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Title:

The Relationship Between the Visuospatial Sketchpad and Dyslexia in 4th-Grade Students

In partial fulfillment of the requirements for the Master's Degree in Language and Communication Disorders

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Abstract

This study examines the relationship between visuospatial sketchpad (VSS) and dyslexia in 30 fourth-grade students with dyslexia. A purposive sampling method and a descriptive correlational design were used. The researcher-developed the VSS test and the dyslexia test adapted by Dr. Ben Sadoon Fatiha from the L'alouette test, were employed to assess the participants. Spearman's rank-order correlation analysis was conducted to explore the relationships between VSS subcomponents and dyslexia, including total words read, correct words, reading accuracy, and speed.

The results showed no significant correlations between the total VSS score and overall reading performance ($p > .05$). However, specific VSS subcomponents demonstrated significant positive correlations with dyslexia. *Visual Pattern Recognition* was positively associated with total words read ($\rho = .382$, $p = .037$), correct words ($\rho = .382$, $p = .037$), and reading speed ($\rho = .382$, $p = .037$). *Static Spatial Layout* was also significantly correlated with total words read ($\rho = .489$, $p = .006$), correct words ($\rho = .523$, $p = .003$), reading speed ($\rho = .523$, $p = .003$), and accuracy ($\rho = .438$, $p = .015$), indicating its strong connection to reading fluency and accuracy.

Other subcomponents like *Movement Planning* and *Dynamic Spatial Attention* also showed significant positive correlations with reading performance measures, suggesting that these abilities enhance fluency and accuracy. In contrast, *Spatial Sequence Processing* was negatively correlated with accuracy ($\rho = -.407$, $p = .026$), indicating a potential trade-off between speed and precision.

These findings suggest that certain visuospatial skills, particularly *Static Spatial Layout* and *Visual Pattern Recognition*, are linked to reading outcomes in dyslexic students. Further research with larger samples is needed to deepen the understanding of these relationships.

Keywords: Visuospatial sketchpad, dyslexia, Fourth-grade students

Résumé

Cette étude examine la relation entre le calepin visuo-spatial (CVS) et la dyslexie chez 30 élèves de quatrième année présentant des troubles dyslexiques. Une méthode d'échantillonnage intentionnel et un devis corrélationnel descriptif ont été utilisés. Un test du CVS élaboré par le chercheur, ainsi qu'un test de dyslexie adapté du test de L'alouette par la Dr Ben Sadoon Fatiha, ont été employés pour évaluer les participants. Une analyse de corrélation de Spearman a été menée afin d'explorer les relations entre les sous-composantes du CVS et la dyslexie, notamment le nombre total de mots lus, les mots corrects, la précision de lecture et la vitesse.

Les résultats n'ont montré aucune corrélation significative entre le score total du CVS et la performance globale en lecture ($p > .05$). Toutefois, certaines sous-composantes spécifiques du CVS ont révélé des corrélations positives significatives avec la dyslexie. La reconnaissance des motifs visuels était positivement associée au nombre total de mots lus ($\rho = .382$, $p = .037$), aux mots corrects ($\rho = .382$, $p = .037$) et à la vitesse de lecture ($\rho = .382$, $p = .037$). L'agencement spatial statique a également présenté une corrélation significative avec le nombre total de mots lus ($\rho = .489$, $p = .006$), les mots corrects ($\rho = .523$, $p = .003$), la vitesse de lecture ($\rho = .523$, $p = .003$) et la précision ($\rho = .438$, $p = .015$), soulignant son lien étroit avec la fluidité et la précision en lecture.

D'autres sous-composantes telles que la planification des mouvements et l'attention spatiale dynamique ont également montré des corrélations positives significatives avec les mesures de performance en lecture, suggérant que ces capacités favorisent la fluidité et la précision. En revanche, le traitement des séquences spatiales était corrélé négativement avec la précision ($\rho = -.407$, $p = .026$), ce qui indique un possible compromis entre vitesse et exactitude.

Ces résultats suggèrent que certaines compétences visuo-spatiales, en particulier l'agencement spatial statique et la reconnaissance des motifs visuels, sont liées aux performances en lecture chez les élèves dyslexiques. Des recherches supplémentaires sur des échantillons plus larges sont nécessaires afin d'approfondir la compréhension de ces relations.

Mots-clés : calepin visuo-spatial, dyslexie, élèves de quatrième année

الملخص

تهدف هذه الدراسة إلى فحص العلاقة بين المفكرة البصرية المكانية وعسر القراءة لدى 30 تلميذاً من تلاميذ السنة الرابعة ابتدائي . تم استخدام أسلوب العينة القصدية، إلى جانب تصميم بحث وصفي ارتباطي. وقد استخدم الباحث اختبار المفكرة البصرية الفضائية الذي قام بتطويره، بالإضافة إلى اختبار عسر القراءة الذي قامت الدكتورة بن سعدون فتيحة بتكييفه من اختبار "الالويت" الفرنسي.

تم إجراء تحليل ارتباط رتبي باستخدام معامل سبيرمان لفحص العلاقة بين اختبار المفكرة البصرية الفضائية ومؤشرات عسر القراءة، مثل: إجمالي الكلمات المقروءة، عدد الكلمات الصحيحة، نوع الأخطاء، سرعة القراءة ودقة القراءة.

أظهرت النتائج أنه لا توجد علاقة ارتباطية ذات دلالة إحصائية بين المجموع الكلي لاختبار المفكرة البصرية المكانية والأداء العام في اختبار عسر القراءة. ($p > .05$) إلا أن بعض المكونات الفرعية للمفكرة البصرية المكانية أظهرت ارتباطات إيجابية ذات دلالة إحصائية مع الأداء في اختبار عسر القراءة. حيث ارتبط التعرف على الأنماط البصرية إيجابياً بعدد الكلمات المقروءة($\rho = .382, p = .037$) ، وعدد الكلمات الصحيحة($\rho = .382, p = .037$) ، وسرعة القراءة ($\rho = .382, p = .037$). كما ارتبط التخطيط المكاني الثابت ارتباطاً إيجابياً بإجمالي الكلمات المقروءة ($\rho = .489, p = .006$)، والكلمات الصحيحة($\rho = .523, p = .003$) ، وسرعة القراءة($\rho = .523, p = .003$) ، والدقة ($\rho = .438, p = .015$)، مما يدل على صلته القوية بالطلاقة والدقة في القراءة.

وأظهرت مكونات أخرى مثل "تخطيط الحركة" و"الانتباه المكاني الديناميكي" ارتباطات إيجابية دالة إحصائياً مع مؤشرات اختبار عسر القراءة، مما يشير إلى أن هذه القدرات تسهم في تحسين الطلاقة والدقة. في المقابل، أظهر "معالجة التسلسل المكاني" ارتباطاً سلبياً مع الدقة.($\rho = -.407, p = .026$)

تشير هذه النتائج إلى أن بعض مؤشرات المفكرة البصرية المكانية، خاصة "التخطيط المكاني الثابت" و"التعرف على الأنماط البصرية"، ترتبط بنتائج القراءة لدى التلاميذ المصابين بعسر القراءة. وتوصي الدراسة بإجراء المزيد من الأبحاث باستخدام عينات أكبر لتعميق فهم هذه العلاقات.

الكلمات المفتاحية :المفكرة البصرية المكانية، عسر القراءة، تلاميذ السنة الرابعة ابتدائي.

SUMMARY

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Introduction

1. Introduction

Learning disabilities (LDs) are neurodevelopmental disorders characterized by persistent difficulties in acquiring and applying academic skills including reading, writing, or mathematics, despite average or above-average intelligence and access to adequate instruction (American Psychiatric Association & American Psychiatric Association, 2013). The DSM-5 classifies these under Specific Learning Disorders (SLD), highlighting deficits in foundational cognitive processes, such as phonological awareness (e.g., sound-letter correspondence), visuospatial processing (e.g., interpreting graphs), and numerical reasoning (e.g., arithmetic fluency)(American Psychiatric Association & American Psychiatric Association, 2013). These deficits are not due to sensory impairments, intellectual disabilities, or socioeconomic disadvantage but instead reflect atypical brain development and connectivity (Norton et al., 2015).

Moreover, The Individuals with Disabilities Education Act (IDEA) categorizes LDs into dyslexia (reading difficulties), dysgraphia (writing challenges), and dyscalculia (mathematical impairments), with dyslexia being the most prevalent(Scaria et al., 2023).

Dyslexia is a neurodevelopmental disorder characterized by persistent difficulties in accurate and fluent word recognition, spelling, and decoding abilities, though normal intelligence, sufficient sensory function, and adequate educational opportunities (M. J. Snowling et al., 2020). These challenges are the result of deficits in the phonological component of language, though recent research underlines the involvement of broader cognitive and sensory processes(Peterson & Pennington, 2015). The individuals with dyslexia exhibit varying degrees of impairment across reading-related skills, which makes it heterogeneous. To account for this variability, researchers have classified dyslexia into distinct subtypes:

1. **Phonological Dyslexia:** Characterized by deficits in phonemic awareness, according to (M. Snowling, 2006a) it is the ability to identify and manipulate speech sounds (e.g., segmenting *cat* into /k/, /æ/, /t/). This subtype disrupts grapheme-phoneme mapping, leading to poor non-word reading (e.g., reading *flig* as *fig*) and spelling errors. Recent Neuroimaging studies associate phonological dyslexia with reduced activation in the left inferior frontal gyrus and temporoparietal regions, which critical for phonological processing(Norton et al., 2015).

2. **Surface Dyslexia:** Marked by impaired whole-word recognition, overreliance on phonological decoding, leading to difficulty reading irregular words (e.g., *yacht* or *colonel*)(Castles &

Coltheart, 1993). This subtype is linked to under activation in the occipitotemporal "visual word form area," which facilitates rapid word recognition(Dehaene et al., 2005). (Ziegler & Goswami, 2005) considers surface dyslexia more prevalent in opaque orthographies like English, where inconsistent spelling-sound rules obstruct lexical retrieval.

3. **Double-Deficit Dyslexia:** Combines phonological deficits with slow rapid automatized naming (RAN), it characterized by an impairment to quickly retrieve verbal labels for symbols (e.g., letters, numbers). This subtype predicts severe reading fluency impairments, as both phonological and retrieval deficits compound decoding inefficiencies(Wolf & Bowers, 1999). Longitudinal studies show children with double-deficit dyslexia are 80% more likely to experience chronic reading struggles than those with single deficits(Kirby et al., 2010).

Furthermore Dyslexia affects approximately 5–12% of children globally, though prevalence varies by language orthography(Peterson & Pennington, 2015). While transparent orthographies like Italian, with consistent letter-sound rules, report lower dyslexia rates (3–5%) opaque orthographies like English report up to (7–10%) (Ziegler & Goswami, 2005)

In Arabic-speaking populations, dyslexia prevalence estimates between 6 and 10%,(Al Lamki, 2012). A unique challenge in Arabic contexts is diglossia, which is the coexistence of Modern Standard Arabic (MSA), used in formal education, and colloquial dialects spoken at home (Saiegh-Haddad & Joshi, 2014) This linguistic duality complicates literacy acquisition, as children must master phonologically and morphologically distinct varieties simultaneously. For example, MSA includes vowel diacritics (ḥarakāt) omitted in most texts, increasing decoding demands for struggling readers(Taha, 2013).

Studies show Arabic-speaking children with dyslexia exhibit slower reading speeds and poorer phonological awareness compared to peers in transparent orthographies (Elbeheri et al., 2011), these deficits are related to varied cognitive impairments, such as phonological deficits, disruptions in rapid naming, working memory, and visuospatial processing:

1. **Phonological Awareness:** Phonological deficits are the most main predictor of dyslexia across languages. Children with dyslexia struggle to segment words into phonemes, blend sounds into words, and manipulate syllables(Vellutino et al., 2004). These difficulties impair decoding, as mapping graphemes to phonemes requires precise phonological representations. For example, dyslexic readers may misread *bat* as *pat* due to poor discrimination of /b/ and /p/(Ramus et al.,

2013). Cross-linguistic studies identify phonological deficits in both transparent such as Finnish and opaque such as French orthographies, though their impact varies with orthographic depth(Landerl et al., 2013).

2. **Rapid Automatized Naming (RAN):** Slow RAN speeds are linked with reading fluency impairments, as delayed retrieval of letter names or numerals disrupts automaticity. For instance, children with RAN deficits take longer to name sequences like *A-3-K-7*, which leads to slower text reading(Kirby et al., 2003). RAN is notably predictive of dyslexia in consistent orthographies such as German, where phonological decoding is mastered early, but fluency remains a lifelong challenge (Landerl & Wimmer, 2008), according to (Norton & Wolf, 2012), RAN deficits reflect inefficiencies in the brain's visual-verbal integration circuits, particularly the cerebellar-thalamic-prefrontal network.

3. **Working Memory (WM):** Dyslexia is correlated with impairments in both verbal and visuospatial WM. Verbal WM deficits are difficulties in retaining phonological information (e.g., repeating non-words like *blonterstaping*), which disturb sentence comprehension and vocabulary acquisition(Smith-Spark & Fisk, 2007). And visuospatial WM deficits, involving impaired manipulation of visual symbols (e.g., mentally rotating letters), contribute to letter reversals (e.g., *b* vs. *d*) and poor orthographic learning(Beneventi et al., 2010a).

These deficits can be explained according to the role of Working memory (WM) in storing temporarily and manipulating information required for various cognitive activities, including learning, reasoning, and problem-solving(Baddeley, 2003). Therefore It impacts academic achievement, particularly in reading, writing, and mathematical abilities(Gathercole et al., 2006). Overall research revealed that working memory deficiency have been consistently linked to learning disabilities, including dyslexia (Swanson & Jerman, 2007).

One of the most influential models of working memory is Baddeley's multi-component model(Baddeley, 2000). This model conceptualizes WM as a system forming multiple interacting components that process and store different types of information:

- **Central Executive:** The core component responsible for directing attention, managing cognitive resources, and coordinating information processing across subsystems(Baddeley, 2012). It plays an essential role in controlling and regulating cognitive tasks, such as problem-solving and decision-making. Studies have revealed that dyslexic individuals often show decrease in executive functions performance, results in difficulties including managing complex cognitive tasks (Smith-Spark & Fisk, 2007).

- **Phonological Loop:** A subsystem involved in processing and maintaining verbal and auditory information. It composes of the phonological store, which temporarily holds auditory information, and the articulatory rehearsal process, which refreshes this information to prevent decay(Baddeley, 2003). Research indicates that dyslexic individuals have deficits with phonological memory tasks, such as digit span and nonword repetition(M. Snowling, 2006a). Thus phonological impairments is widely recognized as a main deficit of dyslexia(Wagner et al., 1997)

- **Episodic Buffer:** it integrates information from the phonological loop, VSSP, and long-term memory, creating a blended representation of experiences(Baddeley, 2000). This component is important for comprehension and complex cognitive tasks, such as reading(Alloway et al., 2006). Research notes that dyslexic individuals may have deficits in binding phonological and visual information, impacting their reading fluency(Perez et al., 2012).

- **Visuospatial Sketchpad (VSS):** The VSS is involved in processing and storing visual and spatial information, supporting tasks like mental imagery, spatial reasoning, and letter recognition (Logie, 2014). Studies suggest that dyslexic children may have impairments in visuospatial memory, manifesting in their reduced ability to distinguish letter orientations (e.g., confusing “b” and “d”) and retain word structure(Bacon & Handley, 2010). The VSS is important for learning orthographically complex languages like Arabic, where visual memory is crucial for word recognition, , due to its unique challenges as a result of its cursive script, contextual letter shapes, and optional diacritics (ḥarakāt) that represent vowels(Abu-Rabia & Siegel, 2002). Studies note that Arabic-speaking dyslexics have letter connectivity and diacritic tracking deficiencies, leading to slower reading speeds and higher error rates compared to English peers (Elbeheri et al., 2011)
  These findings emphasize the role of orthographic depth in shaping cognitive profiles, challenging the universality of phonological deficit models (Wang et al., 2005)

Several studies have explored the cognitive profiles of individuals with dyslexia, with most research focusing on phonological working memory. For instance (Archibald & Gathercole, 2006)found that children with Specific Language Impairment (SLI) exhibited deficits in phonological working memory, measured through a completed comprehensive battery of short-term and working memory, as well as two phonological awareness tasks, which are also relevant to dyslexia-related difficulties.

Also (De Carvalho et al., 2014) conducted a fluency, reading comprehension and phonological processing tests on students from the third to eighth grade, the students with dyslexia exhibited significant deficits in phonological short-term memory, which is correlating with poor reading outcomes.

Additionally (Knoop-van Campen et al., 2018) found that Phonological awareness, a key component of reading development, has been identified as a mediating factor between working memory and reading efficiency in dyslexic and typically developing children , furthermore (Richardson et al., 2004) revealed that dyslexic children showed difficulties in auditory processing tasks, which were associated with their phonological processing impairments Moreover, (Mirahadi et al., 2025)detected phonological awareness interventions combined with transcranial direct current stimulation (tDCS), showing enhancements in automatized naming and verbal short-term memory performances in dyslexic children. To sum up, These results highlight the correlation between phonological processing deficits and reading performance in dyslexia.

On the other hand, research examining the visuospatial sketchpad's role in dyslexia is relatively limited, and results remains a subject of ongoing debate among researchers. While some studies suggest that deficits in the visuospatial sketchpad contribute to the challenges faced by individuals with dyslexia, others have found no significant association.

Several studies have established that children with dyslexia exhibit impairments in visuospatial sketchpad, indicating a possible link between deficits in the visuospatial sketchpad and reading difficulties.

A study by (Poblano et al., 2000) assessed phonological and visuospatial sketchpad in 40 children with dyslexia and 40 typically developing children. The findings revealed that dyslexic children recalled fewer words in phonological tasks and demonstrated significant difficulty in visuospatial tasks, such as assembling puzzles. This suggests that both phonological and visuospatial sketchpad contribute to the deficits in dyslexia.

Moreover (Menghini et al., 2011) demonstrated that dyslexic children performed worse in span tasks tapping verbal, visual-spatial, and visual-object working memory, proving that dyslexia is not only a phonological disorder.

Furthermore, research by (Lipowska et al., 2011). used the Clock Drawing Test, backward Spatial Span, and the Rey-Osterrieth Complex Figure test. to examine visuospatial deficits in dyslexic children. The study identified difficulties in complex visuospatial tasks among dyslexic children, further supporting the hypothesis that visuospatial working memory plays a role in dyslexia.

In addition (Du & Zhang, 2023) performed a meta-analysis examining visuospatial sketchpad in dyslexic populations. They analyzed data from thirteen studies and noted that dyslexic children consistently performed worse on visuospatial sketchpad tasks compared to typically developing peers. This shows that dyslexia may be linked with more than one deficit in working memory, rather than being limited to phonological processing.

