The University of Tehran Press

Journal of Cognitive Science Research

2026, 2(1), 11-23

Home Page: https://jcsr.ut.ac.ir/

Online ISSN: 3092-6777

The Effectiveness of the "Aram" Computerized Cognitive Rehabilitation Program on Improving Visual–Spatial Perception and Working Memory in Students with Specific Learning Disorders

Heydar Shirzadi [1], Mahboubeh Hojjati [1*]

1. Department of Psychology, Na.C., Islamic Azad University, Najafabad, Iran.

***Corresponding Author:** Assistant Professor, Department of Psychology, Na.C., Islamic Azad University, Najafabad, Iran. Email: mahbobe.hojjati@iau.ir

ARTICLE INFO

Article type:
Research Article

Article History:
Received: 29 Dec 2025
Revised: 18 Jan 2026
Accepted: 03 Feb 2026
Published: 31 Mar 2026

Keywords:
Computer-Based Cognitive Rehabilitation (Aram), Visual–Spatial Perception, Working Memory, Specific Learning Disorder

ABSTRACT

Specific learning disorder is among the most common academic challenges in children and can significantly impair cognitive functioning and educational progress. The present study aimed to investigate the effectiveness of the computer-based cognitive rehabilitation program “Aram” on improving visual–spatial perception and working memory in students with specific learning disorder. This quasi-experimental study employed a pretest–posttest design with a control group. The statistical population included 9- to 10-year-old boys with specific learning disorder referred to the Derakhshesh Child and Adolescent Counseling Center in Najafabad during the second half of 2024. Thirty participants were selected through purposive sampling and randomly assigned to experimental and control groups. After sample attrition, data from 27 participants were analyzed. The research instruments included selected subtests of the Wechsler Intelligence Scale for Children–Fifth Edition (WISC-V), including Block Design and Visual Puzzles for assessing visual–spatial perception, and Digit Span and Picture Span for evaluating working memory. The experimental group received the Aram computer-based cognitive rehabilitation intervention in 12 sessions of 45 minutes each, while the control group received no intervention. Data were analyzed using multivariate and univariate analyses of covariance. The findings indicated that, after controlling for pretest scores, the intervention significantly improved visual–spatial perception and working memory in the experimental group compared with the control group ($p < 0.001$). The results suggest that the Aram program can effectively improve cognitive functioning in students with specific learning disorder.

Cite this article: Shirzadi, H. and Hojjati, M. (2026). The Effectiveness of the "Aram" Computerized Cognitive Rehabilitation Program on Improving Visual–Spatial Perception and Working Memory in Students with Specific Learning Disorders. *Journal of Cognitive Science Research*, *2*(1), 11-23. doi:10.22059/jcsr.2026.414771.1049

Publisher: University of Tehran Press
DOI: https://doi.org/ 10.22059/jcsr.2026.414771.1049

Introduction

Specific learning disorder (SLD) is one of the most common neurodevelopmental disorders in childhood and is characterized by persistent difficulties in learning academic skills such as reading, writing, and mathematics despite adequate educational opportunities and normal intellectual functioning (American Psychiatric Association, 2022). These difficulties often extend beyond academic performance and are associated with impairments in cognitive, emotional, and social functioning. Previous studies have shown that children with SLD frequently experience deficits in several cognitive domains that interfere with information processing and academic achievement (Huwaipathirana et al., 2021; McMahon & Hatten, 2021). Therefore, identifying and improving the underlying cognitive deficits associated with SLD has become an important focus of contemporary educational and clinical research.

One of the major cognitive domains associated with learning disorders is visuospatial perception. Visuospatial perception refers to the ability to perceive, organize, analyze, and mentally manipulate visual and spatial information. This ability plays a crucial role in reading, writing, mathematical reasoning, visual–motor coordination, and problem solving. Deficits in visuospatial processing may impair children’s ability to recognize spatial relationships, discriminate shapes and patterns, and accurately process visual information in educational contexts (Newcombe & Frick, 2010; Mix & Cheng, 2012). Recent findings indicate that students with SLD perform significantly weaker than their peers on tasks related to visuospatial perception and visual processing abilities (Seyedsharbati et al., 2021; Javadi Bazargani, 2023). Furthermore, interventions targeting visuospatial skills have demonstrated positive effects on cognitive and academic performance in children with learning disabilities (Pourfarahmand & Taher, 2022).

Another important cognitive component involved in learning processes is working memory. Working memory is a limited-capacity cognitive system responsible for the temporary storage and manipulation of information necessary for learning, comprehension, reasoning, and goal-directed behavior (Baddeley, 2012; Cowan, 2017). Children with SLD commonly exhibit impairments in both verbal and visuospatial working memory, which negatively affect reading comprehension, mathematical performance, and attentional control (Swanson & Sache-Lee, 2001). Recent studies have emphasized the critical role of working memory in academic achievement and cognitive flexibility among students with learning difficulties (Reisian et al., 2025; Norouzi Homayoun et al., 2025). Accordingly, improving working memory capacity has become an important therapeutic target in educational rehabilitation programs.

In recent years, computer-based cognitive rehabilitation has attracted increasing attention as an effective intervention for improving cognitive deficits in children with neurodevelopmental disorders. Cognitive rehabilitation programs are designed to strengthen cognitive functions such as attention, working memory, executive functions, and visuospatial processing through structured and repetitive cognitive exercises (Maggio et al., 2019; Mendez et al., 2022). Evidence suggests that technology-based cognitive interventions can significantly improve cognitive performance and adaptive functioning in children with learning disabilities (Safari Vasal et al., 2022; Amini et al., 2022). In addition, recent studies have highlighted the importance of scientifically designed educational games and digital interventions in promoting cognitive and metacognitive skills among children (Sahraeian, 2025).

One example of these interventions is the computer-based cognitive rehabilitation program “Aram,” which was developed based on attention and working memory models. This program includes structured cognitive exercises targeting working memory, sustained attention, selective attention, and cognitive flexibility through interactive computerized activities (Nejati, 2018).

