The tenth session focused on letter-writing activities using multiple colors and writing letters without dots, requiring children to maintain and manipulate orthographic information while inhibiting habitual responses. The eleventh session integrated several games and exercises from previous sessions into more complex

combined challenges in order to consolidate learning, facilitate generalization, and strengthen the coordinated use of executive-function skills. A final summary and termination session was devoted to reviewing the material and activities completed throughout the intervention, integrating previously acquired skills, providing feedback regarding children's progress, reinforcing confidence in their newly acquired abilities, and formally concluding the therapeutic program. Five days after completion of the intervention, both groups completed the posttest assessments, and the same outcome measures were administered again one month later to evaluate the maintenance of treatment effects.

2.4. Data Analysis

The collected data were analyzed using IBM SPSS Statistics version 26. Descriptive statistics, including means and standard deviations, were calculated to summarize working memory, self-control, and cognitive flexibility scores in the experimental and control groups across the pretest, posttest, and one-month follow-up assessments. To evaluate intervention effects over time, a mixed-design repeated-measures analysis of variance was conducted separately for the dependent variables of working memory, self-control, and cognitive flexibility. In this analytical framework, time, consisting of pretest, posttest, and follow-

up measurements, was treated as the within-subject factor, whereas group, consisting of the neuro-play therapy and control groups, was treated as the between-subject factor. The analysis examined the main effect of time, the between-group effect, and particularly the time $\times$ group interaction to determine whether changes across the three measurement occasions differed significantly between the intervention and control conditions. Prior to conducting the inferential analyses, the relevant statistical assumptions were evaluated. Mauchly's test of sphericity was used to assess the sphericity assumption for the repeated-measures factor, Levene's test was used to examine homogeneity of error variances across groups, and Box's M test was employed to examine the equality of covariance matrices. Statistical significance was evaluated at the conventional alpha level of .05, and effect sizes were reported using eta squared to indicate the magnitude of observed intervention effects.

3. Findings and Results

Descriptive statistics were first calculated for cognitive flexibility, self-control, and working memory in the neuro-play therapy and control groups across the pretest, posttest, and one-month follow-up assessments. The means and standard deviations of the study variables at each measurement occasion are presented in Table 1.

Table 1

Means and Standard Deviations of Cognitive Flexibility, Self-Control, and Working Memory by Group and Measurement Time (N = 60)

Variable	Time	Group	M	SD
Cognitive Flexibility	Pretest	Neuro-Play Therapy	65.30	5.04
		Control	65.21	4.92
	Posttest	Neuro-Play Therapy	68.13	5.39
		Control	65.12	4.76
	Follow-up	Neuro-Play Therapy	67.55	5.55
		Control	64.73	4.73
Self-Control	Pretest	Neuro-Play Therapy	19.45	2.19
		Control	19.15	2.08
	Posttest	Neuro-Play Therapy	20.80	2.17
		Control	19.35	2.31
	Follow-up	Neuro-Play Therapy	21.20	2.06
		Control	19.20	2.05
Working Memory	Pretest	Neuro-Play Therapy	10.45	1.48
		Control	10.15	1.29
	Posttest	Neuro-Play Therapy	11.65	1.79
		Control	10.20	1.32
	Follow-up	Neuro-Play Therapy	12.05	1.82
		Control	10.55	1.31

As shown in Table 1, the two groups had relatively similar mean scores at the pretest stage across all three dependent variables. Following the intervention, the neuro-play therapy group demonstrated increases in cognitive flexibility, self-control, and working memory, whereas only minimal changes were observed in the control group. Cognitive flexibility in the experimental group increased from 65.30 ± 5.04 at pretest to 68.13 ± 5.39 at posttest and remained elevated at 67.55 ± 5.55 at follow-up. Similarly, self-control increased from 19.45 ± 2.19 to 20.80 ± 2.17 at posttest and 21.20 ± 2.06 at follow-up. Working memory also increased from 10.45 ± 1.48 at pretest to 11.65 ± 1.79 at posttest and 12.05 ± 1.82 at follow-up. In contrast, the control group showed comparatively stable scores across the three measurement occasions. These descriptive patterns suggested improvement in all three outcomes following

neuro-play therapy, with the gains generally maintained through the one-month follow-up.

