

# The Effect of a Training Program Based on Working Memory Strategies (Verbal and Symbolic) on Developing Reading Ability among a Sample of Fifth Grade Students with Dyslexia: A Quasi-Experimental Study in El Oued Province

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## Abstract:

This study aimed to examine the effect of a training program based on working memory strategies (verbal and symbolic) on the development of reading ability among students with dyslexia. It also sought to identify differences between pre-test and post-test measures of reading ability indicators. The research was conducted on a purposive sample of eight (08) fifth-grade students with dyslexia from Kouinine municipality in El Oued province. A quasi-experimental method was adopted, employing a single-group design with both pre-test and post-test measures, in addition to a set of tests assessing reading ability at different levels. These included: the word reading ability test (frequent words, non-frequent words, and pseudo-words) and the rapid word naming ability test. After confirming the normality of distribution, the paired samples t-test was applied, alongside calculations of means and standard deviations. Effect size was also computed to verify the significance of the results. The findings revealed that the training program based on working memory strategies had a positive impact on developing reading ability among students with dyslexia. Statistically significant differences were observed between pre-test and post-test measures in reading ability indicators (frequent words, non-frequent words, pseudo-words), in favor of the post-test. The results also indicated statistically significant differences between pre-test and post-test scores in rapid word naming ability, again in favor of the post-test.

**Keywords:** Reading ability; Dyslexia; Working memory; Training program.

## 1- Introduction:

The primary stage of education is regarded as one of the most fundamental phases in a learner's academic journey, as it constitutes the foundation for acquiring diverse knowledge and developing essential practical skills and abilities required for learning, the most significant of which is reading. Reading is typically the first skill taught to a child during the early years, as it represents one of the core components of the educational process. In essence, reading is the

process of extracting information from written language to construct meaning directly, generally involving the interpretation of visual symbols, comprehending them, and storing them. Mastery of reading strongly indicates mastery of other academic subjects, whereas weaknesses in reading inevitably lead to weaknesses across other areas of study.

For this reason, educators, particularly those engaged in designing educational programs, have devoted special attention and focus in the early years of primary education to ensuring that children acquire and master reading skills. Nevertheless, some students experience considerable difficulties in reading ability, which extend to weaknesses and disorders across the entire reading process, including word decoding, recognition of written symbols, phonological processing, letter-sound recognition, and rapid word naming. These dimensions serve as essential indicators for diagnosing dyslexia when deficiencies are evident in them among students.

Since the reading process relies fundamentally on working memory strategies (verbal and symbolic), as it is at this level where information is processed, encoded, and stored in long-term memory, and because working memory is responsible for encoding and decoding written information, it becomes essential to employ memory strategies in training students to enhance and develop their reading abilities at all levels. Applying such strategies in a practical and systematic manner ensures that these students can achieve satisfactory academic outcomes in reading. This can be achieved through the design of training programs specifically tailored for students with dyslexia, employing both verbal and symbolic working memory strategies.

Accordingly, the following research question is posed:

Can working memory strategies (verbal and symbolic) positively influence the development of reading ability among students with dyslexia?

**Sub-questions:**

- Does a program based on working memory strategies (verbal and symbolic) positively affect word reading ability at its three levels (reading frequent words, reading non-frequent words, and reading pseudo-words) among students with dyslexia?
- Does a program based on working memory strategies (verbal and symbolic) positively affect the ability of rapid word naming among students with dyslexia?

**2- Study Hypotheses:**

- There are statistically significant differences between pre-test and post-test scores in word reading ability at its three levels (reading frequent words, reading non-frequent words, and reading pseudo-words) in favor of the post-test among students with dyslexia.
- There are statistically significant differences between pre-test and post-test scores in rapid word naming ability in favor of the post-test among students with dyslexia.

**3- Study Significance:**

The significance of this study lies in the following:

- Highlighting the importance of working memory as a cognitive strategy for developing reading ability among students in general and those with dyslexia in particular, as it plays a fundamental role in decoding and interpreting written symbols. It also contributes to improving educational competence and enhancing academic

performance in reading, which directly impacts other learning activities. This is achieved by providing practical training services that help students develop and improve their reading abilities based on their working memory capacities (verbal and symbolic). Through these strategies, written material is understood, processed, and encoded at the level of working memory, then stored in long-term memory to be retrieved during different educational activities.

- Drawing the attention of those involved in the educational process to the importance of the difficulties faced by students with dyslexia, especially in the early stages of primary education, where the fundamentals of reading and writing are acquired. It also underscores the role of training, therapeutic, and rehabilitative programs in developing reading ability specifically, and educational abilities more broadly, for these students.

#### **4- Study Objectives:**

The aim of this study is to achieve the following objectives: • To assist students with dyslexia in employing working memory strategies (verbal and symbolic) to develop their reading ability across its various dimensions, given that these strategies represent one of the most important learned skills with the potential to positively influence learning capacity. dyslexia by designing a training program based on working memory strategies (verbal and symbolic) to enhance their reading ability, and to test its effectiveness by identifying differences between pre-test and post-test scores on the targeted skills.

#### **5- Operational Definitions:**

##### **5.1- The Training Program Based on Verbal and Symbolic Working Memory Strategies:**

This refers to the experimental variable, consisting of a structured and scientifically designed practical plan based on working memory strategies (verbal and symbolic). Its purpose is to train students with dyslexia to improve the effectiveness of their performance in tasks related to reading skills and to help them master these skills according to established scientific principles.

