

Understanding the Causes of Dysgraphia: A Review Study

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Understanding the Causes of Dysgraphia: A Review Study

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ABSTRACT

Purpose: Dysgraphia, a specific learning disability, impairs writing fluency, coherence, and legibility, posing significant academic, social, and professional challenges. This study explores its multifactorial nature, examining neurological, cognitive, motor, psychological, and environmental causes. It emphasizes early diagnosis, standardized tools, and holistic interventions to address dysgraphia effectively. By synthesizing current research, the review offers insights into improving outcomes for affected individuals.

Design: This study employs a systematic review of secondary data from peer-reviewed journals, book chapters, conference proceedings, and credible online databases. It critically examines recent literature to identify key research objectives, gaps, and potential solutions, with a focus on integrating advanced technologies like neuroimaging and AI-based tools into dysgraphia diagnosis and intervention.

Findings: The review highlights the need for a multidisciplinary approach that blends traditional handwriting training with advanced technologies. It identifies gaps such as a lack of culturally sensitive diagnostic methods, limited focus on adult dysgraphia, and insufficient longitudinal research. Resource equity, teacher training, and public awareness are emphasized as critical for fostering an inclusive and supportive environment for individuals with dysgraphia.

Originality/Value: This study synthesizes diverse research to offer a comprehensive understanding of dysgraphia's complexities. By addressing critical gaps and proposing innovative strategies, it underscores the importance of equitable, accessible solutions that integrate traditional and technological approaches to support individuals across life stages.

Paper Type: Review paper

Keywords: Dysgraphia, learning disability, handwriting, cognitive impairment, intervention strategies, inclusive education

1. INTRODUCTION:

Dysgraphia is a category of learning impairment that causes issues with writing, such as illegible handwriting, spelling difficulties, and difficulty organising thoughts on paper (Drotár, & Dobeš. (2020). [1]). It is characterised as a neurological condition that impairs the capacity to communicate oneself through written language (Hamdioui, et al. (2020). [2]). Dysgraphia does not correspond to a person's intelligence; more importantly, it indicates problems with the fine motor skills required for writing and the cognitive processes associated with communicating through writing (Chung, & Patel. (2015). [3]). This is a specific learning disability that primarily affects written language ability, setting it apart from other learning disabilities, such as dyslexia, which mainly impact reading skills. It is characterized by difficulties in various aspects of writing, including poor handwriting, incorrect letter formation, and a lack of fluency in producing written text. Symptoms of dysgraphia vary in severity and can affect multiple facets of written expression, such as handwriting, spelling, and the organization and flow of written work. Individuals with dysgraphia may also experience challenges in related language tasks, such as reading comprehension and oral expression (McCloskey, & Rapp. (2019). [4]), (Gargot, et al.

(2020). [5]), (Döhla, & Heim. (2016). [6]). According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), dysgraphia is categorized as a learning disability in written expression, diagnosed when an individual's writing skills are below those expected for their age and intelligence level. Dysgraphia frequently coexists with other learning disabilities, such as developmental coordination disorder, attention deficit disorder, and speech impediments (American Psychiatric Association. (2000). [7]).

Writing itself involves at least two stages: the linguistic stage and the motor, expressive, and praxis stage. The linguistic stage encompasses encoding auditory and visual information into symbols, such as written words and letters (Oliveira, et al. (2017). [8]). The motor stage is the expressive stage where written words or graphemes are physically produced. People with dysgraphia often struggle with handwriting and may lack other fine motor skills, which can lead to significant writing fatigue, frequent spelling errors, and difficulties with grammar. Additionally, they may frequently use the wrong word when attempting to express ideas on paper. Dysgraphia often becomes noticeable when children are first introduced to writing, but it can affect individuals across all age groups, including toddlers, teens, and adults (John, & Renumol. (2018). [9]), (Biotteau, et al. (2019). [10]).

