

The Effect of Cognitive-Linguistic Training on Phonological Awareness, Working Memory, Inhibitory Control, and Reading Performance in Children with Developmental Dyslexia. A Multi-Case Quasi-Experimental Study at the Smart Way Educational Center in Dely Ibrahim–Algier

Noureddine Mabrouki

Laboratory of Language and Cognition: Development and Disorders, University of Algiers 2 – Abou El Kacem
Saadallah, Algeria
Noureddine.mabrouki@univ-alger2.dz

Chafika Azdaou

Laboratory of Language and Cognition: Development and Disorders, University of Algiers 2 – Abou El Kacem
Saadallah, Algeria
Chafika.azdaou@univ-alger2.dz

Abstract

This study investigated the effects of a cognitive-linguistic program on phonological awareness, verbal working memory, inhibitory control, and reading performance among five primary school pupils diagnosed with developmental dyslexia. The study adopted a multiple-case quasi-experimental design with pretest- and posttest measures and was conducted at the Smart Way Educational Center in Dely Ibrahim (Algiers) from January 27, 2026, to April 7, 2026. Assessment instruments included a phonological awareness scale, a word and pseudoword reading test, the Stroop test for inhibitory control, and verbal working memory tasks, with the support of clinical interviews, structured observation, and Raven's Progressive Matrices, to control selection criteria. Results reveal an increase in the overall mean score for phonological awareness (from 22.7/60 to 45.0/60) and an improvement in overall reading performance (from 35.2/90 to 68.2/90). Mean reading errors decreased (from 41 to 18), and mean reading duration dropped (from 10.4 to 6.8 minutes). Additionally, Stroop error rates declined, accompanied by positive indicators in verbal working memory. Because all five cases improved in the expected direction, the exact one-sided sign-test yielded a value of ($p = 0.031$). The findings indicate concurrent enhancements in phonological processing, executive control, and reading performance following the training program. Neuroplasticity serves as an interpretative theoretical framework accounting for these behavioral gains rather than a directly measured variable, taking into account methodological limitations of the small sample size and the absence of a control group.

Keywords: developmental dyslexia, cognitive-linguistic training, phonological awareness, working memory, inhibitory control, reading performance, and neuroplasticity.

¹ Received: 20/02/2026; Accepted: 26/09/2026; Published: 10/10/2026

© 2026 The Author. Published by AVADA-CROMA. This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0), which permits unrestricted use, distribution, adaptation, and reproduction in any medium, provided that the original author and source are properly credited.
<https://creativecommons.org/licenses/by/4.0/>

Introduction

Reading is among the most academic skills contingent upon the integration of linguistic and cognitive processes. Not only confined to the visual recognition of letters, but it rather requires converting written symbols into phonological units, temporarily retained and integrated in order to monitor responses and ultimately access meaning. Any persistent disruption across this sequential process leads to slow decoding, high error rates, and poor reading fluency, thus directly impairing academic achievement, motivation, and self-confidence. Jari, Laiss, and Gharbi (2021, pp. 49-50) described reading as a complex activity involving visual perception, auditory discrimination, articulation, and comprehension, emphasizing the centrality of phonological awareness in learning letter-sound correspondences.

Developmental dyslexia presents in children who possess average general intellectual ability and show no overt sensory or neurological impairments, yet experience persistent, specific difficulties in word reading accuracy, reading speed, spelling, and decoding. The literature primarily links this disorder to deficits in phonological processing, often co-occurring with difficulties in working memory, inhibitory control, and attention. The International Dyslexia Association (2025) underscores that these difficulties affect word reading accuracy and/or fluency and persist despite effective instruction, frequently stemming from deficits in phonological and morphological processing components.

Phonological awareness represents a child's ability to perceive the phonological structure of spoken language and intentionally manipulate syllables and phonemes through segmentation, blending, deletion, and substitution. Its significance becomes particularly evident when reading novel words and pseudowords, where the child cannot rely on visual memory or semantic context but must instead apply letter-to-sound conversion rules. A meta-analysis by Ehri et al. (2001) concluded that systematic training in phonemic awareness supports reading acquisition, especially when paired with letter manipulation and reading/writing tasks. Similarly, Jari et al. (2021) observed improvements in word and pseudoword reading following a phonological awareness-based intervention, justifying its inclusion as a core linguistic axis in speech-language pathology interventions.

