International Journal of Humanities and Social Sciences (IJHSS)
ISSN (P): 2319–393X; ISSN (E): 2319–3948
Vol. 14, Issue 1, Jan–Jun 2025; 51–66

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

COGNITIVE DEFICITS UNDERLYING DYSGRAPHIA: A REVIEW STUDY

Drishya Sasidharan[1] & Dr. Suphala Kotian[2]

[1]Research Scholar, Institute of Social Sciences and Humanities, Srinivas University, Mangalore, Karnataka, India.

[2]Research Professor, Institute of Social Science and Humanities, Srinivas University, Mangalore -575001, India.

ABSTRACT

Purpose: *Dysgraphia, a complex and often misunderstood learning disorder, severely disrupts written language production due to multifaceted cognitive deficits. This review delves into the neurological, cognitive, perceptual, and developmental underpinnings of dysgraphia, emphasizing impairments in phonological processing, motor coordination, visual-spatial integration, executive functioning, working memory, and auditory processing. The study highlights the disorder's far-reaching consequences on academic performance, emotional well-being, and professional communication, advocating for early detection and targeted intervention strategies.*

Design: *This review adopts a systematic methodology by synthesizing contemporary evidence from neuroscience, developmental psychology, cognitive neuropsychology, and education research. Drawing upon peer-reviewed journals, conference proceedings, and clinical findings, the paper identifies key etiological pathways, diagnostic complexities, and therapeutic approaches. The study integrates findings on neuroimaging and neurological function to support a shift from motor-centric to cognitively grounded intervention models.*

Findings: *The analysis confirms that dysgraphia arises from interconnected cognitive deficits rather than isolated motor dysfunction. Significant gaps are identified in cultural responsiveness, longitudinal research, and adult-focused interventions. The findings advocate for a multidimensional intervention model blending occupational therapy, cognitive training, and assistive technology*

Originality/Value: *This paper offers a comprehensive cognitive-neurodevelopmental framework for understanding dysgraphia. By addressing diverse etiologies and intervention strategies, it provides valuable insights for clinicians, educators, and researchers. It champions inclusive, evidence-based, and technologically integrated approaches to empower individuals across all life stages affected by dysgraphia.*

Paper type: *Review paper*

KEYWORDS: *Dysgraphia, Cognitive Deficits, Executive Functioning, Phonological Processing, Visual-Spatial Integration, Learning Disability, Neurodevelopmental Disorders, Inclusive Education*

Article History

Received: *09 Apr 2025* | ***Revised:*** *10 Apr 2025* | ***Accepted:*** *11 Apr 2025*

INTRODUCTION

Dysgraphia is a learning disorder that severely restricts an individual's capacity to generate written language, impairing handwriting legibility, spelling accuracy, and verbal expression in writing [1]. This is a specific learning disability

classified as a neurodevelopmental disorder that impairs the cognitive and motor processes necessary for writing [2]. While dysgraphia was formerly thought to be a problem with fine motor coordination, forthcoming study reveals that the underlying causes include phonological processing, visual-spatial integration, working memory, and executive functioning [3,4]. Importantly, dysgraphia is not associated with intellect; rather, it indicates underlying deficiencies in cognitive and motor skills that impair the ability to convey thoughts through writing. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), dysgraphia is a type of written expression disorder that is diagnosed when an individual's writing abilities are significantly below expectations for their age and cognitive level. Dysgraphia differs from other learning impairments, which includes dyslexia, which impacts reading abilities [5]. While these conditions can coexist, dysgraphia has a more particular influence on handwritten fluency, spelling accuracy, and written organization. Dysgraphia is frequently associated with other neurodevelopmental disorders, such as developmental coordination disorder (DCD), attention deficit hyperactivity disorder (ADHD), and speech-language difficulties, complicating diagnosis and management options [6,7].

Dysgraphia is symptomized by major writing difficulties, such as poor handwriting, spelling errors, and impaired written expression, while having acceptable intelligence and education. While dysgraphia is commonly associated with motor abnormalities, research has increasingly indicated that cognitive impairments play an important role in its presentation. These cognitive deficiencies affect an assortment of areas, including executive functioning, working memory, phonological processing, visuospatial ability, and processing speed, all of which contribute to writing difficulties [8.9].

Writing can be described as a complicated cognitive process that necessitates the integration of multiple cerebral systems responsible for motor coordination, language processing, and memory [9]. For individuals with dysgraphia, the breakdown in these processes results in difficulty forming letters, organizing ideas, and executing writing tasks efficiently. Individuals with underlying cognitive deficiencies struggle to plan, organize, and execute written assignments, which frequently leads to frustration, slow writing speed, and poor academic performance [10].

Dysgraphia may exhibit itself in multiple forms, depending on the underlying cognitive conditions. Motor dysgraphia occurs when a person's fine motor control is inadequate, resulting in unreadable handwriting [11]. Others suffer from spatial dysgraphia, which affects the placement and alignment of letters and words on a page. Linguistic dysgraphia, on the other hand, affects spelling, grammar, and sentence building, making it difficult to create coherent written works. These difficulties are frequently caused by neurological variations in brain regions involved in language processing, motor control, and visual perception, such as the prefrontal cortex, cerebellum, superior temporal gyrus, and occipital-parietal cortex. Studies employing brain imaging techniques such as fMRI and EEG have demonstrated that people with dysgraphia perceive writing-related activities differently, bolstering the notion that dysgraphia is a cognitive issue rather than a physical one [12,13].