There are three main forms of dysgraphia, each with unique traits and underlying reasons. Motor dysgraphia, which is frequently caused by neurological or developmental problems affecting motor coordination, is characterised by deficiencies in fine motor abilities that lead to poor handwriting despite adequate cognitive functioning. uneven letter sizes, uneven word spacing, and trouble sustaining writing alignment are all symptoms of spatial dysgraphia, which is characterised by difficulty with spatial orientation and visual-motor integration These problems are frequently linked to deficiencies in spatial thinking and visual perception. Finally, linguistic dysgraphia is characterised by issues with grammar, spelling, and coherent writing. It is usually linked to language processing impairments and frequently coexists with dyslexia and other language-based learning disorders (Amini, et al. (2023). [11]), (James. (2022). [12]).

Dysgraphia has a wide-ranging influence on academic achievement, affecting a variety of topics because writing is such an important ability for success. Students with dysgraphia may fail to decode words precisely and fluently, limiting reading comprehension and vocabulary growth, and resulting in low academic achievement (Severino. (2020). [13]). The tedious nature of writing might further impair their capacity to articulate information, resulting in poorer grades and a sense of academic underachievement. Beyond academics, dysgraphia has important social consequences, since bad handwriting is associated with low self-esteem, poor social functioning, and a lowered feeling of self-worth (Bahr, et al. (2020). [14]). Students with dysgraphia may feel dissatisfied, embarrassed, and lonely, and are frequently misdiagnosed as sloppy or lazy rather than being seen as having a true learning disability. Individuals with dysgraphia may encounter difficulty with writing in maturity, which can hamper career success and daily life. Addressing kids' dysgraphia needs through treatments such as focused handwriting training, assistive technology, and accommodations is critical for their academic performance and social development (Moss, et al. (2024). [15]).

The study will look at the neurological, cognitive, and developmental causes of dysgraphia, particularly focusing on motor, spatial, and linguistic components. It will comprehensively review existing studies on the neurobiological mechanisms that contribute to dysgraphia, such as deficiencies in fine motor skills, visual-spatial processing, and language-based problems. The review will also discuss the impact of genetic, environmental, and educational factors in the development of dysgraphia. This study seeks to explain the causes of dysgraphia by synthesising data from several theoretical frameworks and empirical investigations, with implications for future research and potential therapies.

2. OBJECTIVES OF THE SCHOLARLY REVIEW:

Dysgraphia is a learning condition that impairs an individual's ability to write efficiently and easily, particularly in students. It includes a wide range of neurological, cognitive, motor, and environmental features that lead to challenges with handwriting and written expression. This condition has an impact on individuals not only in the academic field but also on social, emotional, and psychological performance. Although it is common, dysgraphia often goes understudied when it comes to potential roots (O'Donnell & Colvin. (2019). [16]).

This review examines the neuroscience, cognition, perception, motor functions, and psychology factors that contribute to dysgraphia. The study investigates how environmental factors, such as instructional

approaches and cultural contexts, influence the development and maintenance of this handicap. This effort aims to expand understanding of dysgraphia and identify key areas for future research to improve treatment and comprehension.

- (1) To investigate the neurological and genetic causes of dysgraphia
- (2) To analyse the cognitive and perceptual factors contributing to dysgraphia.
- (3) To investigate the psychological and behavioural aspects of dysgraphia
- (4) To explore the environmental and educational factors influencing dysgraphia
- (5) To identify research gaps and opportunities for future studies to address unexplored areas and improve understanding of dysgraphia.
- (6) To evaluate the research agenda using ABCD analysis

3. RESEARCH METHODOLOGY:

As primary sources for this study, several internet databases were used, including Google Scholar, PsyNet, PubMed, Academia, SSRN, Research Gate, Z-Library, and other web-based resources. Over 10,000 publications from over 10,000 journals, some of which have been publishing papers for far longer than a century are included in these databases. There are three main steps in the evaluation process. To make the search procedure easier, keywords were chosen at the beginning. Both whole keywords and separate keyword components can be used in this method. It is vital to remember that this article only uses full-text, peer-reviewed materials that are written in English. The articles go through a screening process before moving on to the following level. In this stage, a thorough assessment is carried out.

