

## **Dyslexia and Its Relationship with Working Memory (Verbal and Symbolic): A Comparative Study on a Sample of Fourth and Fifth Grade primary school students**

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### **ABSTRACT:**

This study addressed the relationship between dyslexia and working memory, as the latter represents one of the essential components in learning to read among children. The aim of this study was to identify the relationship between dyslexia and working memory. A group of fourth and fifth-grade primary school pupils was selected based on a set of diagnostic reading criteria. These individuals were categorized into two groups: typical readers (50) and dyslexic readers (16). The initial classification was based on teachers' opinions and students' results in reading.

This study adopted a comparative descriptive approach. A word reading test and a working memory test (both symbolic and verbal) were administered to all individuals in the study sample to identify potential differences between the two groups in these tests.

The results showed the following:

- A statistically significant difference between the two groupstypical readers and dyslexic readersin the working memory test (symbolic and verbal).
- A statistically significant correlation between reading ability and working memory.

**Keywords:** Dyslexia, Working Memory.

### **INTRODUCTION**

The primary stage is considered one of the most important educational phases that an individual goes through, as it serves as the foundation upon which all subsequent stages of education are built. For this reason, it has attracted significant attention from educators, especially those responsible for formulating educational policies and designing curricula and educational programs. Their focus has

been heavily centered on the process of reading, as it is the most critical skill in learning. Reading aims to strengthen the connection between the student and reading materials, encouraging them to engage with these materials with interest, selecting ideas and information that develop their abilities, allowing them to benefit from and enjoy what they read, and enabling them to acquire knowledge, skills, and competencies.

Through reading, values are instilled, attitudes are shaped, psychological needs are fulfilled, and the relationship between the child and the printed word is reinforced. It is the most important educational subject, and mastering it is an indicator of proficiency in other academic subjects, while weakness in reading is a strong indicator of general academic underachievement.

However, despite the great attention given to reading instruction, many students still experience significant reading difficulties even when instruction is effective and the educational environment is adequate, including teacher competence and the availability of learning tools and aids. These children have been classified as having reading learning difficulties. Reading difficulty is considered one of the most widespread learning disorders in primary schools.

Therefore, in this study, we conducted a precise investigation of one of the most significant factors identified in previous research as being closely linked to dyslexia across various studied languages: working memory, as it represents one of the most essential cognitive components upon which reading is built without which reading cannot be developed.

Dyslexia can be viewed as the reader's inability to use the necessary tools to decode written symbols and then comprehend the meaning of the written material. When a student begins learning to read, they need to retrieve information using working memory, which is responsible for temporarily storing and processing information based on what exists in long-term memory, because reading is not an automatic process but rather a phonological processing of visual information.

Recent studies have shown that at the beginning of learning to read, reliance on working memory is unavoidable. Research on learning difficulties has concluded that a deficit in working memory underlies the challenges faced by students with dyslexia. (Bull, 1997)

In this context, Alloway (2006) affirms that children with special educational needs have working memory impairments, which vary in severity according to the stages outlined in the practice guide for special educational needs, particularly among children who perform below their peers in school.

Several researchers, such as Wright et al. (2001) and Thomas et al. (2003), found a relationship between memory capacity and comprehension. These findings indicate that memory capacity plays a role in comprehension depending on the simplicity or complexity and clarity or ambiguity of the text.

The results indicated that children had no difficulty understanding common topics and images, but they showed particular difficulty in understanding linguistic symbols. It was found that all children did not struggle to recall short sentences compared to long ones.

Farah and Bar-Parah, in a study they conducted, found that word recall largely depends on working memory capacity, and that deficits in working memory lead to disruptions in children's language abilities. This study was conducted on ten children (7 males, 3 females), and the tasks required recalling a set of common images and a set of linguistic symbols.

Findings from research conducted over two decades indicate a correlation between working memory deficits and the fundamental problems faced by children and adults with learning difficulties (dyslexia). (Swanson & Siegel, 2001)

In several long-term studies lasting over six years, researchers (Torgesen & Wagner et al., 1997) pointed out that the importance of rapid naming continues throughout kindergarten and the early primary years. In summary, field studies have shown a strong correlation between reading speed and the development of reading and writing in pupils.

In this context, Bowers, Golden, Kennedy, and Young (1994) emphasized that deficits in rapid naming are directly related to variation in reading and writing skills. These researchers found that beginning readers who struggle with slow recognition of isolated letters and words are likely unable to process letters in working memory quickly enough to help them distinguish between symbols especially those that commonly resemble one another in the words presented to them.

This study also aligned with the findings of Bowers and Wolf (1993), who concluded that students with difficulties in phonological encoding or rapid naming are more likely to face reading comprehension problems compared to their typical peers. This suggests that students experiencing multiple difficulties in the basic skills related to reading and writing are expected to face severe reading problems in the future.