Nevertheless, other studies have identified no significant association between visuospatial sketchpad deficits and dyslexia, which it contrasts the findings we discussed previously, suggesting that impairments in dyslexia may be more linked to phonological processing rather than to visuospatial tasks.

For instance (Ramus, 2003) demonstrated that all dyslexic individuals in their sample study, exhibited phonological deficits, while only a subset showed auditory or motor deficits, and fewer had visual deficits. This suggests that phonological processing difficulties are a core characteristic of dyslexia.

Another study by (Beneventi et al., 2010b) used functional MRI (fMRI) to investigate phonological short-term memory in dyslexic and non-dyslexic children. The findings showed that dyslexic children exhibited reduced activation in brain regions associated with phonological processing during tasks involving phonological storage and serial rehearsal. While the study did not specifically compare visuospatial tasks, the results support the notion that phonological processing difficulties are a core characteristic of dyslexia.

In addition, (Smith-Spark & Fisk, 2007) investigated working memory profiles in individuals with dyslexia. The researchers found that phonological working memory deficits include both simple and complex verbal spans, however the visuospatial sketchpad deficits include only complex spatial span. This suggests that dyslexia is more strongly associated with phonological processing deficits rather than broader working memory impairments.

Another study by (Garcia et al., 2014) examined visuospatial sketchpad for locations, colors, and binding in dyslexic children using recall tasks. The results identified that while some dyslexic children showed minor impairments in certain visuospatial tasks, the overall differences were not statistically significant when compared to typically developing children. This suggests the that visuospatial deficits are not core feature of dyslexia.

Similarly, (Yang et al., 2017) conducted a study to determine if there is an impact of working memory training on reading abilities in dyslexic children. The findings found that while phonological working memory training led to improvements in phonological awareness, visuospatial working memory training led to improvements orthographic awareness.

Furthermore, (Chamberlain et al., 2018) conducted a meta-analysis to reveal the visuospatial abilities in individuals with dyslexia. The study concluded that, on average, participants with dyslexia exhibited poorer visuospatial ability across various tasks. However, the authors noted that the differences varied depending on the type of visuospatial measure used, and the type of the task, suggesting that while there may be some deficits, they are not across all visuospatial tasks.

Also , (Gray et al., 2019) examined working memory profiles in children with dyslexia, developmental language disorder (DLD), or both. The study used block recall and maze memory tasks among other working memory tasks. The findings highlight that the impairments in visuospatial sketchpad performance among dyslexic children was mixed. Some dyslexic children performed comparably to their typically developing peers, suggesting that visuospatial deficits may not be a main characteristic of dyslexia.

The debate regarding the relationship between the visuospatial sketchpad and dyslexia highlights the complexity role of working memory in reading difficulties. While several studies have demonstrated a significant association between visuospatial deficits and dyslexia, others have failed to find compelling evidence. suggesting that various factors influence results such task complexity such as Studies utilizing tasks requiring spatial manipulation (e.g., mental rotation) often report deficits, while simpler spatial span tasks showed mixed results, and sample size and methodology, for example variability in study designs, tools, and sample sizes affects outcomes, highlighting the need for standardized assessments.

Despite increasing research, significant gaps remain:

- **Limited research on Arabic-speaking populations:** There is a shortage of studies examining visuospatial sketchpad in dyslexic individuals, particularly in Algeria, making it difficult to generalize findings from other linguistic and cultural contexts.
- **Lack of standardized assessment tools:** Existing tools do not comprehensively evaluate all components of the visuospatial sketchpad, resulting to incomplete assessments of visuospatial sketchpad in dyslexic individuals.
- **Insufficient correlation studies:** Few studies have explored the link between all symptoms of dyslexia and each component of the visuospatial sketchpad, limiting our understanding of how visuospatial deficits interact with dyslexic characteristics.

Moreover, this study aims to address these gaps by investigating the relationship between visuospatial sketchpad and dyslexia in 4th-grade students. Specifically, it seeks to address the following research question:

1.1. Study Question

Is there a significant correlation between visuospatial sketchpad and dyslexia in fourth grade students?

1.2. Hypothesis

There is a significant correlation between visuospatial sketchpad and dyslexia in fourth grade students.

1.3. Research Objectives:

- **General Objective:**

To investigate the relationship between visuospatial sketchpad (VSS) and dyslexia in 4th grade students.

- **Specific Objectives :**

1. To assess the level of visuospatial sketchpad among 4th grade students.
2. To assess the level of dyslexia (total and correct words read, number of errors, accuracy, speed) among 4th grade students
3. To examine the relationship between visuospatial sketchpad and dyslexia.

1.4. Significance of the Study

This study is significant as it explores a potentially under examined cognitive factor, visuospatial sketchpad in relation to dyslexia in 4th grade students. While dyslexia is often associated with phonological deficits, visual spatial processing may also play a critical role in reading and word recognition.

Identifying a meaningful relationship between VSS and dyslexia could improve early screening and intervention strategies in schools. Teachers, special education professionals, and school psychologists may be able to use this knowledge to design more effective instructional methods and support systems.

The findings of this study may also contribute to educational psychology research by expanding our understanding of the cognitive dimensions of dyslexia, potentially leading to more integrated and individualized learning approaches.

1.5. Procedural Definitions:

The procedural definitions for the key terms in the study:

- **Dyslexia:** A specific learning disorder (SLD) with impairment in reading, diagnosed when an individual demonstrates persistent difficulties in word reading accuracy, reading rate or fluency, and reading comprehension, despite receiving targeted interventions(American Psychiatric Association & American Psychiatric Association, 2013), it is operationally defined as the score obtained by the examinee in the test used in this study.
- **Total Words Read:** The total number of words a student read aloud from the provided reading passage within the time limit, regardless of correctness or fluency. This includes both correctly and incorrectly read words, as assessed by the reading test used in the study.
- **Correct Words Read:** The total number of words the student read aloud accurately, without misreading unfamiliar or novel words, making phoneme- letter errors, confusing visual similarity errors, or committing semantic errors, as determined by the criteria of the test used in this study.
- **Number of Errors:** The total count of mistakes made while reading, including misreading unfamiliar or novel words, phoneme letter errors (e.g., omissions, additions, substitutions, reversals), visual similarity errors (e.g., confusing letters or words with similar shapes),

and semantic errors (e.g., replacing a word with another that alters the meaning of the sentence), as defined by the test used in this study.

- **Accuracy:** Calculated as the proportion of correct words to the total words read. Accuracy (%) = (Correct Words Read / Total Words Read) × 100 This reflects the precision of reading accuracy.
- **Reading Speed (Index):** A rate measure reflecting reading fluency, computed as, Reading Speed = (Total Words Read ÷ Time in Minutes) This index indicates how many words a student reads per minute, capturing both pace and flow.
- **Visuospatial Sketchpad:** A component of working memory responsible for temporary storage and manipulation of visual and spatial information (Logie, 2014), it is operationally defined as the score obtained by the examinee in the test used in this study.
- **Visual Cache**: Defined as the temporary storage system within the visuospatial sketchpad that holds static visual information, such as shapes, colors, and textures. (Logie, 2014).
- **Visual Detail Storage:** Refers to the ability to retain fine-grained details of visual stimuli, such as contrast, line thickness, and intricate design features. It is evaluated through tasks requiring recall or reproduction of visually detailed images after a short interval(Passolunghi & Mammarella, 2010).
- **Visual Pattern Recognition:** Defined as the ability to identify and distinguish complex visual stimuli based on their structural properties. It is measured using visual matching tasks(McAfoose & Baune, 2009).
- **Static Spatial Layout:** Refers to the ability to encode and recall the arrangement of objects in a fixed position. It is assessed through spatial recall tasks, where participants reproduce object placements in a given visual field(McAfoose & Baune, 2009).
- **Color & Texture Representation:** Refers to the ability to process and store information related to color and surface texture of objects. It is measured using visual discrimination tasks, where participants match or recall objects based on color and texture variations(Pinker, 1984).
- **Inner Scribe:** The component responsible for processing spatial relationships, movement planning, and updating spatial locations. (Logie, 2014).
- **Spatial Sequence Processing:** The ability to recall and manipulate sequences of spatial locations or movements. It is assessed using sequential recall tasks, such as ordering a set of locations in a predefined sequence(Passolunghi & Mammarella, 2010).

- **Mental Rotation Mental rotation:** The capacity to mentally manipulate and rotate objects in two- or three-dimensional space. It is evaluated using tasks where participants determine whether rotated objects are identical or mirror images of a reference shape(Hyun & Luck, 2007).
- **Movement Planning:** Refers to the ability to anticipate and coordinate spatially directed movements. It is measured using maze navigation tasks, where participants must plan and execute a movement sequence through a given path(Li et al., 2024).
- **Rehearsal/Refreshing:** The ability to maintain and update visuospatial information through active repetition. It is assessed using tasks that require maintaining a visual stimulus over short delays while performing an interference task(McAfoose & Baune, 2009).
- **Dynamic Spatial Attention:** Defined as the ability to shift and sustain focus on moving objects or changing spatial layouts. It is measured through visual tracking tasks, where participants follow moving targets in a dynamic visual field(Byrne et al., 2007).
- **Fourth-grade students:** Are operationally defined as children between the ages of 9 and 10 years old, who are enrolled in the fourth grade of primary school at the time of data collection.

Method

2. Method

2.1. Research Design

This study employed a quantitative, descriptive correlational research design to examine the relationship between the visuospatial sketchpad (VSS) and dyslexia in 4th-grade students. The primary objective was to determine whether statistically significant associations exist between specific visuospatial processing skills and indicators of dyslexia typically affected by dyslexia.

Data were collected using two tools: the researcher-developed Visual-Spatial Sketchpad (VSS) test and an adapted dyslexia assessment originally developed by L'alouette and adapted by Dr. Ben Sadoon Fatiha for Arabic-speaking learners. These tools allowed for a focused analysis of how components of the visuospatial sketchpad such as visual pattern recognition, spatial layout, and attention relate to reading accuracy, speed, total words read, number of errors, and other dyslexia indicators.

2.2. Participants / Sample

The participants in this study were 4th grade students aged between 9 and 10 years, selected from public primary schools. The target group included students diagnosed with dyslexia.

- **Inclusion Criteria:**
  - Age between 9 and 10 years
  - Currently enrolled in 4th grade
  - Identified with dyslexia through formal or school-based assessments
  - Normal hearing and vision
  - No other diagnosed neurological or intellectual disabilities

- **Exclusion Criteria:**
  - Students with comorbid conditions such as ADHD or autism spectrum disorder
  - Students with uncorrected sensory impairments

2.3. Sampling Method:

A purposive sampling method was used to ensure participants met the specific criteria for studying the relationship between visuospatial skills and dyslexia.

2.4. Tools / Materials

Two main tools were used in this study to assess visuospatial sketchpad (VSS) performance and identify dyslexia among 4th grade students:

2.4.1. Visuospatial Sketchpad Assessment Scale (Developed by the Researcher)

The Visuospatial Sketchpad (VSS) Assessment Scale is a tool developed by the researcher to evaluate visuospatial working memory in children aged 8 to 10. The scale is grounded in the working memory model by Logie (2014), which divides the VSS into two key subsystems:

- Visual Cache: Responsible for temporary storage of visual features such as shapes, colors, and textures.
- Inner Scribe: Responsible for the processing of spatial and movement-related information.

4. Test content

The scale includes 18 tasks grouped under two main dimensions:

❖ **Visual Cache Subscale**

- Visual Detail Storage: Identifying missing items and differences between similar scenes.
- Visual Pattern Recognition: Completing patterns and reproducing color sequences.
- Static Spatial Layout: Reproducing fixed spatial arrangements (e.g., placing objects on a shelf).
- Color and Texture Representation: Recalling and reproducing visual textures and color patterns.

❖ **Inner Scribe Subscale**

- Spatial Sequence Processing: Repeating tapped sequences and mimicking movement sequences.
- Mental Rotation: Identifying rotated or mirrored versions of shapes and letters.

- Movement Planning: Completing sequential drawing tasks and solving mazes.
- Rehearsal/Refreshing: Repeating color sequences after a delay and adding a step to a known sequence.
- Dynamic Spatial Attention: Recalling final positions of moving balls and the sequence of lit images.

Each task is scored based on correct responses, with specific instructions and time limits to ensure standardized administration. The scale provides a comprehensive measure of both static and dynamic visuospatial processing skills.

4.1.1.1. Psychometric Properties

❖ **Validity test**

▪ **Dimension-Total Correlations for Assessing Internal Consistency**

As shown in The table (01) the test demonstrates strong internal consistency validity for both dimensions of the scale. The Pearson correlation coefficients between each dimension and the total score are:

- 0.842 for Dimension 01
- 0.940 for Dimension 02

Both correlations are statistically significant at $p < .01$, indicating that each dimension is highly correlated with the overall scale score. This suggests that both dimensions are measuring constructs that align well with the overall concept assessed by the scale.

Table 1: Dimension-Total Correlations for Assessing Internal Consistency.

Scale Dimension	Pearson's Correlation with Total Score	Significance (p-value)
Dimension 01	0.842**	.000
Dimension 02	0.940**	.000

Note: $p < .01$; all correlations are significant at the 0.01 level (2-tailed).

- **Item-Total Correlations as Evidence of Internal Consistency**

The following table (02) presents the Pearson correlation coefficients between each individual item and the total score of its corresponding dimension. These values assess the degree to which each item contributes to the overall construct being measured. Significance levels indicate whether the correlations are statistically meaningful.

The item-total correlations presented in the table range from 0.361 to 0.861, with all correlations being statistically significant ($p < .05$ or $p < .01$). This indicates that each item contributes meaningfully to the measurement of its respective dimension.

- Most items show strong positive correlations with the total dimension score (r > 0.5), supporting the internal consistency of the scale.
- The highest correlation is observed for Item 06 (r = 0.861), suggesting it is highly representative of its dimension.
- Even the lowest correlation, Item 01 (r = 0.361, p = 0.046), is still statistically significant, though relatively weaker, and might be reviewed for content relevance or clarity.

Table 2: Item-Total Correlations as Evidence of Internal Consistency.

Item	r (Item–Total Correlation)	Sig. (2-tailed)	Item	r (Item–Total Correlation)	Sig. (2-tailed)
01	0.361*	0.046	09	0.560**	0.001
02	0.482**	0.006	10	0.809**	0.000
03	0.537**	0.002	11	0.688**	0.000
04	0.420*	0.019	12	0.708**	0.000
05	0.483**	0.006	13	0.649**	0.000
06	0.861**	0.000	14	0.624**	0.000
07	0.742**	0.000	15	0.763**	0.000
08	0.725**	0.000	16	0.666**	0.000
			17	0.753**	0.000
			18	0.529**	0.002

Note : *p < .05 ; **p < .01*

- **Discriminant Validity Assessed Through Extreme Groups Comparison**

The table (03) presents the results of an extreme groups comparison to evaluate the test's discriminant validity. The upper and lower scoring groups (n = 10 each) were compared using their mean total scores. A statistically significant difference between these groups suggests the test can effectively discriminate between individuals with high and low levels of the measured construct.

The results indicate a significant difference in mean scores between the upper-scoring group (*M* = 42.60, *SD* = 4.12) and the lower-scoring group (*M* = 53.50, *SD* = 0.53), with a p-value of .000, suggesting the difference is statistically significant at $p < .001$.

These findings support the test's psychometric strength, particularly its ability to distinguish between distinct levels of the construct it intends to measure. This adds to the overall evidence of validity.

Table 3: Discriminant Validity Assessed Through Extreme Groups Comparison.

Group	N	Mean Score	Standard Deviation	Significance (p)
Upper Scores	10	42.60	4.12	0.000
Lower Scores	10	53.50	0.53	—

- ❖ **Test Reliability Analysis**

The reliability of the test was assessed using two methods: Split-Half Reliability and Cronbach's Alpha.

- ✓ **Split-Half Reliability**

The split-half reliability method evaluates internal consistency by dividing the test into two equal halves and correlating the scores. The correlation between forms was found to be 0.855, indicating a strong relationship between the two halves. When adjusted using the Spearman-Brown prophecy formula, the reliability coefficient increased to 0.922, suggesting excellent reliability for the full-length test.

Table 4: Split-Half Reliability Analysis of the VSS Test.

Correlation Between Forms	Spearman-Brown Coefficient	Number of Items
0.855	0.922	18

- ✓ **Cronbach's Alpha**

Cronbach’s Alpha was also calculated to assess the internal consistency of the test. A value of 0.858 confirms a high level of reliability, indicating that the test items are consistently measuring the same construct.

Table 5: Cronbach's Alpha Reliability Analysis of the VSS Test.

Cronbach’s Alpha	Number of Items
0.858	18

Both reliability coefficients, Spearman-Brown (0.922) and Cronbach's Alpha (0.858). indicate that the test possesses strong internal consistency. These values suggest that the test is reliable and suitable for assessing the intended construct across all 18 items.

4.1.2. Dyslexia Scale

In order to reveal the relationship between visuospatial sketchpad (VSS) and dyslexia in 4th-grade students, we used the l’Alouette Test, which was adapted to the Algerian context by the researcher Ben Saadoon Fatiha in 2015, as part of her PhD thesis in Developmental Psychology at the University of Tlemcen.

4.1.2.1. Test content

The test measures both quantitative variables related to dyslexia, such as Total words read, Correct words read, Number of errors, Accuracy index, Speed index.

It also includes qualitative variables such as Unfamiliar words, Phoneme letter errors, Verbal similarity, Semantic interference.

4.1.2.2. Psychometric Properties of the Test

- ❖ **Validity tests**

- ➢ **Discriminant Validity Based on Upper and Lower Group Comparison for Quantitative Indicators**

The following table (06) presents the discriminative power of the test by comparing the performance of the lower and upper groups on key quantitative indicators. The discrimination index (T) and the significance level ($p < 0.01$) indicate the extent to which each indicator effectively distinguishes between high- and low-performing individuals.

All measurement indicators show statistically significant differences between the lower and upper groups ($p < 0.01$), as reflected in the high T-values. This suggests that the test items are highly effective in distinguishing between varying performance levels.

- Correct words read and Total words read both show strong discrimination, implying that reading fluency is a key differentiator in performance levels.
- Time Taken and Speed Index indicate significant variance in pacing and processing, with the upper group demonstrating superior efficiency.
- Accuracy Index and Errors both exhibit clear distinctions, highlighting that more proficient test-takers not only perform tasks faster but with greater precision.

These results confirm that the test possesses robust discriminative validity, effectively differentiating participants based on their reading performance and related cognitive metrics.

Table 6: Discriminant Validity Based on Upper and Lower Group Comparison for Quantitative Indicators.