Dysgraphia has an impact beyond academic achievement since writing is essential for learning, communication, and self-expression. Students with dysgraphia frequently suffer with reading comprehension, vocabulary acquisition, and academic performance, resulting in low achievement and frustration. Beyond academics, the emotional and social consequences are substantial, as writing difficulties are sometimes misconstrued as carelessness, resulting in low self-esteem, anxiety, and social isolation. If left untreated, dysgraphia can last until adulthood, hurting career possibilities, professional communication, and daily writing duties [14,15].

This study explores a spectrum of cognitive deficits encompassing auditory processing, executive functioning, visual-spatial integration, motor coordination, and speech processing, attributed to neurological, developmental, or cognitive dysfunctions influenced by neurobiological, genetic, and environmental factors. Writing, essential in academic and professional contexts, profoundly impacts well-being and productivity. Investigating dysgraphia's cognitive, neurological, and developmental underpinnings aims to bridge theoretical insights with effective therapies. Synthesizing diverse research categories reveals commonalities, gaps, and contradictions, advancing understanding of dysgraphia's origins across developmental, cognitive, and neurological domains, essential for refining diagnostics, educational strategies, and interventions. This groundwork supports future interdisciplinary studies, fostering dialogue on enhanced evaluation and therapeutic approaches.

OBJECTIVES OF THE SCHOLARLY REVIEW

Writing is a complex cognitive process that consists of two primary stages: the linguistic stage and the motor and praxis stage. The linguistic stage involves encoding auditory and visual information into symbols, such as letters and words. The motor and praxis stage requires fine motor coordination to physically execute written symbols. Individuals with dysgraphia struggle with impairments in these components, which significantly affects an individual's ability to produce written language. These deficits include a wide range of cognitive deficiencies, including auditory processing, executive functioning, visual-spatial integration, motor coordination, and speech processing. These could be the outcome of neurological, developmental, or cognitive dysfunctions that are influenced by neurobiological, genetic, and environmental factors. Writing is an invaluable skill in both academic and professional settings, and it can have an impact on an individual's general well-being and productivity. This study investigates the cognitive, neurological, and developmental bases of dysgraphia, with the goal of bridging the gap between theoretical understanding and effective therapeutic options.

- To investigate the Cognitive Deficits associated with dysgraphia.
- To explore the Neurological Foundations of dysgraphia

REVIEWS OF LITERATURE

Understanding dysgraphia as a complex learning disability demands an investigation of its multidimensional underlaying causes, which include neurological in origin, cognitive, motor, psychological, and environmental aspects. This article of research has focused on identifying the underlying deficiencies and fundamental warning signs linked with dysgraphia, integrating the findings of the field of neuroscience, cognitive psychology, and education-related research. This section synthesizes major findings across different categories by conducting a thorough evaluation of existing research and identifying commonalities, gaps, and contradictions in the present literature. This review intends to provide a thorough knowledge of the origins of dysgraphia by combining developmental, cognitive, and neurological perspectives, which will aid in the refinement of diagnostic criteria, educational initiatives, and therapeutic interventions. Finally, this section lays the groundwork for future multidisciplinary research on dysgraphia, driving conversations about more effective evaluation and therapeutic strategies.

Cognitive Deficits Underlying Dysgraphia

Dysgraphia is caused by a combination of cognitive and perceptual deficits, particularly the interaction of working memory, visual-motor integration, and improper language processing [17]. These impediments have a significant impact on writing fluency, accuracy, and coherence, affecting not just academic accomplishment but also daily activities and

overall well-being. Furthermore, the common coexistence of dysgraphia with other learning problems, such as dyslexia and ADHD, highlights the condition's complexities leads to the notion of cognitive impairments [18].

Dysgraphia is a complex writing condition characterized by deficiencies in several cognitive domains, including *Phonological Processing, Motor Coordination, Visual-Spatial Processing, Executive Function, And Auditory Processing*. These deficiencies stem from neurological, developmental, and cognitive dysfunctions, which are frequently influenced by genetic, environmental, and neurobiological variables. We will look at these shortcomings in greater depth below, including their underlying causes and theoretical justifications.

Phonological Processing Deficits

Phonological processing is the capacity of the brain to identify, regulate, and remember sounds that are spoken, which is crucial to spelling, reading, and writing. It enables people to transform sounds (phonemes) into written symbols (graphemes), resulting in accurate spelling and word retrieval [19]. Dysgraphia, on the other hand, is characterized by phonological processing deficiencies that make it difficult to construct written words, resulting in frequent spelling errors, trouble recovering words, and inconsistent written expression. These obstacles frequently make writing a long and mentally demanding process, leading to dissatisfaction and avoidance of writing assignments [20]. Dysgraphia's phonological processing abnormalities linked to neurological problems in the left hemisphere's language network, particularly in the superior temporal gyrus, angular gyrus, and Broca's region [21].

Phoneme-grapheme mapping, the ability to match sounds to their corresponding letters—can lead to unexpected spelling errors, such as letter deletions, substitutions, and reversals. For instance, a person with dysgraphia might spell "friend" as "frend" or "elephant" as "elefant," reflecting a challenge in distinguishing between correct and incorrect phonetic representations. These difficulties are particularly prominent with irregular words that do not follow standard phonetic patterns [22,23].