4. REVIEWS OF LITERATURE:

Understanding dysgraphia as a type of complex learning disability requires exploring its multidetermined etiology. Summary of current study investigates the extensive research focused on identifying the caused and which are the main risk factors associated with the dysgraphia. Through a systematic review of existing studies, this section attempts to draw attention to the core findings across various fields ranging from neurological, cognitive and motor factors to psychological and environmental. The main effort is to integrate current knowledge while identifying gaps and contradictions in accessible research. The review integrates developmental, cognitive, and neurological perspectives to provide a thorough knowledge of dysgraphia's origin. This will help advance diagnostic, educational, and therapeutic approaches. This section establishes a foundation for future discussions on interdisciplinary approaches to dysgraphia.

4.1 The neurological and genetic causes of dysgraphia

Dysgraphia is widely accepted as a neurological disorder caused by malfunctions in the regions of the brain responsible for writing, motor coordination and cognitive processing. Recent neuroimaging studies have further pointed to key brain regions (the parietal lobe, cerebellum, frontal lobe and motor cortex) involved in dysgraphia. These areas of the brain handle facilities with fine motor skills, spatial awareness, and executive functions—all key ingredients to the process of writing (Biotteau, et al. (2019) [17]), (Döhla, et al. (2018) [18]).

Table 1: The neurological and genetic causes of dysgraphia

Serial No	Study Content	Summary of the Study	Reference
1	The Brain Science Behind Dyslexia and related disorders	The sensory and motor inputs needed for handwriting are processed by the parietal lobe. to interfere with handwriting accuracy and fluency, interfere with coordination, and interfere with the connection between the motor cortex and parietal lobe.	Habib. (2021).[19]
2	Developmental Dysgraphia	Motor planning and execution- cerebellum Abnormalities in this region, for example, can	Lopez, et al. (2018). [20]

		cause fine motor control problems that manifest as slow, early labour-intensive handwriting and difficulty keeping strokes smooth and steady.	
3	How Handwriting is Controlled by the Brain as It Develops: A Review	The premotor cortex is responsible for planning and organizing motor sequences, and studies show decreased activation for motor sequences in individuals with dysgraphia. This results in problems starting and maintaining motor tasks like writing	Palmis, et al. (2019). [21]
4	Brain Areas Involved in Spelling Memory and Working Memory	Frontal Lobe helps to coordinate voluntary muscle movements. Because of this atypical activation pattern, the dysgraphia learner struggles to execute complex, overlapping motor actions that underlie fluent handwriting.	Rapp, et al. (2016). [22]
5	Automated Systems for Diagnosing Dysgraphia in Children	Motor Cortex: Coordinates muscle movement involving complex predictive motion. Dysgraphia is associated with atypical activation patterns in this region.	Kunhoth, et al. (2024).[23]
6	The Complex Genetic Basis of Specific Learning Disorders	Familial clustering of dysgraphia indicates an inheritance pattern. Variants within genes such as <i>DYX1C1</i> are associated with impairment of motor sequencing and fine motor control.	(Georgitsi, et al. (2021). [24]
7	Attention and Learning Disorders	Gene-Environment Interaction: Adverse prenatal or perinatal conditions combined with genetic predisposition increase dysgraphia risk.	Wasserstein, et al. (2017).[25]
8	Neuropsychology of Learning Disabilities	Focusing on 21 genes that help with reading and writing, explains that problems with these genes can cause issues in brain development, affecting areas needed for language skills.	Fletcher & Grigorenko. (2017). [26]