##### **5.2- Reading Ability:**

This is the dependent variable, defined as the ability to transform written symbols into spoken symbols, in addition to understanding their meanings and distinguishing between them. It requires visual, auditory, motor, and cognitive coordination. In this study, it is measured at two levels: word reading ability (frequent words – non-frequent words – pseudo-words) and rapid naming ability, using a set of tests developed by Professor Alis Ismail.

#### **Theoretical Framework:**

##### **6- Definition of Reading:**

• **Definition by Marie de Maistre:** Reading is a complex activity in which auditory, visual, and motor mechanisms contribute. It is not limited to sound recognition but also involves understanding the meanings of words, which requires the engagement of general intelligence and prior experience.

**Reading** is the process through which language is received by an individual through sight and hearing. It requires three conditions:

- Visual perception of written symbols.
- Recognition of written symbols.
- Linking written symbols to their linguistic meaning.

Thus, reading is a cognitive-organic process aimed at translating written symbols into meanings and ideas. (Al-Hassoun et al., 1996, p.79)

### **6-1- Definition of Dyslexia:**

Specific reading difficulties are commonly referred to as dyslexia. There is no doubt that dyslexia represents a serious problem. Numerous studies indicate that failure in learning to read is among the most prevalent issues faced by children with learning disabilities. The survey study conducted by Kirk and Elkins (1975) on learning disability programs revealed that 60%–70% of children enrolled in such programs suffered from reading difficulties, identifying reading as the most widespread academic problem among individuals with learning disabilities. The growing number of children experiencing dyslexia has attracted the attention of experts and researchers, prompting them to intensify efforts to address this issue. Hallind emphasized this by stating: “*Reading difficulties (dyslexia) are a disorder with severe effects on the academic, social, and emotional development of a large number of students.*” (Al-Saidi, 2009).

• **Frierson’s Definition (1967):** A partial deficit in the ability to read or comprehend, where the individual engages in either silent or oral reading. (Hafez, 1998, p.57).

• **Borel-Maisonny’s Definition:** A specific difficulty in recognizing, understanding, and reproducing written symbols, resulting in disorders in learning to read between the ages of 5 and 8 years, which later extend to writing, comprehension of texts, and school libraries. (Pialoux, 1975, p.189).

• **World Dyslexia Association Definition:** A difficulty in learning language, manifested in the inability to decode language, process information, and comprehend sounds. These difficulties are not related to age, intellectual capacity, learning potential, or sensory impairments. (Baltaji, 2010, p.18).

### **6-2- Definition of Rapid Naming:**

Rapid naming refers to the speed of recalling (phonetic) symbols for letters and words (Al-Sartawi et al., 2009). Growing evidence has demonstrated that reading difficulties among students are strongly associated with specific aspects of letter and word recognition, as well as encoding and rapid naming.

These tasks are applied to measure reading ability, serving as an important indicator of printed word development. They may also be valuable in diagnosing certain types of reading difficulties in children. Problems related to retrieval from the lexical dictionary often represent the primary cause of fluency issues in reading, which in turn affect comprehension in primary school children, as well as older children who struggle with word recognition and reading.

The relationship between reading and rapid naming is well-established in research and literature. Naming tasks have been found to be highly correlated with reading ability. Scholars agree that rapid naming is a strong predictor of reading skill development. Some researchers proposed the “double-deficit hypothesis,” suggesting that individuals with deficits in both phonological awareness and rapid naming are at risk of severe reading difficulties. These researchers argue that rapid naming contributes to the development of sub-skills in reading that phonological awareness alone does not support.

Kirby, Parrial, and Pfeiffer conducted a study examining the correlation between phonological awareness and rapid naming in kindergarten and the development of reading skills in fifth grade. Results indicated that phonological awareness had a stronger correlation with reading skills in kindergarten and first grade, but this correlation gradually declined over time. In contrast, rapid naming showed a weak but statistically significant correlation in kindergarten and first grade, which progressively increased and became stronger in the higher grades.

The findings further revealed that the correlation of phonological awareness with reading achievement measures remained consistent across all tests, while the correlation of rapid naming was weaker with the pseudo-word reading test compared to other achievement measures (word recognition and syllable comprehension). (Abu Al-Diyar, 2012, p.45).

Wolf, Bowers, and Biddle (2000) noted that rapid naming is an independent predictor in languages with transparent orthographies such as German and Dutch. Wimmer, Mayringer, and Landerl (1998) demonstrated that German-speaking children with reading difficulties in the second grade displayed high accuracy in reading pseudo-words but exhibited significant slowness and spelling weaknesses. Rapid naming skills, particularly number naming, were among the strongest predictors of reading fluency in this group. However, the significance of phonological units declined at more advanced stages. (Abu Al-Diyar, 2012, p.45).

A longitudinal study conducted by Schatschneider (2004) and colleagues confirmed that rapid naming skills in preschool, such as rapid letter naming, were among the strongest predictors of reading fluency in the second grade (Abu Al-Diyar, 2012, p.46). This finding is consistent with Schatschneider et al. (2004), who assessed a broad range of linguistic and cognitive competencies among students that could be linked to reading acquisition, concluding that phonological abilities, letter knowledge and rapid naming, were among the most critical factors for reading success.

Similarly, a long-term study by Kirby et al. (2005) involving students aged 5 to 10 years demonstrated that the contribution of rapid naming increased with age, developing progressively as children advanced in years (Swanson, H.L., 1999).