However, reading performance does not rely on phonological processing alone; children must retain sound sequences while blending them, inhibit rapid guessing or inappropriate responses, and monitor and correct errors. Verbal working memory provides a temporary store for processing sounds and syllables, while inhibitory control prevents automatic, inappropriate responses. Lasbat (2021, pp. 615–634) showed difficulties among children with dyslexia in working memory and inhibitory control mechanisms, accounting for common manifestations such as hesitation, impulsivity, deletions, and substitutions during reading. Consequently, an intervention restricted strictly to reading repetition may yield limited gains unless it incorporates activities targeting the executive resources that support decoding.

Functional neuroplasticity provides a framework for explaining the improvability of these skills. Systematic training and other repeated experiences can modify the efficiency of functional connectivity of neural systems involved in language, attention, and memory. Neuroscientific literature has shown evidence of some functional brain changes following behavioral and language interventions for individuals with dyslexia, particularly in brain areas and circuits involved in phonological processing and reading, but these results have some limitations related to sample size and design (Temple et al., 2003; Barquero et al., 2014). The current study used evidence of functional neuroplasticity to help explain skill improvements but did not collect data on neurophysiological outcomes directly.

The research gap appears in that a number of Arab studies have evaluated phonological skills and reading performance individually and have explored executive skills as comorbid conditions, but few studies have combined evaluating phonological skills and executive functions together in a speech-language intervention to assess generalization effects on word/pseudoword reading accuracy and fluency. Hence, this study used an integrated approach and framework to address the research gap: cognitive-linguistic training is the independent variable; phonological skills and executive functions are the immediate targets of the training; reading skills are the main dependent variable; and neuroplasticity is the main interpretive framework for results, not a dependent variable.

Research Problem

The core research problem is that reading difficulties in children with developmental dyslexia stem not only from phonological processing deficits but also may interact with limited working memory capacity, impaired response inhibition, and rapid guessing during decoding. While literature confirms the efficacy of phonological awareness training in improving reading skills, executive function research underscores the critical role of working memory and inhibitory control in regulating reading performance. However, integrating these components into a unified speech-language pathology intervention and systematically examining pre- to posttest changes across each target variable and overall reading performance remains under-researched within the local context. Accordingly, this study tests the effects of an integrated cognitive-linguistic program that combines phonological training with executive support mechanisms in five cases.

Main Research Question

Does the cognitive-linguistic training program significantly affect phonological awareness, verbal working memory, inhibitory control, and reading performance in children with developmental dyslexia?

Sub-Questions

- Are there differences between pretest and posttest measurements in phonological awareness levels in children with developmental dyslexia?
- Are there differences between pretest and posttest measurements across verbal working memory indices in children with developmental dyslexia?
- Are there differences between pretest and posttest measurements across inhibitory control indices in children with developmental dyslexia?
- Are there differences between pretest and posttest measurements in reading performance, specifically word and pseudoword reading accuracy, total reading errors, and completion time, in children with developmental dyslexia?

Study Hypotheses

General Hypothesis: The cognitive-linguistic training program positively impacts phonological awareness, verbal working memory, inhibitory control, and reading performance in children with developmental dyslexia.

- **Sub-Hypothesis 1:** There are differences between pretest and posttest scores in phonological awareness, favoring the posttest measurement.
- **Sub-Hypothesis 2:** There are differences between pretest and posttest scores across verbal working memory indices, favoring the posttest measurement.
- **Sub-Hypothesis 3:** There are differences between pretest and posttest scores across inhibitory control indices, favoring the posttest measurement.
- **Sub-Hypothesis 4:** There are differences between pretest and posttest scores in reading performance in terms of accuracy, total errors, and reading time, favoring the posttest measurement in children with developmental dyslexia.

Study Objectives and Significance

This study aims to quantify pre-to-post intervention changes in phonological awareness, verbal working memory, inhibitory control, and reading performance following a structured cognitive-linguistic intervention. Additionally, it provides a detailed descriptive profile of individual case responses to determine whether gains in reading fluency and accuracy coincide with enhancements in targeted phonological and executive skills.