Dysgraphia is rooted in neurological dysfunctions involving specific brain regions responsible for fine motor skills, spatial awareness, and cognitive coordination. The parietal lobe, which plays a significant role in integrating sensory and motor information, is particularly significant in handwriting tasks. Studies have proved disrupted connectivity between the parietal lobe and motor cortex in individuals with dysgraphia, impairing their ability to coordinate hand movements and execute smooth writing sequences. These disruptions are compounded by issues in the cerebellum, which is essential for motor planning and execution. Research has shown that cerebellar abnormalities result in slow, labour-intensive handwriting, with individuals often struggling to maintain consistent pressure and fluency (Palmis, et al. (2019). [27]), (Hamdioui, & Vaivre-Douret. (2020).[28]), (Baumann, et al. (2022).[29]). Dysgraphia has a strong genetic component, as evidenced by family and twin studies that show its hereditary nature. Specific genes, such as *DYX1C1*, linked to motor coordination and cognitive skills, are associated with dysgraphia and overlap with other learning disabilities like dyslexia. Dopamine-regulating genes also contribute, affecting fine motor skills and executive function. Environmental factors, such as adverse prenatal conditions, often amplify these genetic predispositions. Dysgraphia frequently co-occurs with conditions like ADHD, suggesting shared genetic pathways. Understanding these genetic contributions helps improve early diagnosis and enables tailored interventions, though further research is needed to explore gene-environment interactions and distinct genetic markers (Zhuravlova. (2018).[30]), (Georgitsi, et al. (2021). [31]), (Cali, et al. (2023).[32]).

4.2 The cognitive and perceptual factors contributing to dysgraphia

Dysgraphia is not just a motor-based disorder; it is also heavily influenced by cognitive and perceptual challenges. These challenges often include problems with working memory, difficulties in visual-motor integration, and impairments in language processing, all of which are crucial for the writing process (Döhla, & Heim. (2016).[33]).

Table 2: The cognitive and perceptual factors contributing to dysgraphia

Serial No	Area & Focus of the Research	The result of the Research	Reference
1	Brain Regions Involved in Spelling Memory and Working Memory in Dysgraphia	Limitations in working memory impede the ability to organize and execute writing tasks. This results in fragmented sentences, poor structure, and frequent omissions. Working memory deficits are compounded by challenges in attention and executive function.	Rapp, et al. (2016). [34]
2	Improving Handwriting Skills in Children with Dysgraphia through Visual and Touch Training	Deficits in visual-motor integration affect handwriting fluency and legibility. Individuals struggle with letter spacing, alignment, and feedback processing, leading to inconsistent writing and reduced self-correction.	Chang, & Yu. (2017). [35]
3	Written Expression Disorder and Dysgraphia: Definition, Diagnosis, and Treatment	Dysgraphia involves phonological, orthographic, and semantic deficits, disrupting sound-to-letter mapping, spelling rule application, and coherent sentence construction.	Chung, et al. (2020). [36]
4	How Perceptual-Motor Skills Training Improves Executive Functions in Students with Dysgraphia	Combined impairments in cognitive and perceptual areas lead to compounded difficulties. Working memory and visual processing issues together result in slow and error-prone writing.	Falahatgar Mutlaq, et al. (2024). [37]
5	Neurobiological Insights into the Difference Between Developmental Dyslexia and Dysgraphia	Dysgraphia and dyslexia share overlapping deficits in phonological and orthographic processing. These shared mechanisms exacerbate writing challenges, particularly when both conditions co-occur.	Vlachos & Avramidis. (2020). [38]
6	Attention Training Affects Academic Performance in Students with Dysgraphia	Dysgraphia is linked with deficits in attention and executive function, leading to difficulties in maintaining focus and organizing complex writing tasks.	Raji, et al. (2024). [39]
7	Impact of Cognitive Rehabilitation on Attention and Response Inhibition in Students with Dysgraphia	Impairments in visual and auditory processing complicate the ability to integrate sensory feedback during writing, leading to reduced fluency and accuracy.	Roshan, et al. (2024). [40]

Dysgraphia is caused by a variety of cognitive and perceptual challenges, with an emphasis on the interaction of working memory, visual-motor integration, and language processing deficiencies. Such deficiencies substantially decrease writing fluency, accuracy, and coherence, which may affect the daily activities as well as overall wellbeing of a human being. Furthermore, the coexisting nature of dysgraphia with other forms of learning disorders, such as dyslexia and ADHD, emphasizes the condition's complexity and the necessity for a thorough diagnostic approach (Lino & Chieffo. (2022). [41]).

4.3 Motor Skills and Handwriting Difficulties

Individuals with dysgraphia encounter major challenges associated with motor skill deficiency diseases as writing requires extensive fine motor coordination, graphomotor skills, and hand-eye coordination. These deficiencies distinguish dysgraphia from other handwriting issues that may result from insufficient training or other external factors such as environmental challenges (Burakevych, et al. (2017). [42]).