### **6-3- Relationship Between Rapid Naming Ability and Dyslexia:**

For a student to formally acquire reading and writing skills, they must first develop speed in naming and spelling words, as well as the ability to recognize printed letters and oral language. Students with strong rapid naming abilities and awareness of basic reading concepts achieve higher levels of proficiency in acquiring and applying reading and writing skills in advanced school grades.

The study by Holopainen, Ahonen, and Lyytinen (2001) with Finnish-speaking children revealed that young children with reading difficulties exhibited deficits in phonological awareness during the preschool stage, prior to receiving reading instruction. However, these difficulties were characterized primarily by slowness. Given that Arabic is considered a relatively transparent orthographic language, rapid naming is expected to be a highly significant indicator in the early school grades (Abu Al-Diyar, 2012, p.46).

## **7- Definition of Working Memory:**

Working memory is the active component of memory, responsible for activating information stored in long-term memory and employing it to process new information, prepare it, and encode it for subsequent storage.

### **7-1- Characteristics of Working Memory:**

Researchers agree on several defining characteristics of working memory, including the following:

- \_ It is an important, flexible, and highly vital cognitive process essential for many daily life activities.
- \_ It requires focused attention during the performance of tasks.
- \_ Working memory has a limited and fragile capacity, as any information stored within it can be easily lost during performance.
- \_ Access to information in working memory is conscious and deliberate; therefore, it demands effort from the individual to complete tasks that rely on working memory resources. (Sulaiman, 2009, p.7)

### **7-2- Types of Working Memory:**

There are multiple types of working memory, but the present study focuses on three essential types that play a crucial role in accurate reading performance:

- Verbal working memory.
- Symbolic working memory.

#### **7-2-1- Verbal Working Memory:**

Verbal working memory refers to a set of cognitive processes that carry out the temporary storage and processing of verbal information, such as sounds and written texts (Sulaiman, 2009, p.8).

**Definition of Baddeley and Hitch:** Verbal working memory is a specialized storage system whose function is to retain verbal information, referred to as the “phonological component” (Ashour, 2011, p.10).

In this context, Wagner et al. (1997) described reading difficulties as noticeable struggles in mastering essential skills, including word recognition, spelling, and reading comprehension. The present evidence indicates that short-term verbal memory is strongly associated with the progress achieved in reading during the early years of instruction, and that its role in learning phonological (sound) processing is closely tied to reading development, rather than being merely incidental in nature (Abu Al-Diyar, 2012, p.73).

Baddeley (2006) highlights that the phonological loop in working memory is responsible for either retaining or losing read or heard information. This loop comprises two subsystems: the first is the phonological store (verbal memory), in which read or heard information is retained for approximately two seconds before decaying, unless reinforced through rehearsal and repetition. This implies the existence of a subsidiary cognitive process, rehearsal, necessary for maintaining verbal information in an active state within the phonological store. Consequently, this store depends on another subsidiary component: the articulatory rehearsal system (Abu Al-Diyar, 2012, p.59).

### **7-2-2- Symbolic Working Memory:**

Symbolic working memory refers to a set of non-verbal systems responsible for processing spatial and visual images, perceiving spatial relationships, and encoding them through information-processing systems known as the central processor.

Caponie (1992) conducted a study to explore the relationship between speech perception and phonological decoding skills among adult students with specific reading difficulties, as well as the extent to which they employed compensatory strategies in speech perception. The first experiment was designed to examine:

- Perception of separate phonemes in word tests involving minimal pairs.
- Perception of the meaning of separate speech units in main texts, based on the assumption that the phonological deficit in students with learning difficulties was not statistically significant when distinguishing small separate speech units compared to peers in the control group (the consonant group).

The second experiment revealed that the number of errors among students with reading difficulties exceeded those of the control group. Findings showed that the effect of the text on both groups was similar, but the key difference lay in perception, as the performance of the learning difficulties group lagged behind that of the control group (Al-Abdullah, 2007, p.22).

These components function simultaneously in complete integration, coherence, and harmony, leading to the encoding and retention of new information (Ashour, 2011).

Masad Abu Al-Diyar (2012) emphasizes that the subsidiary component of rehearsal plays a critical role in reading difficulties. This skill requires the learner to focus attention on the words being read and then employ the strategy of subvocal rehearsal to process the word (i.e., the encoding strategy, or symbolic memory) in order to maintain the word as active within verbal working memory.

## **8- The Training Program:**

### **8-1- Definition of the Training Program:**

A training program is a set of courses in a particular field of study. Al-Tuhani (2002) identifies the most prominent principles in designing training programs as follows:

- Training relies on motivation as a key factor for success and effectiveness, depending largely on the trainee's drive and willingness to learn.
- Training depends on the effectiveness and active participation of the trainee in the learning process.
- Training builds on the trainee's prior and current experiences.
- Learning new material may interfere with the recall of previously acquired knowledge.
- The effectiveness of training is linked to feedback, as knowledge of results enhances learning (Al-Khatib, 2008).

### **8-2- Training Needs of Students with Dyslexia:**

Reading is a mental, emotional, and motivational process that involves interpreting symbols and signs received through the eyes, understanding meanings in light of prior experience, connecting previous knowledge with those meanings, drawing inferences, engaging in critique and judgment, and solving problems.

For reading to achieve its objectives in the learning process, it must address a set of needs primarily aimed at developing fundamental reading skills:

- \_ The need to distinguish written words within the context of a phrase and to associate each with its form, leading to pronouncing the word upon seeing its script.
- \_ The need to associate meaning with the symbol, resulting in understanding the phrase.
- \_ The need to read multiple sentences revolving around a connected meaning, leading to comprehension of integrated ideas.
- \_ The need to distinguish individual words, a more advanced stage of discrimination than the first, which contributes to fluency in reading.
- \_ The need to identify words in material not previously seen, achieved by discriminating individual letters and linking each letter to its sound and form. This process develops the ability to read additional material, followed by writing words and sentences, which consolidates the intended skill and enables mastery of new skills.