Weak phonological awareness, such as the ability to segment words into individual sounds and manipulate those sounds, makes tasks like rhyming, syllable segmentation, and sound blending particularly challenging for individuals with phonological difficulties [25].

Phonological working memory, which allows people to store and handle sound-based information while writing, is connected to phonological processing problems. once impaired, it becomes difficult to recall the right spelling of words, particularly those words are longer or more complicated [25]. As a result, pupils with dysgraphia may fail to retain word patterns and regularly misspell words, even if they have written them correctly previously. These issues go beyond spelling and affect sentence structure and general writing flow, making writing more difficult and time-consuming.

Individuals with dysgraphia can improve their spelling skills, word retrieval, and writing confidence by addressing phonological processing deficiencies by an early detection and following therapeutic options with evidence based.

Motor Coordination and Automatization Deficits

Writing is consisting of profound number of complex motor skill that calls for exact brain, muscle, and sensory coordination. Planning, fine motor control, and the capacity to perform actions automatically are a part of it. However, dysgraphia sufferers frequently experience difficulties with automatization and motor coordination, which have a major effect on their writing endurance and fluency, and speed of handwriting [26].

Motor coordination deficits in dysgraphia primarily affect *fine motor control*, the precise coordination of small muscle movements, particularly in the hands and fingers, which are essential for writing. These movements require a combination of dexterity, hand-eye coordination, and muscle stability to execute controlled and fluid handwriting, the deficits in fine motor control, making writing a slow, effortful, and frustrating task [27]. These difficulties can result in poor letter formation, irregular spacing, inconsistent handwriting, and rapid hand fatigue, this, may lead to avoidance behaviour towards handwriting due to the excessive need of physical as well as cognitive efforts.

The cerebellum, motor cortex, and basal ganglia are key players in motor coordination, movement regulation, and motor learning, and these dysfunctions form the neurological basis of fine motor control deficiencies in dysgraphia [28]. According to research, those who have dysgraphia may have less cerebellar activation, which impairs their capacity to organize and carry out fluid motor sequences. In a similar vein, there is impaired neuronal connection between the motor cortex and basal ganglia, which hinders the development of automatic handwriting movements and fine motor precision. These neurological variations demonstrate that dysgraphia's fine motor control deficiencies are connected to variations in brain function rather than just a lack of practice [29,30].

There are many common symptoms showed by individuals with dysgraphia, some of them are.

- *Inconsistent letter formation, size and spacing*: Letters may be too large, too small, uneven, or misaligned.
- *Poor pencil grip and hand positioning*: Many tend to hold the pencil too tightly, leading to muscle strain and discomfort, while others struggle to maintain a stable grasp, frequently adjusting their grip while writing. This lack of control affects letter formation, writing pressure, and overall fluency, making handwriting appear uneven and inconsistent.
- *Difficulty maintaining steady pencil pressure*: Some individuals press too hard on the paper, leading to fatigue, while others may apply too little pressure, resulting in faint or illegible writing.
- *Slow and effortful handwriting*: Writing speed is significantly slower due to the need for conscious effort in forming each letter.
- *Poor hand-eye coordination*: Difficulty guiding the pen smoothly across the page, leading to jerky or irregular strokes.

Specific treatments as well as customized treatment plannings are necessary to address fine motor difficulties in dysgraphia. Through hand-strengthening exercises, fine motor skill games, and handwriting training programs, occupational therapy can assist improve hand muscles, grip stability, and writing endurance. For people who have trouble with fine motor control, multisensory learning strategies and assistive technology such as speech-to-text software, typing programs, and smartpens offer other writing techniques. [31,32,33].

Visual-Spatial and Magnocellular Processing Deficits in Dysgraphia

Visual-spatial deficits in dysgraphia refer to difficulties in recognizing and interpreting spatial relationships visually, which affect writing tasks such as letter spacing, staying on lines, and organizing words on the page. This often leads to messy or illegible handwriting due to poor spatial awareness. Essentially, individuals with dysgraphia struggle to "see" where to place words and letters correctly on the paper [34]. These deficits hinder the perception of spatial relationships between letters and words, disrupting proper alignment and spacing. In cases of spatial dysgraphia, deficits in visual-motor integration and spatial awareness further impact an individual's ability to organize their writing effectively on the page.

- *Poor alignment*: of letters and words is one of the main problems caused by visual-spatial deficiencies. A lot of people with dysgraphia struggle to write in lines, with consistent letter sizes, and with words spaced consistently. Their writing may therefore seem haphazard and challenging to read. These issues result from a diminished capacity to assess spatial relationships, which impacts their writing's sense of structure and proportion. For instance, handwriting patterns might be irregular and inconsistent if letters are positioned too closely together, too far apart, or out of alignment with the baseline [35].
- *Mirror writing and letter reversals* are frequent problems linked to visual-spatial impairments. Many people with dysgraphia often mix up letters with similar shapes, including "b" and "d," "p" and "q," or "m" and "w." This is especially noticeable in younger kids whose writing abilities are still growing. The incapacity to recognize the proper alignment of letters is the cause of these spatial processing problems rather than ignorance. When writing swiftly, people with dysgraphia may also have trouble with directionality, which causes them to write letters or numerals backwards or reverse entire words [36].
- *The ability to maintain consistent margins, line spacing, and paragraph alignment:* may be hampered by poor visual tracking and spatial organization. As a result, text appears congested, with words thrown across the page and lines spaced unevenly. People with visual-spatial dysgraphia may struggle to copy text from a board or other piece of paper because they have difficulty accurately tracking letters and words from one location to another [37]. This makes written expression even more challenging, as it usually results in missing words, skipped lines, or misaligned characters.