To examine whether the observed changes were statistically significant, a mixed-design repeated-measures analysis of variance was conducted. Time, consisting of pretest, posttest, and follow-up assessments, was entered as the within-subject factor, while group was entered as the between-subject factor. Before conducting the main analysis, the assumptions of the repeated-measures model were evaluated. Mauchly's test of sphericity and Levene's test of equality of error variances supported the relevant assumptions. Box's M test also indicated homogeneity of the covariance matrices across groups, Box's $M = 120.67$, $F(90, 8900.78) = 1.03$, $p = .40$. The results of the mixed ANOVA for the three dependent variables are presented in Table 2.

Table 2

Mixed Repeated-Measures ANOVA Results for Cognitive Flexibility, Self-Control, and Working Memory

Variable	Effect	df	F	p	η^2
Cognitive Flexibility	Time	2, 114	70.11	< .001	.55
	Time $\times$ Group	4, 114	21.56	< .001	.43
	Group	2, 57	3.03	.050	.10
Self-Control	Time	2, 114	35.32	< .001	.38
	Time $\times$ Group	4, 114	7.61	< .001	.21
	Group	2, 57	3.10	.050	.10
Working Memory	Time	2, 114	107.42	< .001	.65
	Time $\times$ Group	4, 114	14.67	< .001	.34
	Group	2, 57	3.65	.032	.12

As presented in Table 2, the main effect of time on cognitive flexibility was statistically significant, $F(2, 114) = 70.11$, $p < .001$, $\eta^2 = .55$, indicating significant changes in cognitive flexibility scores across the three measurement occasions. More importantly, the time $\times$ group interaction was also significant, $F(4, 114) = 21.56$, $p < .001$, $\eta^2 = .43$, demonstrating that the pattern of change over time differed between the neuro-play therapy and control groups. The between-subject effect of group was also significant at the .05 level, $F(2, 57) = 3.03$, $p = .050$, $\eta^2 = .10$. For self-control, a significant main effect of time was found, $F(2, 114) = 35.32$, $p < .001$, $\eta^2 = .38$, together with a significant time $\times$ group interaction, $F(4, 114) = 7.61$, $p < .001$, $\eta^2 = .21$. The between-group effect was likewise significant, $F(2, 57) = 3.10$, $p = .050$, $\eta^2 = .10$, indicating that the overall pattern of self-control scores differed between the study groups. Finally, working memory showed the strongest main effect of time, $F(2, 114) = 107.42$, $p < .001$, $\eta^2 = .65$. The time $\times$ group interaction was also statistically significant, $F(4, 114)$

$= 14.67$, $p < .001$, $\eta^2 = .34$, demonstrating that working memory improved differently over time in the experimental group compared with the control group. A significant between-group effect was also observed for working memory, $F(2, 57) = 3.65$, $p = .032$, $\eta^2 = .12$. Overall, the significant time $\times$ group interactions across all three outcomes indicated that neuro-play therapy was associated with improvements in cognitive flexibility, self-control, and working memory, and the descriptive follow-up scores suggested that these improvements were maintained one month after the intervention.

4. Discussion

The present study examined the effectiveness of a neuro-play therapy-based intervention in improving working memory, self-control, and cognitive flexibility in children with learning disabilities. The findings demonstrated significant improvements across all three executive-function

outcomes in the intervention group compared with the control group. Specifically, the mixed repeated-measures analyses showed significant main effects of time and significant time $\times$ group interactions for cognitive flexibility, self-control, and working memory. These results indicated that changes across pretest, posttest, and follow-up were not merely attributable to the passage of time, but rather differed systematically according to group membership. The magnitude of the time effects was particularly notable for working memory, followed by cognitive flexibility and self-control. Moreover, the intervention-related gains were maintained at the one-month follow-up, suggesting that the effects of neuro-play therapy were not restricted to immediate post-intervention improvement. Overall, the findings support the effectiveness of structured neuro-play therapy in strengthening core executive processes in children with learning disabilities.