### 8-3- Problems Requiring Training in the Early Grades of Primary School:

The most prominent problems, particularly in the Arabic language, can be summarized as follows:

- \_ Similarity in pronunciation between certain letters, such as (ت، ط)، (ك، ق)، (س، ص)، (ث، ذ).
- \_ A high degree of similarity in the written forms of some phonetic letters, making them difficult to distinguish, such as (ب، ت، ث)، (ج، ح، خ)، (د، ز)، (س، ش).
- \_ The multiple forms of certain letters, such as هـ and ك.
- \_ Variation in the written form of letters depending on their position in the word, initial, medial, or final, such as (ي، ي، ي).
- \_ Neglect of diacritical marks and their omission from letters, which makes pronunciation difficult for students in the early grades.
- \_ Tanween (nunation), which is pronounced but not written in the word.
- \_ Certain letters are pronounced differently, such as the feminine “taa” at the end of a word (e.g., شجرة). It is pronounced as /t/ in connected speech and as /h/ in pausal position, so the sound changes while the symbol remains the same.
- \_ The connection of the preposition “lam” with words beginning with the definite article (ال) in its solar and lunar forms, which results in the omission of the hamzat al-wasl (e.g., للرجل – للقمر).
- \_ Fundamental issues also arise with letters that are pronounced but not written (e.g., هذا، الذي), where the alif is omitted after the haa in the first word.

### 9- The Training Program Based on Working Memory Strategies (Verbal and Symbolic):

• **Program Name:** A Training Program Based on Working Memory Strategies (Verbal and Symbolic).

• **Identification and Diagnosis of the Problem:**

The central difficulty lies in students’ struggle to master accurate reading skills. Several symptoms are observed, including inability to read words, whether familiar, unfamiliar, or pseudowords, along with errors such as letter reversal, substitution, or omission, in addition to slow reading. Dyslexia is diagnosed through a set of tests, namely Raven’s Progressive

Matrices intelligence test, the reading ability test, and the rapid word-naming test developed by Professor Laïs Ismail.

• **Program Objectives:**

– The program seeks to develop the reading ability of a sample of fifth-grade students with dyslexia by strengthening their reading skills across three dimensions: word reading (familiar, unfamiliar, and pseudowords) and rapid naming, thereby enabling students to read words correctly.

– More specifically, the program aims to improve accuracy and correctness in word reading and to enhance rapid naming by enabling students to employ verbal working memory strategies in processing, storing, and quickly retrieving letters.

• **Theoretical Basis of the Program:**

The theoretical foundation of the program is built upon working memory strategies, both verbal and symbolic. It was designed following systematic methodological steps and informed by findings from Arab and international studies that examined the role of working memory in reading and its relation to dyslexia, particularly in word reading and rapid naming. Among these studies:

– A longitudinal study spanning five years conducted by Wagner et al. (1997), which tracked hundreds of children from kindergarten through fourth grade. The study employed a variety of measures related to phonological awareness, verbal memory, short-term memory, and rapid naming. Results across three time points indicated that phonological awareness was among the most significant predictors of differences in word-level reading ability. In contrast, measures of short-term verbal memory did not show the same independent predictive power. Regarding verbal working memory tasks, children with reading difficulties exhibited marked inconsistencies and noticeable weaknesses in performance. The study further concluded that a wide range of cognitive tasks could independently predict reading achievement beyond short-term verbal memory and phonological awareness (Abu Al-Diyar, 2012, p.73).

– Other studies, such as those by Gutierrez et al. (2004) and Henry (2010), demonstrated that children with learning difficulties exhibit deficiencies in working memory for language comprehension, sentence and paragraph writing, story composition, problem solving, and certain arithmetic operations, in which they differ from typically developing children (Abu Al-Diyar, 2012, p.74).

From this perspective, it is evident that children with dyslexia face challenges in recognizing written symbols, letters and words, struggling to process, encode, and store them for later retrieval. This difficulty is particularly pronounced in word reading and rapid naming. Consequently, the program employed working memory strategies, both verbal and symbolic, to strengthen the reading ability of these students.

• **Methods Used in the Program:**

The training of children with dyslexia will rely on the Orton–Gillingham Approach, incorporating its fundamental strategies (such as verbal and symbolic memory), along with training activities tailored to the needs of the students.

**Target Group:**

The group targeted by the program consists of male and female fifth-grade primary school students with dyslexia.

### Main Axes of the Training Program:

- **First Axis:** The practical axis, which consists of training to develop reading ability in its two dimensions (the ability to read words and the ability of rapid naming) using working memory strategies (verbal and symbolic) and by applying practical training methods.
- **Second Axis:** Measuring reading ability through pre-testing and post-testing, followed by a comparison of the results.

### Dimensions of the Training Program:

The program was divided into two main dimensions, each comprising a set of items that varied and progressed in difficulty:

- **First Dimension:** The ability to read words (familiar words, unfamiliar words, and pseudowords).
- **Second Dimension:** The ability of rapid naming.