Table 3: Motor Skills and Handwriting Difficulties

Serial No	Study Content	Summary of the Study	Reference
1	Differentiating Dysgraphia and General Handwriting Issues	Dysgraphia is a specific learning disability rooted in neurological dysfunction, whereas general handwriting difficulties often result from limited practice or temporary motor delays. Dysgraphia involves persistent, specific motor and cognitive integration deficits.	Orim, et al. (2023). [43]
2	Fine Motor Skills and dysgraphia	Fine motor skill deficits lead to difficulty in controlling pencil grip, maintaining consistent pressure, and executing precise movements, resulting in fatigue and irregular letter formation.	Šafářová, et al. (2021). [44]
3	Graphomotor Skills in children	Impaired graphomotor skills disrupt the integration of cognitive planning and motor execution, leading to slow, fragmented, and error-prone writing patterns. This affects the ability to form letters fluently and maintain consistent spacing.	(Medojević. (2024). [45])
4	Hand-Eye Coordination and dysgraphia	Deficits in hand-eye coordination reduce the ability to align letters with writing lines, maintain uniform letter sizes, and space words correctly. This lack of synchronization between visual input and motor output leads to illegible handwriting.	Ariyo. (2024). [46]
5	Factors Predict Writing Abilities in Adolescents with Dysgraphia.	Dysgraphia is often associated with significantly reduced writing speed due to the time needed to form each letter. This slow pace impacts academic tasks requiring written output under time constraints.	Hen-Herbst & Rosenblum. (2019). [47]
6	Neurological Basis of Motor Deficits	Neurological studies show that disruptions in the motor cortex, cerebellum, and premotor areas contribute to difficulties in motor coordination and planning required for handwriting. These areas exhibit atypical activation patterns in individuals with dysgraphia.	Aiello, et al. (2022). [48]
7	Combined Impact of Cognitive and Motor Deficits	Dysgraphia involves the interaction of motor skill deficits with cognitive challenges, such as working memory and executive function issues, resulting in compounded writing difficulties.	Aiello, et al. (2022). [48]

The readability of handwriting requires a variety of motor abilities. Thus, handwriting difficulties lead to dysgraphia, underlining the intricate interplay of neurological and motor abnormalities. It demonstrates how deficiencies in fine motor skills, graphomotor integration, and hand-eye coordination contribute to illegible and slow writing, which frequently affects scholastic performance and daily duties. The cumulative impact of motor and deficiencies in cognitions, such as working memory and organizational problems, aggravate the condition and make writing tasks substantially more difficult. Understanding these motor-related issues is critical for creating effective diagnostic tools and focused

interventions that address both the neurological and motor elements of dysgraphia (Irie, et al. (2021). [50]).

4.4 Psychological and Behavioural Factors as Reasons for Dysgraphia

Dysgraphia has been associated not only by physical and cognitive deficiencies, but also by severe psychological and behavioural difficulties, particularly in children. Children who live in a poor family environment or face various stressors have poor mental health, which might damage their learning abilities. Genetically predisposed mental problems can also induce dysgraphia (Aremu & Adewunmi. (2023). [51]). These elements often emerge in response to the problems connected with writing, having a substantial impact on individuals' intellectual, emotional, and social development. Understanding these psychological and behavioural elements is critical for offering complete help to people with dysgraphia (Mayes, et al. (2023). [52]).