The significant improvement observed in working memory is consistent with previous evidence indicating that working-memory capacities in children with specific learning disabilities are amenable to systematic intervention. Okur and Aksoy demonstrated that a structured working-memory intervention package improved the working-memory performance of primary school students with specific learning disabilities (Okur & Aksoy, 2025). Similarly, Soltani and colleagues reported that cognitive non-motor rehabilitation enhanced working memory in children with reading-related learning disabilities (Soltani et al., 2023). The present findings also align closely with the study by Ghanbari and Talebi, who found that neuropsychological play therapy improved executive functions and working memory in children with learning disorders (Ghanbari & Talebi, 2025). Taken together, these converging findings suggest that working-memory limitations in children with learning disabilities should not be viewed as fixed deficits, but as cognitive functions that can improve through repeated, structured, and developmentally appropriate practice.

The improvement in working memory can be explained by the cognitive demands embedded in the intervention protocol. Many of the neuro-play activities required children to retain rules, remember sequences, manipulate numbers or letters, recall object locations, and coordinate two or more streams of information simultaneously. Such tasks directly recruit the active maintenance and manipulation processes central to working memory. According to contemporary models, working memory depends on the coordinated interaction between temporary storage systems and

attentional control processes that bind and manipulate information during complex cognitive activity (Baddeley et al., 2021). Repeated exposure to tasks requiring simultaneous processing and storage may therefore have strengthened the children's capacity to maintain task-relevant information while inhibiting interference. This mechanism is particularly important in the context of learning disabilities, because academic tasks such as reading comprehension, mathematical problem-solving, spelling, and written composition require ongoing coordination between incoming information and previously retained material.

The findings regarding working memory may also be interpreted in relation to the broader role of executive functioning in academic problem-solving. Schäfer and colleagues showed that working memory, inhibition, and cognitive flexibility jointly contribute to problem-solving performance in elementary school students (Schäfer et al., 2024). Neuro-play therapy may therefore have been effective because it did not isolate working memory from other executive processes. Instead, the children were repeatedly required to remember information while also shifting attention, controlling impulses, and adapting to changing rules. This integrated activation may be more representative of real-world learning demands than narrowly focused single-process training. The result may be a more transferable form of cognitive improvement, particularly when play activities require sustained attention and active problem-solving rather than simple repetition.

The significant improvement in self-control was another important finding. The intervention group showed a more favorable trajectory of self-control scores from pretest to posttest and follow-up than the control group. This result is theoretically plausible because neuro-play therapy involves repeated opportunities to practice response inhibition, rule following, waiting, behavioral regulation, and delayed gratification. These processes represent central components of self-control. Prior research has shown that self-control is strongly related to adaptive regulation of behavior when immediate impulses compete with longer-term goals (Zahrai et al., 2022). In the context of the current intervention, children were frequently required to suppress automatic responses, follow changing instructions, tolerate temporary frustration, and wait for appropriate opportunities to act. Repeated practice of these behaviors within structured play may gradually strengthen the inhibitory control needed for more adaptive self-regulation.

The present finding is also consistent with broader evidence linking self-control to learning, adjustment, and academic functioning. Zhang and colleagues emphasized the importance of self-control in relation to academic performance and mental-health-related educational functioning (Zhang et al., 2024). Although their study involved a different population, the underlying principle is relevant: effective learning depends partly on the ability to control attention, regulate behavior, and remain engaged in goal-directed activity. Similarly, Rodríguez and colleagues examined associations between self-control and broader indicators of self-regulation and self-efficacy (Rodríguez et al., 2025). These findings reinforce the interpretation that self-control is not an isolated behavioral trait, but part of a broader executive-regulatory system that shapes how individuals respond to demands, distractions, and challenges.

For children with learning disabilities, the capacity for self-control may be especially vulnerable because repeated experiences of failure can trigger frustration, avoidance, impulsive responding, and reduced persistence. Neuro-play therapy may reduce these difficulties by creating a context in which inhibitory control is practiced without the evaluative pressure associated with academic tasks. A child who must wait for a turn, follow a sequence, reverse a response, or adapt behavior to a game rule is practicing self-regulation in a motivating and emotionally safer environment. Over time, these experiences may help transform regulatory behavior from externally guided performance into a more internalized form of control. In this regard, the significant time $\times$ group interaction for self-control suggests that the intervention did more than simply improve mood or engagement; it altered the pattern of regulatory performance across repeated measurement occasions.