### Program Units:

- **Unit One:**
  - *Sub-goal:* Recognizing letters and sounds both within words and in isolation.
  - *Preparation Phase:* A stage of recognizing different sounds and their diacritics (letter–sound association, detecting sounds in words).
- **Unit Two:** Rapid recognition of the phonemes that constitute a word or blending them together to form a new word (at this stage, the child trains on quickly distinguishing letters according to their sounds).
  - *Sub-goal:* Helping the child to quickly discriminate sounds within words.
- **Unit Three:** The stage of processing syllables and analyzing words into syllables while calculating time.
  - *Sub-goal:* Training the child to quickly recognize letters by their sounds (recognizing words through their sounds) by relying on auditory memory.
- **Unit Four:** Recognizing letters through images while calculating time.
  - *Goal:* Rapid recognition of letters within the word.
- **Unit Five:** Recognizing images through sound.
  - *Goal:* Recognizing images that contain the required sounds, while measuring time and response speed.
- **Unit Six:** Rapid naming of sounds from words.
  - *Goal:* Training to enhance the speed of naming sounds by utilizing phonological memory.
- **Unit Seven:** Recognizing words that are similar in sound and form, with emphasis on rapid recognition.
  - *Goal:* Learning to associate letters and sounds in different positions and forms.
- **Unit Eight:** Rapid detection of new and unfamiliar sounds and words.
  - *Goal:* Training the child to read new and unfamiliar letters and words as quickly as possible.
- **Duration of the Program:** The program is delivered over 12 sessions spread across 6 weeks, at a rate of two sessions per week, with each session lasting 45 minutes.

- **Tools Used in the Program:** Several tools and means are used in the program, including:
  - Pictures and illustrated cards.
  - Alphabet cards.
  - Computer.
  - Whiteboard and felt pens.
  - Blank sheets.
  - Notebooks and pencils.
  - Pictures of animals and objects.

**10- Study Sample:**

The study sample is defined as a partial group from the study population selected in a specific manner to conduct the study on, and then using those results to generalize them to the original population (Ubaidat, 1999, p. 84). The study was conducted on a sample of fifth-grade primary school students with dyslexia from Abdelhamid Ben Badis School and Khalwati Belkacem School in Kouinine, El Oued province.

**11- Method of Selecting the Sample and Its Size:**

The sample represents part of the original study population. It consists of selecting a number of individuals for a specific study in such a way that they represent the larger group from which they were drawn (Bousna, 2007). The purpose of selecting the sample is to obtain information about the original population.

The study population comprised 20 fifth-grade primary school students with reading difficulties, under the condition that any child with one of the following difficulties would be excluded:

- Repetition of the academic year.
- Clear visual impairment.
- Obvious language disorder.
- Severe academic weakness across all school subjects.
- Hyperactivity.
- Sensory or intellectual disability.

From these 20 students with reading difficulties, a total of 8 students were diagnosed with dyslexia and purposively selected. This selection followed the exclusion of cases with the aforementioned conditions and after administering Raven’s Progressive Matrices to determine intelligence level, as well as the diagnostic reading ability test.

**12- Basic Characteristics of the Study Sample:**

The age range of the sample was between 9.5 and 12 years. Their academic level was the fifth grade of primary school, with an average intelligence score of 20.67. All of them were diagnosed with dyslexia, and their total number was 8 students.

**Table (01): Characteristics of the Study Sample**

Academic Level	Mean Age (Months)	Mean Intelligence	Number
Fourth Grade	130.25	20.67	05

<b>Fifth Grade</b>			03
<b>Total</b>		08	

### 12- Study Boundaries:

The study was delimited to temporal, spatial, thematic, and human boundaries:

- **Temporal boundaries:** from 10/01/2025 to 18/03/2025.
- **Spatial boundaries:** Khalwati Belkacem School and Abdelhamid Ben Badis School in Kouinine, El Oued.
- **Human boundaries:** Fifth-grade primary school students with dyslexia.

### 13- Study Tools:

To verify the objectives of the research, the following tools were adopted:

#### 13-1- Reading Test:

This test was developed by Dr. Ismail Laïs, a speech therapy specialist and former professor at the University of El Oued. It measures reading ability by instructing the student to read a set of words at three levels: familiar words, unfamiliar words, and pseudowords. It is structured as follows:

- **Familiar Words:** A test of 40 words, divided into simple words (less difficult). The student is told: “*We will show you a set of words,*” and is asked to read the words in order. Scoring: (1) for a correct word and (0) for an incorrect one.
- **Unfamiliar Words:** A test of 40 words divided into two categories: simple (20 words) and compound (20 words). This test is more difficult than familiar words. Scoring: (1) for a correct word and (0) for an incorrect one.
- **Pseudowords:** This test consists of two parts:
  - The first part: letters combined to form a meaningless word.
  - The second part: a meaningful word with its letters scrambled.

The student is told: “*A set of words will be shown to you,*” and is asked to read the words in order. Scoring: (1) for a correct word and (0) for an incorrect one.

- **Pseudo-Words:**

This test consists of two parts:

- \_ The first part: a set of letters arranged to form a meaningless word.
- \_ The second part: a meaningful word with its letters scrambled.

The child is instructed: “*You will be shown a set of words, and you are asked to read them in order.*” Scoring: (1) for a correct word and (0) for an incorrect one.

#### Psychometric Properties of the Reading Test:

- **Reliability of the Test:**

Reliability is considered one of the essential qualities that any test must possess. Bashir Maamria defines it as “*the extent of accuracy, stability, and consistency in the results of the tool when applied two or more times to the same trait on different occasions*” (Maamria, 2007). He also defines it as “*consistency in results*”, and a test is considered reliable if it produces the same outcomes when reapplied to the same individuals under the same conditions (Ibrahim, 2000, p.42).