Applied significance lies in formulating an integrative speech-language clinical model. This framework connects phonological structure processing with verbal retention, inhibition of impulsive guessing, and self-correction strategies, instead of limiting the intervention to conventional repetitive reading drills.

Operational Definitions

- **Cognitive-Linguistic Training:** A structured 12-session intervention program combining auditory discrimination, syllable and phoneme manipulation, and grapheme-to-phoneme (letter-to-sound) conversion, working memory exercises, response inhibition tasks, and target word/pseudoword decoding drills.

- **Phonological Awareness:** The composite score obtained by a child across subtests assessing rhyme recognition, syllable segmentation, phoneme/sound identification, blending, deletion, and phonemic substitution tasks.

- **Verbal Working Memory:** Operationalized performance metrics derived from forward and backward digit span and pseudoword repetition tasks as indicators of verbal storage capacity and active processing.

- **inhibitory control:** Operationalized indices of interference error counts and response time in the Stroop test, supplemented by structured observation protocols tracking impulsive guessing and self-correction behavior.

- **Reading Performance:** The number of words and pseudowords read correctly (decoded units), total error counts, and task completion time recorded across pretest and posttest evaluations.

- **Developmental Dyslexia:** A persistent impairment in word reading accuracy, decoding, and fluency in school-aged children who exhibit average intellectual ability (measured via Raven's Progressive Matrices) and show no primary sensory or neurological deficits accounting for the condition.

Theoretical Framework

Phonological Awareness and Decoding

Phonological awareness allows the child to shift from using language automatically to analyzing its sound structure. When the child realizes that a word can be divided into syllables and phonemes, they become able to link each sound unit to the appropriate written symbol. The effect of this awareness is clearly evident in pseudowords; because they have no prior lexical representation, they require the application of the pure phonological route. Improvement in pseudowords is considered a stronger indicator of decoding development than improvement in familiar words alone, because the latter may be read by memorization or visual recognition.

Training typically moves from broader tasks such as rhyme and syllable segmentation to more precise and complex tasks involving blending, deletion, and phonemic substitution. This progression serves the principle of moving from the large sound unit to the small one and reduces cognitive load on the child. The reviewed literature indicates that sound training is most closely related to reading acquisition when combined with letters and reading and writing tasks, because isolated oral activities may improve awareness of sounds without guaranteeing transfer of effect to written text. Therefore, the current program linked each phonological skill with a direct reading application (National Reading Panel, 2000).

Working Memory and Inhibitory Control in Reading

Working memory theory explains that reading requires temporary retention of verbal information during processing. A child reading a multisyllabic word needs to keep the first syllable

active until processing the rest of the syllables and then blending them. If the phonological loop is limited, they may delete a sound, reverse the order, or lose the beginning of the word before reaching its end. Forward digit span provides an estimate of short-term verbal retention, while backward span requires retention and processing together, and pseudoword repetition is close to decoding requirements because it reduces reliance on meaning and lexical knowledge (Baddeley & Hitch, 1974; Baddeley, 2000).

Inhibitory control protects reading from inaccurate automatic responses. The child may guess the word from its first letter, choose a familiar word visually similar to it, or continue an error simply because they started it. Correction requires stopping the first response, returning to phonological analysis, and comparing the output with the written model. The Stroop test assesses a child's ability to resist interference and control dominant responses, serving as an auxiliary indicator of executive control. While improvement in the Stroop test alone does not guarantee better reading, its association with reduced guessing errors and faster reading times reinforces the interpretation that the child has become more capable of pausing and self-monitoring.

Functional Neuroplasticity as an Interpretive Framework

Neuroplasticity refers to the nervous system's ability to modify its structure, function, or connectivity efficiency in response to experience and training. This malleability is prominent in childhood, where learning is repeated within networks that have not yet reached maximum specialization. Neuroimaging studies in dyslexia have provided evidence that behavioral and linguistic interventions may be accompanied by changes in the activity of reading regions, particularly the left temporoparietal and frontal regions (Temple et al., 2003; Barquero et al., 2014).