Previous findings have demonstrated that the Aram program can significantly improve cognitive functioning, particularly working memory and visuospatial abilities, in children with learning difficulties (Saeidmanesh et al., 2025). However, despite growing evidence regarding the effectiveness of cognitive rehabilitation interventions, limited studies have simultaneously examined the effects of the Aram program on both visuospatial perception and working memory in students with specific learning disorder, particularly in Iranian educational settings. Therefore, the present study aimed to investigate the effectiveness of the Aram computer-based cognitive rehabilitation program on improving visuospatial perception and working memory in students with specific learning disorder.

Method

Research Design and Participants

The present study employed a quasi-experimental design with a pre-test–post-test control group arrangement. The statistical population consisted of all male students aged 9 to 10 years (third- and fourth-grade elementary school students) diagnosed with specific learning disorder (SLD) and referred to the Darakhshesh Child and Adolescent Counseling Center in Najafabad during the second half of 2024.

The sample size was determined based on established methodological criteria for experimental and quasi-experimental designs in behavioral sciences, which recommend a minimum baseline of 15 participants per group to achieve adequate statistical power and satisfy the assumptions required for analysis of covariance (ANCOVA) (Delavar, 2018). Accordingly, a total of 30 male students were selected from among 87 boys with SLD using purposive sampling and randomly assigned to two groups of 15 participants each: an experimental group and a control (waiting-list) group.

Selection was based on the following inclusion criteria: age range of 9 to 10 years (enrolled in third or fourth grade), male gender, informed consent from both the student and parents, diagnosis of learning disorder involving impairment in reading, writing, or mathematics based on a clinical interview in accordance with DSM-5, confirmed diagnosis of specific learning disorder and eligibility to receive special education services by the center's officials and psychologist through review of their registered records, absence of comorbidity with other neurodevelopmental disorders, cognitive ability above the borderline range (IQ $\geq$ 90) as determined by the Colored Progressive Matrices of Raven's Children (RPM), no receipt of other intervention or educational services during the previous 6 months, and no psychiatric treatment before or during the study. The exclusion criteria included unwillingness of the child or family to continue participation, absence from more than two consecutive training sessions, and receiving other educational services.

Among the initial sample, 14 participants were in third grade (7 assigned to the experimental group and 7 to the control group) and 16 participants were in fourth grade (8 assigned to the experimental group and 8 to the control group). During the implementation of the intervention, however, three participants were excluded due to attrition, including absence from more than two sessions and insufficient cooperation during the sessions. These included two participants from the fourth-grade experimental group and one participant from the fourth-grade control group. Accordingly, the final statistical analysis was conducted on data from 27 participants.

Measurement Tools

Wechsler Intelligence Scale for Children, Fifth Edition (WISC-V): The Wechsler Intelligence Scale for Children, Fifth Edition consists of 21 subtests. Thirteen subtests have been retained from the fourth edition of the Wechsler Intelligence Scale for Children. These subtests include Block Design, Similarities, Matrix Reasoning, Digit Span, Coding, Vocabulary, Symbol Search, Information, Picture Concepts, Letter-Number Sequencing, Cancellation, Comprehension, and Arithmetic. In addition, eight new subtests have been added to this test, namely Figure Weights, Visual Puzzles, Picture Span, Naming Speed Literacy, Naming Speed Quantity, Immediate Symbol Translation, Delayed Symbol Translation, and Recognition Symbol Translation (Karami et al., 2020). A review of the available sources concerning the psychometric properties of the WISC-V indicates the desirable reliability and validity of this scale. Evidence related to the internal consistency reliability of the test, reported in the WISC-V Technical and Interpretive Manual, based on split-half reliability and test-retest reliability in the general sample, at the subtest level ranges from 0.81 to 0.94, and at the index level ranges from 0.88 to 0.96 (Wechsler, 2014). The Technical and Interpretive Manual of the WISC-V shows that the concurrent validity of this scale with other valid intelligence tests is at an acceptable level. In addition, the Persian version of the WISC-V has been standardized by Kamkari and Shakerzadeh and has desirable psychometric properties.

Block Design Subtest: The Block Design subtest in the Wechsler test is an instrument used to assess visuospatial abilities, organization, and problem-solving. Within a specified time limit, the examinee sees a pattern or picture on the screen or on the test booklet and reconstructs the design using two-colored blocks (Karami and Karami, 2018). This subtest measures sensorimotor coordination, fluid intelligence, visual perception and visual organization, simultaneous processing, spatial visualization, figure-ground differentiation and orientation, and the analysis and synthesis of visual stimuli.

Visual Puzzles Subtest: Visual Puzzles effectively measures spatial visualization abilities and visual perception. This subtest is designed to assess the cognitive dimensions associated with solving visual problems. Within a specified time limit, the examinee sees a completed puzzle on the screen or on the test booklet and selects three response options that, when combined, solve the puzzle (Karami and Karami, 2018). The Cronbach's alpha coefficient for the Visual Puzzles subtest is usually reported to be above 0.80, indicating good reliability for this subtest (Wechsler, 2014).

Digit Span Subtest: The Digit Span subtest in the Wechsler tests includes three types: Digit Span Forward, Digit Span Backward, and Digit Span Sequencing. This subtest measures sequencing, short-term memory, information transfer, auditory processing, attention and concentration, neural trace, information registration, simultaneous processing, mental operations and manipulation, and visuospatial imagery. The administration of this subtest is as follows: in the forward condition, the participant repeats the digits presented by the examiner in the same order; in the backward condition, the digits must be repeated in reverse order; and in the sequencing condition, numbers are presented with greater complexity and the individual must recall them in a specific sequence. Some studies have reported Cronbach's alpha values between 0.80 and 0.90 for these subtests (Wechsler, 2008; Karami and Karami, 2018).

Picture Span Subtest: Picture Span assesses visual memory, recognition, and attention and is logically related to intelligence and cognitive abilities. The reliability coefficient for the Picture Span subtest has been reported to be approximately 0.85 (Wechsler, 2014). The administration procedure is as follows: a child is presented with a page containing one or more images within a specified time, and then the examinee selects the image or images from the response page (Karami and Karami, 2018).