The magnocellular system is a part of the brain that helps us to detect motion, understand spatial relationships, and track visual information. Studies show that when this system isn't working properly, it can lead to visual-spatial challenges in dysgraphia, making it difficult to keep letters in the right position, follow words while writing, and organize text. According to the Magnocellular Deficit Hypothesis [38]. weakened activity in this system makes it harder to process spatial information, which in turn affects writing organization and letter formation. fMRI scans reveal that people with dysgraphia have less activity in the occipital-parietal cortex, the area of the brain that handles visual-spatial processing and coordinates motor movements needed for writing [39].

Interventions for dysgraphia should focus on enhancing spatial awareness, letter alignment, and visual tracking through multisensory writing techniques, such as using raised-line paper and tactile activities. Visual tracking exercises, eye-tracking, and spatial awareness training can further improve hand-eye coordination and spatial organization. Assistive technologies like speech-to-text software, smartpens, and structured writing programs, along with occupational therapy, can help develop fine motor control and improve writing skills.

Working Memory and Executive Functioning Deficits

Working memory refers to the temporary retention of information, especially when doing a task. This has a substantial impact on their ability to structure, maintain coherence, and regulate the mechanics of handwriting. Such limitations make writing a difficult, effortful, and frequently frustrating endeavour, both in terms of academic performance and overall written communication abilities. Working memory is essential for spelling recollection and learning while writing, as well as sentence structure and coherence preservation [40].

The neurological basis of working memory is linked to the prefrontal cortex, specifically the dorsolateral prefrontal cortex (DLPFC), which is important for working memory and executive function. According to research, people with dysgraphia have reduced brain activation in these areas, which contributes to deficiencies in planning, self-monitoring, and cognitive flexibility. Furthermore, poor neuronal connection between the prefrontal cortex and other language-processing areas impairs the capacity to organize thoughts and complete writing activities efficiently [41,42]. The Executive Dysfunction Hypothesis (Diamond, 2013) states that persons with dysgraphia struggle to initiate, structure, and modify their written work due to deficiencies in self-regulation, task organization, and cognitive flexibility [43]. This neurological perspective emphasizes the notion that dysgraphia-related writing issues are more than just a question of practice; they are caused by executive function impairment.

Dysgraphia causes issues with working memory, including.

- Remembering spelling rules and word structures when writing.
- Managing various thoughts when writing big sentences or paragraphs.
- Focusing on sentence structure and grammatical perfection might lead to disordered writing.
- Revising and editing written material, as individuals may forget what they meant to write before finishing sentences.
- Difficulty processing many writing components, including spelling, punctuation, and phrase flow, resulting in frequent errors and a lack of logical development [44,45,46].

Executive Functioning and Its Impact on Writing

Executive functioning is a collection of cognitive skills that allows people to plan, organize, self-monitor, and manage their behaviour. Writing necessitates strong executive function abilities to develop ideas, arrange content, and assure clarity and coherence. In dysgraphia, deficiencies in executive functioning can lead to,

- Inadequate arrangement might lead to unclear or repetitious written content.
- Inconsistent sentence structure and lack of logical flow might impact readability.
- Procrastination or avoidance of writing assignments due to difficulty commencing them.
- Lack of self-monitoring can lead to unrecognized spelling, punctuation, and grammar problems.
- Difficulties with task persistence can hinder efficient completion of written assignments.

Many people with dysgraphia fail to follow formal writing processes like brainstorming, outlining, drafting, and rewriting because they find it difficult to break down work into manageable steps [47]. This makes written assignments difficult and can lead to irritation and worry over writing chores.

These difficulties extend beyond academics, affecting professional responsibilities such as drafting emails, taking meeting notes, and planning written projects. Weak self-monitoring and cognitive flexibility make it difficult to recognize faults and correctly structure written text, reducing overall communication skills [48]. Dysgraphia-related working memory and executive function deficiencies can cause frustration, avoidance of writing, and lower productivity in both school and workplace contexts if not treated properly.

Working memory and executive functioning deficiencies in dysgraphia are addressed by interventions that improve cognitive organization, task management, and self-monitoring abilities. Working memory support measures, such as chunking information, using visual organizers, and implementing multimodal learning techniques, can assist reduce cognitive load and increase recall [49]. Executive function training focuses on structured writing stages, checklists, and templates to improve organization and planning, while assistive technology solutions such as speech-to-text software, word prediction programs, and organizational applications offer alternatives to traditional handwriting. These tactics help people with dysgraphia write more efficiently, structure their ideas more effectively, and perform better in school and in work [50].

Auditory Processing Deficits in Dysgraphia

Auditory processing refers to the brain's ability to interpret, analyse, and make sense of sounds. It is essential for phoneme recognition, sound discrimination, and auditory memory, all of which play a crucial role in spelling, reading, and writing. In dysgraphia, auditory processing deficits can lead to difficulties in distinguishing similar sounds, recalling spelling patterns, and transcribing spoken words into written form. These challenges contribute to frequent spelling errors, phoneme-grapheme mismatching, and difficulty structuring written sentences [51]. Neurological basis of auditory processing deficits shows dysgraphia are linked to dysfunctions in the temporal cortex, particularly in the superior temporal gyrus, which is responsible for speech perception and phonological processing. Studies using functional MRI (fMRI) and EEG have revealed [52].