However, three levels must be distinguished: behavioral improvement that the current study measures directly; cognitive interpretation that links it to improved phonological processing and executive control; and neural interpretation based on results of other studies that used imaging. Therefore, it is not correct to say that the study "proved the reshaping of brain pathways," but rather that its results are consistent with the principle of neuroplasticity and allow a cautious theoretical interpretation of the malleability of performance after systematic training.

Methodological Procedures

Method and Design

The study adopted a multiple-case quasi-experimental design with pretest and posttest measures. Each case was assessed before applying the program, then received training sessions in the same sequence with difficulty level adapted to the child's performance, and was reassessed after the intervention ended. This design allows comparison of change within each case and comparison of change trends among the five cases. Pre-post differences are interpreted within the limits of this design's characteristics, taking into account the absence of a control group and the possible influence of practice, maturation, or accompanying school factors.

Sample and Study Location

The study was conducted at the Smart Way Educational Center in Dely Ibrahim, Algiers Province, during the period from 27/01/2026 to 07/04/2026. The sample consisted of five cases selected purposively from primary-school students, with ages ranging from 8 years and 8 months to 10 years. Cases were included based on a previous speech-language diagnosis of developmental dyslexia, supported by specialized assessment of reading and linguistic skills, with the use of available medical and psychological data to exclude other disorders or factors explaining the difficulty. Inclusion criteria also included regular school attendance and parental consent, while cases with general intellectual disability, uncorrected hearing or visual impairment, or severe neurological disorder that could explain reading performance were excluded.

Table 1: Demographic and Educational Characteristics of Cases

Case	Gender	Age	Grade Level
C1	Male	9 years	4th year of primary school
C2	Female	8 years and 8 months	3rd year of primary school
C3	Male	10 years	5th year of primary school
C4	Female	9 years and 6 months	4th year of primary school
C5	Male	8 years and 10 months	3rd year of primary school

Study Instruments and Intervention Program

Study instruments were selected to achieve direct correspondence between variables and measurements: the phonological awareness scale to measure the linguistic variable, working memory tasks and the Stroop test to measure the two executive dimensions, and the word and pseudoword reading test to measure reading performance, while interview, observation, and Raven were used to control inclusion and exclusion criteria and describe the case, not as dependent variables of the program.

Clinical Interview and Structured Observation

A semi-structured clinical interview was conducted with each case's guardian to collect data related to developmental, linguistic, and school history, the onset of reading difficulty, previous intervention, and relevant health data. Structured observation was used directly with the child during reading tasks to monitor performance patterns such as hesitation, guessing, deletion, substitution, pausing, and self-correction. The interview or observation was not used to issue a new diagnosis of dyslexia; case inclusion was based on a previous speech-language diagnosis supported by specialized assessment of reading and linguistic skills.

Raven's Progressive Matrices

Raven's Progressive Matrices were used to verify that the level of nonverbal reasoning in the cases did not indicate general intellectual disability that could explain the reading difficulty. Thus, the test was used within exclusion criteria and to control case homogeneity from a general cognitive perspective, not as a measure of program outcomes.

Phonological Awareness Scale

The phonological awareness scale adapted by researcher Azdaou Chafika (2012) as reported in Jari et al. (2021, p. 48) was used to measure rhyme, segmentation, first and last sound identification, blending, deletion, and substitution skills. Its dimensions were used in a manner suitable for the studied age group, with pre- and post-administration to measure change in sound processing.

Stroop Test for Inhibitory Control

The Stroop test was used to estimate the ability to resist interference and inhibit automatic responses through the number of errors and completion time. The test is not presented as a diagnostic tool for dyslexia but as an indicator of executive control accompanying reading performance (Stroop, 1935; Lasbat, 2021).

Verbal Working Memory Tasks

Working memory tasks included forward digit span, backward digit span, and pseudoword repetition. These tasks were used to estimate the ability to temporarily retain verbal information and process it during decoding. They are based on the working memory conception that combines temporary storage and active processing of information, and their results are interpreted in the study as performance indicators related to verbal working memory, not as an independent comprehensive standardized executive functions battery (Baddeley & Hitch, 1974; Baddeley, 2000).