Internal consistency reliability was calculated using Cronbach's Alpha according to the PNR project. The results of the comprehensive reading test were: Alpha = 0.87.

• **Validity:**

The validity of the test refers to its ability to measure what it is intended to measure in relation to aspects of individual behavior. It is the degree to which the test measures what it was designed to measure (Mansi, 1996, p.113). In the PNR project, factorial validity was applied, and factor analysis yielded the following results: familiar words (0.80), unfamiliar words (>0.84), and pseudo-words (0.86).

**13-2- Rapid Naming Test:**

The content of this test includes two cards. The first card is presented to the child, who is asked to name the four colors displayed at the bottom, ensuring that they are familiar with them. The exercise may be repeated once if necessary. Then the second card is presented, consisting of a table of colored words that include numbers, color names, and pictures.

This test comprises a set of colors, shapes, and pictures:

- **Colors:** Includes 40 color names, each printed in color. The child is instructed to identify the color of the word rather than reading the word itself.
- **Shapes:** Includes 40 items (numbers, shapes, and colors). The child is asked to read these items.
- **Pictures:** Includes 25 different pictures, and the child is asked to name them.

Scoring is based on the time taken by the child to complete the test. The child is asked to respond as quickly as possible. An additional 5 seconds are added for each error, ensuring that the naming is accurate and performed line by line, from right to left.

**Psychometric Properties of the Rapid Naming Test (Objects – Mixed – Numbers + Shapes) according to the PNR project:**

- Reliability coefficient:  $\alpha = 0.69$ .
- Factorial validity confirmed through factor analysis (Smail-Layes et al., 2015).

**13-3- Raven's Progressive Matrices Test:**

This test consists of 20 images grouped into three sets of sheets, each containing different patterns. Each pattern has a missing part, and this missing part is included among several options illustrated below the pattern. The child is required to point to the correct option to complete the original figure, one after another. An explanatory example is provided initially to ensure the child understands the procedure.

In the present study, this test was used as a diagnostic tool to identify the sample individuals. The average intelligence score of the sample was estimated at **20.53**. None of the students in the original population sample were excluded on the basis of their intelligence level, as their scores fell within the normal range. Exclusion was applied for the reasons mentioned earlier. These tests were administered in the same environment and during the same academic year in which the current study was conducted; therefore, they were adopted without recalculating their validity and reliability.

**14- Statistical Methods Used:**

To measure and statistically test the hypotheses of the study, the t-test was employed to determine the significance of differences between the pre-test and post-test scores. The

Statistical Package for the Social Sciences (SPSS), version 16, was used. Additionally, the arithmetic mean and standard deviation were calculated.

The following statistical procedures were applied:

- **t-test:** to calculate the significance of differences between means.
- **Degree of homogeneity of the two samples:** measured by comparing their variances, calculated by dividing the larger variance by the smaller one (F-ratio).
- **Normality of the frequency distribution** of the research sample in both pre-test and post-test measures. Normality was verified by calculating skewness for the research sample.

**15- Presentation and Analysis of the Study Results:**

**15-1- Presentation and Analysis of the First Hypothesis:**

The first sub-hypothesis states: *“There are statistically significant differences between the pre-test and post-test in word reading ability (overall), and in its three levels (familiar words – unfamiliar words – pseudo-words), in favor of the post-test among students with dyslexia.”*

Accordingly, each level will be examined individually, in addition to the overall word reading ability. To test the validity of this hypothesis, normality of distribution was verified using the Shapiro–Wilk test and by calculating the skewness coefficient. The results are shown below:

**Table (02): Tests of Normality of Distribution**

Ability	Shapiro Test		Skewness		Decision
	(Pre-test N=8)	Shapiro Test (Post-test N=8)	Skewness (Pre-test N=8)	(Post-test N=8)	
<b>Familiar word reading</b>	0.9560	0.1730	-0.472	-1.309	Normal distribution
<b>Unfamiliar word reading</b>	0.986	0.991	-0.146	-0.088	Normal distribution
<b>Pseudo-words</b>	0.336	0.630	0.218	0.041	Normal distribution
<b>Overall word reading ability</b>	0.978	0.115	0.233	-0.794	Normal distribution

From the results presented in the table concerning familiar word reading, since the significance level of the Shapiro test was estimated at (.9560 / .1730) for the pre-test and post-test, respectively, and both values are greater than (0.05), it can be inferred that the distribution is normal. The skewness coefficient was estimated at (-0.472 / -1.309), and both values fall within the range (-3, 3). The normal distribution curve was also observed.

For unfamiliar word reading, the significance level of the Shapiro test was estimated at (0.986 / 0.991) for the pre-test and post-test, respectively. Since both values are greater than (0.05), this indicates normal distribution. The skewness coefficient was estimated at (-0.146 / -0.088), and both values lie within the range (-3, 3). The normal distribution curve was confirmed.

Similarly, for pseudowords, the significance level of the Shapiro test was estimated at (0.336 / 0.630) for the pre-test and post-test, respectively. Both values exceed (0.05), indicating normal

distribution. The skewness coefficient was estimated at (0.218 / 0.041), and both values fall within the range (-3, 3). The normal distribution curve was also verified.