The study found that the two groups with language impairments performed the worst on tasks involving executive working memory. These two groups were characterized by deficits in reading ability, reading comprehension, and a clear weakness in overall language proficiency particularly in receptive and expressive language disorders. Although the study did not establish psychological factors as the cause of the language impairment, it highlighted the association between language disorders and working memory difficulties.

Based on the aforementioned cognitive analysis, the following research questions were proposed:

- Is there a statistically significant difference between the mean scores of typical readers and dyslexic readers in working memory?
- Is there a statistically significant correlation between working memory and reading ability?

**Research Hypotheses:**

- There is a statistically significant difference between the mean scores of typical readers and dyslexic readers in working memory.
- There is a statistically significant correlation between working memory and reading ability.

**Objectives of the Study:**

- To identify the performance levels of typical readers and students with dyslexia.
- To highlight the level of working memory among students with reading difficulties and to pave the way for further in-depth studies on the subject.
- To explore the relationship between working memory and dyslexia among fourth and fifth-grade primary school students.

- To determine the differences between dyslexic and typical readers in reading ability and working memory.
- To define the characteristics of individuals with dyslexia in relation to reading ability and working memory.

### **Definition of Terms in the Study:**

#### **1/ Dyslexia:**

A persistent and specific difficulty in learning written language that affects children who do not suffer from any sensory or motor impairments, who have a normal intellectual level, have been enrolled in school for approximately one year, and show a desire to learn. It refers to an individual who has a deficit or specific difficulty in acquiring written language without the presence of sensory, mental, or behavioral disorders. Dyslexia is identified by administering a reading test (frequent words, non-frequent words, and pseudo-words).

#### **2/ Working Memory:**

It is the store that includes essential operations, namely maintaining a limited amount of information in an active state. It also involves selecting and retrieving relevant information while excluding irrelevant ones. Additionally, it includes performing tasks such as applying rules to data, task execution, planning, and directing performance.

Working memory connects incoming information with that already stored in long-term memory. In this study, working memory is measured using a symbolic working memory test and a verbal working memory test developed and proposed by Professor LaïsIsmail.

### **Field Study Procedures**

#### **1. Methodology Used:**

It is well known that the nature of the study determines the type of methodology employed. Since the subject of our research involves studying the relationship between dyslexia and working memory in a sample of fourth- and fifth-grade primary school pupils, the appropriate methodology for this type of research is the descriptive method. This method is defined as one that interprets the current state of a phenomenon or problem by identifying its conditions, dimensions, and describing the relationships between them, with the aim of reaching an accurate scientific description of the phenomenon or problem, based on its associated characteristics. (Lahlah&Aboubakr, 2001)

#### **2. Research Sample:**

The sample represents a portion of the overall population being studied. It involves selecting a number of individuals for a given study in a way that makes them representative of the larger group from which they were chosen. (Bousnina, 2007)

These individuals constitute the sample, and the larger group is the original study population. The purpose of selecting the sample is to obtain information about the original population. The study population consisted of 66 male and female pupils in the fourth and fifth years of primary education.

Children were selected based on specific exclusion criteria, and were excluded if they met any of the following:

- Repeating the academic year
- Obvious visual impairment
- Clear speech or language disorder
- Significant academic underachievement in all school subjects
- Attention deficit hyperactivity disorder (ADHD)

### 1.1 Temporal Boundaries:

The study was conducted over a period extending from 22/12/2013 to 08/04/2014.

### 1.2 Spatial Boundaries of the Study:

The study was carried out at Hammi Belkacem and Aoun El Bachir Primary Schools, located in the municipal district of El-Megrene.

### 1.3 Sample Characteristics:

The age of the sample ranges between 9.5 and 11 years. Their educational level corresponds to the fourth and fifth grades of primary school. They were classified into two groups: dyslexic readers and typical readers. The group of typical readers consisted of 50 pupils, while the dyslexic group included 16 pupils. The following table presents the study sample:

**Table (1):** Study Sample Distribution.

50	<b>Typical Readers – 4th and 5th Grade</b>
16	<b>Dyslexic Readers – 4th and 5th Grade</b>
66	<b>Total</b>

**Table (2):** Characteristics of the Sample by Grade Level.

<b>Percentage(%)</b>	<b>Number</b>	<b>Grade Level</b>
63.63%	42	<b>4th Grade</b>
36.36%	24	<b>5th Grade</b>

## Research Tools

To carry out the field study, tools are needed to assist in its implementation. Research tools are the means through which the researcher collects data. In this study, we relied on a primary tool, namely the **reading test**.

### 1. Reading Test:

It is a diagnostic test composed of words designed to assess the pupil's reading ability. It is divided into:

#### 1.1. Frequent Words:

This section of the test consists of 40 words, divided into two parts:

- **Complex words (20)**
- **Simple words (20)**

These words are commonly used by the pupil and are considered less difficult. The child is told: "We will present a set of words in front of you, and we ask you to read them in order." A score of (1) is given for each correctly read word, and (0) for each incorrect one.