Word and Pseudoword Reading Test

The word and pseudoword reading test by Laiss Ismail (2015), as documented in Jari, Laiss, and Gharbi (2021, p. 48), was used to measure reading performance in terms of accuracy of reading low-frequency and high-frequency words and pseudowords, the number of errors, their type, and completion time. Pseudowords acquire diagnostic and functional value because they reduce reliance on visual memorization and prior lexicon and reveal more clearly the efficiency of letter-to-sound conversion and decoding.

Cognitive-Linguistic Training Program

The cognitive-linguistic training program was designed by the researchers within the framework of the current study, based on the principles of systematic training in phonological awareness and linking sound to letter and actual reading, with the integration of working memory and inhibitory control activities relevant to decoding requirements. Literature supports this integration when sound training is combined with letters and actual reading practice. The program consisted of twelve sessions at two sessions per week, with session duration ranging between 35 and 45 minutes, organized in four progressive stages: sound preparation, phonemic processing, cognitive-linguistic integration, and then transition to reading (Ehri et al., 2001; National Reading Panel, 2000).

Stage	Session	Central Objective	Brief Activity Examples
Sound preparation	1-3	Raising auditory attention and awareness of rhyme and syllable	Sound discrimination, rhyme judgement, clapping for segmentation
Phonemic processing	4-7	Developing blending, deletion, substitution, and sound position identification	Picture and word cards, sound blending, changing a phoneme within a word
Cognitive-linguistic integration	8-10	Linking letter to sound and supporting working memory and inhibition of guessing	Sound sequences, "Stop-Analyze-Read" cards, graded words
Transition to reading	11-12	Consolidating the phonological route and improving accuracy and fluency	Pseudoword reading, timed guided reading, self-correction

Table 2: Components of the Training Program

Source: Prepared by the researchers based on program objectives and principles of phonological and cognitive training.

The application sequence was kept constant across the five cases: pretest of instruments related to target variables, then implementation of the twelve sessions according to the four stages, then re-administration of the same measures after the program ended. Qualitative indicators related

to reading were recorded during sessions, such as error pattern, guessing, pausing, and self-correction, so that judgment would not be limited to the numerical score alone. These indicators were used to interpret each case's trajectory and compare quantitative change with direct observation of performance.

Statistical Treatment and Individual Performance Analysis

Arithmetic means, mean differences, and improvement percentages were used to describe change between pretest and posttest measures, with presentation of change direction at the level of the five cases. Given the small sample size and reliance on a multiple-case design, the exact one-sided sign test was used to examine the regularity of difference direction according to directional hypotheses; if all five cases improved without ties, the probability of this direction under the null hypothesis equals 0.03125, i.e., $1/2^5$. Qualitative analysis of individual performance was also conducted by comparing error patterns, guessing, self-correction, and reading time before and after the intervention to complement quantitative interpretation and show differences between case response trajectories.

Presentation and Analysis of Results

Results are presented in this section at two integrated levels: first, through arithmetic means of the five cases in the pretest and posttest; second, through individual analysis of change direction in each case. The mean is used here for descriptive comparative purposes, while the multiple-case design remains based on tracking each child's response individually.

Phonological Awareness Results

Table 3: Phonological Awareness Results Before and After the Program

Skill	Mean of Five Cases-Pretest /10	Mean of Five Cases-Posttest /10	Mean Difference (Post–Pre)	Improvement Percentage
Rhyme	4.1	7.8	+3.7	90.24%
Syllable segmentation	4.6	8.2	+3.6	78.26%
First and Last Sound Identification	4.3	8.0	+3.7	86.04%
Phonemic blending	3.8	7.6	+3.8	100%
Phonemic deletion	3.1	6.9	+3.8	122.58%
Phonemic substitution	2.8	6.5	+3.7	132.14%
Total /60	22.7	45.0	+22.3	98.23%

The values in the table represent the arithmetic mean of the five cases' scores in each skill, not the scores of a single case. The improvement percentage was calculated according to the formula:

improvement percentage = $[(\text{posttest mean} - \text{pretest mean}) \div \text{pretest mean}] \times 100$. Accordingly, the total mean increased from 22.7/60 to 45.0/60, a difference of 22.3 points and an improvement percentage of 98.23%. The highest percentages were recorded in substitution and phonemic deletion, while all five cases showed a positive direction in the total score; therefore, the exact one-sided sign-test probability reached 0.031. This result supports the first hypothesis within the limits of sample size and study design.