Auditory processing plays a crucial role in several aspects of language and writing. It allows individuals to distinguish between similar phonemes, maintain word sequences accurately, and translate spoken language into written form. However, individuals with dysgraphia often experience disruptions in auditory processing, affecting their ability to recognize and differentiate similar sounds (such as confusing /b/ with /p/ or /d/ with /t/), convert speech sounds into written letters, and recall word sequences essential for constructing grammatically correct sentences. They struggle with processing spoken instructions, which complicates tasks involving writing from memory, dictation, or remembering spelling patterns. These challenges manifest in inconsistent and sometimes illegible writing, where errors like omitted sounds, letter substitutions, or incorrect word segmentation occur due to weak auditory processing skills [53,54].

Common Challenges Caused by Auditory Processing Deficits in Dysgraphia

Phoneme Discrimination Difficulties: Phoneme discrimination is the ability to recognize subtle differences between speech sounds. Individuals with auditory processing deficits may have trouble distinguishing between similar-sounding words or syllables, leading to spelling mistakes and mispronunciations. For example, they might confuse words like "cat" and "cut" or "ship" and "chip", resulting in errors in written expression [55].

Poor Auditory Working Memory: Auditory working memory is essential for holding and manipulating auditory information during tasks such as spelling, reading, and writing. For individuals with dysgraphia and auditory processing deficits, this ability is often compromised, leading to difficulties in remembering and sequencing sounds within words, which results in spelling errors. Additionally, they struggle to recall multi-syllabic words or long sentences, hindering their writing fluency [56]. Following verbal instructions for writing assignments becomes challenging, making it difficult to complete tasks accurately. These difficulties in retaining spoken information while transcribing it into written form contribute to word omissions, incomplete thoughts, and challenges in organizing ideas effectively.

Difficulty with Phoneme-to-Grapheme Mapping: Phoneme-to-grapheme mapping, the process of converting spoken sounds into written letters, is often impaired in individuals with dysgraphia. These individuals frequently struggle to establish strong sound-symbol associations, which leads to several challenges, including inconsistent spelling, even for commonly used words. They may rely heavily on phonetic spelling, writing words as they sound rather than following standard spelling conventions (e.g., spelling "fone" instead of "phone"). Additionally, they may have difficulty applying spelling rules consistently, resulting in errors in word endings, plurals, and verb tenses [57].

Poor Auditory Processing Speed: Processing speed refers to the rate at which the brain interprets and responds to auditory input. For individuals with dysgraphia, slower processing speed can make it more challenging to decode spoken language, recall information, and translate words into written text. As a result, they may struggle to keep up with notetaking during lectures, have trouble transcribing dictation accurately, and face challenges in formulating responses during timed writing tasks [58]. These difficulties hinder their ability to perform efficiently in academic settings, especially when quick processing of auditory information is required.

The neurological basis of auditory processing deficits in dysgraphia involves several key brain mechanisms. Weakened neural activation in the superior temporal gyrus impairs phoneme recognition and the ability to differentiate sounds, which is essential for accurate writing. Additionally, poor connectivity between auditory and motor regions disrupts the ability to translate sounds into written letters, further complicating the writing process. Moreover, reduced processing efficiency in auditory working memory makes it more challenging to retain and manipulate phonological information during writing tasks. The Auditory Deficit Hypothesis (Ramus et al., 2003) posits that individuals with compromised auditory processing skills struggle with phonological awareness and word recognition, which results in persistent difficulties with writing and spelling. These neurological factors contribute significantly to the writing challenges observed in individuals with dysgraphia [59].

Auditory processing deficits can significantly impact both academic success and daily functioning, particularly for individuals with dysgraphia. These individuals often struggle with spelling tests, written assignments, and following spoken instructions, which can lead to lower academic performance and frustration. They may avoid complex vocabulary and experience anxiety in time-sensitive writing tasks, such as timed exams. In everyday life, these challenges extend to tasks like writing professional emails, taking phone messages, and transcribing verbal information [60]. The difficulties caused by impaired auditory processing can persist into adulthood, affecting communication and task completion both at school and in professional settings [61].

Intervention strategies for auditory processing deficits in dysgraphia focus on enhancing phonological awareness, improving writing accuracy, and providing structured support. Phonological awareness training involves activities like phoneme segmentation and rhyming exercises to strengthen sound recognition. Multisensory spelling techniques and assistive technology, such as speech-to-text and text-to-speech software, help reduce cognitive load and improve writing. Structured writing supports, including graphic organizers and extra time for tasks, accommodate processing speed challenges and help students organize their thoughts more effectively.

DISCUSSION AND CONCLUSION

This study provides an in-depth exploration of the cognitive deficits underlying dysgraphia, emphasizing that writing difficulties stem not only from motor impairments but also from a complex interplay of neurological, cognitive, and perceptual dysfunctions. The findings demonstrate that deficits in phonological processing, motor coordination, visual-spatial integration, working memory, executive function, and auditory processing contribute to the challenges experienced by individuals with dysgraphia [62]. These impairments significantly affect writing fluency, accuracy, and organization, underscoring the necessity of a multidimensional approach to diagnosis and intervention. Study emphasis the need of early identification and tailored intervention strategies that address specific cognitive deficits. Approaches such as multisensory writing techniques, phonological training, executive function coaching, and assistive technologies (e.g., speech-to-text software) can improve writing performance and overall academic outcomes [63].