Significance Level	Discrimination Index (T)	Lower Group (Mean ± SD)	Upper Group (Mean ± SD)	Measurement Indicator
0.01	21.31	134 ± 8	164 ± 6	Correct words read
0.01	17.41	117 ± 12.34	309 ± 80.03	Time Taken (in seconds or units)
0.01	55.53	11.27 ± 3.99	44.72 ± 5.51	Errors
0.01	11.17	170 ± 3	178 ± 0	Read Words
0.01	12.70	75.15 ± 2.60	94.96 ± 2.76	Accuracy Index
0.01	27.26	13.65 ± 5.09	68.54 ± 13.92	Speed Index

Discriminant Validity Based on Upper and Lower Group Comparison for Qualitative Indicators"

The following table (07) presents the discrimination degree between the lower and upper performance groups for the test's qualitative scale indicators. The discrimination index (T) and significance levels ($p < 0.001$) indicate strong statistical evidence that each indicator significantly differentiates between the two groups.

All indicators show very high T-values and statistical significance ($p < 0.001$), indicating that these qualitative measures are extremely effective at distinguishing between lower and upper performing groups.

- Unfamiliar Words: The upper group shows markedly higher performance.
- Phoneme Letter Errors: This indicator shows the largest discrimination index (T = 39.22).
- Verbal Similarity: High discrimination here suggests that upper-group participants are better at recognizing sound-based relationships between words.
- Semantic Interference: The presence of a significant gap between groups highlights the upper group's superior ability to inhibit irrelevant semantic cues.

The qualitative indicators analyzed here demonstrate strong psychometric validity, particularly in assessing deeper linguistic and cognitive processing skills.

Table 7: Discriminant Validity Based on Upper and Lower Group Comparison for Qualitative Indicators.

Significance Level	Discrimination Index (T)	Lower Group (Mean ± SD)	Upper Group (Mean ± SD)	Measurement Indicator
0.000	21.06	0.00 ± 0.00	4.96 ± 1.22	Nonsense Words / Unfamiliar Words
0.000	39.22	5.58 ± 1.77	27.73 ± 4.01	Phoneme Deletion / Sound-Letter Emission
0.000	37.31	2.12 ± 1.87	10.69 ± 1.29	Verbal Similarity / Phonological Similarity
0.000	28.23	0.00 ± 0.00	7.31 ± 1.32	Semantic Interference

- **Reliability tests**

  - **Test-Retest Reliability: Correlation Between Sections for Quantitative Data**

The table (08) below presents the inter-section correlation coefficients for the test's quantitative indicators, obtained through a test-retest reliability analysis. This method assesses the stability and consistency of scores over time. Each indicator is accompanied by its confidence interval (CI), significance level, and degrees of freedom (df = 28).

All indicators exhibit high correlation coefficients (ranging from 0.81 to 0.87), which suggests excellent test-retest reliability. This means the test yields consistent results over time, an essential quality in educational and psychological measurement.

- Significance: The p-values (< 0.001) for all correlations indicate that the relationships between initial and repeated measures are statistically significant and unlikely due to chance.
- Confidence Intervals: The relatively narrow confidence intervals around each coefficient reinforce the precision of these reliability estimates. For example, the "Correctly Read Words" and "Speed Index" both show a strong and reliable range (0.75–0.94).
- Top Indicators: The highest stability was observed for the Correctly Read Words and Speed Index, each with a correlation of 0.87, suggesting these are particularly robust measures of reading performance.

Table 8: Test-Retest Reliability: Correlation Between Sections for Quantitative Data.

Measurement Indicator	Correlation Coefficient	Confidence Interval (90%)	Significance Level	Degrees of Freedom
Total Words Read	0.81	0.63 – 0.90	0.000	28
Number of Errors	0.83	0.68 – 0.92	0.000	28
Correct Words Read	0.87	0.75 – 0.94	0.000	28
Accuracy Index	0.86	0.72 – 0.93	0.000	28
Speed Index	0.87	0.75 – 0.94	0.000	28

✓ **Test-Retest Reliability: Correlation Between Sections for Qualitative Data**

The table (09) presents the inter-section correlation coefficients for the qualitative scale indicators, based on a test-retest reliability procedure. Each result includes a confidence interval (CI), significance level, and degrees of freedom (df = 28).

All indicators demonstrate very high test-retest reliability, with correlation coefficients ranging from 0.81 to 0.97. These values indicate that the qualitative components of the test are highly consistent over time.

- Phoneme Letter Errors stands out with a near-perfect correlation of 0.97, and a very narrow confidence interval (0.95–0.99). This suggests the task is highly stable and reliable in measuring phonological manipulation skills across test administrations.
- Semantic Interference and Verbal Similarity also show excellent reliability ($r = 0.96$ and $r = 0.94$, respectively), reflecting consistent performance in tasks that require executive functioning and deep linguistic processing.
- Unfamiliar Words shows a slightly lower, but still strong, correlation ($r = 0.81$), which may reflect slightly greater variability in decoding unfamiliar items across testing sessions.
- Statistical Significance: All correlations are highly significant ($p < 0.001$), providing strong evidence that the consistency is not due to random chance.

These findings confirm that the qualitative indicators of the test are highly stable over time, reinforcing their value in diagnostic assessments, longitudinal studies, and intervention monitoring. The extremely high correlation coefficients further enhance the test’s credibility as a reliable instrument for evaluating advanced cognitive and linguistic processes.

Table 9: Test-Retest Reliability: Correlation Between Sections for Qualitative Data.

Measurement Indicator	Correlation Coefficient	Confidence Interval (CI)	Significance Level	Degrees of Freedom
Unfamiliar Words	0.81	0.64 – 0.90	0.000	28
Phoneme Letter Errors	0.97	0.95 – 0.99	0.000	28
Verbal Similarity	0.94	0.88 – 0.97	0.000	28
Semantic Interference	0.96	0.91 – 0.98	0.000	28

2.5. Procedure

The study followed a structured, multi-phase procedure. After obtaining the necessary approvals from school, the research was conducted in two main stages.

In the pilot phase, the Visual-Spatial Sketchpad (VSS) Assessment Scale, developed specifically for this study, was administered to a sample of 31 students from fourth and fifth grades in public schools. This pilot aimed to assess the psychometric properties of the tool and to ensure its reliability and validity within the Algerian educational context. Alongside evaluating the scale, a list of students already diagnosed with dyslexia and meeting the study's inclusion criteria was compiled in collaboration with school administrators. Minor refinements were made to the assessment items based on the pilot findings to enhance clarity and cultural appropriateness.

Following the pilot, the main phase of data collection was conducted. Students from the pre-identified dyslexic group were selected to participate in the primary application of the VSS Assessment Scale. Each student was assessed individually in a quiet room within the school setting to minimize distractions and maintain standardized testing conditions.

The data collection process extended over approximately five weeks, from April 6 to May 8, 2025, and included the administration of assessment tools, classroom observations, and systematic documentation of student performance.

2.6.Data Collection

Data were collected in-person within public school environments, in spaces arranged to provide quiet and comfortable testing conditions. The researcher administered all tools individually to ensure accuracy, consistency, and appropriate pacing.

During the pilot study, data were collected from 31 fourth- and fifth-grade students to evaluate the VSS tool's psychometric properties, including internal consistency and construct validity. As part of the same phase, a list of dyslexic students. previously diagnosed and aligned with the study's criteria, was established through collaboration with school staff.

In the main study, quantitative data were collected from this group of diagnosed dyslexic students, who completed both the VSS Assessment Scale and the Dyslexia Scale. The researcher also recorded performance behaviors and observations during testing.

All data were carefully documented, securely stored, and analyzed using SPSS software, with confidentiality and ethical research standards upheld throughout the study.

Results

3. Results

3.1. Demographic Characteristics of the Study Sample

- The total number of diagnosed dyslexia cases across all schools in the sample is 30. The sample includes 18 males and 12 females, indicating a higher representation of males (60%) among diagnosed cases. Certain schools, such as Abi Ishaq, Noah Aisha, and Sheikh Saleh Dawoudi, reported higher concentrations of cases (3 each), four schools (e.g., Abi Mahdi Issa) reported no diagnosed cases, which may reflect either a true absence of cases or under-identification due to limited resources.

Table 10: Demographic Characteristics of the Study Sample.

Primary School	Diagnosed Dyslexia Cases	Male	Female
Abi Mahdi Issa	0	0	0
Sheikh Ahmed Farsous	2	0	2
Sheikh Baabd Al-Rahman Al-Kurthi	2	1	1
Noah Aisha	3	0	3
Sheikh Abi Yaqub	2	2	0
Abi Ishaq	3	3	0
Abdullah Bouras	1	1	0
Hassiba Ben Bouali	3	2	1
Qabbani Mohamed	1	1	0
Abi Ammar Abdul Kafi	2	1	1
Mamane Suleiman	3	1	2
Sheikh Hamo Fakhar	1	1	0
Aisha Umm al-Mu'minin	2	0	2
Sheikh Hamo Issa Al-Nouri	2	2	0
Sheikh Saleh Dawoudi	3	2	1
Total	30	18	12

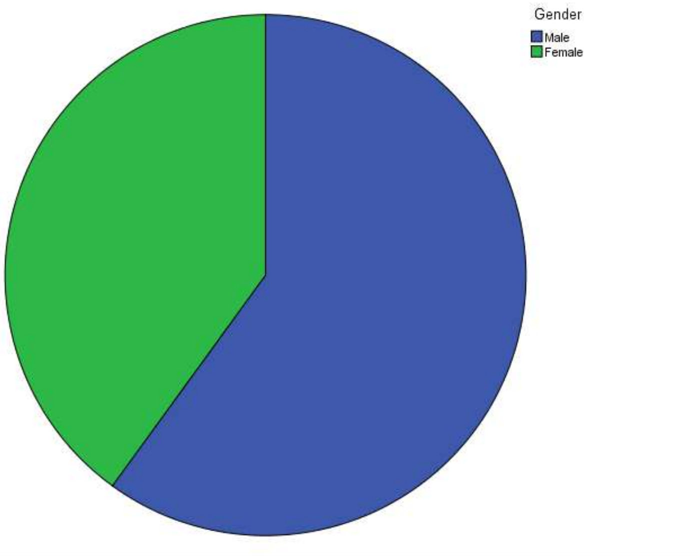

Figure 1: Percentage Distribution of the Study Sample by Demographic Characteristics.

The demographic data provides a foundational understanding of the distribution of dyslexia cases across the participating schools.

3.2. Descriptive Statistics of Test Scores for the Study Sample

3.2.1. Descriptive Statistics for VSS Test Scores in the Study Sample

Descriptive statistics were calculated for the Visuospatial Sketchpad (VSS) test and its components (Table). The sample consisted of 30 participants. The total VSS scores ranged from 68 to 112, with a mean of 87.13 (SD = 11.72), indicating moderate to high visuospatial sketchpad levels across the sample.

Among individual components, the Color and Texture Representation subtest had the highest mean (M = 5.57, SD = 0.73), suggesting strong performance in recognizing visual details. The lowest mean was observed in Mental Rotation (M = 3.17, SD = 1.26), indicating that participants found this subcomponent more challenging.

The Visual Cache and Inner Scribe scores, which represent broader working memory systems, also showed wide variability (SD = 9.67 and 5.38, respectively). This variation suggests individual differences in how students mentally store and manipulate spatial information. Overall, these statistics provide a foundation for interpreting the relationships between VSS and reading performance variables in the subsequent analysis.

Table 11: Descriptive Statistics for VSS Test Scores in the Study Sample.

Component	N	Min	Max	Mean	SD
Visual Detail Storage	30	2.0	6.0	4.17	1.51
Visual Pattern Recognition	30	2.0	6.0	4.83	1.34
Static Spatial Layout	30	2.0	6.0	5.00	1.11
Color Texture Representation	30	4.0	6.0	5.57	0.73
Visual Cache	30	28	71	49.07	9.67
Spatial Sequence Processing	30	2.0	6.0	4.23	1.04
Mental Rotation	30	2.0	6.0	3.17	1.26
Movement Planning	30	3.0	6.0	4.93	1.08
Rehearsal Refreshing	30	2.0	6.0	4.53	1.07
Dynamic Spatial Attention	30	2.0	6.0	4.33	1.03
Inner Scribe	30	27	47	38.07	5.38
Total VSS Score	30	68	112	87.13	11.72

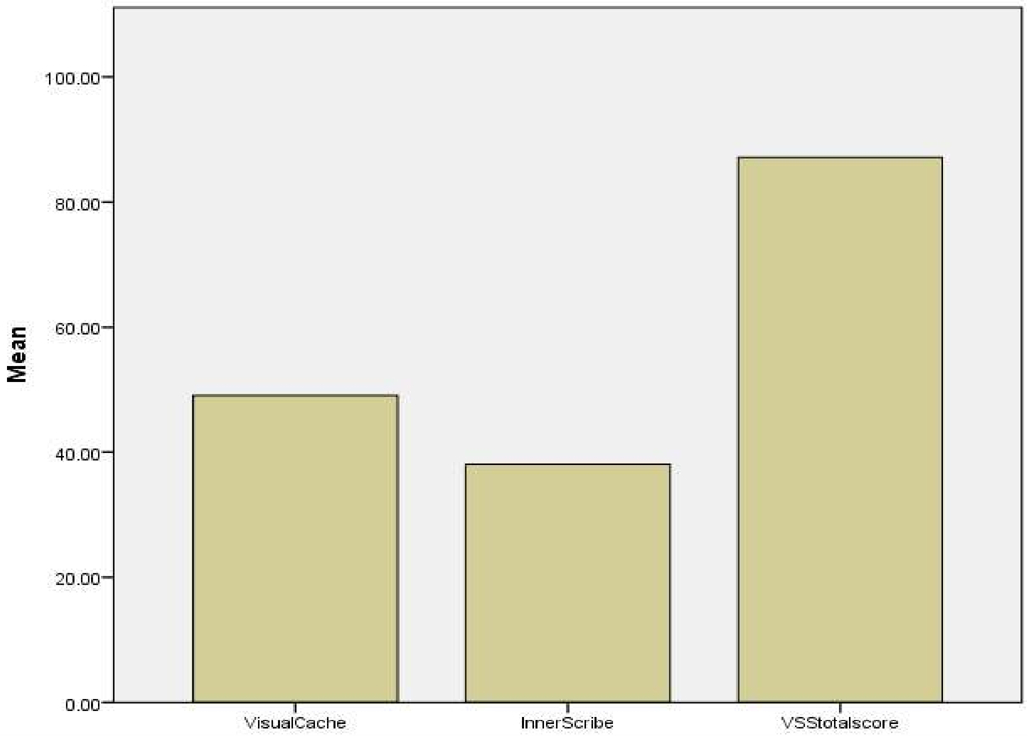

Figure 2: Bar Chart of VSS Performance: Total Score and Its Dimensions in the Study Sample.

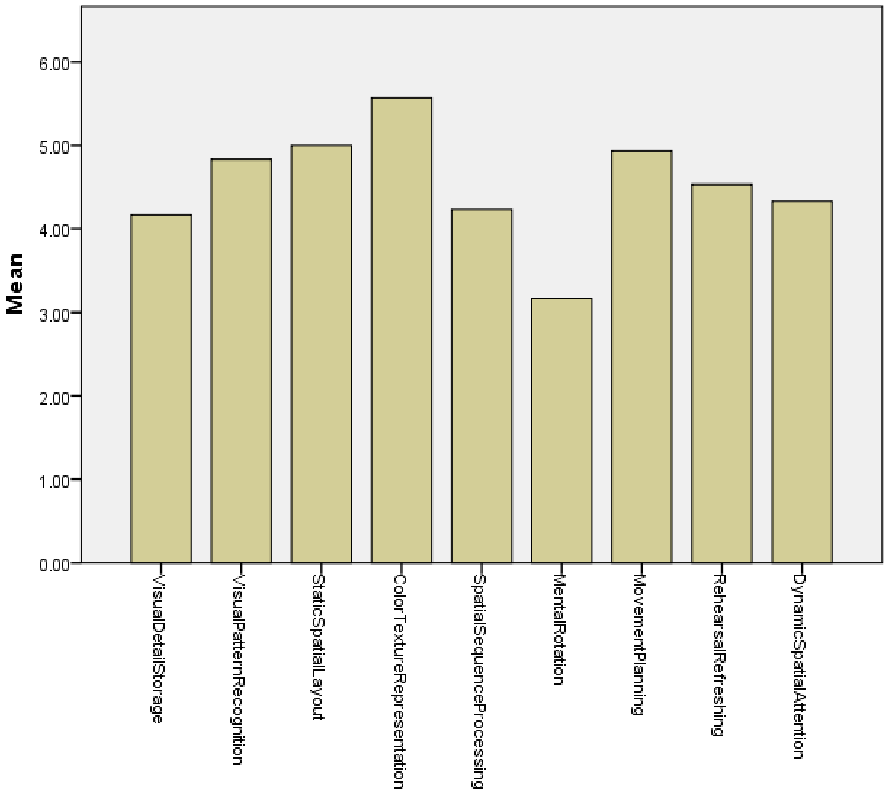

Figure 3: Bar Chart of VSS Performance: Components in the Study Sample.

3.2.2. Descriptive Statistics of Dyslexia Test Quantitative Scores in the Study Sample:

Descriptive statistics were also computed for the participants' scores on the dyslexia test. The average number of total words read was 65.67 (SD = 44.39), with a wide range from 4 to 143 words, indicating substantial variability in reading fluency across the sample.

Participants made an average of 21.47 errors (SD = 14.24), while the number of correct words read had a mean of 44.20 (SD = 35.57). The accuracy index, representing the percentage of correct words out of total words read, had a mean of 58.05% (SD = 20.06), with values ranging from 21.4% to 89.5%.

The speed index, calculated based on correct words per minute, mirrored the correct words read (M = 44.20, SD = 35.57), which suggests that speed and accuracy were closely aligned for this task. These results reflect a broad distribution in reading skill levels within the sample, providing a useful basis for examining correlations with visual-spatial abilities.

Table 12: Descriptive Statistics of Dyslexia Test Scores in the Study Sample.