Working Memory and Inhibitory Control Results

Table 4: Inhibitory Control and Working Memory Results

Indicator	Mean of Five Cases—Pretest	Mean of Five Cases—Posttest	Mean Difference	Description of Change
Stroop errors	18	9	-9	Decrease in interference errors
Stroop time in minutes	5.6	3.9	-1.7	Decrease in response time
Forward digit span /10	5.2	7.1	+1.9	Increase in verbal retention capacity
Backward digit span /10	3.4	5.8	+2.4	Increase in retention capacity and processing
Pseudoword repetition /10	3.8	6.7	+2.9	Increase in phonological retention capacity

The values in the table represent the mean performance of the five cases before and after the program. The mean Stroop errors decreased from 18 to 9, and the mean completion time decreased from 5.6 to 3.9 minutes, indicating improvement in resisting interference and inhibiting automatic responses. In working memory, the mean forward span increased from 5.2 to 7.1, backward span from 3.4 to 5.8, and pseudoword repetition from 3.8 to 6.7. Individual analysis showed that the direction of improvement was present in all five cases in working memory and inhibitory control indices, and the exact one-sided sign-test probability reached 0.031 for each dimension, supporting the second and third hypotheses within the limits of the study design.

Reading Performance Results**Table 5: Reading Performance Results Before and After the Program**

Indicator	Mean of Five Cases—Pretest	Mean of Five Cases—Posttest	Mean Difference	Direction of Improvement
Reading high-frequency words (/30)	16.4	25.8	+9.4	Large improvement
Reading low-frequency words (/30)	11.2	22.6	+11.4	Clear improvement
Reading pseudowords (/30)	7.6	19.8	+12.2	Strong improvement
Total (/90)	35.2	68.2	+33	General improvement
Number of errors	41	18	-23	Decrease in errors
Reading time in (minutes)	10.4	6.8	-3.6	Improved fluency

The values represent the mean performance of the five cases in the two measurements. The mean total reading score increased from 35.2/90 to 68.2/90, the mean number of errors decreased from 41 to 18, and the mean reading time decreased from 10.4 to 6.8 minutes. The largest difference was in pseudoword reading, followed by low-frequency words, an order consistent with the program's focus on letter-to-sound conversion and decoding. All five cases recorded a positive direction in reading indicators, and the exact one-sided sign-test probability reached 0.031, supporting the fourth hypothesis within the limits of sample size and the multiple-case design.

Change By Case**Table 6: Improvement Percentages and Notes by Case**

Case	Phonological Awareness	Reading Performance	Inhibitory Control	Working Memory	General Note
C1	101%	92%	55%	41%	Decrease in guessing and impulsivity
C2	85%	76%	42%	38%	Slow but steady improvement
C3	96%	88%	50%	46%	Reduction in deletion and substitution
C4	110%	97%	61%	52%	Improved letter-sound mapping

C5	99%	84%	48%	44%	Improved segmentation and attention
----	-----	-----	-----	-----	-------------------------------------

The individual results reveal that improvement was not equal but was positive for all. The fourth case achieved the largest change, coinciding with improved letter–sound mapping and inhibitory control, while the second case's response was slower due to slow processing and the need for repetition of instructions. This variability confirms the importance of multiple-case design; it shows that the same program needs adaptation of dosage and type of assistance and that the group mean does not substitute for clinical analysis of each child's trajectory.

Discussion of Results

Linguistic and Phonological Interpretation of Results

Phonological awareness showed improvement in all skills, and more so in blending, deletion, and substitution. This can be explained by the progression from broad sound units to precise phonemic processing and by linking oral tasks to letters and words. The results align with the study by Jari et al. (2021), which documented improvements in reading proficiency after phonological awareness training, and are consistent with evidence supporting the effectiveness of integrating phonemic awareness instruction with reading and writing and with recommendations that consider phonemic awareness and phonics as essential components of reading instruction (Ehri et al., 2001; National Reading Panel, 2000).