Dysgraphia presents significant barriers to academic success and daily communication, affecting both self-expression and self-esteem. This research highlights the necessity of shifting from a traditional motor-based perspective to a more comprehensive cognitive framework, which considers the underlying neurological and cognitive mechanisms responsible for writing difficulties [64].

Addressing dysgraphia requires a multidisciplinary approach, integrating neuroscience, education, psychology, and assistive technology to develop effective, evidence-based interventions. Additionally, equitable access to resources, teacher training, and public awareness initiatives are crucial in fostering an inclusive learning environment [65,66]. Future research should prioritize longitudinal studies, culturally responsive interventions, and advancements in neuroimaging to refine diagnostic accuracy and improve intervention strategies [66].

By recognizing dysgraphia as a cognitive disorder rather than solely a handwriting difficulty, this study contributes to evolving perspectives in research and education. With sustained efforts in policy, practice, and awareness, individuals with dysgraphia can experience greater academic success, improved mental well-being, and enhanced opportunities for professional growth in a more supportive and inclusive society.

REFERENCE

1. *Chung, P. J., Patel, D. R., & Nizami, I. (2020). Disorder of written expression and dysgraphia: definition, diagnosis, and management. Translational pediatrics, 9(Suppl 1), S46.*
2. *Aremu, E., & Adewunmi, A. T. (2023). Understanding the nature of dysgraphia: Exploring its meaning, symptoms, impacts and advancing management strategies. Journal of Studies in Humanities, 13(1), 54-62.*
3. *Chung, P., & Patel, D. R. (2015). Dysgraphia. International Journal of Child and Adolescent Health, 8(1), 27.*
4. *Ardoin, M. D. B. (2023). A Phenomenological Study of Early Childhood Teachers' Lived Experiences and Perceptions of Their Training in Recognizing Dysgraphia in Young Children.*
5. *American Psychiatric Association. (2000). Diagnostic and statistical manual of mental disorders. Text revision*
6. *McCloskey, M., & Rapp, B. (2019). Developmental dysgraphia: An overview and framework for research. Developmental Dysgraphia, 34(3-4), 1-18*

7. *Gargot, T., Asselborn, T., Pellerin, H., Zammouri, I., M. Anzalone, S., Casteran, L., ... & Jolly, C. (2020). Acquisition of handwriting in children with and without dysgraphia: A computational approach. PloS one, 15(9), e0237575.*
8. *Biotteau, M., Danna, J., Baudou, É., Puyjarinet, F., Velay, J. L., Albaret, J. M., & Chaix, Y. (2019). Developmental coordination disorder and dysgraphia: Signs and symptoms, diagnosis, and rehabilitation. Neuropsychiatric disease and treatment, 5(1), 1873-1885.*
9. *Amini, M., Tavakoli Targhi, A., Hosseinzadeh, M., Farivar, F., & Bidaki, R. (2023). Identifications of developmental dysgraphia on the basis of dynamic handwriting features. International Journal of Nonlinear Analysis and Applications, 14(1), 3179-3188.*
10. *Berninger, V. W., & Richards, T. L. (2012). The writing brain: Coordinating sensory/motor, language, and cognitive systems in working memory. In Past, present, and future contributions of cognitive writing research to cognitive psychology (pp. 537-563). Psychology Press.*
11. *Olive, T. (2014). Toward a parallel and cascading model of the writing system: A review of research on writing processes coordination. Journal of writing research, 6(2), 173-194.*
12. *Deuel, R. K. (1995). Developmental dysgraphia and motor skills disorders. Journal of child Neurology, 10(1_suppl), S6-S8.*
13. *Borges, M. T., Aprígio, L. C. S., Azoni, C. A. S., & Crenitte, P. A. P. (2020). Types of handwriting and signs of dysgraphia in children and adolescents with learning difficultie. Revista CEFAC, 22(6), e17719.*
14. *Zoccolotti, P., & Friedmann, N. (2010). From dyslexia to dyslexias, from dysgraphia to dysgraphias, from a cause to causes: A look at current research on developmental dyslexia and dysgraphia. Cortex, 46(10), 1211-1215.*
15. *Aremu, E., & Adewunmi, A. T. (2023). Understanding the nature of dysgraphia: Exploring its meaning, symptoms, impacts and advancing management strategies. Journal of Studies in Humanities, 13(1), 54-62.*
16. *Obatta, M. I., Adama, G. C., & Onu, V. C. (2020). Effect of scsffolding strategy on creative writing ability of in-school adolescents with dysgraphia. International Journal of Youth Empowerment and Entrepreneurship Development, 2(1), 251-262.*
17. *Gruendemann, J. (2023). A Neuropsychologically-Based Deficit-Remediation Approach to Assessment Interpretation and Intervention Prescription to Promote Effective Writing Development in Students with Developmental Dysgraphia (Doctoral dissertation, Alliant International University).*
18. *Neyshabur, I. (2014). The effect of cognitive-motor exercises on motor-writing skills in dysgraphia patients. Advances in Environmental Biology, 8(12), 1680-1687.*
19. *Campbell, R., & Butterworth, B. (1985). Phonological dyslexia and dysgraphia in a highly literate subject: A developmental case with associated deficits of phonemic processing and awareness. The Quarterly Journal of Experimental Psychology, 37(3), 435-475.*