Raven's Colored Progressive Matrices for Children (RPM): Raven's Progressive Matrices were first standardized in England by Raven in 1938 (Raven, 2000). This test has two forms: one for children aged 5 to 9 years and another for individuals 9 years and older, including adults (Nodei et al., 2016). Raven's Progressive Matrices is a nonverbal intelligence test that is widely used across different cultural and socioeconomic groups worldwide (Westberg et al., 2017). The administration of the Raven intelligence test is such that it consists of a series of patterns and diagrams, part of which is incomplete, and the examinee is expected to choose the correct missing part from several options printed below the figure (Raven, 2000). Obtaining a score of 90 or above on this test was considered as the inclusion criterion for participants.

Procedure

In the pre-test phase, both the experimental and control groups completed the pre-test assessments. The Block Design and Visual Puzzles subtests of the WISC-V were used to assess visuospatial perception, while the Digit Span and Picture Span subtests were utilized to measure working memory.

Subsequently, the experimental group received the computer-based cognitive rehabilitation intervention (ARAM) in 12 individual sessions, each lasting 45 minutes, conducted three times per week. The control group received no intervention during this period and remained on a waiting list. The intervention was delivered using the ARAM Memory and Attention Rehabilitation Software, developed by Najati (2018) based on the Sohlberg and Mateer attentional model and Baddeley's working memory model. The ARAM program consists of a series of hierarchically organized tasks designed to enhance various dimensions of attention and working memory. The core functional features and principles of the program are detailed in Table 1.

Table 1. Principles and Structural Features of the ARAM Program

Feature	Description
Hierarchical Difficulty	Tasks were organized hierarchically, with difficulty increasing based on the user's performance.
Immediate Reinforcement	Correct task performance was followed by immediate reinforcement.
Multi-Dimensional Attention	Tasks were designed according to different dimensions of attention.
Engagement & Motivation	Tasks were engaging and enjoyable, thereby increasing the patient's motivation.
Repetition & Mastery	Tasks could be repeated until the patient reached the desired level of mastery.
Performance-Based Advancement & Therapist Oversight	Advancement within the program was determined based on the patient's performance, and therapist supervision was required to upgrade task difficulty.

Additionally, if a child was unable to achieve 80% accuracy at a given level, that level was repeated (Nemat et al., 2024). The tasks included in the ARAM program consisted of: Colored Houses Task, Faces Task, Similar Windows Task, Marked Tables Task, Fragmented Images Task, Acronym Formation Task, Last Colors Task, Animal Tracking Task, Repeated Images Task, Word–Letter Matching Task, and Delayed Color Matching Task. All tasks comprised ten levels of difficulty, which were adjusted according to the number of stimuli, presentation speed, stimulus complexity, and governing task rules.

The implementation procedure was as follows: the therapist first explained the task instructions to the patient, after which the patient performed the task. Feedback for correct responses was provided automatically and intelligently by the software. Evaluation of performance at the end of each task, as well as selection of the task type and difficulty level, was conducted by the therapist. Each student began at the simplest level of each task and was not permitted to progress to a higher level until achieving at least 80% correct responses. Depending on the student's performance, it was possible for two consecutive sessions to be completely identical in terms of training content. Overall, each participant had 45 minutes to complete eight games per session. If the participant did not demonstrate sufficient progress, the same level of the game was repeated in the subsequent session.

At the end of the training sessions, a post-test was administered to both groups in the final session. To respect participants' privacy, they were assured that all information would remain confidential and would be used solely for research purposes. In addition, to observe the principles of research fairness and prevent any deprivation of participants' rights, the control group was informed after the experimental intervention and post-test that, if they wished, they would also be offered the same educational intervention. Finally, the collected data were analyzed using SPSS version 27, employing multivariate analysis of covariance (MANCOVA) and univariate analysis of covariance (ANCOVA).

Table 2. Description of the Tasks Administered in the Aram Cognitive Rehabilitation Program (Najati, 2018)

Execution time	Task Title	Task Description	Cognitive Value
Week 1	Colored Houses	Participants were required to identify a target stimulus, namely a colored house, among visually similar distractors that differed only in color.	This task primarily engaged sustained attention, selective attention, and inhibitory control.
	Similar Windows	Participants selected windows behind which the same image was displayed.	This task was designed to strengthen visuospatial span and working memory.
Week 2	Faces	Participants categorized faces according to skin color, hair color, and facial expression.	This task required selective attention and inhibitory control.
	Marked Tables	A sequence of tables containing numbers or black dots in one of the cells was presented to participants, who were then required to memorize the locations of the marks. Subsequently, four response options were displayed, and the correct option had to be selected based on the location of each mark in the previously presented sequence.	This task engaged the visuospatial sketchpad and the phonological loop of working memory.
Week 3	Fragmented Images	Several images were divided into separate fragments, each of which was presented briefly to participants. They were required to retain the fragments in memory and then select the correct image from among four alternatives.	This task primarily engaged the visuospatial sketchpad.
	Repeated Images	A series of images was presented, and participants had to identify whether each image had been previously shown.	This task engaged the visuospatial sketchpad and the phonological loop.
Week 4	Animal Tracking	A grid containing an animal image in one of its cells was presented. Arrows then appeared in different directions, and participants were required to follow the indicated path and select, from four alternatives, the cell in which the animal would arrive at the end of the route.	This task engaged and strengthened the visuospatial sketchpad.
	Last Colors	A sequence of colors was presented and then interrupted at an unspecified point. Participants were required to identify the last two or more colors from the response options.	This task updated working memory and strengthened the central executive component of working memory.

Results

For data analysis, descriptive statistics including mean and standard deviation, as well as inferential statistics including multivariate and univariate analysis of covariance (MANCOVA and ANCOVA), were used. Data analysis was performed using SPSS version 27.