Reading Performance Variable	N	Min	Max	Mean	SD
Total Words Read	30	4.0	143	65.67	44.39
Number of Errors	30	3.0	57	21.47	14.24
Correct Words Read	30	1.0	128	44.20	35.57
Accuracy Index (%)	30	21.4	89.5	58.05	20.06
Speed Index	30	1.0	128	44.20	35.57

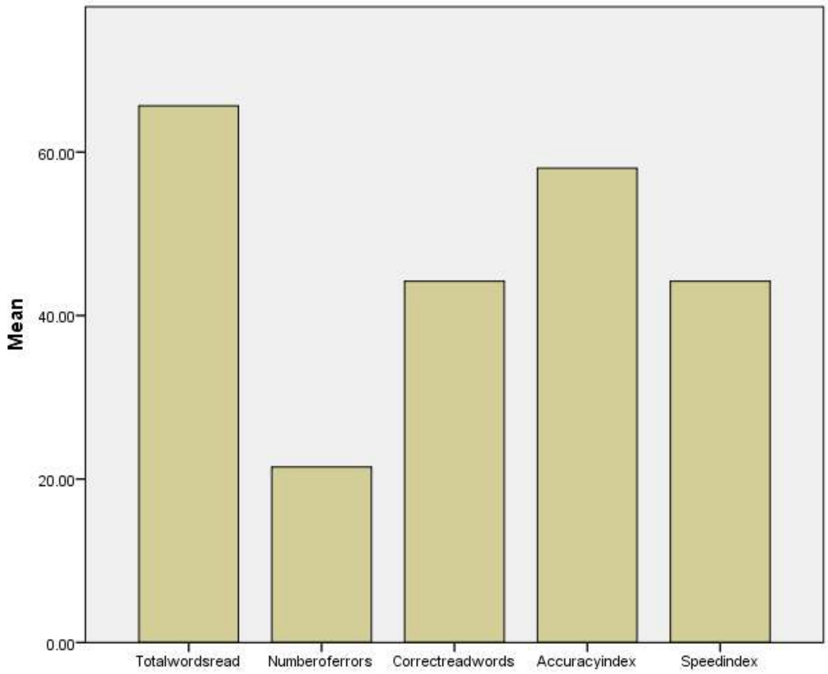

Figure 4: Bar Chart of Dyslexia Test Scores in the Study Sample.

3.2.3. Descriptive Statistics of Dyslexia Test Qualitative Scores in the Study Sample:

In the qualitative section of the dyslexia test, common error types were recorded to better understand the reading challenges experienced by the students. All 30 participants (100%) exhibited difficulties in decoding unfamiliar words, such as the inability to recognize or pronounce new words, reversal of letter order within words, and substitution of unfamiliar words with familiar but incorrect alternatives.

Additionally, all students demonstrated phoneme-letter level errors, including additions, omissions, or transpositions of phonemes; replacement of letters with visually similar ones (e.g., confusion between ب and ت); skipping words or entire lines; re-reading the same word or phrase; and producing fragmented or interrupted reading.

Harakat-related difficulties were also widespread. Students often ignored harakat entirely, applied incorrect vowel sounds, or struggled to integrate vowel markings into smooth, fluent reading, all of which hindered phonological accuracy in Arabic script.

Furthermore, 20 students (66.7%) made verbal similarity errors, such as substituting visually similar words, misreading due to visual-perceptual confusion, or struggling to retrieve familiar words, even when they were high-frequency or had been practiced before.

Interestingly, no semantic interference errors were recorded, suggesting that while surface-level decoding and phonological processing were impaired, deeper levels of semantic understanding remained relatively intact.

In addition to these error types, all 30 students exceeded the normative reading time of 3 minutes and 19 seconds, reflecting reduced reading fluency and slower cognitive processing. Moreover, every student employed compensatory strategies to support their reading. These included finger-tracking to maintain focus, leaning closely toward the text to enhance visual attention, guessing words from context instead of decoding, hesitating before difficult words, slowly sounding out or blending individual letters, and over-emphasizing specific letters or syllables.

These behaviors reflect conscious attempts to cope with decoding difficulties and demonstrate the students' efforts to scaffold their reading through visual or verbal support techniques. Overall, the findings highlight how dyslexia manifests not only through quantifiable deficits but also through observable, adaptive strategies in the learning environment.

Table 13: Frequency and Percentage of Error Types in the Dyslexia Test (Qualitative Section).

Behavior / Error Type	Number of Students	Percentage (%)
Unfamiliar Word Errors	30	100%
Phoneme/Letter Errors	30	100%
Verbal Similarity Errors	20	66.7%
Semantic Interference Errors	0	0%
Exceeded Normative Reading Time (>3:19)	30	100%
Use of Compensatory Strategies	30	100%

3.3. Normality Test Results:

Tests of normality were conducted using both the Kolmogorov–Smirnov and Shapiro–Wilk methods to assess whether the distributions of the study variables met the assumptions of normality (Table). The Shapiro–Wilk test, which is more appropriate for small samples ($n < 50$), was used as the primary reference for interpretation.

Results indicated that the total VSS score (Shapiro–Wilk $p = .245$) and accuracy index ($p = .152$) were normally distributed, as their p-values exceeded the .05 threshold.

However, total words read ($p = .025$), number of errors ($p = .009$), correct words read ($p = .019$), and reading speed ($p = .019$) all showed significant deviations from normality ($p < .05$), indicating non-normal distributions for these variables.

Based on these results, Spearman's rank-order correlation was selected for further analysis, as it does not assume normal distribution and is suitable for non-parametric data.

Table 14: Shapiro-Wilk Test of Normality for VSS and Dyslexia Scores.

Variable	Shapiro–Wilk Statistic	df	Sig. (p)
Total Words Read	.919	30	.025
Number of Errors	.902	30	.009
Correct Words	.914	30	.019
Accuracy Index	.948	30	.152
Speed Index	.915	30	.019
Total VSS Score	.956	30	.245

$p > .05$ = Normal distribution

$p < .05$ = Not normal distribution

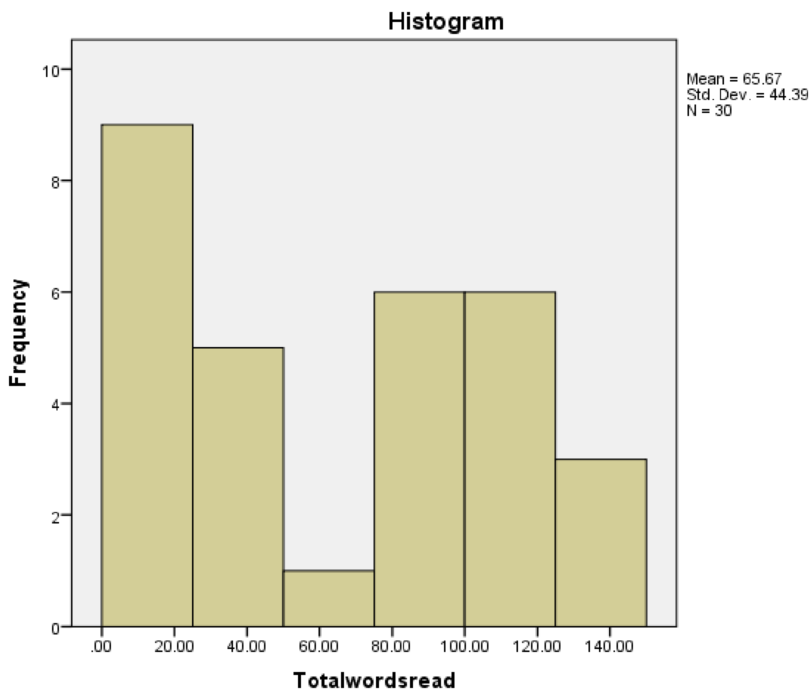

Figure 5: Histogram of Total Words Read for Normality Testing.

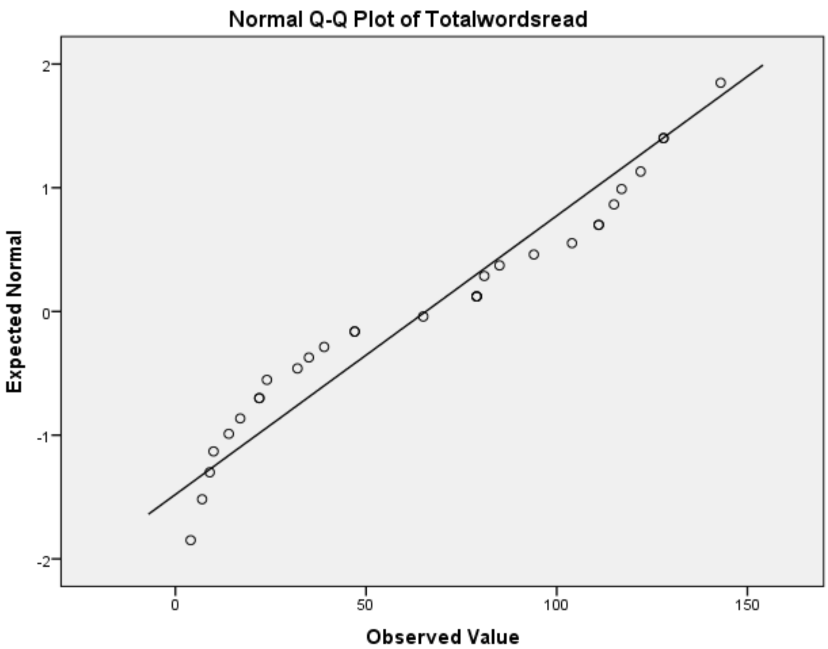

Figure 6: Q-Q Plot Assessing Normality of Total Words Read Scores.

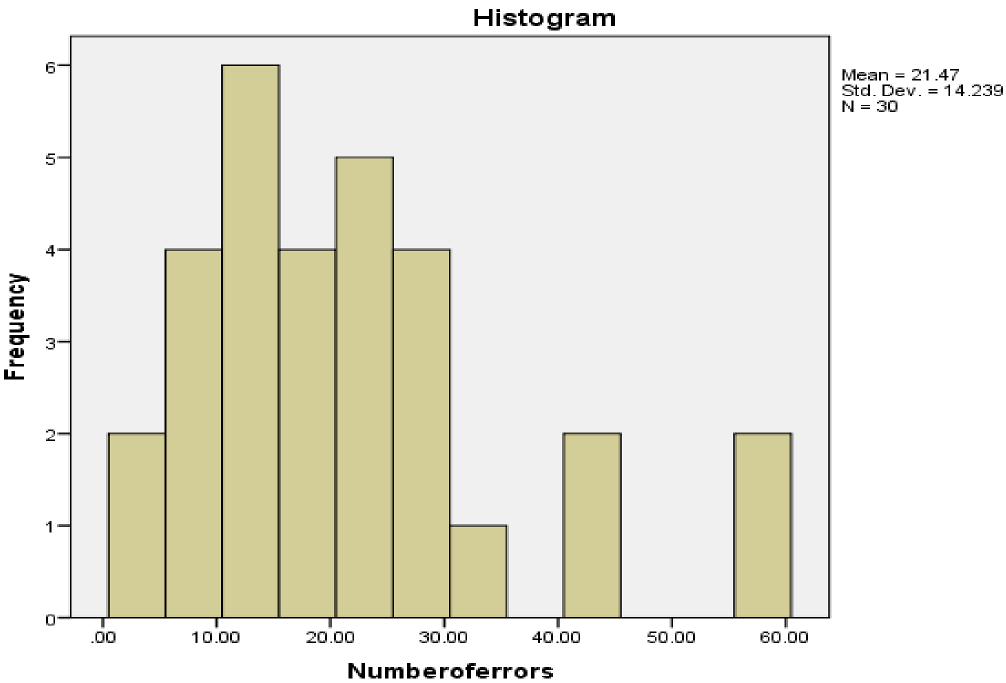

Figure 7: Histogram of Number of errors for Normality Testing.

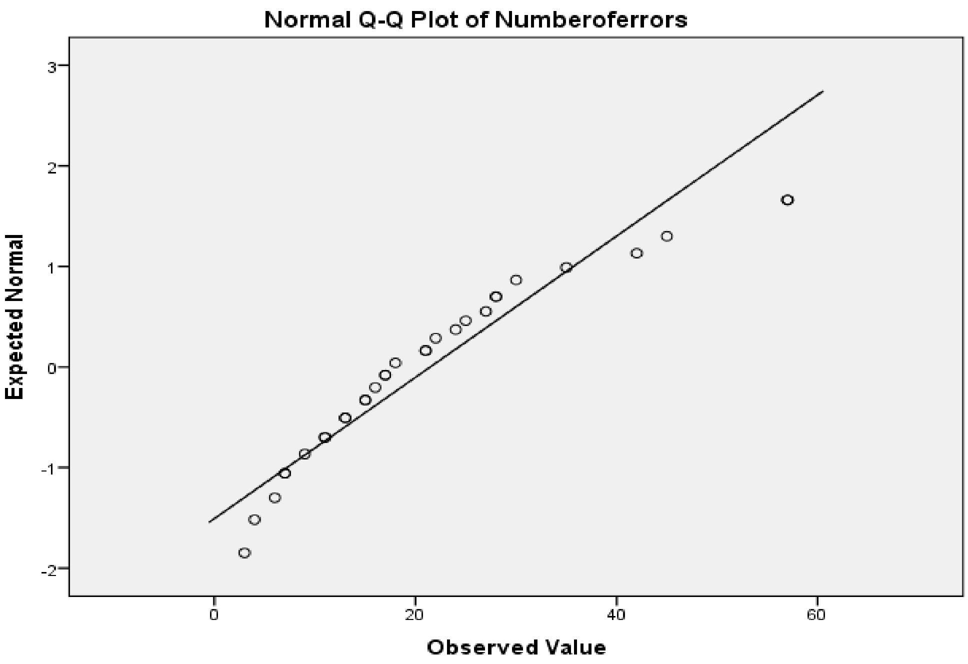

Figure 8: Q-Q Plot Assessing Normality of Number of errors Scores.

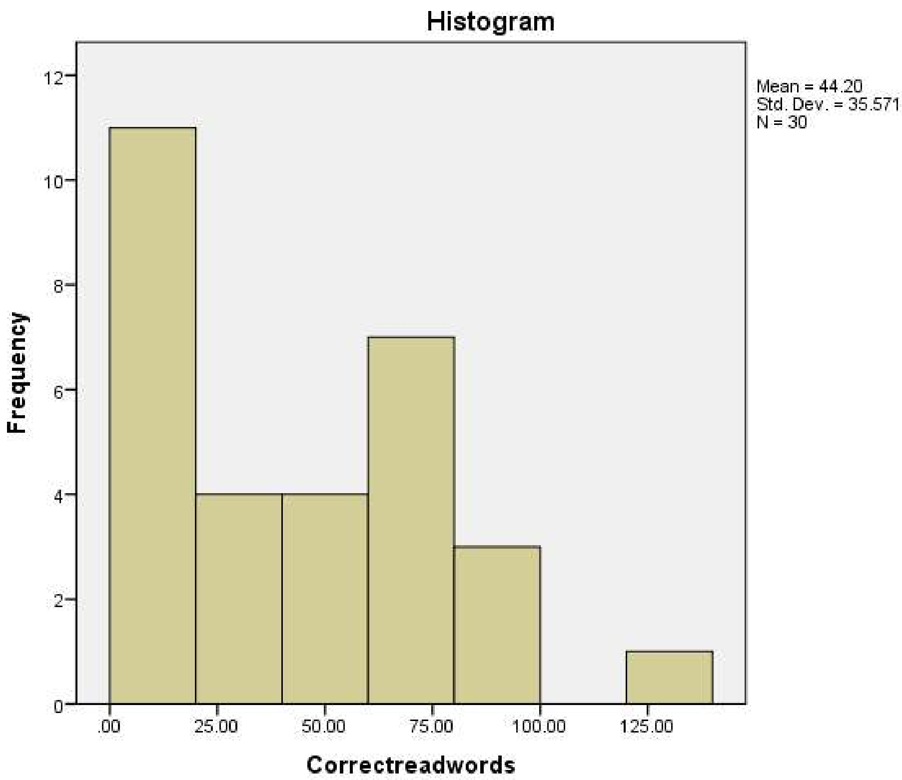

Figure 9: Histogram of Correct Words Read for Normality Testing.

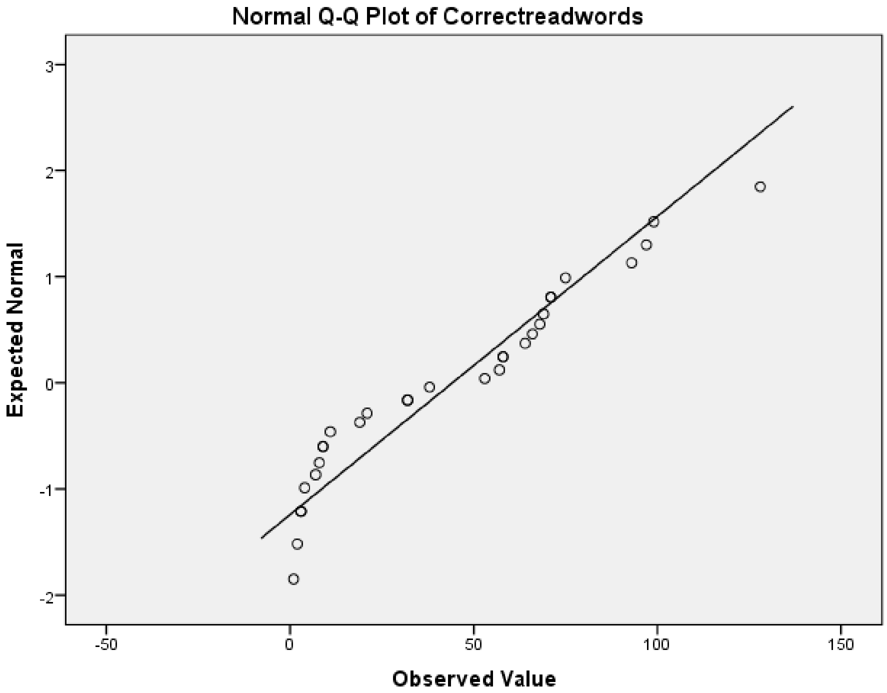

Figure 10: Q-Q Plot Assessing Normality of Correct words read Scores.

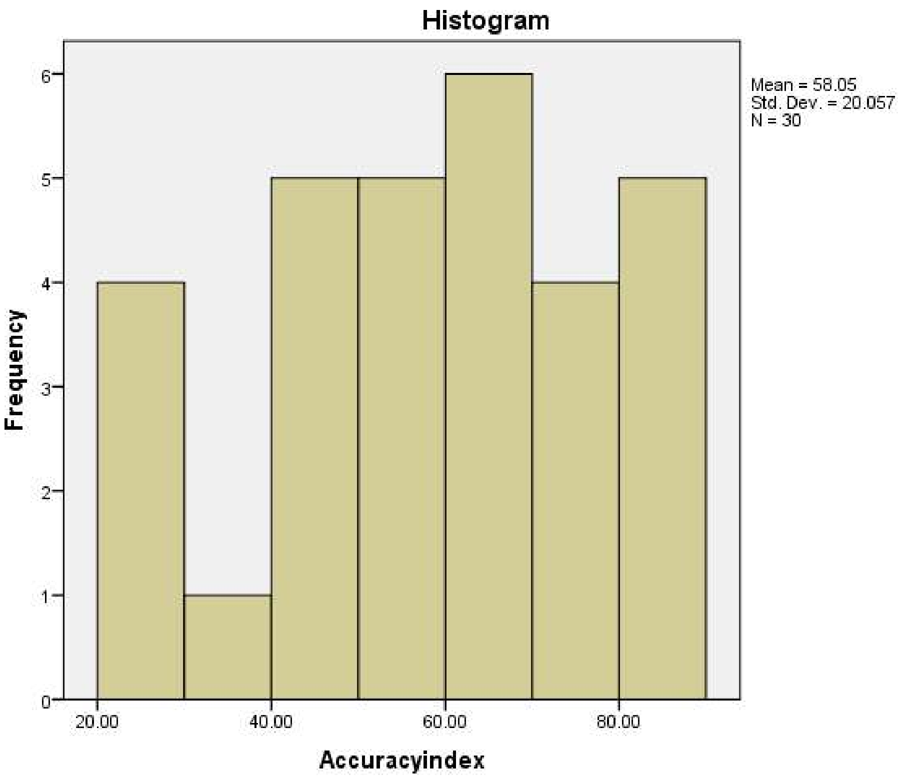

Figure 11: Histogram of Accuracy index for Normality Testing.