20. *Rapcsak, S. Z., Beeson, P. M., Henry, M. L., Leyden, A., Kim, E., Rising, K., ... & Cho, H. (2009). Phonological dyslexia and dysgraphia: Cognitive mechanisms and neural substrates. Cortex, 45(5), 575-591.*
21. *Snowling, M., Stackhouse, J., & Rack, J. (1986). Phonological dyslexia and dysgraphia—a developmental analysis. Cognitive Neuropsychology, 3(3), 309-339.*
22. *Marinelli, C. V., Putzolu, A., De Salvatore, M., Iaia, M., & Angelelli, P. (2018). Developmental phonological dyslexia and dysgraphia in a regular orthography: a case study. Journal of InterDisciplinary Research Applied to Medicine, 2(1), 67-82.*
23. *Shea, J., Wiley, R., Moss, N., & Rapp, B. (2022). Pseudoword spelling ability predicts response to word spelling treatment in acquired dysgraphia. Neuropsychological Rehabilitation, 32(2), 231-267.*
24. *Campbell, R., & Butterworth, B. (1985). Phonological dyslexia and dysgraphia in a highly literate subject: A developmental case with associated deficits of phonemic processing and awareness. The Quarterly Journal of Experimental Psychology, 37(3), 435-475.*
25. *Rapcsak, S. Z., Beeson, P. M., Henry, M. L., Leyden, A., Kim, E., Rising, K., ... & Cho, H. (2009). Phonological dyslexia and dysgraphia: Cognitive mechanisms and neural substrates. Cortex, 45(5), 575-591.*
26. *Biotteau, M., Chaix, Y., & Albaret, J. M. (2015). Procedural learning and automatization process in children with developmental coordination disorder and/or developmental dyslexia. Human movement science, 43, 78-89.*
27. *Smits-Engelsman, B. C. M. (1995). Theory-based diagnosis of fine-motor coordination development and deficiencies using handwriting tasks. Nijmegen: NICI, Nijmeegs Instituut voor Cognitie en Informatie.*
28. *Palmis, S., Danna, J., Velay, J. L., & Longcamp, M. (2019). Motor control of handwriting in the developing brain: A review. Developmental Dysgraphia, 123-140.*
29. *Nicolson, R. I., & Fawcett, A. J. (2011). Dyslexia, dysgraphia, procedural learning and the cerebellum. Cortex, 47(1), 117-127.*
30. *Habib, M. (2021). The neurological basis of developmental dyslexia and related disorders: A reappraisal of the temporal hypothesis, twenty years on. Brain sciences, 11(6), 708.*
31. *Prunty, M., & Barnett, A. L. (2019). Understanding handwriting difficulties: A comparison of children with and without motor impairment. In Developmental Dysgraphia (pp. 141-154). Routledge.*
32. *Lopez, C., & Vaivre-Douret, L. (2021). Influence of visual control on the quality of graphic gesture in children with handwriting disorders. Scientific Reports, 11(1), 23537.*
33. *Beeraka, N. M., Nikolenko, V. N., Khaidarovich, Z. F., Valikovna, O. M., Aliagayevna, R. N., Arturovna, Z. L., ... & Sinelnikov, M. Y. (2022). Recent investigations on the functional role of cerebellar neural networks in motor functions & nonmotor functions-neurodegeneration. Current neuropharmacology, 20(10), 1865-1878.*
34. *Garje Mona, P., Dhadwad, V., Yeradkar, M. R., Adhikari, A., & Setia, M. (2015). Study of visual perceptual problems in children with learning disability. Indian Journal of Basic and Applied Medical Research, 4(3), 492-97.*

35. *Vukoja, N. (2024). Dyslexia and Dysgraphia in Learning English as a Foreign Language: A Case Study of Croatian EFL Learners (Doctoral dissertation, Josip Juraj Strossmayer University of Osijek. Faculty of Humanities and Social Sciences. Department of English Language and Literature).*
36. *Dotterer, C. (2023). Taking the Mask Off Dysgraphia. In Routledge International Handbook of Visual-motor skills, Handwriting, and Spelling (pp. 396-411). Routledge.*
37. *Heeringa, H. (2024). The Visual Brain and Peripheral Reading and Writing Disorders: A Guide to Visual System Dysfunction for Speech-Language Pathologists. Routledge.*
38. *Stein, J. (2018). The magnocellular theory of developmental dyslexia. Reading and dyslexia: From basic functions to higher order cognition, 103-134.*
39. *Vukoja, N. (2024). Dyslexia and Dysgraphia in Learning English as a Foreign Language: A Case Study of Croatian EFL Learners (Doctoral dissertation, Josip Juraj Strossmayer University of Osijek. Faculty of Humanities and Social Sciences. Department of English Language and Literature).*
40. *Jafari, F., Arjmandnia, A. A., & Rostami, R. (2021). The effect of neuropsychological rehabilitation program on working memory and response inhibition of students with dysgraphia. The Journal Of Psychological Science, 20(98), 233-46.*
41. *Rosenblum, S. (2018). Inter-relationships between objective handwriting features and executive control among children with developmental dysgraphia. PloS one, 13(4), e0196098.*
42. *Khan, K., & Lal, P. (2023). Executive dysfunctions in different learning disabilities: A review. Journal of Indian Association for Child and Adolescent Mental Health, 19(2), 126-142.*
43. *Filipe, M. (2021). How do executive functions issues affect writing in students with neurodevelopmental disorders. Executive Functions and Writing; Limpo, T., Olive, T., Eds, 160-180.*
44. *Romani, C. (1999). Developmental surface dysgraphia: What is the underlying cognitive impairment? The Quarterly Journal of Experimental Psychology: Section A, 52(1), 97-128.*
45. *Vlachos, F., & Karapetsas, A. (2003). Visual memory deficit in children with dysgraphia. Perceptual and motor skills, 97(3_suppl), 1281-1288.*
46. *Zoccolotti, P., & Friedmann, N. (2010). From dyslexia to dyslexias, from dysgraphia to dysgraphias, from a cause to causes: A look at current research on developmental dyslexia and dysgraphia. Cortex, 46(10), 1211-1215.*
47. *Ghafori, R., Heirani, A., & Aghadsi, M. T. (2018). Effect of motor exercises on serum level of brain-derived neurotrophic factor and executive function in children with dysgraphia. J. Kermanshah Univ. Med. Sci, 22, e79187.*
48. *Graham, S. T. E. V. E., Harris, K. R., & Olinghouse, N. A. T. A. L. I. E. (2007). Addressing executive function problems in writing. Executive function in education: From theory to practice, 216-236.*