For overall word reading ability, the significance level of the Shapiro test was estimated at (0.978 / 0.115) for the pre-test and post-test, respectively. Since both values are greater than (0.05), this confirms normal distribution. The skewness coefficient was estimated at (0.233 / -0.794), and both values lie within the range (-3, 3). The normal distribution curve was observed. Accordingly, the paired-samples t-test could be applied. Using SPSS software (version 16), the results were obtained as follows:

**Table (03): Means, Standard Deviations, t-values, and Significance Levels Between Pre-Test and Post-Test in Overall Word Reading Ability and Its Three Levels.**

Statistical Indicators  Variables	Pre-test (N=8)		Post-test (N=8)		t-value	df	Sig.	Effect Size ( $\eta^2$ )
	M	SD	M	SD				
Familiar word reading	23.50	3.11	35.75	4.20	-13.89	7	.000	0.96
Unfamiliar word reading	21.12	3.31	31.62	3.42	-8.47			0.91
Pseudo-words	12.25	3.45	26.20	4.43	-8.91			0.91
Overall word reading ability	56.87	7.01	93.62	7.81	-14.46			0.96

From the results presented in Table (03): The t-values were (-13.89, -8.47, -8.91, -14.46) for familiar word reading, unfamiliar word reading, pseudo-words, and overall word reading ability, respectively, all at a significance level of (0.000). Since the hypothesis was directional, the p-value (0.000) was divided by two, yielding (0.000), which is below the threshold of (0.05). This indicates statistically significant differences between pre-test and post-test scores in all measured abilities, in favor of the post-test. To confirm practical significance, effect size ( $\eta^2$ ) was calculated. The values were (0.96, 0.91, 0.91, 0.96), all of which exceed (0.14), indicating large effect sizes.

**15-2- Presentation and Analysis of the Results of the Second Hypothesis:**

The second hypothesis states: *“There are statistically significant differences between the pre-test and post-test measurements in the ability of rapid word naming, in favor of the post-test among students with dyslexia.”*

To test the validity of this hypothesis, normality of distribution was verified using the Shapiro–Wilk test and by calculating the skewness coefficient. The results are presented below:

**Table (04): Normality Test**

Ability	Shapiro Test		Skewness Coefficient (2.2)	Decision
	Pre-test (N=8)	Post-test (N=8)		

<b>Rapid Naming</b>	0.640	0.412	-0.739 / 0.888	Normal distribution
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From the table presented above, the results of the Shapiro–Wilk test are shown. Since the significance level of the Shapiro test was estimated at (.6400 / .412) for the pre-test and post-test respectively, and both values are greater than (0.05), this indicates the normality of distribution. In addition, the skewness coefficient was estimated at (-0.739 / 0.888), with both values falling within the acceptable range (-3, 3). The normal distribution curve was also observed. Accordingly, the paired-samples *t*-test could be applied. Using the SPSS software (version 16), the results were as follows:

**Table (05): Means, Standard Deviations, t-Value, and Significance Between Pre-test and Post-test in Rapid Word Naming Ability**

Statistical Indicators	M	SD	t-value	df	Sig.	Effect Size ( $\eta^2$ )
<b>Observations</b>						
<b>Pre-test (N=8)</b>	30.125	4.015	-11.233	7	0.000	0.947
<b>Post-test (N=8)</b>	47.750	3.412				

From the results in Table (05): The *t*-test value was estimated at (-11.233) with a significance level of (0.000, since the hypothesis is directional, the *p*-value (0.000) was divided by two, yielding (0.000), which is below the threshold (0.05). This confirms statistically significant differences between the pre-test and post-test scores in rapid word naming ability, in favor of the post-test, to confirm practical significance, the effect size ( $\eta^2$ ) was calculated. The value was (0.947), which is well above (0.14), indicating a large effect size.

## 16- Interpretation and Discussion of the Study Results

### 16-1- Interpretation and Discussion of the First Hypothesis Results

The first hypothesis states that there are statistically significant differences in word reading ability at three levels, familiar words, unfamiliar words, and pseudowords, in favor of the post-test among students with dyslexia.

As shown in Table (03), there were statistically significant differences between pre-test and post-test scores in all three levels of word reading ability, in favor of the post-test. The training program had a positive impact on improving the reading ability of students with dyslexia across different word types. Specifically:

- Students developed their ability to decode written symbols.
- They improved recognition of spoken letters and their corresponding shapes in different word positions.
- Training was provided gradually: beginning with familiar words (frequently used and easier to recognize), then moving to unfamiliar words (requiring decoding and matching sounds to cognitive representations), and finally to pseudowords (requiring recognition of letter sounds and forms in various positions and practicing the creation of new word forms).

The pseudoword stage is particularly critical, as it plays a central role in equipping children with dyslexia to generalize their decoding and recognition skills to new and unfamiliar words, thereby enhancing overall reading ability.

The training program yielded positive outcomes because, through its content and structured sessions, students were systematically trained to employ verbal working memory strategies to identify the sounds of written letters, and symbolic working memory strategies to recognize their shapes. They were subsequently trained to read and recognize these letters in different positions and to generate new words, thereby enriching their lexical repertoire. This process fostered the development and enhancement of their word-reading ability.

According to Al-Khazraji, weak memory skills are among the most prominent characteristics of individuals with reading difficulties, as these students often fail to employ automatic strategies. Visual memory impairments may hinder their ability to recall certain letters and words, while symbolic memory deficits can disrupt sequencing skills, such as ordering letters within a word or words within a sentence. Likewise, auditory memory difficulties may impair the ability to retain letter sounds and subsequently blend them into words.