### 1.2. Non-Frequent Words:

This section also consists of 40 words, divided into two parts:

- **Complex words (20)**
- **Simple words (20)** This section is more difficult for the child compared to the frequent words section.
  - **Part 1:** Composed of letter combinations that form a word-like structure but have no actual meaning.
  - **Part 2:** Consists of meaningful words with scrambled letters.

The child is told: "We will present a set of words in front of you, and we ask you to read them in order." A score of (1) is given for each correct word, and (0) for each incorrect one.

### Exclusion Criteria for This Test:

- Repeating the academic year
- Clear visual impairment
- Hearing impairment (uses a hearing device)
- Attention deficit hyperactivity disorder
- Clear language disorder
- Severe difficulty in understanding the test or its instructions
- Significant academic underachievement across all subjects

## 5.2 Working Memory Test:

This test consists of two subtests: **symbolic memory** and **verbal memory**.

### 5.2.1 Symbolic Memory:

This test presents a series of unarranged numbers and shapes. A card is shown to the child displaying numbers and shapes. The child is asked to point with their finger to the numbers and shapes in the correct order **without verbal repetition**, using only finger pointing. The child must be familiar with the presented numbers and shapes. The examiner should read the series slowly to allow the examinee to process it.

### Scoring:

- Correct pointing to all numbers and shapes in the required order: **1 point**
- Any missing elements or incorrect order: **0 points**

### 5.2.2 Verbal Memory:

This test consists of a series of four words, including names of animals and objects. The examiner reads the sequence to the child and asks the child to repeat it verbally—**first naming the animals in order from largest to smallest**, then naming the objects in any order.

#### Scoring:

- Recalling all names (animals and objects) in the correct order: 1 point
- Recalling all names with an error in order: 0.5 points
- Recalling fewer names but with correct order: 0.5 points
- Recalling fewer names with incorrect order: 0 points

### Psychometric Properties

#### ➤ First / Test Validity:

The validity of the working memory test was verified using the internal consistency method, by calculating the correlation coefficient between each subtest (symbolic and verbal memory) and the total score of the working memory test.

**Table (3):** Correlation between the Total Working Memory Score and Symbolic and Verbal Memory Scores in the Study Sample.

Significance Leve	Total Working Memory Score	Standard Deviation	Mean	Variable
Significant at the 0.000 level	$r = 0.873$	4.17	1.956	Symbolic Working Memory
Significant at the 0.000 level	$r = 0.842$	4.841	1.7676	Verbal Working Memory

#### ➤ Second / Reliability:

The reliability was calculated using Cronbach's alpha coefficient for both the reading test and the working memory test:

- **Reading Test:**The Cronbach's alpha coefficient for the reading test and its components was **0.930**.
- **Working Memory Test:**The overall Cronbach's alpha coefficient for the working memory test was **0.63**.

#### ➤ Presentation and Analysis of Results – First Hypothesis:

Below are the results related to the first hypothesis, which states that there are statistically significant differences between the two groups—typical readers and dyslexic readers—in working memory (both symbolic and verbal).

**Table (4):** Difference Between Typical Readers and Dyslexic Readers in the Symbolic Working Memory Test.

Significance Leve	t-value	Standard Deviation	Mean	Group
Significant at the 0.009 level	2,47	2,021	4,47	Typical Readers / n = 50
		1,402	3,22	Dyslexic Readers / n = 16

It appears from this table that there is a statistically significant difference at the level of 0.009 between the two groupstypical readers and dyslexic readerswhich indicates a higher level of symbolic working memory among typical readers compared to dyslexic readers.

**Table (5):** Difference Between Typical Readers and Dyslexic Readers in the Verbal Working Memory Test

Significance Leve	t-value	Standard Deviation	Mean	Group
Not Significant	0,721	1,8654	4,930	Typical Readers / n = 50
		1,4361	4,563	Dyslexic Readers / n = 16

It appears from this table that there is no statistically significant difference between the two groupstypical readers and dyslexic readerswhich indicates a higher level of verbal working memory among typical readers compared to dyslexic readers.

➤ **Presentation of the Results for the Second Hypothesis:**

This hypothesis states that there is a correlation between reading ability and working memory (verbal and symbolic).

**Table (6):** Correlation Between the Total Reading Score and Symbolic Working Memory in the Study Sample.

Significance Leve	Correlation Coefficient (r)	Standard Deviation	Mean	Variable
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Not Significant	0.227	19.83	77.94	<b>Total Reading Score</b>
		1.95	4.17	<b>Symbolic Working Memory</b>

It appears from this table that there is no statistically significant difference between the two groups typical readers and dyslexic readers which indicates a higher level of performance in the verbal working memory test among typical readers compared to dyslexic readers.