Table 3. Demographic Characteristics of the Experimental and Control Groups

Variable	Category	Experimental Group (n = 13)	Control Group (n = 14)	Total Sample (N = 27)
Age (years)	Mean ± SD	8.99 ± 0.22	8.97 ± 0.33	–
	Min – Max	8.72 – 9.44	8.34 – 9.61	–
Grade level	3rd grade	7 (53.8%)	7 (50.0%)	14 (51.9%)
	4th grade	6 (46.2%)	7 (50.0%)	13 (48.1%)
Type of LD	Reading disorder	8 (61.5%)	6 (42.9%)	14 (51.9%)
	Writing disorder	2 (15.4%)	4 (28.6%)	6 (22.2%)
	Mathematics disorder	3 (23.1%)	4 (28.6%)	7 (25.9%)
Economic status	Good	2 (15.4%)	3 (21.4%)	5 (18.5%)
	Moderate	3 (23.1%)	9 (64.3%)	12 (44.4%)
	Poor	8 (61.5%)	2 (14.3%)	10 (37.0%)
Father's education	Master's degree	1 (7.7%)	1 (7.1%)	2 (7.4%)
	Bachelor's degree	3 (23.1%)	6 (42.9%)	9 (33.3%)
	Associate degree	4 (30.8%)	5 (35.7%)	9 (33.3%)
	High school diploma	5 (38.5%)	2 (14.3%)	7 (25.9%)
Mother's education	Master's degree	3 (23.1%)	2 (14.3%)	5 (18.5%)
	Bachelor's degree	5 (38.5%)	10 (71.4%)	15 (55.6%)
	Associate degree	4 (30.8%)	0 (0.0%)	4 (14.8%)
	High school diploma	1 (7.7%)	2 (14.3%)	3 (11.1%)

Table 4. Mean and Standard Deviation of the Main Scales in the Pretest and Posttest

Scale	Group	N	Pretest M	Pretest SD	Posttest M	Posttest SD
Visuospatial perception	Control	14	34.71	7.95	35.21	7.07
	Experimental	13	35.69	8.51	41.77	2.92
Working memory	Control	14	9.50	2.274	9.27	2.125
	Experimental	13	9.31	2.446	11.69	2.564

Before conducting the multivariate and univariate analyses, the necessary assumptions were examined. The Shapiro–Wilk test showed that the distribution of posttest scores for visuospatial perception and working memory was normal in both the experimental and control groups ($p > 0.01$). In addition, Box's M test for the homogeneity of covariance matrices indicated that the homogeneity assumption was satisfied (Box's M: $M = 0.548$, $F = 0.167$, $p = 0.919$). Levene's test was also non-significant for both variables, indicating equality of variances (visuospatial perception: $F = 0.076$, $p = 0.784$; working memory: $F = 4.597$, $p = 0.042$). Furthermore, the slope of the regression line for the pretests was examined and confirmed in the analysis of covariance, indicating a significant correlation between the pretests and posttests and the fulfillment of the assumption of linearity. Therefore, all necessary assumptions for parametric analyses, including ANCOVA and MANCOVA, were met, and the validity of the statistical analysis results is ensured.

Table 5. Results of Multivariate Tests (MANCOVA) for Visuospatial Perception and Working Memory

Statistic	Value	F	df	Hypothesis df	sig	Partial Eta Squared	Observed Power
Pillai's Trace	0.855	65.022	2	22	< 0.001	0.855	1.000
Wilks' Lambda	0.145	65.022	2	22	< 0.001	0.855	1.000
Hotelling's Trace	5.911	65.022	2	22	< 0.001	0.855	1.000
Roy's Largest Root	5.911	65.022	2	22	< 0.001	0.855	1.000

The results of the MANCOVA indicate that there was a statistically significant difference between the experimental and control groups in the linear combination of the two dependent variables, visuospatial perception and working memory (Wilks' Lambda: $F(2, 22)=65.022$, $p<0.001$, $\eta^2=0.855$). These findings suggest that the implemented intervention program was able to enhance participants' performance in both cognitive components simultaneously and effectively.

Table 6. Results of Univariate Covariance Analysis (ANCOVA) for the Subscales of Visuospatial Perception

Subscale	Source	SS	df	MS	Sig	Eta
Block Design	Pretest	671.362	1	671.362	< 0.001	0.849
	Group	70.179	1	70.179	< 0.001	0.371
Visual Puzzles	Pretest	213.408	1	213.408	< 0.001	0.922
	Group	29.754	1	29.754	< 0.001	0.621

The results of the analysis of covariance presented in Table 4 indicate that pretest scores in both subscales Block Design and Visual Puzzles played a significant role in predicting posttest performance ($p < 0.001$). After controlling for the effect of the pretest, a significant difference was observed between the experimental and control groups in both abilities. The obtained effect sizes indicate that the implemented intervention made a substantial contribution to enhancing participants' visuospatial skills ($\eta^2= 0.371$ for Block Design and $\eta^2= 0.621$ for Visual Puzzles).

Overall, these findings suggest that the intervention program was able to significantly and markedly improve the performance of the experimental group in both constructing spatial patterns (Block Design) and solving visual problems (Visual Puzzles).

Table 7. Results of Univariate Analysis of Covariance (ANCOVA) for Working Memory Subscales

Subscale	Source	SS	df	MS	F	Sig	Partial Eta Squared
Digit Span Forward	Group	39.715	1	39.715	111.735	0.000	0.842
	Error	-	-	-	-	-	-
Digit Span Backward	Group	36.372	1	36.372	62.220	0.000	0.748
	Error	-	-	-	-	-	-
Digit Span Sequencing	Group	40.022	1	40.022	74.278	0.000	0.780
	Error	-	-	-	-	-	-
Picture Span	Group	34.280	1	34.280	26.470	0.000	0.524
	Error	-	-	-	-	-	-

The results of the analysis of covariance presented in Table 5 indicate that there was a significant difference between the experimental and control groups in all working memory subscales, including Digit Span Forward, Digit Span Backward, Digit Span Sequencing, and Picture Span ($p < 0.001$). In addition, the high effect size values across all four variables, ranging from 0.524 to 0.842, indicate that the implemented intervention made a very substantial contribution to improving working memory performance. Overall, these findings confirm that the educational intervention used was able to significantly and meaningfully enhance participants' performance across all dimensions of working memory.