49. *Alevriadou, A., & Giaouri, S. (2015). The impact of executive functions on the written language process: Some evidence from children with writing disabilities. Journal of Psychologists and Counsellors in Schools, 25(1), 24-37.*

50. *Nathan, A. M. (2009). The impact of executive function skills on writing: A comparison of fifth-grade students with learning disabilities and students with typical development. University of Nevada, Reno.*

51. *Tajik, S., Adel Ghahraman, M., Tahaie, A. A., Hajiabolhassan, F., Jalilvand Karimi, L., & Jalaie, S. (2012). Deficit of auditory temporal processing in children with dyslexia-dysgraphia. Aud Vestib Res, 21(4), 76-83.*

52. *Holland, J. L. (2014). Train the brain to hear: Understanding and treating auditory processing disorder, dyslexia, dysgraphia, dyspraxia, short term memory, executive function, comprehension, and ADD/ADHD. Universal-Publishers.*

53. *Mekki, S. A., ELsafy, E. H., Ghannam, W. H., & Gad, N. H. (2022). Assessment of central auditory processing impairment and cognitive profiles in children with specific learning disabilities. The Egyptian Journal of Hospital Medicine, 88(1), 2280-2287.*

54. *Rapcsak, S. Z., Beeson, P. M., Henry, M. L., Leyden, A., Kim, E., Rising, K., ... & Cho, H. (2009). Phonological dyslexia and dysgraphia: Cognitive mechanisms and neural substrates. Cortex, 45(5), 575-591.*

55. *Campbell, R., & Butterworth, B. (1985). Phonological dyslexia and dysgraphia in a highly literate subject: A developmental case with associated deficits of phonemic processing and awareness. The Quarterly Journal of Experimental Psychology, 37(3), 435-475.*

56. *Holland, J. L. (2014). Train the brain to hear: Understanding and treating auditory processing disorder, dyslexia, dysgraphia, dyspraxia, short term memory, executive function, comprehension, and ADD/ADHD. Universal-Publishers.*

57. *Béland, R. (1999). Phonological spelling in a DAT patient: The role of the segmentation subsystem in the phoneme-to-grapheme conversion. Cognitive Neuropsychology, 16(2), 115-155.*

58. *Graham, N. L. (2014). Dysgraphia in primary progressive aphasia: Characterisation of impairments and therapy options. Aphasiology, 28(8-9), 1092-1111.*

59. *Marinelli, C. V., Putzolu, A., De Salvatore, M., Iaia, M., & Angelelli, P. (2018). Developmental phonological dyslexia and dysgraphia in a regular orthography: a case study. Journal of InterDisciplinary Research Applied to Medicine, 2(1), 67-82.*

60. *Holland, J. L. (2014). Train the brain to hear: Understanding and treating auditory processing disorder, dyslexia, dysgraphia, dyspraxia, short term memory, executive function, comprehension, and ADD/ADHD. Universal-Publishers.*

61. *Filipe, M. (2021). How do executive functions issues affect writing in students with neurodevelopmental disorders. Executive Functions and Writing; Limpo, T., Olive, T., Eds, 160-180.*

62. *Feifer, S. G. (2022). Assessing and Intervening with Children with Written. Best Practices in School Neuropsychology: Guidelines for Effective Practice, Assessment, and Evidence-Based Intervention, 451.*

63. *Eghbali, A., Vahedi, H., & Rezaei, R. (2023). Comparison of Visual-Spatial Performance, Attention Problems, and Cognitive Processing Speed in Male Students with and without Specific Learning Disabilities in Writing. Iranian Evolutionary Educational Psychology Journal, 5(3), 43-57.*

64. *Blank, R., Barnett, A. L., Cairney, J., Green, D., Kirby, A., Polatajko, H., ... & Vinçon, S. (2019). International clinical practice recommendations on the definition, diagnosis, assessment, intervention, and psychosocial aspects of developmental coordination disorder. Developmental Medicine & Child Neurology, 61(3), 242-285.*

65. *Addressing dysgraphia requires a multidisciplinary approach, integrating neuroscience, education, psychology, and assistive technology to develop effective, evidence-based interventions. Additionally, equitable access to resources, teacher training, and public awareness initiatives are crucial in fostering an inclusive learning environment*