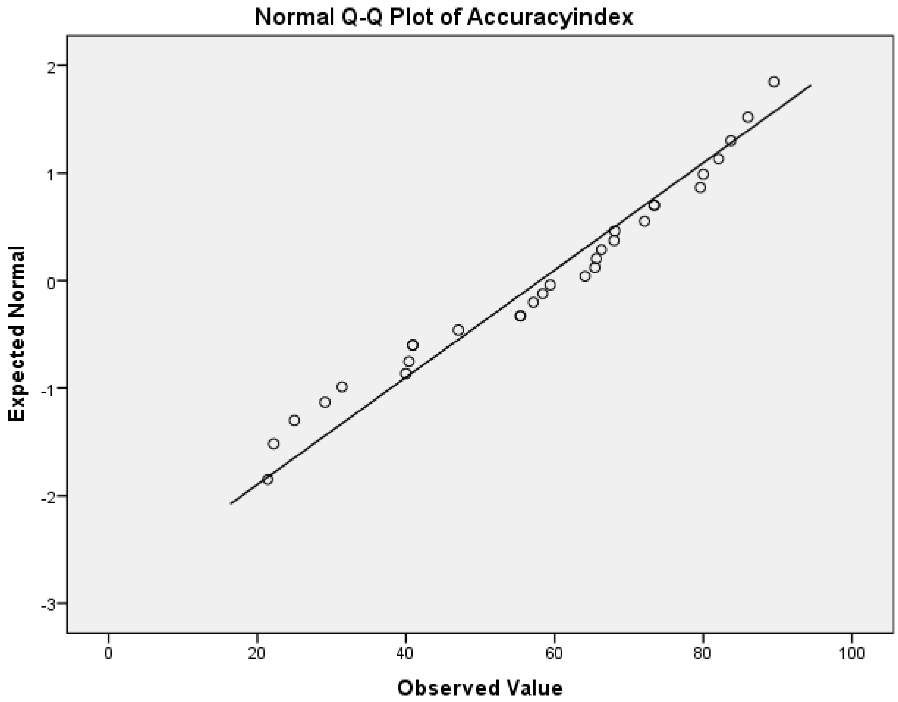

Figure 12: Q-Q Plot Assessing Normality of Accuracy Index Scores.

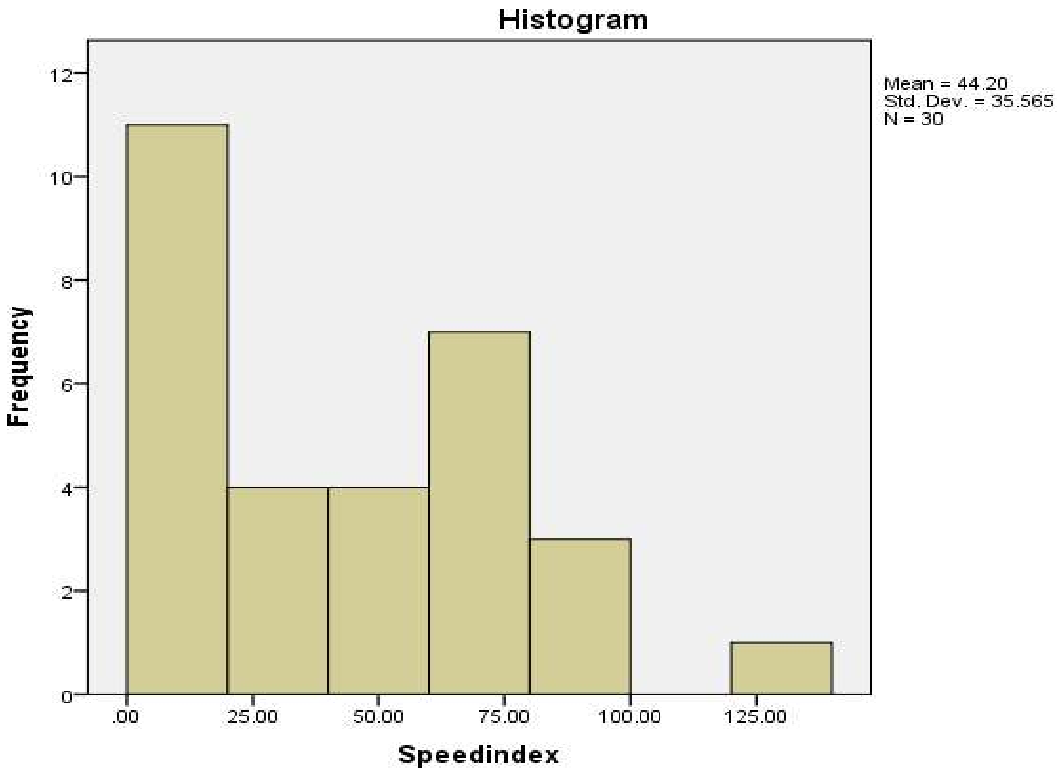

Figure 13: Histogram of Speed index for Normality Testing.

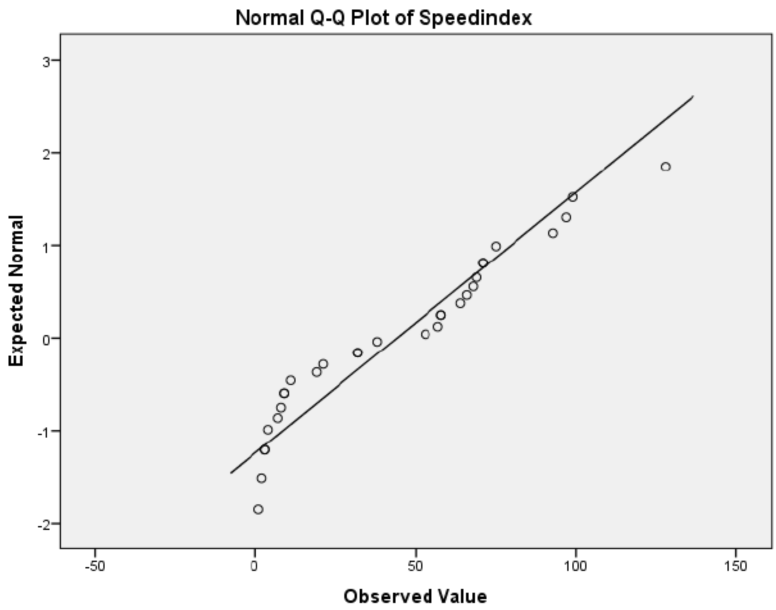

Figure 14: Q-Q Plot Assessing Normality of Speed Index Scores.

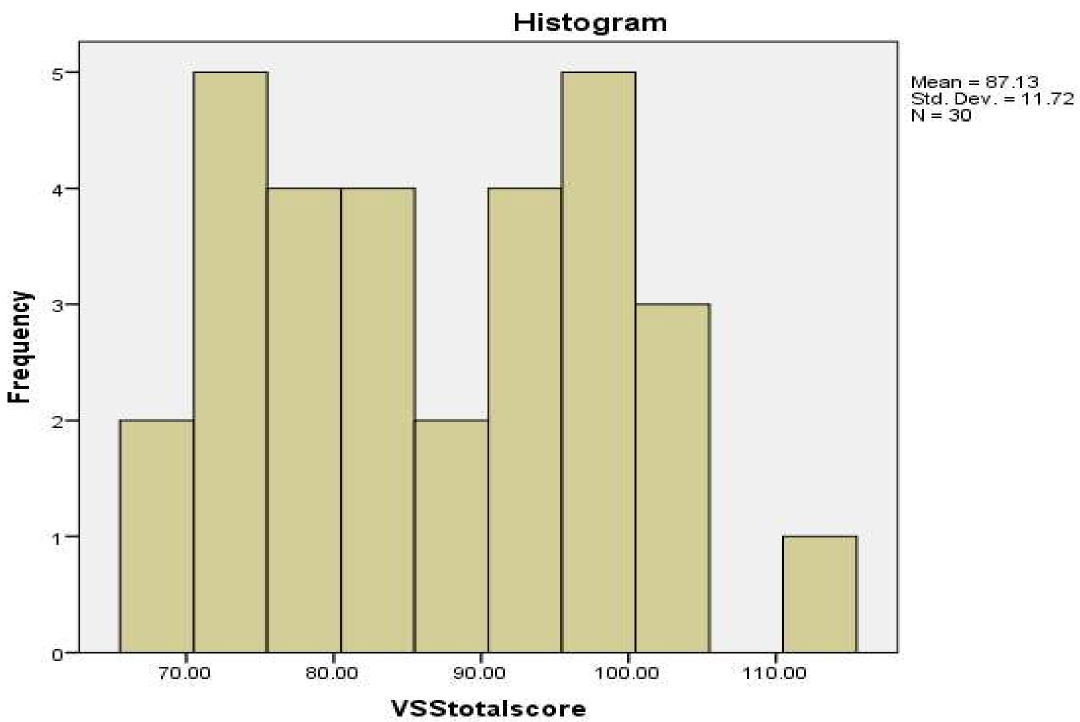

Figure 15: Histogram of Vss total score for Normality Testing.

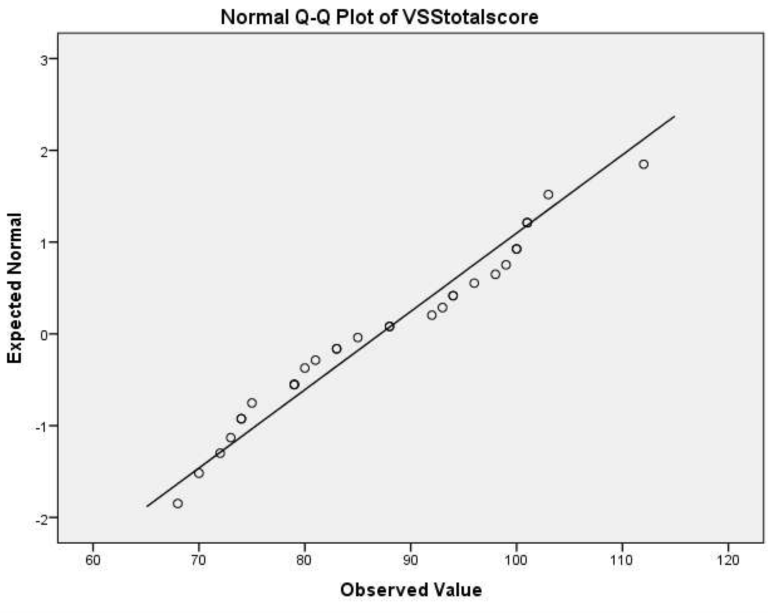

Figure 16: Q-Q Plot Assessing Normality of VSS total Score.

3.4. Correlation Between VSS Total Score and Dyslexia test score

Spearman's rank-order correlation was conducted to examine the relationships between the total visual-spatial sketchpad (VSS) score and various Dyslexia indicators. The results indicated that none of the correlations were statistically significant ($p > .05$).

Specifically, the correlation between VSS total score and number of errors was weak and positive ($\rho = .271$, $p = .147$), suggesting a non-significant trend where students with higher VSS scores made slightly more errors, although this relationship did not reach statistical significance. The correlations with total words read ($\rho = .167$, $p = .379$), number of correct words ($\rho = .127$, $p = .504$), accuracy ($\rho = .076$, $p = .689$), and speed ($\rho = .127$, $p = .504$) were all weak and non-significant, indicating no meaningful association between overall VSS ability and dyslexia test outcomes in this sample.

Table 15: Correlation Between VSS Total score and Dyslexia score.

Variable	ρ (Spearman's rho)	Sig. (p-value)
Total Words Read	.167	.379
Number of Errors	.271	.147
Correct Words Read	.127	.504
Accuracy (%)	.076	.689
Speed	.127	.504

3.5. Correlational Analysis Between VSS Components and Dyslexia Test Results

Spearman's rank-order correlations were calculated to examine the relationships between individual visuospatial sketchpad components and reading performance. The results showed several statistically significant positive correlations, suggesting that specific VSS abilities are meaningfully associated with dyslexia outcomes.

➢ Significant Findings:

- Visual Pattern Recognition was significantly positively correlated with total words read ($\rho = .382$, $p = .037$), correct words read ($\rho = .382$, $p = .037$), and reading speed ($\rho = .382$, $p = .037$).
- Static Spatial Layout showed the strongest and most consistent correlations, being significantly associated with:
    - Total words read ($\rho = .489$, $p = .006$)
    - Correct words read ($\rho = .523$, $p = .003$)
    - Reading speed ($\rho = .523$, $p = .003$)
    - Accuracy ($\rho = .438$, $p = .015$)

- Spatial Sequence Processing was negatively correlated with accuracy ($\rho = –.407$, $p = .026$).

- Movement Planning was positively correlated with:
    - Total words read ($\rho = .384$, $p = .036$)
    - Number of errors ($\rho = .416$, $p = .022$)

- Dynamic Spatial Attention showed significant positive correlations with:
  - Total words read (ρ = .387, p = .034)
  - Correct words read (ρ = .371, p = .043)
  - Reading speed (ρ = .395, p = .031)

➢ Non-Significant Findings:

- Visual Cache, Visual Detail Storage, and Color and Texture Representation were not significantly correlated with any reading performance variables (all p > .05), though some weak-to-moderate trends were observed. For example, Color and Texture Representation had moderate but non-significant correlations with total words read (ρ = .324, p = .080), which may become meaningful in a larger sample.

- Inner Scribe, Rehearsal Refreshing, and Mental Rotation were not significantly correlated with any reading measures (p > .05). Though Rehearsal Refreshing approached significance with speed (ρ = –.357, p = .053).

Table 16: Correlational Analysis Between VSS Components and Dyslexia Test Results.

VSS Component	Total Words	Errors	Correct Words	Accuracy	Speed
Visual Cache	.114	.215	.085	.073	.085
Visual Detail Storage	.250	.217	.217	.097	.217
Visual Pattern Recognition	.382*	.265	.382*	.304	.382*
Static Spatial Layout	.489**	.310	.523**	.438*	.523**
Color & Texture Representation	.324	.303	.304	.268	.304
Inner Scribe	–.021	.123	–.085	–.159	–.089
Spatial Sequence Proc.	–.266	–.186	–.301	–.407*	.015
Mental Rotation	.200	.224	.162	.104	–.018
Movement Planning	.384*	.416*	.348	.288	.275
Rehearsal Refreshing	–.288	–.168	–.294	–.179	–.357†
Dynamic Spatial Attention	.387*	.331	.371*	.221	.395*

*p < .05, **p < .01

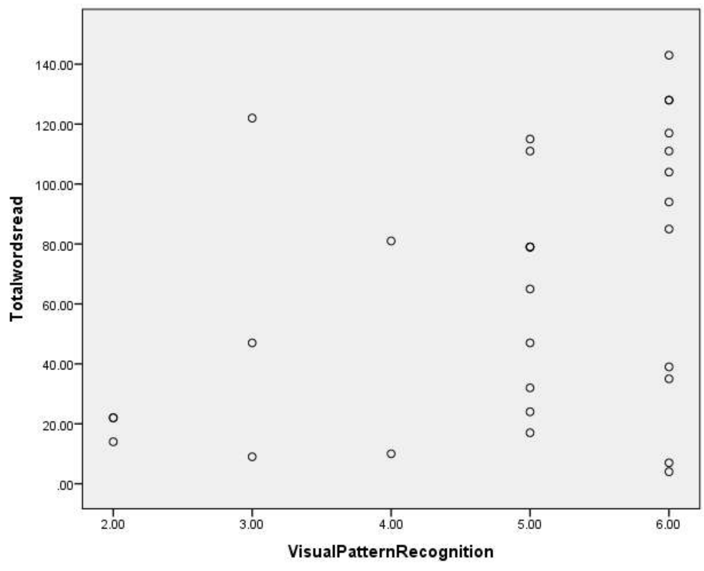

Figure 17: Scatter Plot of Visual Pattern Recognition and Total Words Read.

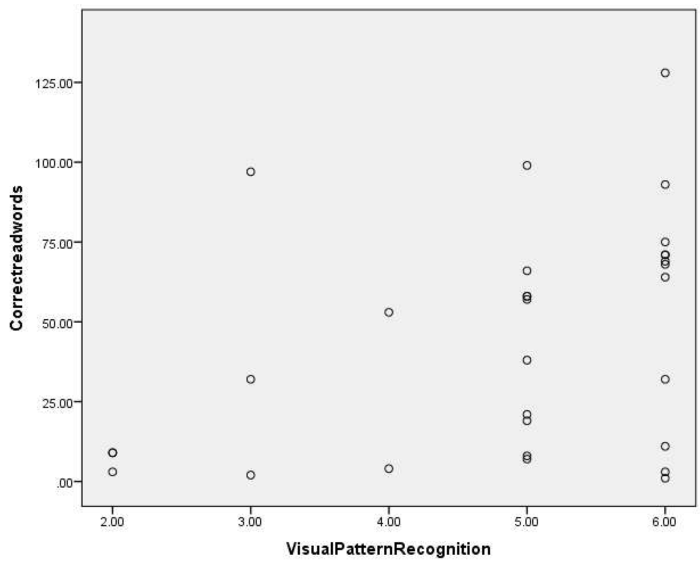

Figure 18: Scatter Plot of Visual Pattern Recognition and Correct Words Read.