Discussion and Conclusion

The present study aimed to investigate the effectiveness of the computer-based cognitive rehabilitation program "Aram" on visuospatial perception and working memory in students with specific learning disorder. The findings indicated that the intervention had a significant positive effect on visuospatial perception. This finding is consistent with previous studies demonstrating the effectiveness of computer-based cognitive rehabilitation in improving visuospatial abilities and related cognitive functions among children with learning difficulties (Capurso et al., 2024; Kim et al., 2024; Maresca et al., 2024; Royatvand Ghiyathvand & Amiri Majd, 2018; Kakavand & Keshavarz, 2019; Haghighatpanah et al., 2019). These findings suggest that targeted cognitive exercises can improve the processing, organization, and interpretation of visual and spatial information in students with learning disorders.

The positive effect of the Aram program on visuospatial perception may be explained by the structure of the intervention itself. Cognitive rehabilitation interventions are designed to strengthen basic cognitive skills such as attention, working memory, information processing, and executive functions, all of which play an important role in visuospatial processing. Numerous studies have shown that regular and targeted cognitive training can lead to structural and functional changes in brain regions associated with visuospatial processing (Karbach & Verhaeghen, 2014; Klingberg, 2010). Furthermore, the use of computer technologies in cognitive rehabilitation allows individualized and adaptive exercises with immediate feedback, which may increase students' motivation, active participation, and intervention effectiveness. Compared with traditional interventions, these computerized approaches provide greater opportunities for repeated and consistent practice and may improve visuospatial memory, visual information processing speed, and visuomotor coordination in students with learning disorders.

The findings also showed that the Aram cognitive rehabilitation program had a significant positive effect on working memory in students with specific learning disorder. This finding is in line with previous studies indicating that computer-based cognitive rehabilitation interventions can improve working memory performance and executive functioning in children with learning difficulties (Trigueros et al., 2024; Chan et al., 2024; Shapiro, 2024; Rute Pérez et al., 2023; Alivand Vafa et al., 2024; Amini et al., 2022; Khanjani & Salehi Aghdam Afi, 2018; Faizi Pur et al., 2018). Since working memory is a fundamental cognitive component involved in learning, reasoning, comprehension, and academic performance, strengthening this ability may substantially improve students' educational functioning and cognitive flexibility.

One possible explanation for the improvement in working memory is that repeated and adaptive cognitive exercises activate and strengthen neural systems involved in verbal, visuospatial, and executive aspects of working memory. Through repeated stimulation of neural pathways, more efficient cognitive processing patterns may gradually develop. In addition, gradual progression of task difficulty based on individual performance, along with immediate reinforcement and therapist supervision, may increase persistence, cognitive engagement, and sustained attention during rehabilitation sessions. Previous studies have similarly suggested that structured and individualized cognitive rehabilitation programs can effectively improve working memory and related academic skills in students with learning disorders (Shaban et al., 2024). Therefore, computer-based cognitive rehabilitation programs such as Aram may serve as an effective complementary intervention for strengthening working memory and related cognitive functions in students with specific learning disorder.

Despite the important findings of the present study, several limitations should be acknowledged. First, the sample size was relatively small, which may limit the generalizability of the findings. Second, the study was conducted only on male students aged 9 to 10 years; therefore, caution should be exercised in generalizing the results to female students or other age groups. Third, the absence of a follow-up phase prevented the evaluation of the long-term stability of the intervention effects. In addition, some environmental and educational factors that may influence cognitive performance were beyond the researchers' control.

Based on these limitations, future studies are recommended to use larger and more diverse samples, include both genders and different educational levels, and conduct follow-up assessments to evaluate the long-term effectiveness of cognitive rehabilitation interventions. It is also suggested that future research compare different computer-based cognitive rehabilitation programs and examine their effects on other cognitive and academic variables such as attention, academic achievement, and executive functions. From a practical perspective, educational and counseling centers may benefit from integrating scientifically designed computer-based cognitive rehabilitation programs into intervention plans for students with learning disorders.

In conclusion, the findings of the present study demonstrated that the Aram computer-based cognitive rehabilitation program significantly improved visuospatial perception and working memory in students with specific learning disorder. These findings highlight the importance of technology-based cognitive interventions in strengthening cognitive functioning and supporting the educational development of students with learning difficulties. Therefore, structured computer-based cognitive rehabilitation programs may be considered effective complementary interventions in educational and clinical settings for children with specific learning disorder.

Declarations

Author Contributions

All authors contributed equally to the conceptualization, study design, data collection, data analysis, and writing of this research.

Data Availability Statement

The data and datasets generated and analyzed in this study are available from the corresponding author upon reasonable request.

Acknowledgements

The authors sincerely appreciate all the students and parents who supported and assisted in conducting this study.

Ethical considerations

All stages of this study were conducted in accordance with the ethical principles stated in international research guidelines. Informed consent was obtained from the students and their parents, and the confidentiality of their information was maintained throughout the research process. This study was approved by the Research Ethics Committee of the Islamic Azad University, Najafabad Branch, under the ethics code IR.IAU.NAJAFABAD.REC.1404.013.

Funding

This study did not receive any specific grant from public, commercial, or nonprofit funding agencies.

Conflict of interest

The authors declare that there was no conflict of interest in conducting this research.