Table 4: Psychological and Behavioural Factors as Reasons for Dysgraphia

Serial No	Study Content	Summary of the Study	Reference
1	Co-occurrence with ADHD	Dysgraphia often co-occurs with ADHD, where deficits in executive functioning, attention, and self-regulation compound writing difficulties. Inconsistent focus leads to incomplete and poorly organized written work.	Mayes, et al. (2018). [53]
2	Impact of Neurofeedback on Anxiety, Dyslexia, and Dysgraphia	Persistent struggles with writing can result in heightened anxiety, especially during timed tasks or high stakes writing assignments. This often manifests as avoidance, perfectionism, or test anxiety, creating a cycle of frustration and reduced performance.	Jafari Nodoushan, et al. (2022). [54]
3	Emotional Impact and Handwriting quality.	Dysgraphia significantly affects self-esteem, with individuals feeling embarrassed or inadequate due to their inability to meet academic or social expectations. This can lead to feelings of isolation and reluctance to participate in group activities.	Hen-Herbst & Rosenblum. (2022). [55]
4	Behavioural Responses	Responses to writing challenges vary, including disruptive Behaviour to divert attention from their struggles, withdrawal from tasks, or reliance on verbal expression or memorization to compensate for writing deficits.	Sarvarian, et al. (2023). [56]
5	Social Implications	The inability to keep up with peers in written tasks can lead to social withdrawal or feelings of being misunderstood. Difficulty expressing oneself in writing often results in missed opportunities for social engagement.	Kalenjuk, et al. (2022). [57]
6	Academic Stress and Burnout: Educators' Perspectives on Dysgraphia	Repeated academic struggles, especially in writing-heavy subjects, contribute to academic burnout. The effort required to complete writing tasks often leaves individuals mentally and physically exhausted.	Kalenjuk, et al. (2024). [58]
7	Role of Support Systems	Support systems that provide accommodations, such as extended time or	Attoor & Nadu. (2024). [59]

		alternative formats, help alleviate stress and build confidence. Encouragement from teachers, parents, and peers fosters resilience.	
8	Long-Term Psychological Effects: Assessment and Tailored Intervention Strategies from a Psycholinguistic Perspective	Prolonged writing difficulties, if left unaddressed, can lead to chronic feelings of inadequacy, low self-worth, and avoidance of professional or academic pursuits requiring written communication.	Shevchenko, et al. (2024). [60]

The psychological and behavioural factors play a significant role in the development and recurrence of dysgraphia. It emphasizes how anxiety, stress, low self-esteem, and other mental habits can form a psychological barrier to effective writing, compounding the motor and cognitive difficulties inherent in dysgraphia. These issues often result in behaviours of avoidance, decreased motivation, and social retreat, all of which affect the practice and improvement of writing abilities (Abed, et al. (2023). [61]). Attention problems and executive functioning concerns, especially when combined with co-occurring illnesses such as ADHD, intensify the difficulties that dysgraphia patients encounter. The inability to organize thoughts, focus on activities, and self-monitor writing complicates the situation even further. Furthermore, environmental constraints and a lack of adequate support systems can worsen emotional and behavioural difficulties, resulting in a cycle of frustration and failure. Recognizing the psychological impact of the condition and applying techniques such as counselling, positive reinforcement, and personalized accommodations can help to boost confidence and reduce anxiousness. This integrative approach guarantees that interventions extend beyond the technical components of writing to promote emotional resilience and a positive learning experience (Choirunnisa, et al. (2024). [62]).

4.5 Environmental and Educational Factors as causes of dysgraphia.

Environmental and educational variables can also influence the onset or persistence of dysgraphia. These factors, while not direct causes, have a considerable impact on how writing abilities are learned and reinforced during important developmental times. Early learning contexts, instructional quality, and availability to resources all influence a child's capacity to develop writing competency. Furthermore, societal and cultural standards, financial realities, and classroom dynamics can all worsen writing challenges, particularly for people who are already vulnerable.

Table 5: Environmental and Educational Factors as causes of dysgraphia.

Serial No	Study Content	Summary of the Study	Reference
1	Early Childhood Learning Environment	Limited exposure to writing activities and lack of quality resources during early childhood can delay the development of fine motor and graphomotor skills.	Klim-Klimaszewska & Nazaruk. (2018). [63]
2	Inconsistent or Ineffective Instruction: indicators of Dysgraphia and Dyslexia	Traditional or rigid teaching methods, insufficient emphasis on handwriting, and lack of individualized support can hinder writing skill development.	Baggett, et al. (2024). [64]
3	Socioeconomic Status	Low-income families often face barriers to accessing specialized support, such as occupational therapy or individualized educational plans, impacting writing skills.	Sheymardanov, et al. (2020). [65]