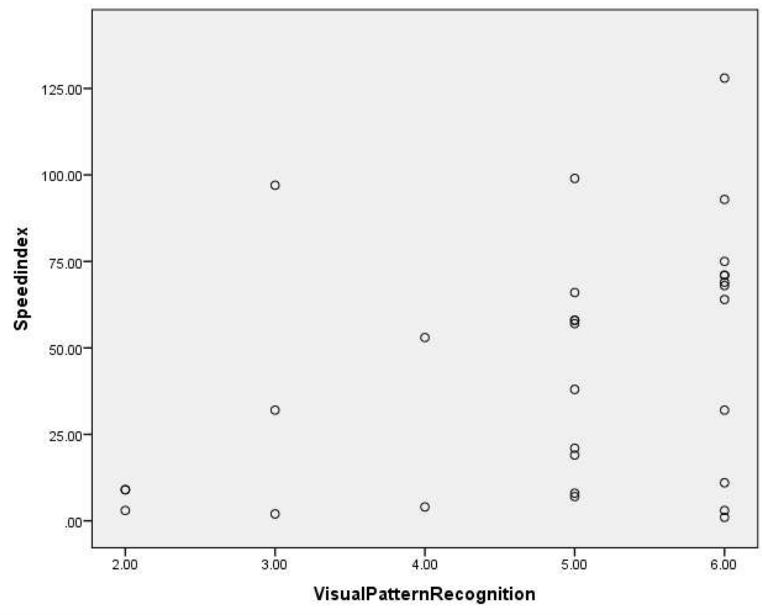

Figure 19: Scatter Plot of Visual Pattern Recognition and Speed Index.

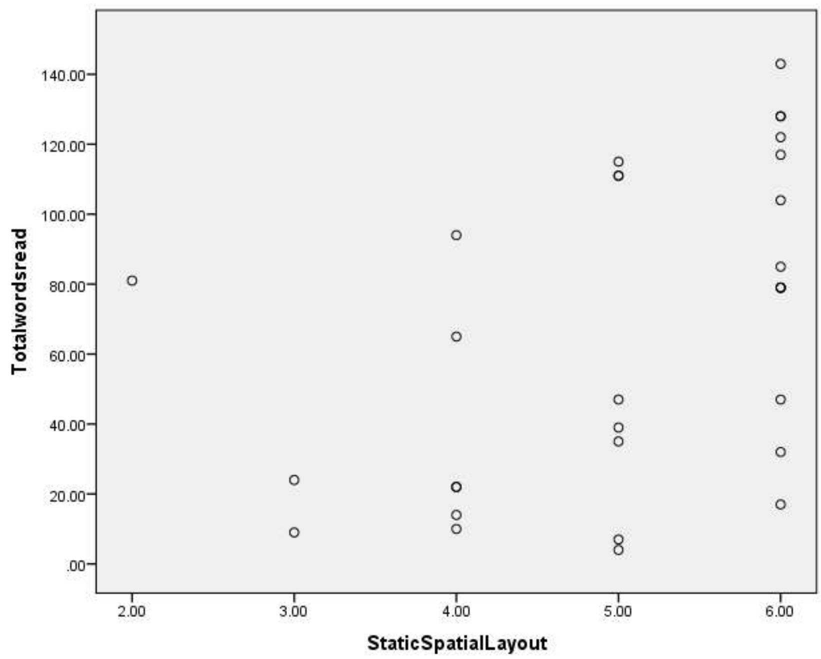

Figure 20: Scatter Plot of Static Spatial Layout and Total Words Read.

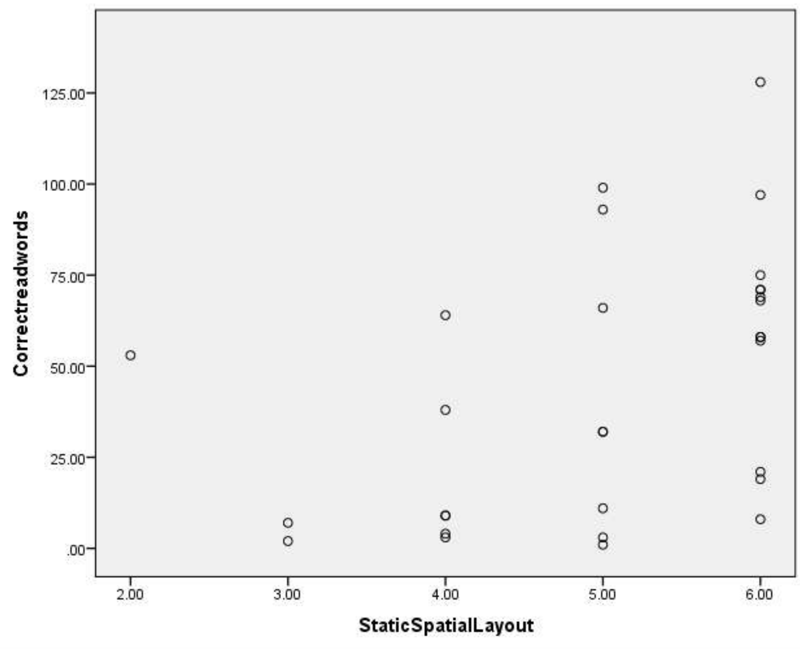

Figure 21: Scatter Plot of Static Spatial Layout and Correct Words Read.

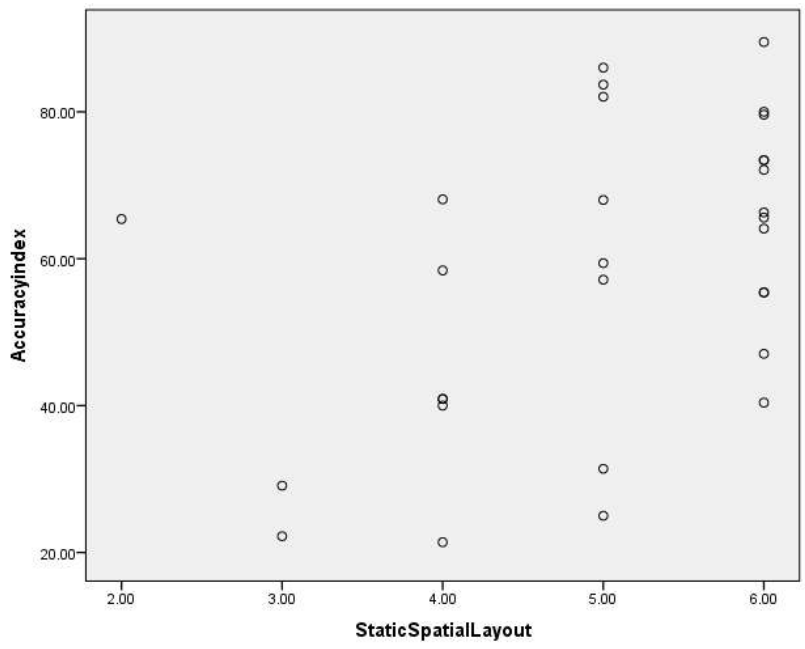

Figure 22: Scatter Plot of Static Spatial Layout and Accuracy Index.

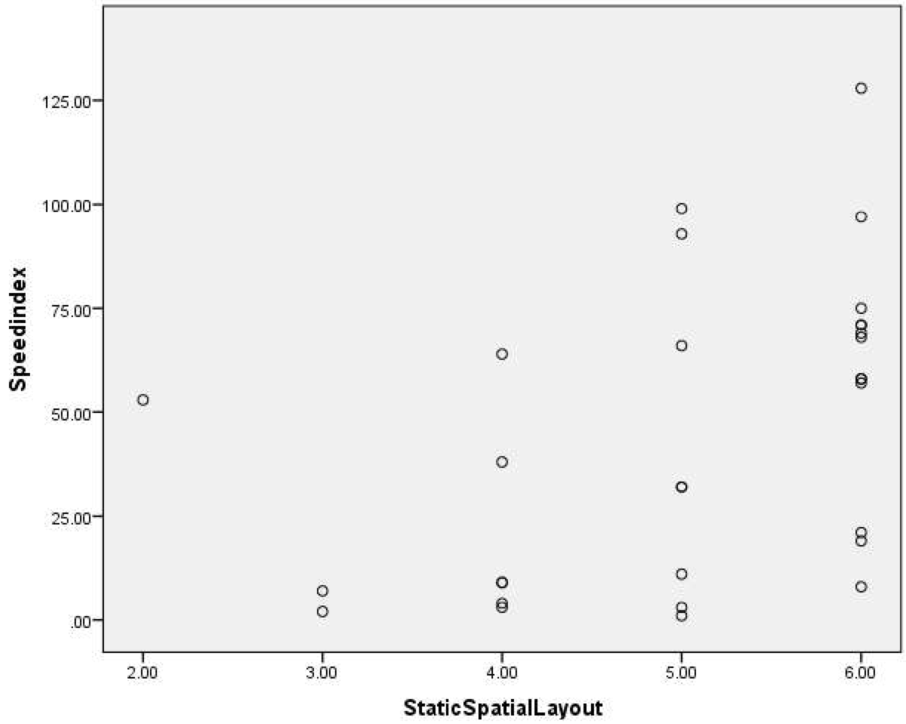

Figure 23: Scatter Plot of Static Spatial Layout and Speed Index.

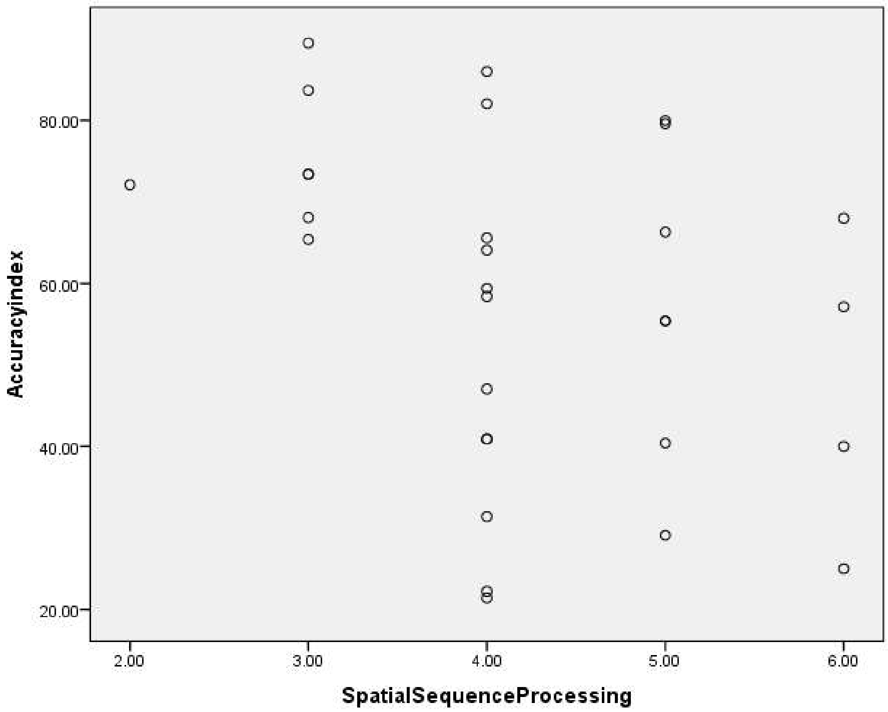

Figure 24: Scatter Plot of Spatial Sequence Processing and Accuracy Index.

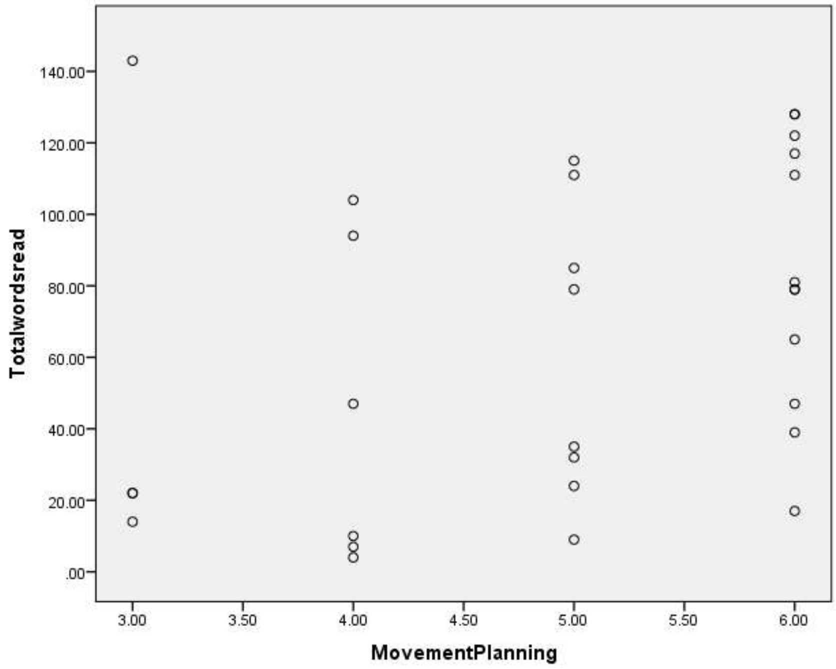

Figure 25: Scatter Plot of Movement Planning and Total Words Read.

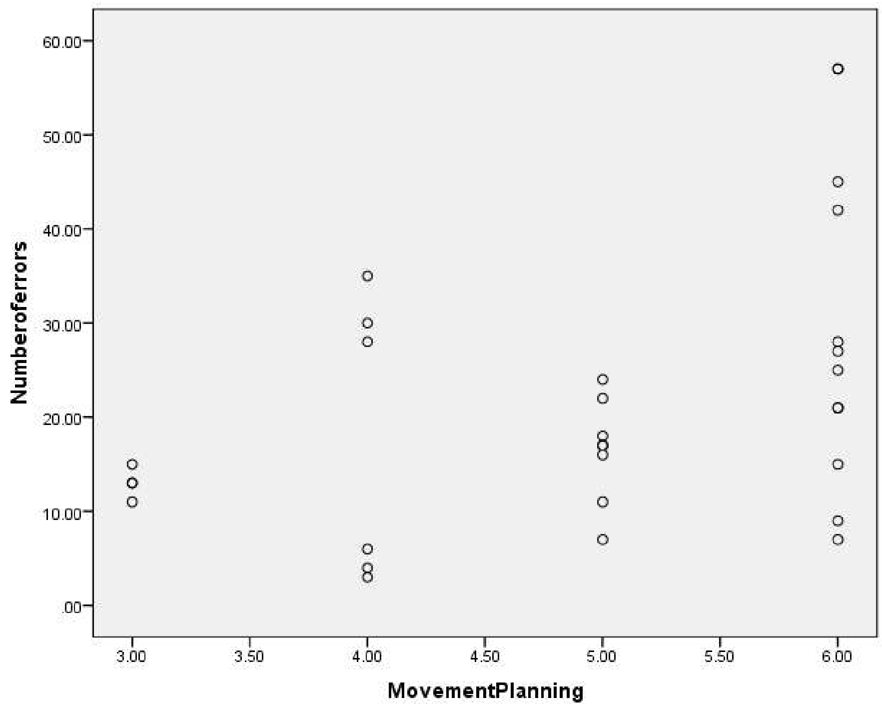

Figure 26: Scatter Plot of Movement Planning and Number of Errors.

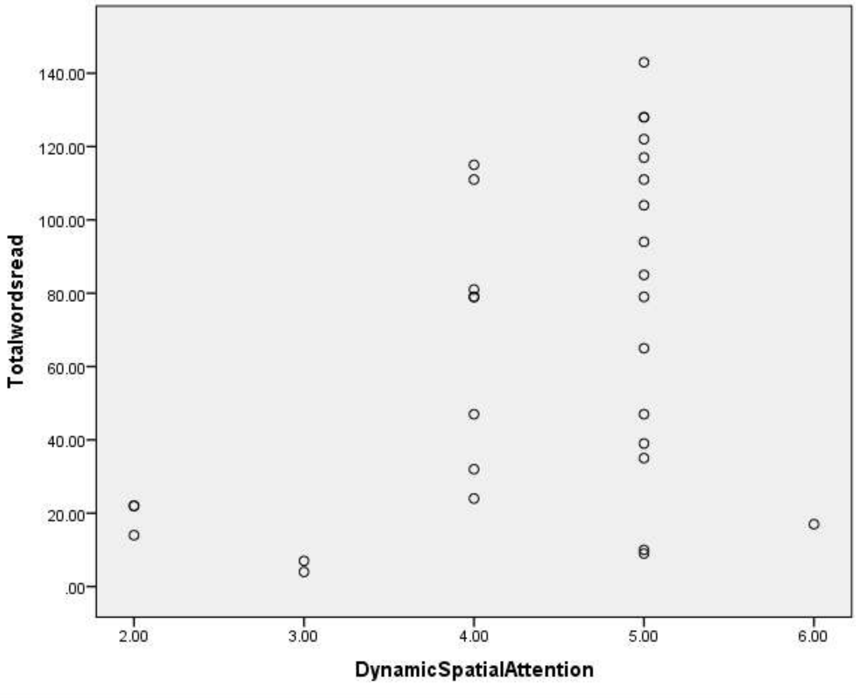

Figure 27: Scatter Plot of Dynamic Spatial Attention and Total Words Read.

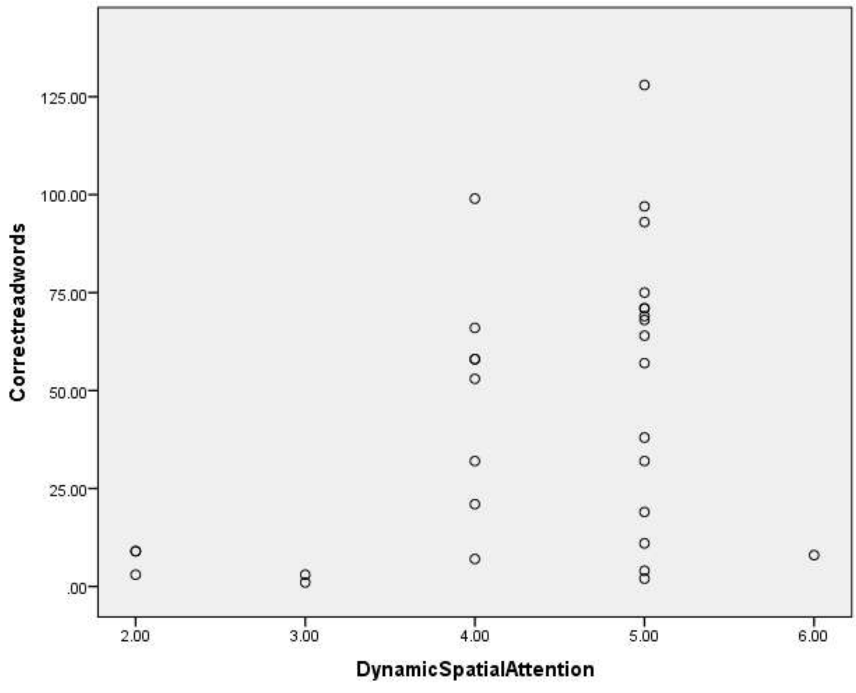

Figure 28: Scatter Plot of Dynamic Spatial Attention and Correct Words Read.