The significant improvement in cognitive flexibility represents the third major finding of the study. The intervention group demonstrated a clear increase in cognitive flexibility after neuro-play therapy, and the effect remained evident at follow-up. This result accords with the findings of Hassanvand and Arjmandnia, who reported that cognitive games improved cognitive flexibility in children with mathematics disorder (Hassanvand & Arjmandnia, 2019). It is also compatible with the findings of Soltani and colleagues, who showed that cognitive rehabilitation improved cognitive flexibility in children with reading learning disabilities (Soltani et al., 2023). Furthermore, Ghanbari and Talebi found broader executive-function

improvements after neuropsychological play therapy in children with learning disorders (Ghanbari & Talebi, 2025). These studies collectively support the view that cognitive flexibility can be enhanced through structured, repeated engagement in tasks that require children to abandon habitual responses and adopt alternative strategies.

The mechanisms underlying this improvement are closely related to the nature of play-based cognitive challenges. Cognitive flexibility requires individuals to shift between mental sets, reinterpret situations, generate alternatives, and revise unsuccessful strategies. Blom and colleagues demonstrated the importance of cognitive flexibility for generating novel responses in children with developmental language difficulties (Blom et al., 2021). In neuro-play therapy, many tasks involve changing rules, reversing instructions, reorganizing sequences, and responding to new task demands. These activities require children to disengage from one cognitive set and rapidly adopt another. Repeated exposure to such situations may reduce rigid response patterns and strengthen the ability to switch between perspectives and strategies. This capacity is especially relevant for children with learning disabilities, who may become cognitively inflexible when a familiar academic strategy fails.

The observed improvement in cognitive flexibility may also be explained by the interdependence of executive functions. Cognitive flexibility rarely operates independently; successful switching usually requires working memory to maintain the new rule and inhibitory control to suppress the previous one. Diamond's model conceptualizes working memory, inhibition, and cognitive flexibility as core executive functions that interact to support higher-order reasoning and adaptive behavior (Diamond, 2013). The present intervention appears to have targeted these processes simultaneously rather than sequentially. Accordingly, improvement in cognitive flexibility may have been reinforced by parallel gains in working memory and self-control. For example, a child may become better able to switch strategies not only because flexibility itself improves, but also because the child can hold the new rule in mind and inhibit the previously dominant response.

The results are also compatible with evidence showing that executive functions are shaped by environmental and developmental experiences. Romero and colleagues demonstrated that complex developmental experiences can influence executive-function performance in children (Romero et al., 2025). While the nature of multilingual exposure differs from a therapeutic intervention, the broader

implication is that executive processes remain sensitive to repeated cognitive stimulation. This supports the neuroplasticity-based rationale of neuro-play therapy. The intervention repeatedly exposed children to tasks involving memory, inhibition, shifting, sequencing, and problem-solving within an enriched environment. Such repeated activation may have supported more efficient use of executive resources and strengthened the behavioral expression of these cognitive functions.

Another important aspect of the present findings is that the intervention effects were maintained during the one-month follow-up. This suggests that the observed improvements were not purely transient responses to therapist attention or novelty. Maintenance may have occurred because the intervention relied on active practice rather than passive instruction. Children repeatedly used cognitive skills in changing contexts, which may have encouraged consolidation and transfer. The use of varied games may also have reduced context dependency, allowing children to apply executive strategies beyond a single task format. This interpretation is consistent with the broader intervention literature emphasizing the importance of repeated and structured cognitive engagement in children with specific learning disabilities (Guo & Keles, 2025). Although parent-involved interventions differ from neuro-play therapy, systematic reviews in this field indicate that multidimensional and context-sensitive interventions can improve outcomes when they address the broader cognitive and behavioral needs of children rather than relying on a single instructional technique.

The play-based format may also have enhanced intervention effectiveness by increasing engagement and reducing performance-related anxiety. Individuals with learning disabilities are at increased risk of anxiety-related difficulties, and intervention research has emphasized the need for psychologically supportive approaches in this population (Beaudoin et al., 2025). A child who anticipates failure during conventional academic exercises may disengage before meaningful cognitive practice occurs. In contrast, structured play can create opportunities for challenge without reproducing the negative emotional associations linked to classroom failure. This may allow children to sustain attention, tolerate mistakes, and persist with cognitively demanding tasks. The likely reduction in perceived threat could therefore have indirectly facilitated improvements in executive functioning.