**Table (7):** Correlation Between the Total Reading Score and Verbal Working Memory in the Study Sample.

Significance Level	Correlation Coefficient (r)	Standard Deviation	Mean	Variable
Significant	2,115	19,832	77,94	<b>Reading Score</b>
		1,7676	4,841	<b>Verbal Working Memory Score</b>

It appears from this table that there is a statistically significant correlation between reading and verbal working memory.

**1. Discussion of the Results for the First Hypothesis:**

This hypothesis states that there are statistically significant differences between the two groups typical readers and dyslexic readers in working memory (symbolic and verbal). Tables (4) and (5) show that there are statistically significant differences between typical readers and dyslexic readers in the symbolic working memory test, but no significant differences in the verbal working memory test.

The ability to learn is strongly linked to working memory, as the effects of educational experiences must be retained in order to build upon them and benefit from them during learning. Thus, memory difficulties may lead to various symptoms depending on the nature and degree of the memory impairment on one hand, and the nature of the learning task on the other. If a child has difficulty recognizing and retrieving auditory, visual, and kinesthetic-tactile information, their performance on any task requiring such knowledge or retrieval will be affected accordingly.

These findings are consistent with those of several researchers such as Wright et al. (2001) and Thomas et al. (2003), who confirmed a relationship between memory span and comprehension. Their results indicate the role of memory capacity in understanding, depending on the simplicity or complexity, clarity, or ambiguity of the text.

The results also indicated that children had no difficulty understanding common topics and images, but they showed specific difficulty in understanding linguistic symbols. Furthermore, all children found it easier to recall short sentences compared to longer ones.

Farah and Bar-Parah found in a study that word recall relies heavily on working memory capacity, and that impairment in working memory leads to disturbances in the child's linguistic ability. This study was conducted on ten children (7 males and 3 females), who were asked to recall a set of common images and a set of linguistic symbols.

These results also align with the study by Swanson (1999), which found a relationship between working memory deficits and short-term memory in individuals with dyslexia, where statistically significant differences were observed in favor of the typical group.

The absence of statistically significant differences in the verbal working memory test, as shown in the results, indicates that both groupstypical and dyslexic readersachieved similar outcomes. This may be due to the fact that verbal memory is required by both groups to support reading development. Most cognitive psychologists emphasize that to understand how students learn, one must first understand the full system by which individuals process informationthat is, tracking the flow of information during learning from initial reception to processing in the brain in terms of perception, transformation, elaboration, and finally putting it into action either verbally, behaviorally, or through storage.

Current evidence indicates that short-term verbal memory is strongly correlated with reading achievements in the early years of learning to read, and that it plays a role as part of phonological processing development related to reading, rather than being a mere incidental factor.(Suha, Saleh, 2019)

## **2. Discussion of the Results for the Second Hypothesis:**

The second hypothesis in this study stated that there is a statistically significant correlation between dyslexia and working memory within the study sample, which highlights the relationship between reading ability and working memory.

These results are consistent with the findings of a study which showed that the two groups with language impairments performed the worst on executive working memory tasks. These groups were characterized by disorders in reading ability, reading comprehension, and a clear deficiency in overall language proficiencyparticularly in receptive and expressive language impairment. Although the study did not establish psychological causes for the language impairment, it aligns with the findings of Miyake and Shah regarding the role of working memory in helping individuals interpret written language during reading.

Reading comprehension is linked to the ability to interpret the text, and difficulties in comprehension, initiation, and accuracy in understanding words are attributed to diminished information in working memory.(Abu Al-Diyar, 2012, p. 65)

This is also consistent with a study conducted by Wagner and colleagues on several hundred children followed from kindergarten to fourth grade. A set of diverse measures were applied, including: phonological awareness, verbal memory, short-term memory, and rapid naming. Among the key

findings over three different time periods was that phonological awareness skills and individual differences in word-level reading were predictable, whereas verbal memory and short-term memory skills were not strong predictors.

Regarding verbal working memory tasks, it is well-established that children with reading difficulties show a marked decline in such tasks. In samples of children, dozens of working memory tasks have been shown to predict future reading achievement more accurately than verbal memory, short-term memory, or even phonological awareness measures.

## CONCLUSION

The primary and fundamental objective of this study was to identify the differences in working memory between typical readers and dyslexic readers within the study sample, and to examine the relationship between dyslexia and working memory through the administration of a reading test and a working memory test.

Based on the results obtained from this study, it can be concluded that:

There are statistically significant differences between typical readers and dyslexic readers in symbolic working memory, while no significant differences were found in verbal working memory. A statistically significant correlation was also found between working memory and reading ability.

This indicates that working memory is a key component in learning to read among pupils and has a clear impact on the acquisition of reading ability.

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