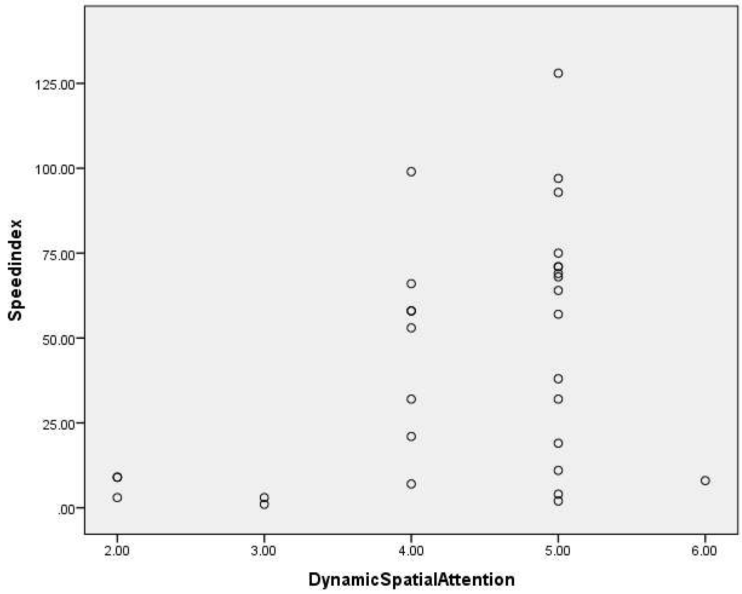

Figure 29: Scatter Plot of Dynamic Spatial Attention and Speed Index.

3.6. Summary of Key Findings

This research aimed to answer the following question:
"Is there a relationship between visuospatial sketchpad and dyslexia in 4th-grade students?"
To guide this inquiry, the study was framed by the following objectives:

1. To assess the level of visuospatial sketchpad among 4th-grade students. This was addressed through tasks evaluating visuospatial sketchpad.
2. To assess dyslexia indicators among 4 th-grade. This objective was achieved through measures of total words read, correct words read, number of errors, accuracy index, speed index.
3. To examine the relationship between visuospatial sketchpad and dyslexia. This was investigated through statistical analyses of correlations between visuospatial and dyslexia indicators.

The results indicated that the total Visuospatial Sketchpad (VSS) score was not significantly correlated with the overall dyslexia test score. Consequently, the primary hypothesis proposing a significant relationship between overall visuospatial sketchpad and dyslexia in 4th-grade students is not supported. Based on these findings, the alternative hypothesis stating that no significant relationship exists between the total VSS score and dyslexia is accepted for this sample.

However, several specific components of the VSS, including Visual Pattern Recognition, Static Spatial Layout, Spatial Sequence Processing, Movement Planning, and Dynamic Spatial Attention, showed statistically significant positive correlations with key dyslexia indicators such as total words read, correct words read, speed index, and accuracy index.

This suggests that dyslexia may be more closely associated with targeted visuospatial processing abilities rather than with overall VSS capacity.

DISCUSSION

4. Discussion

The aim of this study was to explore the relationship between the Visuospatial Sketchpad (VSS) and dyslexia in fourth-grade students, using a comprehensive and theory-driven assessment framework grounded in (Logie, 2014) re-conceptualization of working memory. Interestingly, and somewhat unexpectedly, the results did not support the initial hypothesis. There was no significant correlation between the overall VSS score and dyslexia scores in this sample. This outcome raises important questions, not only about the methodology used, but also about how we conceptualize and assess visuospatial components in relation to reading difficulties. It also highlights the need to examine how these findings align or diverge from existing research.

In fact, the results echo a number of earlier studies that similarly failed to establish a clear connection between visuospatial sketchpad and dyslexia. particularly when those skills were measured using isolated or overly simplistic tasks. For example, (Duranovic et al., 2015) employed the Paper Folding Test, which evaluates mental visualization using two-dimensional stimuli. Their study found no consistent differences between dyslexic and non-dyslexic readers. This suggests that relying on individual visual tasks might not capture the full complexity of visuospatial processing as it relates to literacy development.

A similar pattern emerged in the findings of (Winner et al., 2001), who used both the Vandenberg Mental Rotation Test and the Rey-Osterrieth Complex Figure (ROCF) to examine spatial abilities. Their research showed no substantial differences between adolescents with dyslexia and their typically developing peers across several spatial domains, including mental rotation, visual scanning, and visual memory.

Additional evidence comes from (Brunswick et al., 2010), whose study involved directional recall and reproduction tasks. They too found no notable advantages or disadvantages among dyslexic participants at the group level. Similarly, (Helland & Asbj∅rnsen, 2003) drew from well-established assessment tools such as the WISC-R and the Aston Index. both of which primarily rely on two-dimensional stimuli. Like others, their results did not reveal clear spatial deficits in dyslexic students.

Even when researchers shifted focus to spatial reasoning in relation to mathematics, the pattern remained. (Tosto et al., 2014)used the Spatial Reasoning Test by Smith and Lord (2002), it identified links between spatial ability and mathematical skills, but not reading. This reinforces the idea that certain visuospatial tasks may not be well-suited to revealing literacy-related differences.

Taken together, these findings suggest a consistent theme, when visuospatial skills are assessed using isolated tasks or without a strong theoretical framework, the insights gained about dyslexic learners tend to be limited. It’s possible that the complexity of visuospatial cognition, and its interaction with reading requires more integrative, contextually rich approaches to assessment.

One of the key strengths of this study lies in its methodological design. Unlike earlier research that often relied on one or two subtests to assess visuospatial ability, this study employed a broader, theory-based battery grounded in (Logie, 2014) multicomponent model of the Visuospatial Sketchpad (VSS). This model draws a clear distinction between the visual cache, responsible for storing static visual details, and the inner scribe, which handles dynamic spatial and sequential information. It also accounts for the influence of executive functions, which help manage, refresh, and manipulate spatial content. By including a diverse set of components, such as visual detail storage, visual pattern recognition, static spatial layout, color and texture representation, spatial sequence processing, mental rotation, movement planning, rehearsal/refreshing, and dynamic spatial attention. this study offered a more nuanced and multidimensional assessment of the VSS system than most previous research.

This theoretical clarity played a central role not only in shaping the assessment itself but also in interpreting the findings, particularly the lack of a significant correlation between the total VSS score and dyslexia. Rather than viewing this null result as a failure, it can be better understood as a reflection of the VSS's inherent complexity. As (Logie, 2014) argues, the VSS isn’t a single, unified function but a network of interconnected subsystems. When all these components are averaged into one composite score, the result may mask the individual contributions of specific subsystems, some of which may be strongly linked to reading ability, while others are not. In this case, the cognitive signals that matter most for dyslexia could be diluted by less relevant elements, ultimately obscuring meaningful patterns.

Notably, when the data were examined at the component level, several specific VSS functions, such as visual pattern recognition, static spatial layout, spatial sequence processing, movement planning, and dynamic spatial attention. were found to correlate significantly with dyslexia scores. These results align closely with known cognitive processes involved in reading. For instance, spatial sequence processing plays a critical role in maintaining the correct order of letters within words, something dyslexic learners often find difficult(Goswami, 2011). Likewise, dynamic spatial attention, which supports smooth visual scanning and the ability to shift attention across lines of text, has been identified as a core issue in dyslexia by visual attention-based theories (Vidyasagar & Pammer, 2010).

Visual pattern recognition, another key component, is directly tied to orthographic processing. This ability helps readers identify and recall recurring letter groupings and word forms, skills that typically developing readers learn to automatize, but which remain effortful and error-prone for many with dyslexia.

Static spatial layout, another component found to be significantly correlated, pertains to how spatial arrangements are perceived, structured, and mentally organized. While this element isn't commonly featured in mainstream reading research, difficulties in processing spatial layout could plausibly contribute to issues such as losing one's place on the page, tracking lines of text, or confusing similarly shaped letters (Brunswick et al., 2010). These seemingly small spatial lapses can disrupt the fluidity and accuracy of reading, especially in young or struggling readers.

Movement planning, though more traditionally associated with motor coordination and physical actions, may also play a subtle but important role in reading. It helps guide eye movements and the coordination of saccades, the rapid jumps our eyes make as we scan lines of text. Both are essential for fluent reading and writing (Stoodley et al., 2005). A disruption in this planning process could result in slower or more erratic reading patterns, especially in children with dyslexia, for whom reading often lacks rhythm and fluency.

By contrast, some components of the VSS, specifically visual detail storage (measured through tasks involving color and texture), mental rotation, and rehearsal/refreshing. did not show any significant correlation with dyslexia scores. While initially this may seem surprising, the lack of connection actually reinforces the broader argument, not all visuospatial skills are relevant to the reading process. Some simply don't engage the cognitive demands required by literacy tasks.

Take visual detail storage, for example, this refers to the brain's ability to encode and recall surface-level features of visual stimuli, such as hue, brightness, or texture. While these details are clearly important for recognizing objects in daily life (like telling apart a red apple from a green one), they contribute little to nothing in the context of reading. Alphabetic literacy relies on recognizing abstract, symbolic forms, not richly detailed visual objects. Discriminating between the letters *b* and *d*, for instance, depends on subtle spatial orientation, not on color or texture. As (M. Snowling, 2006) pointed out, dyslexia is fundamentally tied to phonological decoding and orthographic processing rather than low-level visual perception. This view is echoed in visual attention theories, which suggest that the core dysfunction lies within the dorsal visual stream, not the ventral one (Vidyasagar & Pammer, 2010).

Mental rotation, often used as a benchmark measure in visuospatial testing, also failed to show a meaningful link to dyslexia in this study. While this skill is crucial in STEM contexts and spatial reasoning tasks, its relevance to reading appears limited. Mental rotation requires imagining how objects move or turn in three-dimensional space. Reading, on the other hand, is a two-dimensional, largely static task. Letters are processed in upright, fixed orientations. Though earlier theories proposed that letter reversals in dyslexic children might stem from poor mental rotation, these ideas haven’t stood up to empirical scrutiny. Research now suggests that letter reversals are more of a developmental phase than a persistent indicator of spatial difficulty (Simos et al., 2002).

Lastly, the rehearsal/refreshing component, measuring one’s ability to sustain visual or spatial images through mental rehearsal, did not correlate with reading performance either. This isn’t entirely unexpected. While this kind of internal rehearsal is important for visual memory tasks, it doesn’t seem to align with what reading demands. In reading, especially fluent reading, there’s limited time or need to hold onto visual-spatial images. Instead, success depends more on rapid integration of phonological, orthographic, and attentional processes. Unlike the phonological loop, where verbal rehearsal is directly tied to decoding and comprehension, visual rehearsal hasn't shown a consistent connection to literacy outcomes(Smith-Spark & Fisk, 2007).

The pattern of results in this study reinforces an increasingly accepted perspective, dyslexia does not reflect a broad visuospatial impairment but rather a set of selective cognitive vulnerabilities. Specific components of the Visuospatial Sketchpad (VSS), particularly those involving color perception, three-dimensional spatial manipulation, or non-verbal rehearsal appear unrelated to the core deficits traditionally associated with dyslexia. These include difficulties with phonological awareness, orthographic processing, and visual attention control.

In this context, it's easy to see why relying on a total VSS score to predict dyslexia risk is problematic; important relationships can remain hidden unless the system is analyzed at the subcomponent level.

Framed within (Logie, 2014) multicomponent working memory model, the findings become even more informative. The significant correlations with visual pattern recognition and static spatial layout seem to reflect weaknesses within the visual cache, which is responsible for storing visual details. In contrast, associations found with spatial sequence processing, movement planning, and dynamic spatial attention suggest involvement of the inner scribe, which manages dynamic and sequential spatial information. This pattern of associations points toward a dual vulnerability in dyslexia, affecting both visual storage and spatial manipulation, yet not extending across the entire visuospatial system.

That said, it’s worth noting the limitations. The sample size (n = 30), while consistent with earlier studies in this field such as (Duranovic et al., 2015; Von Károlyi et al., 2003), may have reduced the statistical power needed to detect weaker or more nuanced associations. It's entirely possible that smaller effect sizes, especially for less central VSS components, went undetected. Future studies should seek to replicate these findings with larger and more diverse populations, ideally spanning different orthographic systems and educational contexts, to evaluate whether these component-level patterns hold more broadly.

Taken together, these results speak to the value of a multicomponent, theory-guided approach to cognitive assessment in dyslexia. Traditional studies have often relied on single-task or global visuospatial measures, which may fail to capture the complexity of the systems involved. This study demonstrates that breaking the VSS into its core processes, rather than treating it as a unified construct, provides far more insight into how specific visuospatial functions relate to the reading difficulties experienced by students with dyslexia.

4.1. Implications

The findings from this study carry important implications across multiple domains, including clinical practice, educational training, research methodology, and policy development. By demonstrating that only specific components of the Visuospatial Sketchpad (VSS) are meaningfully associated with dyslexia, this research challenges the notion of broad visuospatial deficits in learning disorders. Instead, it argues for more targeted and nuanced frameworks in both assessment and intervention.

- ❖ **Implications for Clinical Practice**

Perhaps the most immediate clinical implication is the need to rethink how visuospatial skills are evaluated in psychoeducational assessments. Many traditional screening tools rely on composite or global scores, which can obscure specific cognitive difficulties. As this study shows, such aggregate measures risk missing critical patterns, especially when only certain subcomponents of the VSS are implicated in dyslexia. For clinicians working with children who present with reading challenges, the findings support a more differentiated assessment approach. Including measures that specifically assess visual pattern recognition, spatial sequencing, and attentional control could significantly improve diagnostic accuracy.

Furthermore, these results suggest that interventions should not be based on the assumption of a generalized visuospatial weakness in dyslexic learners. Instead, targeted strategies that address specific deficits, such as training in spatial sequencing, attentional cueing, or letter-pattern recognition, may be far more effective. On the other hand, activities aimed at improving skills like mental rotation or color-based visual memory are unlikely to result in reading gains, given that these domains did not show significant links to dyslexia severity in this study.

- ❖ **Implications for Future Research**

This study adds to a growing body of evidence suggesting that dyslexia is not a monolithic disorder but rather a heterogeneous condition with multiple cognitive underpinnings. By applying a theory-driven, component-based model grounded in (Logie, 2014) framework of working memory, the research highlights the value of dissecting cognitive processes rather than relying on broad diagnostic labels.

Moving forward, future research should aim to replicate and expand these findings with larger, more demographically diverse samples. This would help clarify whether the same VSS components are consistently linked to reading outcomes across different languages, writing systems, and developmental stages. Importantly, studies that include neurocognitive measures, such as eye-tracking, EEG, or fMRI, could provide further insight into how specific visuospatial processes (e.g., movement planning, dynamic spatial attention) are represented in the brain and interact with the neural circuitry of reading.

There's also a need to explore whether interventions designed around these VSS components can lead to measurable improvements in decoding, fluency, or comprehension. Such research could help bridge the gap between cognitive theory and classroom practice, grounding educational interventions in empirical evidence.

Lastly, the study highlights the critical role of sample size in cognitive research. While the findings aligned with theoretical expectations and echoed earlier studies, the relatively modest sample (n = 30) may have constrained the ability to detect subtler patterns or moderate effects. To build a more reliable evidence base, future investigations should aim for larger cohorts and consider examining moderating variables, such as attentional capacity, co-occurring developmental disorders, or socioeconomic status.

- **Implications for Training and Policy**

The implications of these findings extend beyond research and clinical practice into teacher education and policy development. Educators particularly those in training or specializing in learning disabilities, should receive more comprehensive instruction on the cognitive foundations of reading. Not all visuospatial or memory deficits are relevant to literacy, and it is crucial that teachers understand that a child struggling with reading may not necessarily have broad visual or spatial difficulties. Instead, targeted weaknesses in spatial sequencing or attentional shifting may be at play.

At the policy level, this research supports the development of more refined diagnostic and intervention frameworks. Educational screening protocols should incorporate tasks that assess the specific visuospatial components linked to reading, rather than relying solely on general cognitive or memory tests. Doing so would reflect best practices rooted in current research and would likely lead to better outcomes for students by enabling more precise and individualized support.

Moreover, policymakers should move away from one-size-fits-all approaches to dyslexia remediation. Funding models, curricular guidelines, and professional development resources should prioritize interventions that target the specific cognitive mechanisms known to underlie literacy difficulties. Adopting frameworks informed by models like (Logie, 2014)which clearly distinguish between different visuospatial and executive processes, can support more equitable and effective educational planning. In the long run, this can enhance learning outcomes and deepen our understanding of neurodiversity in school-age populations.

4.2. Limitations

While this study offers valuable insights into the relationship between visuospatial functioning and dyslexia in primary school children, it is essential to acknowledge several limitations that may have influenced both the scope of the research and how the findings should be interpreted.

Perhaps the most notable limitation is the sample size. With only 30 fourth-grade students included, the statistical power of the analysis was inherently constrained. Although this number aligns with those seen in similar studies e.g., (Duranovic et al., 2015; Von Károlyi et al., 2003), a larger cohort would have enhanced both the reliability and generalizability of the results. Small samples increase the likelihood of Type II errors, in other words, failing to detect genuine effects due to limited data. They also restrict the ability to investigate more nuanced interactions, such as how different components of the VSS may vary with demographic factors like age, gender, or verbal skills.

Practical limitations also played a role. Time constraints and restricted access to schools made recruitment challenging. The process was heavily influenced by school calendars, administrative policies, and the availability and willingness of both parents and teachers to support the research. These constraints not only impacted sample size but also shaped the demographic diversity of participants. As students were drawn from a relatively narrow set of educational environments, there is a risk that the findings may not fully apply to children from different socioeconomic or cultural backgrounds. This, in turn, limits the external validity of the study.

Another consideration is the methodological scope. While the study made a meaningful contribution by assessing a range of visuospatial subcomponents within (Logie, 2014) theoretical framework, it was still limited by the tools available. Some cognitive constructs, especially those involving real-time attentional shifts or eye movement dynamics, are difficult to capture with paper-based or static assessments. Incorporating more dynamic or digital tools might have offered a fuller picture of how these components operate during actual reading tasks.

Additionally, the cross-sectional design of the study means that it captured only a single moment in each participant's development. While useful for identifying patterns and associations, this approach cannot provide information about causal relationships or how these cognitive abilities evolve over time. For instance, some visuospatial weaknesses may emerge only after reading instruction begins, while others might diminish with age, intervention, or increased reading experience. A longitudinal approach would be better suited to explore these developmental trajectories.

Despite these limitations, the study offers a solid foundation for future research. It identifies particular components of the VSS that warrant closer examination and illustrates the value of using theory-driven, multicomponent assessments in the study of learning disorders. That said, the results should be viewed as preliminary and exploratory, contributing to a growing body of knowledge rather than offering definitive conclusions. As the field continues to evolve, these findings may serve as a stepping stone toward more refined and impactful research.