References

Alivandi Vafa, M., Shalchi, B., Farhoodi, M., Nazari, M. A., & Obeidi Houri Leila, L. (2024). Comparison of the effectiveness of computer-based cognitive rehabilitation and non-computer-based intervention on improving auditory and visual working memory in patients with stroke in Tabriz. *Journal of Mazandaran University of Medical Sciences*, *34*(231), 112–125. https://doi.org/10.34172/mj.2024.019

American Psychiatric Association. (2022). *Diagnostic and statistical manual of mental disorders* (5th ed., text rev.; DSM-5-TR). American Psychiatric Association Publishing. https://doi.org/10.1176/appi.books.9780890425787

Amini, A., Almasi, A., & Norouzi Homayoun, N. (2022). Effectiveness of sensory-motor integration exercises and computerized cognitive rehabilitation on executive functions (working memory, response inhibition, and cognitive flexibility) in children with attention-deficit/hyperactivity disorder. *Empowerment of Exceptional Children*, *13*(2), 79–95. https://doi.org/10.22034/ceciranj.2022.318579.1619

Baddeley, A. (1992). Working memory. *Science*, *255*(5044), 556–559. https://doi.org/10.1126/science.1736359

Baddeley, A. (2012). Working memory: Theories, models, and controversies. *Annual Review of Psychology*, *63*, 1–29. https://doi.org/10.1146/annurev-psych-120710-100422

Caporusso, E., Cardinali, F., Bucciarelli, F., Razzano, L., & Piegari, G. (2024). Current perspectives on computerized cognitive remediation: Efficacy and application. *Rivista Sperimentale di Freniatria*, *148*(3), 45–62. https://doi.org/10.3280/RSF2024-003003

Chan, A. T. C., Ip, R. T. F., Tran, J. Y. S., Chan, J. Y. C., & Tsoi, K. K. F. (2024). Computerized cognitive training for memory functions in mild cognitive impairment or dementia: A systematic review and meta-analysis. *npj Digital Medicine*, *7*(1), Article 1. https://doi.org/10.1038/s41746-023-00987-5

Cicerone, K. D., Mott, T., Azulay, J., & Friel, J. C. (2004). Community integration and satisfaction with functioning after intensive cognitive rehabilitation for traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *85*(6), 943–950. https://doi.org/10.1016/j.apmr.2003.07.019

Cornoldi, C., Giofrè, D., Orsini, A., & Pezzuti, L. (2014). Differences in the intellectual profile of children with intellectual vs. learning disability. *Research in Developmental Disabilities*, *35*(9), 2224–2230. https://doi.org/10.1016/j.ridd.2014.05.013

Cowan, N. (2017). The many faces of working memory and short-term storage. *Psychonomic Bulletin & Review*, *24*(4), 1158–1170. https://doi.org/10.3758/s13423-016-1191-6

Dehn, L. B., Piefke, M., Toepper, M., Kohsik, A., Rogalewski, A., Dyck, E., Schneider, W., & Beblo, T. (2020). Cognitive training in an everyday-like virtual reality enhances visual-spatial memory capacities in stroke survivors with visual field defects. *Topics in Stroke Rehabilitation*, *27*(6), 442–452. https://doi.org/10.1080/10749357.2020.1716531

Delavar, A. (2018). *Research methods in psychology and educational sciences* (5th ed.). Virayesh Publishing.

Derikvand, M., Shahni Yilagh, M., & Hajiyakhchali, A. (2023). The comparison of effects of computer cognitive rehabilitation (ARAM) and practical rehabilitation games (Attention Games) on working memory, response inhibition, and reading comprehension of students with dyslexia. *Quarterly Journal of Child Mental Health*, *10*(1), 78–92. http://dx.doi.org/10.61186/jcmh.10.1.7

Devi, A., & Kavya, G. (2023). Dysgraphia disorder forecasting and classification technique using intelligent deep learning approaches. *Progress in Neuro-Psychopharmacology & Biological Psychiatry*, *120*, Article 110647. https://doi.org/10.1016/j.pnpbp.2022.110647

Dutt, S., & Ahuja, N. J. (2021). Comparison of classification methods used in machine learning for dysgraphia identification. *Turkish Journal of Computer and Mathematics Education*, *12*(11), 1886-1891 .https://pdfs.semanticscholar.org/597b/747650844ee4a01e23949ebfeb162322016a.pdf

Eyvazi, S., Karami, J., & Yazdanbakhsh, K. (2024). The effectiveness of the "Hamrah" cognitive rehabilitation package on improving visual-perceptual problems in students with dysgraphia. *Cognitive Psychology Quarterly*, *11*(4), 60–73. http://jcp.khu.ac.ir/article-1-3666-en.html

Feizipour, H., Sepehrianazar, F., Issazadegan, A., & Ashayeri, H. (2019). The effectiveness of cognitive rehabilitation on processing speed, working memory capacity, executive function, and quality of life in multiple sclerosis patients: A quasi-experimental study. *Studies in Medical Sciences*, *30*(10), 804–818. http://umj.umsu.ac.ir/article-1-4688-en.html

Geary, D. C. (1994). *Children's mathematical development: Research and practical applications*. American Psychological Association. https://doi.org/10.1037/10163-000

Haghighat Panah, A., Esteki, M., & Moghaddam, K. (2019). Impact of video games on creativity and spatial perception preschoolers. *Journal of New Thoughts on Education*, *15*(3), 229-256. https://doi.org/10.22051/jontoe.2019.14586.1726

Harley, J. P., Allen, C., Braciszewski, R. E., Cicerone, K. D., Dahlberg, C., Malec, J. F., ... & Smigelski, J. S. (1992). Cognitive rehabilitation: A systematic, functionally oriented service. *Journal of Head Trauma Rehabilitation*, *7*(3), 57–69. https://scholar.google.com/scholar?q=Harley+Cognitive+rehabilitation

Hewapathirana, C., Abeysinghe, K., Maheshani, P., Liyanage, P., Krishara, J., & Thelijjagoda, S. (2021). A mobile-based screening and refinement system to identify the risk of dyscalculia and dysgraphia learning disabilities in primary school students. *In 2021 10th International Conference on Information and Automation for Sustainability (ICIAfS)*, 11–13. https://doi.org/10.1109/ICIAfS52090.2021.9605998

Imani, Z., Jajarmi, M., & Mahoor, H. (2024). Comparison of the effectiveness of brain-based learning and self-regulation strategies on the academic achievement of students with specific learning disabilities. *Journal of Study and Innovation in Education and Development*, *4*(2), 109–124. https://doi.org/10.61838/jsied.4.2.7

Javadi Bazargani, M., Estski, M., Shahriyari Ahmadi, M., & Kooshki, S. (2023). Comparison of visual perception infradian rhythms in students with and without special learning disorder. *Quarterly Journal of Child Mental Health*, *9*(4), 140–151 http://childmentalhealth.ir/article-1-1266-en.html

Jeannerod, M. (1997). *The cognitive neuroscience of action*. Blackwell Publishing.