The intervention may also be understood in relation to participation and child-centered educational experience.

Allen and colleagues emphasized the importance of recognizing the voices and lived experiences of pupils with severe learning disabilities in educational contexts (Allen et al., 2024). Although the current intervention was therapeutic rather than curricular, its play-based structure similarly places the child in an active rather than passive role. Children interact, make choices, respond to changing situations, and receive immediate feedback. This active participation may be particularly important for children who have experienced repeated correction or failure in formal learning contexts. Neuro-play therapy therefore combines cognitive training with a participatory format that may support motivation and perceived competence.

The current findings also contribute to understanding the relationship between working memory and broader higher-order cognition. Li and colleagues showed that metacognitive processes predict critical thinking beyond the contribution of working memory alone (Li et al., 2024). This suggests that improving working memory may be most beneficial when it occurs within activities that also require monitoring, evaluation, adaptation, and strategy selection. The neuro-play therapy protocol used in the present study incorporated precisely these kinds of demands. Children were not simply asked to remember information; they had to monitor rules, correct errors, adapt responses, and integrate feedback. Thus, the intervention may have promoted broader executive coordination rather than isolated gains in storage capacity.

5. Conclusion

Overall, the findings suggest that neuro-play therapy is a potentially effective intervention for improving core executive functions in children with learning disabilities. The strongest time effect was observed for working memory, but significant improvements were also evident for cognitive flexibility and self-control. These effects are consistent with previous research on working-memory training, cognitive rehabilitation, cognitive games, and neuropsychological play therapy (Ghanbari & Talebi, 2025; Hassanvand & Arjmandnia, 2019; Okur & Aksoy, 2025; Soltani et al., 2023). The results can be explained by the combined effects of repeated executive-function practice, the integrated recruitment of memory, inhibition, and cognitive shifting, and the motivational advantages of a play-based therapeutic environment. The maintenance of gains at follow-up further suggests that the intervention may produce changes that persist beyond the immediate treatment period.

The present study had several limitations that should be considered when interpreting the findings. The sample was selected from counseling centers in a single district of Tehran using purposive sampling, which limits the generalizability of the findings to children from other geographical, socioeconomic, educational, and cultural contexts. The sample size was relatively modest, and the study included children with different types of specific learning disabilities without conducting separate subgroup analyses for reading, writing, and mathematics disorders. The follow-up period was limited to one month, so the longer-term stability of the observed improvements remains uncertain. Some outcome measures relied on questionnaire-based assessment, which may be affected by response bias, and potentially relevant variables such as sleep quality, medication use, family functioning, socioeconomic status, school support, and concurrent educational experiences were not fully controlled.

Future research should replicate the study with larger and more heterogeneous samples recruited from multiple educational and clinical settings and should examine whether intervention effects differ across specific learning-disability subtypes. Longer follow-up periods, such as six months and one year, would help determine whether improvements in executive functioning remain stable over time. Future studies could also combine self-report measures with objective neuropsychological tasks, computerized executive-function assessments, teacher and parent ratings, and where feasible neurophysiological indicators. Comparative trials examining neuro-play therapy against other evidence-based cognitive rehabilitation programs would also clarify its relative effectiveness. In addition, mediation analyses could investigate whether improvements in working memory, inhibition, or cognitive flexibility explain subsequent changes in academic performance, emotional adjustment, classroom behavior, or motivation.

From a practical perspective, neuro-play therapy may be incorporated into school counseling, learning-disability clinics, psychological rehabilitation centers, and child-focused intervention programs as a structured adjunct to academic remediation. Practitioners may benefit from using progressively challenging games that simultaneously engage working memory, response inhibition, attention shifting, sequencing, and problem-solving rather than training each skill in isolation. Activities should be adapted to the developmental level and specific cognitive profile of each child and implemented in a supportive environment that emphasizes mastery, participation, and constructive

feedback. Teachers, counselors, and parents can also reinforce intervention gains by using brief rule-switching games, memory challenges, sequencing tasks, and self-control exercises in everyday educational and home settings, thereby increasing opportunities for generalization of executive skills beyond the therapeutic context.

Authors' Contributions

Authors equally contributed 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

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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.

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