From this perspective, it becomes clear that children with dyslexia do not spontaneously employ memory strategies in a way that allows them to recognize letters and words, decode symbols, or arrange letters into meaningful, or even meaningless, word structures. For this reason, the training program sought to explicitly equip them with cognitive memory strategies to strengthen their reading skills. The positive results confirmed this, demonstrating that when students were trained to leverage their memory capacities, their ability to read words improved significantly. The training activities emphasized developing the ability to link sounds within working memory to form new meaningful words that could be added to their mental lexicon. This was achieved by applying verbal and symbolic memory strategies through active information processing.

In the training sessions, word-encoding strategies were systematically activated, whether for familiar words (commonly used and easily recognized), unfamiliar words (requiring decoding), or pseudowords (lacking semantic meaning and therefore more challenging). By emphasizing symbolic working memory strategies, the results demonstrated measurable improvements in students' reading abilities across all levels.

Baddeley (2006) notes that the phonological loop within working memory is responsible for retaining or losing information that is read or heard. It consists of two subcomponents: the *phonological store* (verbal memory), where auditory or visual-verbal information is temporarily retained for approximately two seconds, and the *articulatory rehearsal system*, which refreshes this information through subvocal rehearsal to prevent it from fading (Abu El-Diyar, 2012, p.59).

Masad Abu El-Diyar (2012) emphasizes the pivotal role of rehearsal in overcoming reading difficulties. Reading requires learners to focus on the target word and employ subvocal repetition (encoding or symbolic memory strategies) to process it, thereby keeping the word active within verbal working memory. This principle was at the heart of the training program: students with dyslexia were trained to encode letters and words through verbal and symbolic working memory, which enabled them to store and retrieve information when needed. This

explains the program's positive impact, reflected in statistically significant improvements in post-test performance, confirming the development of word-reading ability across all levels.

### **16-2- Interpretation and Discussion of the Second Hypothesis**

The second hypothesis states: *“There are statistically significant differences between the pre-test and post-test in rapid naming ability, in favor of the post-test among students with dyslexia.”*

As shown in Table (05), significant differences emerged in favor of the post-test for word-naming speed. This improvement can be attributed to the program's structured progression: Initial training began with reading familiar words, it advanced to unfamiliar and pseudowords, requiring decoding and symbol-sound association. Students were then trained in operations such as adding, omitting, or substituting letters to form new words. Finally, the program incorporated rapid naming and word-reading exercises, gradually accelerating the pace until students could read fluently without hesitation or excessive spelling-out.

The training produced a clear positive effect on naming speed, which is a key diagnostic marker of dyslexia. Difficulties in recognizing or spelling letters, whether by form or sound, directly impede reading fluency, manifesting as slow or labored reading. Thus, the latter stages of the program specifically targeted reading fluency, aiming to help students achieve an appropriate pace without stumbling over written words.

This goal was successfully achieved, as reflected in the results. Wolf (1991) underscores that the relationship between reading and rapid naming is strongly established in both research and literature, with naming tasks consistently shown to correlate with reading proficiency (Abu El-Diyar, 2012, p.45).

Our study also aligns with that of Kirby, Parilla, and Pfeiffer, who examined the correlation between rapid naming in kindergarten and the subsequent development of reading skills in fifth grade. Their results showed that while the correlation of rapid naming was weak but statistically significant at the kindergarten and first-grade levels, it gradually increased in strength in later grades. They also found that the correlation of rapid naming was weaker with pseudoword reading compared to other achievement measures such as word recognition and passage comprehension (Abu El-Diyar, 2012, p.45).

These findings underscore the importance of developing rapid naming skills at all educational stages, particularly in the early grades, to provide students with early interventions that enhance this ability. The results of the present study demonstrated that, following rapid naming activities, students exhibited clear improvement in rapid word naming. This development enabled them to recognize words more quickly than before. In other words, training in letter-sound association and word recognition significantly enhanced their reading fluency.

This finding is consistent with Schatschneider et al. (2004), who evaluated a broad range of linguistic and cognitive skills related to reading acquisition. They concluded that phonological abilities, especially letter knowledge and rapid naming, are among the most reliable predictors of successful reading development. Similarly, a longitudinal study by Kirby et al. (2005), conducted on a sample of students aged 5 to 10 years, found that the contribution of rapid naming skills to reading proficiency increases with age. This conclusion is also highlighted by Abu El-Diyar (2012).

## General Conclusion

The present study examined the impact of a training program based on working memory strategies (verbal and symbolic) in enhancing reading ability among students with dyslexia. It employed a quasi-experimental design and was applied to a purposive sample of eight (8) students with dyslexia, carefully selected from a group of twenty (20) identified as having weaknesses in reading ability. Selection criteria included the absence of sensory or intellectual disabilities, no grade repetition, and an average level of intelligence, as verified through diagnostic testing.

Reading ability was assessed across three levels, familiar words, unfamiliar words, and pseudowords, in addition to rapid word naming. The training program, structured around verbal and symbolic working memory strategies, was implemented over six weeks with two sessions per week. It included targeted training activities designed to strengthen students' reading abilities. After completing the program, students' reading abilities were reassessed.

The results revealed the following:

- Significant differences were found between pre-test and post-test scores in reading ability across its three levels, in favor of the post-test, demonstrating the positive effect of the program on developing word-reading skills.
- Significant differences were also observed in rapid word naming, again in favor of the post-test, confirming the program's effectiveness in improving this skill.

Based on these findings, it can be concluded that the training program, grounded in verbal and symbolic working memory strategies, proved effective in developing the reading ability of students with dyslexia. These results highlight the importance of incorporating such programs into educational interventions designed for this population, as they provide a structured and evidence-based approach to overcoming reading difficulties.

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