High improvement percentages should not be interpreted as evidence of complete mastery; a high percentage may result partly from a low pretest score. Therefore, the discussion relied on absolute difference, direction of improvement, and quality of performance, not on percentage alone. The absence of a control group remains a barrier to isolating the effect of practice or maturation, although the consistency of improvement across cases and skills supports the association of improvement with the applied intervention, taking into account the limits of the design.

Cognitive-Executive Interpretation of Results

The decrease in Stroop errors and time, with improvement in backward digit span and pseudoword repetition, indicates that training did not remain at the sound level but supported retention and monitoring mechanisms. This result agrees with Lasbat (2021), who showed the association of dyslexia with difficulties in inhibition and working memory. Functionally, the "Stop–Analyze–Read" activities and self-correction allowed inhibiting guessing, while sound sequences and pseudowords supported the child's ability to retain phonological information during blending.

However, it cannot be definitively stated that executive improvement is entirely independent of the child's familiarity with the tasks; performance may be affected by retesting. Therefore, results should be considered supporting indicators, not a comprehensive neuroexecutive diagnosis. The strength of interpretation increases because the change in tests was accompanied by consistent behavioral observations, such as decreased impulsivity and increased self-correction, not merely improved numerical scores.

Effect of Training on Reading Performance

The larger increase in pseudowords supports the idea of a transfer of the training effect to the phonological route; the child cannot retrieve a pseudoword from the lexicon but applies letter–sound conversion, retains the sounds, and then blends them. Improved working memory also explains the decrease in deletion and order reversal, while improved inhibition explains the decrease in guessing and rapid substitution. Thus, reading performance appears to result from the integration of linguistic and executive improvement, not from a single isolated skill.

The results are also consistent with evidence indicating that interventions targeting skills related to decoding are more effective than general unspecified interventions. However, the current sample does not allow testing a correlational relationship or a mediation model proving that improved executive functions caused improved reading. Accordingly, improvements are interpreted as concurrent changes consistent with the program's logic and the adopted design (Galuschka et al., 2014).

Neural Interpretation in Light of Functional Neuroplasticity

The recorded change can be understood as a behavioral expression of the malleability of reading systems to adapt to systematic practice. Gradual repetition, feedback, and multisensory input may enhance the efficiency of sound processing, letter–sound mapping, and executive monitoring. This reading is consistent with studies and reviews that linked reading interventions to changes in the activity of phonological processing regions and reading networks (Temple et al., 2003; Barquero et al., 2014).

However, the current study did not measure brain activity and therefore cannot identify a specific neural region that changed or prove the reshaping of a particular pathway. Neuroplasticity here is an interpretive framework supported by previous research, while direct evidence in this study remains behavioral: increased scores, decreased errors and time, and improved control during reading. This formulation responds to the principle of scientific caution and prevents moving from functional improvement to an unmeasured neural conclusion.

Applied Speech-Language Implications

Results support adopting speech-language intervention that integrates phonological awareness training with actual reading, instead of isolating rhyme or segmentation tasks from the letter and written word. Focusing on pseudowords appears particularly useful because it forces the child to use letter–sound conversion instead of relying on visual memory of familiar words. "Stop–Analyze–Read" activities and self-correction also allow introducing an executive dimension that serves response organization during reading without turning executive functions into an independent diagnosis.

Results also indicate the importance of tracking accuracy, time, and error type indicators concurrently. An increase in the number of correct words alone is not sufficient if the child continues to rely on guessing or requires excessive time, and improvement in reading time should be interpreted alongside decreased errors and increased self-correction. This perspective allows building speech-language follow-up more sensitive to the trajectory of change within a single case, especially in small samples where the group mean is less capable of showing individual differences.

Conclusion and Recommendations

Across all five observed cases, the study concluded that cognitive-linguistic training was associated with concurrent improvement in phonological awareness, working memory, inhibitory control, and reading performance. Reading improvement appeared in increased accuracy of words and pseudowords, decreased errors, and reduced reading time. Individual analysis also showed that all cases improved, with variation related to difficulty pattern, processing speed, and need for assistance. Sign-test results supported the directional hypotheses at a probability value of 0.031, and this significance is interpreted within the limits of the small sample and absence of a control group.