4.3. Recommendations

Building on the findings and limitations of this study, a number of practical and theoretical recommendations can be offered to educators, clinicians, and researchers working at the intersection of visuospatial functioning and dyslexia.

- **Practical Implications for Educational Practice and Assessment**

One clear takeaway is the need to move beyond overly general assessments when evaluating visuospatial sketchpad in children with dyslexia. Rather than relying solely on composite scores or broad measures of spatial ability, school psychologists and educators should focus on specific subcomponents of the Visuospatial Sketchpad (VSS). In this study, elements such as spatial sequence processing, dynamic spatial attention, and visual pattern recognition showed stronger links to dyslexia than others, highlighting where targeted evaluation may be most informative.

In the classroom, this more precise understanding can guide the development of tailored interventions. For instance, students who struggle with sequencing might benefit from structured visual tracking activities or exercises that reinforce phoneme-grapheme connections using spatial cues. Similarly, training aimed at boosting attentional control particularly visual attention across lines of text, could be a valuable complement to traditional phonological interventions. Together, these approaches offer a more holistic framework for supporting struggling readers.

Additionally, assessment practices would benefit from adopting multi-component, theory-informed tools that align with established models like (Logie, 2014)reconceptualization of working memory. Such frameworks allow for a richer, more nuanced understanding of individual learning profiles and help ensure that support strategies are truly personalized to each learner’s cognitive strengths and weaknesses.

❖ Directions for Future Research

The study also opens up several promising avenues for future inquiry. First and foremost, replication with larger and more diverse samples is essential. Expanding the sample size would improve statistical reliability and allow for exploration of key moderating variables such as age, gender, bilingualism, or co-occurring developmental disorders that may influence the relationship between VSS and reading.

Second, there's a clear need to continue refining theoretical models of working memory as they relate to literacy. This study was among the few to directly apply (Logie, 2014) model to dyslexia, but more research is needed to fully understand how the visual cache and inner scribe interact with phonological and orthographic processing over time. Incorporating neurocognitive methods, like eye-tracking or neuroimaging, could offer a deeper look at the underlying brain mechanisms and provide a bridge between theory and neurological evidence.

Third, future studies should consider the ecological validity of the tasks being used. While lab-based measures are valuable for control and consistency, they don’t always reflect the real-world demands of learning and reading in educational contexts. Tools such as virtual reality environments, interactive digital tasks, or simulated classroom scenarios might offer richer, more realistic assessments of how spatial and attentional processes influence literacy.

Finally, advancing this line of research will require collaboration across disciplines. Educational psychologists, neuroscientists, cognitive theorists, and classroom educators each bring unique insights, and working together will be crucial for designing tools and interventions that are both scientifically grounded and practically effective. These findings reinforce the idea that dyslexia extends beyond phonological challenges alone, calling for a multidimensional perspective that respects the full complexity of the reading process.

In short, this research contributes to a more precise, component-based understanding of how visuospatial sketchpad intersect with dyslexia. By shifting the focus from broad diagnostic labels to specific cognitive processes, both educational practice and research can move toward more targeted, effective, and compassionate support for students with dyslexia.

Conclusion

5. Conclusion

This study set out to explore the relationship between dyslexia and the Visuospatial Sketchpad (VSS), using a comprehensive and theory-based framework grounded in (Logie, 2014)multicomponent model of working memory. Departing from earlier studies that often leaned on narrow or single-task assessments, this research aimed to capture the full complexity of the VSS by examining its various subsystems. Much of the existing literature e.g.,(Brunswick et al., 2010; Helland & Asbj∅rnsen, 2003; Winner et al., 2001) focused on isolated visual-spatial tasks, which may have inadvertently missed subtle but meaningful cognitive patterns linked to dyslexia. By contrast, this study attempted to fill that gap, offering a more granular look into which visuospatial components matter most.

Although the overall VSS score did not show a significant correlation with dyslexia severity, a more detailed component-level analysis revealed valuable patterns. Specifically, components such as spatial sequence processing, dynamic spatial attention, visual pattern recognition, static spatial layout, and movement planning emerged as significantly linked to dyslexia measures. These findings align with established theoretical perspectives that emphasize the role of visual attention (Vidyasagar & Pammer, 2010), orthographic recognition (M. Snowling, 2006), and sequence tracking (Goswami, 2011) in literacy development.

Importantly, this study adds to the growing consensus that dyslexia should not be seen as a monolithic condition. Rather, it is a heterogeneous learning difficulty, shaped by domain-specific cognitive differences. By adopting a multicomponent view of visuospatial processing, the research moves beyond generic labels and sheds light on which aspects of spatial cognition are most relevant to reading impairments. This approach not only helps clarify mixed findings in previous studies but also strengthens the case for targeted assessments that differentiate between distinct visuospatial processes instead of relying on total or averaged scores.

On a practical level, the results underscore the value of designing assessment tools and educational interventions that focus on the most relevant visuospatial subskills. Educational psychologists and intervention specialists may find it especially helpful to emphasize activities that build visual attention, sequencing, and spatial organization, rather than investing in generalized visuospatial training that might not directly impact reading outcomes.

Theoretically, the study reinforces the utility of (Logie, 2014) model in disentangling the cognitive systems underlying literacy. It suggests that looking at the visual cache and inner scribe separately, and considering their interaction with executive functions, offers a more accurate picture of how reading difficulties unfold in children with dyslexia.

In closing, while the absence of a significant correlation at the total VSS level might initially appear to weaken the visuospatial-dyslexia link, this should not be mistaken for a lack of connection. Instead, the findings here point to specific cognitive threads, especially those tied to spatial tracking, visual focus, and sequence management, that meaningfully intersect with the reading challenges seen in dyslexic learners. Adopting a multicomponent perspective, both in research and in practice, can lead to more personalized, effective, and ultimately empowering approaches to supporting students with dyslexia. Through this lens, we can better understand their needs and help unlock their potential.

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APPENDIX

Appendix 01

	الانشطة	التقييم		
01	• يقوم الطفل برؤية صورة لمشهد معين لمدة ثلاثون ثانية ونقوم بعرض نفس المشهد لكن يحتوي على سبعة اشياء ناقصة ويقوم الطفل بتحديدها.	نقطة واحدة في حالة استجابة صحيحة واحدة	نقطتين في حالة استجابتين صحيحتين	ثلاثة نقاط في حالة ثلاثة او اربعة استجابات صحيحة
02	• نقوم بعرض صورتين أمام الطفل، كلاهما تحملان نفس المشهد، لكن بوجود سبعة اختلافات بين كلا الصورتين، ويقوم الطفل بتحديدها.	نقطة واحدة في حالة استجابة واحدة او استجابتين الى ثلاثة استجابات صحيحة	نقطتين في حالة اربعة الى خمسة استجابات صحيحة	ثلاثة نقاط في حالة ستة الى سبعة استجابات صحيحة
03	• يتم عرض رسم تحتوي على دوائر ملونة متناوبة ويقوم الطفل بتكملة جزء من هذه الرسمة بحيث تحتوي على سبعة دوائر غير ملونة.	نقطة واحدة في حالة استجابة واحدة او استجابتين الى ثلاثة استجابات صحيحة	نقطتين في حالة اربعة الى خمسة استجابات صحيحة	ثلاثة نقاط في حالة ستة الى سبعة استجابات صحيحة
04	• يقوم الطفل بتجميع سبعة خرزات على العمود، بعد رؤيته لنموذج يحوي سبعة خرزات مرتبة على اساس اللون لمدة عشرون ثانية.	نقطة واحدة في حالة استجابة واحدة او استجابتين الى ثلاثة استجابات صحيحة	نقطتين في حالة اربعة الى خمسة استجابات صحيحة	ثلاثة نقاط في حالة ستة الى سبعة استجابات صحيحة
05	• يقوم الطفل بترتيب سبعة حيوانات بلاستيكية فوق رف فارغ، بعد رؤيته لمدة عشرون ثانية لصورة تحتوي على نفس الألعاب مرتبة ترتيبا معينا.	نقطة واحدة في حالة استجابة واحدة او استجابتين الى ثلاثة استجابات صحيحة	نقطتين في حالة اربعة الى خمسة استجابات صحيحة	ثلاثة نقاط في حالة ستة الى سبعة استجابات صحيحة
06	• يقوم الطفل برسم خريطة كنز ذات سبعة معالم، بعد أن يتم عرض أمامه صورة لخريطة الكنز لمدة عشرون ثانية.	نقطة واحدة في حالة استجابة واحدة او	نقطتين في حالة اربعة الى خمسة	ثلاثة نقاط في حالة ستة الى سبعة استجابات صحيحة

		استجابتين الى ثلاثة استجابات صحيحة	استجابات صحيحة	
07	• يقوم الطفل بتلوين رسمة تحتوي على سبعة أشكال مرتبة، بعد أن يتم عرض امامه رسمة اخرى لمدة خمسة عشر ثانية تحتوي على هاته الاشكال ملونة بترتيب معين.	نقطة واحدة في حالة استجابة واحدة او استجابتين الى ثلاثة استجابات صحيحة	نقطتين في حالة اربعة الى خمسة استجابات صحيحة	ثلاثة نقاط في حالة ستة الى سبعة استجابات صحيحة
08	• يقوم الطفل باعادة ترتيب اشياء ذات ملامس معينة، بعد أن نقوم بعرض أمامه لهاته الملامس لمدة خمسة عشر ثانية مرتبة بترتيب معين.	نقطة واحدة في حالة استجابة واحدة او استجابتين الى ثلاثة استجابات صحيحة	نقطتين في حالة اربعة الى خمسة استجابات صحيحة	ثلاثة نقاط في حالة ستة الى سبعة استجابات صحيحة
09	• يقوم الطفل بتكرار لمس سبعة خانات التي لمسها الفاحص على الجدول بتسلسل معين.	نقطة واحدة في حالة استجابة واحدة او استجابتين الى ثلاثة استجابات صحيحة	نقطتين في حالة اربعة الى خمسة استجابات صحيحة	ثلاثة نقاط في حالة ستة الى سبعة استجابات صحيحة
10	• يقوم الطفل باعادة نمذجة سبعة حركات بعد رؤيتها على البطاقات.	نقطة واحدة في حالة استجابة واحدة او استجابتين الى ثلاثة استجابات صحيحة	نقطتين في حالة اربعة الى خمسة استجابات صحيحة	ثلاثة نقاط في حالة ستة الى سبعة استجابات صحيحة
11	• نقوم بعرض صور لاربعة رموز والطفل يحدد الرمز مقلوبا ومعكوسا	نقطة واحدة في حالة تحديد وضعيات رمز واحد بشكل صحيح	نقطتين في حالة تحديد وضعيات رمزين الى ثلاثة رموز بشكل صحي	ثلاثة نقاط في حالة تحديد وضعيات اربعة رموز بشكل صيح
12	• نقوم بعرض صور لاربعة صور لحروف لاتينية والطفل يحدد الحرف مقلوبا ومعكوسا ومقلوبا معكوسا	نقطة واحدة في حالة تحديد وضعيات رمز واحد	نقطتين في حالة تحديد وضعيات رمزين الى ثلاثة رموز بشكل صحي	ثلاثة نقاط في حالة تحديد وضعيات اربعة رموز بشكل صيح

		بشكل صحيح		
13	• نقوم بعرض رسم لمنزل على سبعة مراحل ويقوم الطفل باعادة رسم المنزل وفق المراحل.	نقطة واحدة في حالة استجابة واحدة او استجابتين الى ثلاثة استجابات صحيحة	نقطتين في حالة اربعة الى خمسة استجابات صحيحة	ثلاثة نقاط في حالة ستة الى سبعة استجابات صحيحة
14	• يقوم بحل متاهة بأن يوصل الارنب من بداية المتاهة الى نهايتها.	نقطة واحدة في حالة قيامه بثلاثة اخطاء	نقطتين في حالة ارتكابه لخطأ واحد او خطأين	ثلاثة نقاط في حالةلم يرتكباي خطأ
15	• نقوم بالنقر بتسلسل على خمسة مكعبات ملونة (مثل أحمر –أزرق–أخضر – بني)، ويُطلب من الطفل تكرار التسلسل بعد تأخير عشرة ثوانٍ.	نقطة واحدة في حالة تطبيق التسلسل بثلاثة اخطاء	نقطتين في حالة تطبيق التسلسل بوجود خطأين او خطا واحد	ثلاثة نقاط في حالة تطبيق التسلسل بدون اخطاء
16	• نقوم بوضع عشرة صور فوق الطاولة ونلمس خمسة صور ونطلب من الطفل اعادة لمس الصور بنفس التسلسل ولمس صورة اضافية مثلا تكون بعد لمس الصورة الثالثة.	نقطة واحدة في حالة تطبيق التسلسل بثلاثة اخطاء	نقطتين في حالة تطبيق التسلسل بوجود خطأين او خطا واحد	ثلاثة نقاط في حالة تطبيق التسلسل بدون اخطاء
17	• نقوم برمي كرة في الارض وبعد ان تقوم بالتوقف نطلب من الطفل تحديد المكان الاخير اين توقفت الكرة عن النط. نعيد النشاط اربعة مرات	نقطة واحدة في حالة استجابتين صحيحتين	نقطتين في حالة وجود ثلاثة استجابات صحيحة	ثلاثة نقاط في حالة القيام باستجابة صحيحة في كل مرة
18	• نقوم باستخدام مصباح يدوي لتسليط الضوء على سبعة صور لحيوانات وخضر وفواكه في غرفة مظلمة، ويُطلب من الطفل تذكر ترتيب الصور التي تم تسليط الضوء عليها.	نقطة واحدة في حالة استجابتين صحيحتين	نقطتين في حالة اربعة الى خمسة استجابات صحيحة	ثلاثة نقاط في حالة ستة الى سبعة استجابات صحيحة

Appendix 2

The Lark and the Elephant" – Full Text

القُبَّرَةُ وَالفِيلُ

يُحْكَى أَنَّ قُبَّرَةً اتَّخَذَتْ حُفْرَةً فِي الأَرْضِ تَضَعُ فِيهَا بَيْضَتَهَا، وَبَاضَتْ عَلَى طَرِيقِ الفِيلِ الَّذِي كَانَ يَمُرُّ إِلَى مَشْرَبٍ يَتَرَدَّدُ إِلَيْهِ.وَفِي أَحَدِ الأَيَّامِ حَطَّمَ الفِيلُ العُشَّ وَ قَتَلَ فِرَاخَهَا.

حَزِنَتْ القُبَّرَةُ حُزْنًا شَدِيدًا لَمَّا عَلِمَتْ أَنَّ مَا أَصَابَهَا مِنَ الفِيلِ لاَ مِنْ غَيْرِهِ، فَطَارَتْ وَحَطَّتْ عَلَى رَأْسِهِ بَاكِيَةً وَقَالَتْ لَهُ :هَلْ فَعَلْتَ هَذَا اسْتِصْغَارًا لِأَمْرِي وَاحْتِقَارًا لِشَأْنِي !؟ قَالَ :نَعَمْ ...

فَتَرَكَتْهُ وَذَهَبَتْ إِلَى جَمَاعَةِ الطَّيْرِ، فَشَكَتْ إِلَيْهِنَّ عُدْوَانَ الفِيلِ عَلَى عُشِّهَا وَقَتْلِ فِرَاخِهَا وَطَلَبَتْ مِنْهُنَّ أَنْ يَفْقَأْنَ عَيْنَيْهِ، فَفَعَلْنَ ذَلِكَ، وَبَقِيَ لاَ يَهْتَدِي إِلَى طَرِيقِ مَطْعَمِهِ وَمَشْرَبِهِ إِلاَّ مَا يَجِدُهُ عَلَى الأَرْضِ قَرِيبًا مِنْهُ.

ثُمَّ جَاءَتْ القُبَّرَةُ إِلَى غَدِيرٍ فِيهِ ضَفَادِعُ كَثِيرَةٌ،فَشَكَتْ إِلَيْهِنَّ مَانَالَهَا مِنَ الفِيلِ وَ قَالَتْ: أَطْلُبُ مِنْكُنَّ أَنْ تَنْزِلْنَ فِي وَادٍ عَمِيقٍ وَ تَأْخُذْنَ فِي النَّقِيقِ وَ الضَّجِيجِ ،فَفَعَلْنَ ذَلِكَ، وَ لَمَّا عَطِشَ الفِيلُ ظَنَّ أَنَّ فِي مَكَانٍ نَقِيقِ الضَّفَادِعِ مَاءً، فَجَرَى نَحْوَ الصَّوْتِ، فَوَقَعَ فِي الوَادِي، وَهَلَكَ.

فَطَارَتْ القُبَّرَةُ تُرَفْرِفُ فَوْقَ رَأْسِهِ،وَقَالَتْ : أَيُّهَا الفِيلُ الظَّالِمُ،إِنَّكَ احْتَقَرْتَنِي، وَظَلَمْتَنِي، وَلَكِنَّنِي رَغْمَ صِغَرِ جُثَّتِي فَإِنَّنِي أَعْظَمُ مِنْكَ حِيلَةً وَأَوْسَعُ عَقْلاً.

Appendix 3

Quantitative and Qualitative Data Collection Sheet for Dyslexia Assessment

بطاقة جمع المعلومات عن الحالة

الإســـم :.................................. تــاريخ الفحـص : - - / - - / - -

اللـــقب :..................................

تاريخ الميلاد : - - / - - / - - الســـن :.............

القسم : .... الجنس :..............

معلومات حول البصر(الرؤية) :.................يضع النظارات:.......... في أي سن؟.............

I. ملاحظات أثناء عملية الفحص :

إضطرابات الكلام : - التردد في القراءة

- الملامح التي تظهر أثناء القراءة

الأشكال الدفاعية (التأتأة القرائية،التتبع بالأصبع،التشويق و الزفير أثناء القراءة، الضغط على الحروف)

ملاحظات حول التتبع البصري:...

ملاحظات حول القدرات الانتباهية:..

السلوكات التي يبديها المفحوص أثناء الاختبار:..

....

II. النتائج :

المؤشرات الكمية:

- الزمن المستغرق أثناء القراءة (ز.م)..........
- عدد الكلمات المقروءة (ع.ك.م)......
- عدد الأخطاء (ع.أخ)........
- عدد الكلمات المقروءة بطريقة صحيحة(ع.ك.م.ص)....
- مؤشر الدقة(ع.ك.م،ع.ك.م.ص) ....
- مؤشر السرعة(ع.ك.م.ص،ز.م) ....

المؤشرات الكيفية:

طبيعة الأخطاء المرتكبة

- الكلمات الغريبة:
- إرسال حرف-صوت:
- التشابه اللفظي :
- التداخل الدلالي :

م.د = (ع.ك.م.ص / ع.ك.م) × 100   م.س = (ع.ك.م.ص / ز.م) × 199

III. التوصلة :

....

....