Karami, E., & Karami, R. (2018). *Rāhnamā-ye āzmūn-e hūsh-e Weksler-e kūdakān [Manual of the Wechsler Intelligence Scale for Children (Digital stimulus version, 21 subtests)]* (D. A. Karami & D. R. Karami, Trans.). Ravansanji.

Karami, E., Karami, R., & Alipour, A. (2020). Psychometric properties of the Wechsler Intelligence Scale for Children—Fifth Edition. *Educational Measurement Quarterly*, *11*(41), 97–125. https://doi.org/10.22054/jem.2021.51727.2036

Karbach, J., & Verhaeghen, P. (2014). Executive-control and working-memory training: Effects on intelligence. *Psychological Science*, *25*(11), 2027–2037. https://doi.org/10.1177/0956797614548725

Kashavarz, S., & Kakavand, A. (2019). A study of numerical processing speed, explicit and implicit memory, active and passive memory, mental retention ability, and visual-spatial skills in students with dyscalculia. *Quarterly Journal of Child Mental Health*, *6*(2), 53–67. http://childmentalhealth.ir/article-1-730-en.html

Khanjani, Z., Salehi Eghdam, K., & Afi, E. (2018). The effectiveness of cognitive rehabilitation-based training in improving visual and auditory memory in children with learning disorders accompanied by hyperactivity and without hyperactivity. *Journal of Cognitive Psychology*, *6*(1), 23–35. https://sanad.iau.ir/en/Article/972506?FullText=FullText

Khodaei, M., Andalib Kourayem, M., & Zarghami, E. (2022). The effectiveness of computer-based cognitive exercises on memory, attention and concentration in the elderly with mild Alzheimer's disease living in nursing homes. *Aging Psychology*, *8*(4), 329–347. https://doi.org/10.22126/jap.2022.8499.1674

Kim, W. C., Jeong, Y. J., Jeong, Y. G., & Lee, K. H. (2024). Computer-assisted rehabilitation shows greater efficacy than traditional in visuospatial skills and cognition in neglect patients. *Journal of Motor Behavior*, *56*(4), 511–518. https://doi.org/10.1080/00222895.2024.2336520

Klingberg, T. (2010). *Training and plasticity of working memory*. Oxford University Press. https://doi.org/10.1016/j.tics.2010.05.002

Lipka, O., Sarid, M., Aharoni Zorach, I., Bufman, A., Hagag, A. A., & Peretz, H. (2020). Adjustment to higher education: A comparison of students with and without disabilities. *Frontiers in Psychology*, *11*, Article 580719. https://doi.org/10.3389/fpsyg.2020.00923

Maggio, M. G., De Luca, R., Molonia, F., Porcari, B., Destro, M., Casella, C., ... & Calabrò, R. S. (2019). Cognitive rehabilitation in patients with traumatic brain injury: A narrative review on the emerging use of virtual reality. *Journal of Clinical Neuroscience*, *61*, 1–4. https://doi.org/10.1016/j.jocn.2018.12.020

Maresca, G., Corallo, F., De Cola, M. C., Formica, C., Giliberto, S., Rao, G., Crupi, M. F., Quartarone, A., & Pidalà, A. (2024). Effectiveness of the use of virtual reality rehabilitation in children with dyslexia: Follow-up after one year. *Brain Sciences*, *14*(7), 655. https://doi.org/10.3390/brainsci14070655

Marr, D. (2010). *Vision: A computational investigation into the human representation and processing of visual information*. MIT Press. https://doi.org/10.7551/mitpress/9780262514620.001.0001

McMahon, M., & Hatton, C. (2021). A comparison of the prevalence of health problems among adults with and without intellectual disability: A total administrative population study. *Journal of Applied Research in Intellectual Disabilities*, *34*(1), 316–325. https://doi.org/10.1111/jar.12785

Mendes, L., Oliveira, J., Barbosa, F., & Castelo-Branco, M. (2022). A conceptual view of cognitive intervention in older adults with and without cognitive decline: A systemic review. *Frontiers in Aging*, *3*, Article 844725. https://doi.org/10.3389/fragi.2022.844725

Mix, K. S., & Cheng, Y. L. (2012). The relation between space and math: Developmental and educational implications. *Advances in Child Development and Behavior*, *42*, 197–243. https://doi.org/10.1016/B978-0-12-394388-0.00006-X

mohamad Panahi, N., & Bayat Mokhtari, L. (2024). The effect of visual spatial perception training on improving theory of mind in students with learning disabilities. *Research in School and Virtual Learning*, *12*(1), 81–90. https://doi.org/10.30473/etl.2024.70444.4157

Moinalghorabaie, A., Eslami, A., & Fadaei, A. (2015). The prevalence of specific learning disabilities among primary school students in North Khorasan Province. *Journal of Learning Disabilities*, *5*(1), 101–124. https://jld.uma.ac.ir/article_366_7eac6963b42bef6836d40c587ae6dd98.pdf?lang=en

Nejati, V. (2018). *Comprehensive cognitive rehabilitation handbook in developmental disorders*. Roshd-e Farhang.

Nemati, Sh., Badri Gargari, R., Vahedi, Sh., & Mehrganfard Jirandeh, Z. (2024). The application of cognitive rehabilitation on comprehension, production, and numerical calculations in students with specific learning disorder with impairment in mathematics. *Applied Psychological Research Quarterly*, *15*(1), 53–72. https://doi.org/10.22059/japr.2024.333955.644085

Newcombe, N. (2015). *Thinking about spatial thinking: New typology, new assessments*. Routledge.