The study affirms that speech-language intervention for dyslexia should link conscious manipulation of sounds with letter–sound mapping, verbal retention, inhibition of guessing, and self-correction, instead of limiting to re-reading words. Neuroplasticity provides a reasonable theoretical explanation for the malleability of improvement, but it does not represent a directly measured outcome. Thus, the core value of the study lies in building an intervention model with limited variables, clear instruments, and consistency between questions, hypotheses, and results.

Recommendations

- Early detection of dyslexia indicators, especially slowness, deletion, substitution, guessing, and difficulty with pseudowords.
- Adopting programs that integrate phonological awareness, letter–sound mapping, working memory, and inhibitory control within interconnected functional objectives.
- Linking every sound activity to a reading or writing task to ensure transfer of training effect to academic performance.
- Monitoring accuracy, time, error type, and self-correction, not limiting to the total score.
- Adapting session duration and level of assistance according to each case's profile, with family and teacher involvement in home and school reinforcement.
- Replicating the study on a larger sample with a control group, using individual raw scores, nonparametric tests, effect sizes, and follow-up measurement to verify continuity of improvement.
- Using neuroimaging techniques or electrophysiological indicators in later studies only when wishing to test neuroplasticity hypotheses directly.

Study Limitations

The main limitations for the current study are the small sample, absence of a control group, short follow-up period, and reliance on some supportive clinical tasks instead of a comprehensive standardized executive battery. Also, the use of percentages in cases with low pretest scores may exaggerate the impression of improvement magnitude. These limitations are taken into account when interpreting results, and they should not be generalized to all children with developmental dyslexia outside the studied sample and context.

References

- Azdaou, C. (2012). *Phonological awareness and reading acquisition processes in the child: A longitudinal follow-up study from the beginning of first primary year to the beginning of second primary year* [in Arabic]. University of Algiers 2.
- Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 8, pp. 47–89). Academic Press.
- Baddeley, A. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*, 4(11), 417–423.
- Barquero, L. A., Davis, N., & Cutting, L. E. (2014). Neuroimaging of reading intervention: A systematic review and activation likelihood estimate meta-analysis. *PLOS ONE*, 9(1), e83668. <https://doi.org/10.1371/journal.pone.0083668>
- Ehri, L. C., Nunes, S. R., Willows, D. M., Schuster, B. V., Yaghoub-Zadeh, Z., & Shanahan, T. (2001). Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's meta-analysis. *Reading Research Quarterly*, 36(3), 250–287. <https://doi.org/10.1598/RRQ.36.3.2>
- Galuschka, K., Ise, E., Krick, K., & Schulte-Körne, G. (2014). Effectiveness of treatment approaches for children and adolescents with reading disabilities: A meta-analysis of randomized controlled trials. *PLOS ONE*, 9(2), e89900. <https://doi.org/10.1371/journal.pone.0089900>
- International Dyslexia Association. (2025). *Definition of dyslexia*. <https://dyslexiaida.org/definition-of-dyslexia>
- Jari, B., Laiss, I., & Gharbi, A. (2021). A training program to develop phonological awareness aimed at improving reading ability in a poor reader: A case study of a fourth primary year student [in Arabic]. *Journal of Psychological and Educational Sciences*, 7(4), 48–68.
- National Reading Panel. (2000). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction*. National Institute of Child Health and Human Development.

- Raven, J. C. (1938). *Progressive Matrices: A perceptual test of intelligence*. H. K. Lewis.
- Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 18(6), 643–662.
- Temple, E., Deutsch, G. K., Poldrack, R. A., Miller, S. L., Tallal, P., Merzenich, M. M., & Gabrieli, J. D. E. (2003). Neural deficits in children with dyslexia ameliorated by behavioral remediation: Evidence from functional MRI. *Proceedings of the National Academy of Sciences*, 100(5), 2860–2865. <https://doi.org/10.1073/pnas.0030098100>