Niemeijer, M., Sværke, K. W., & Christensen, H. K. (2020). The effects of computer based cognitive rehabilitation in stroke patients with working memory impairment: A systematic review. *Journal of Stroke and Cerebrovascular Diseases*, *29*(12), Article 105265. https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.105265

Nodayi, K., Samad, G., & Karami, H. (2016). The relationship between working memory capacity and reading performance in students: An executive function study. *Journal of Cognitive Psychology*, *4*(3), 11–20. http://jcp.khu.ac.ir/article-1-2631-fa.html

Norouzi Homayoun, M., Lester, D., Hataminejad, M., & Sadri Demirchi, E. (2025). Neurocognitive differences in attention, memory, and executive functions between individuals with epilepsy and healthy controls: Evidence from Shiraz, Iran. *Journal of Cognitive Science Research*, *3*(1), 60–69. https://doi.org/10.22059/jcsr.2025.404866.1024

Pourfaraman, M., & Taher, M. (2022). The effectiveness of visual skill-based computer games on visual-auditory-spatial perception and reading tracking speed of students with special learning disabilities. *Journal of Learning Disabilities*, *10*(2), 200–211. https://jld.uma.ac.ir/article_1103_4a64a03f7d101e8d3103110b2551370c.pdf?lang=en

Raven, J. (2000). The Raven's progressive matrices: Change and stability over culture and time. *Cognitive Psychology*, *41*(1), 1–48. https://doi.org/10.1006/cogp.1999.0735

Reisian, F., Ghasemzadeh, S., & Ghobari Bonab, B. (2025). Free rein: How freedom in outcome preserves working memory and protects skilled performance under high pressure. *Journal of Cognitive Science Research*, *3*(1), 38–49. https://doi.org/10.22059/jcsr.2025.404839.1023

Roitavand Ghiasvand, N., & Amiri-Majd, M. (2019). The effectiveness of the Captain Log cognitive software on visual-spatial perception in students with learning disabilities. *Journal of Exceptional Children*, *19*(1), 1–10. http://joec.ir/browse.php?a_code=A-10-692-1&slc_lang=fa&sid=1

Rute-Pérez, S., Rodríguez-Domínguez, C., Vélez-Coto, M., Pérez-García, M., & Caracuel, A. (2023). Effectiveness of computerized cognitive training by VIRTRAEL on memory and executive function in older people: A pilot study. *Brain Sciences*, *13*(4), 684. https://doi.org/10.3390/brainsci13040684

Saeidmanesh, M., Vaziri, F., & Azizi Bondarabadi, M. (2025). Examining the effectiveness of computerized cognitive rehabilitation on the working memory of students with learning disabilities. *Journal of Disability Studies*, *15*, 28–36. http://jdisabilstud.org/article-1-3199-en.html

Safavi Vesal Morvarid, S., Nazari, M. A., & Bafandeh Qara Maleki, H. (2022). The effectiveness of cognitive rehabilitation in improving working memory, visual processing, and spatial understanding in children with mathematical learning disorder. *Journal of Neuropsychology*, *8*(29), 85–104. http://childmentalhealth.ir/article-1-1258-en.html

Sahraeian, K. (2025). Design characteristics of educational games for developing metacognitive skills: A systematic review. *Journal of Cognitive Science Research*, *3*(1), 70–90. https://doi.org/10.22059/jcsr.2025.407738.1031

Seyyed Sharbat, M., Zarei, H. A., & Hoseininasab, S. D. (2021). Comparative study of visual-spatial working memory perception in normal students and students with special learning disabilities. *The Scientific Journal of Rehabilitation Medicine*, *10*(5), 988–1001. https://doi.org/10.32598/SJRM.10.5.15

Shaban, A., Chang, V., Amodu, O. D., Attia, M. R., & Abdelhamid, G. S. M. (2024). A systematic review of working memory applications for children with learning difficulties: Transfer outcomes and design principles. *Education Sciences*, *14*(11), 1260. https://doi.org/10.3390/educsci14111260

Shapiro, L. (2024). *Trial tests cognitive rehab with VR-based exercise to boost memory*. Medical News Today. https://multiplesclerosisnewstoday.com/news-posts/2024/09/10/trial-cognitive

Swanson, H. L., & Sachse-Lee, C. (2001). Mathematical problem solving and working memory in children with learning disabilities: Both executive and phonological processes are important. *Journal of Experimental Child Psychology*, *79*(3), 294–321. https://doi.org/10.1006/jecp.2000.2587

Trigueiro, M. J., Lopes, J., Simões-Silva, V., Vieira de Melo, B. B., Simões de Almeida, R., & Marques, A. (2024). Impact of VR-based cognitive training on working memory and inhibitory control in IDD young adults. *Healthcare*, *12*(17), 1705. https://doi.org/10.3390/healthcare12171705

Tsaousides, T., & Gordon, W. A. (2009). Cognitive rehabilitation following traumatic brain injury: Assessment to treatment. *Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine*, *76*(2), 173–181. https://doi.org/10.1002/msj.20099

Vestberg, T., Reinebo, G., Maurex, L., Ingvar, M., & Petrovic, P. (2017). Core executive functions are associated with success in young elite soccer players. *PLoS One*, *12*(2), Article e0170845. https://doi.org/10.1371/journal.pone.0170845

Wechsler, D. (2003). *WISC-IV technical and interpretive manual*. Pearson.

Wechsler, D. (2008). *WAIS-IV: Wechsler Adult Intelligence Scale*. Pearson.

Wechsler, D. (2014). *WISC-V technical and interpretive manual*. Pearson.

Zelinski, E. M., & Reyes, R. (2009). Cognitive benefits of computer games for older adults. *Gerontechnology*, *8*(4), 220–235. https://doi.org/10.4017/gt.2009.08.04.004.00