4	Cultural Attitudes Toward Literacy: Exploring Teachers' Perceptions of Supporting Learners	Societal and cultural norms, such as the complexity of writing systems or high literacy expectations, can increase writing demands and exacerbate difficulties.	Tebele & Chaka. (2024). [66]
5	Overemphasis on Academic Performance	High-pressure environments that prioritize academic achievement can lead to anxiety, avoidance Behaviours, and reduced writing practice.	Gergő. (2024). [67]
6	Lack of Awareness and Support in Schools: Social and Academic Factors	Insufficient teacher training, delayed identification of writing difficulties, and limited resources in schools contribute to the persistence of dysgraphia.	Sianga, et al. (2024). [68]
7	Peer and Social Influences	Comparisons with peers can lower confidence, while social isolation from avoiding writing tasks can exacerbate emotional and behavioural difficulties.	Rajesh, et al. (2023). [69]

Inadequate early childhood education circumstances, insufficient handwriting training, and a shortage or absences of resources can hinder the development of elementary writing skills (Kapamba & Mwanza. (2024). [70]). Moreover, cultural attitudes toward literacy, economical restraints, and atmosphere in the classroom, related to teachers' attention, motivation also to a person's ability to develop and refine writing skills. These forces often interplay with psychological and neurological weaknesses, worsening the difficulties that dysgraphia patients experience. Early identification, teacher training, and equal access to resources are all critical. Addressing these variables through focused treatments and supportive environments can help lessen their impact, ensuring that people with dysgraphia have the resources and encouragement they need to flourish academically and socially.

4.6 Comorbidities and Related Disorders

Dysgraphia is frequently can see as linked to other neurodevelopmental disorders and psychiatric conditions that exhibit similar cognitive, motor, or behavioural characteristics in students. These comorbidities, include dyslexia – difficulty in reading, ADHD, and developmental coordination deficit, not only complicate but also increase dysgraphia's symptoms (Velichenkova. (2024). [71]). Motor impairments in developmental coordination disorder or executive function deficits in ADHD, for example, may exacerbate the already difficult issues of writing fluency, legibility, and coherence (Ashraf & Najam. (2020). [72]).

Table 6: Comorbidities and Related Disorders.

Serial No	Study Content	Summary of the Study	Reference
1	Dyslexia	Dysgraphia and dyslexia share deficits in phonological processing and orthographic awareness. Dyslexia primarily affect reading, while dysgraphia impacts writing fluency and coherence. Interventions often need to target both reading and writing skills.	Iyer, et al. (2023). [73]
2	Developmental Coordination Disorder (DCD)	DCD involves fine motor impairments that exacerbate the motor aspects of dysgraphia, including grip strength, letter formation, and graphomotor execution. Occupational therapy is often recommended to address these overlapping issues.	Lopez, et al. (2017). [74]

3	Attention-Deficit/Hyperactivity Disorder (ADHD)	ADHD symptoms, such as inattention, impulsivity, and executive function deficits, compound writing difficulties. Challenges include task organization, planning, and maintaining focus during extended writing tasks.	Puyjarinet, et al. (2023). [75]
4	Autism Spectrum Disorder (ASD)	Handwriting difficulties in ASD stem from motor planning deficits, sensory sensitivities, and executive functioning challenges, which overlap with dysgraphia symptoms. Sensory-motor therapies can benefit individuals with both conditions.	Intriago, et al. (2021). [76]
5	Anxiety Disorders	Anxiety can be both a cause and consequence of dysgraphia. Performance anxiety, avoidance Behaviours, and cognitive overload exacerbate writing difficulties, creating a cycle of frustration and reduced practice.	Hamdioui, & Vaivre-Douret. (2021). [77]
6	Dyscalculia and Nonverbal Learning Disabilities (NVLD)	Dysgraphia overlaps with spatial reasoning and visual-spatial deficits seen in dyscalculia and NVLD. These challenges affect handwriting alignment, letter placement, and numerical organization in written tasks.	Muktamath, et al. (2022). [78]

The multidimensional nature of dysgraphia is demonstrated by its frequent comorbidity with other diseases such as dyslexia, ADHD, developmental coordination problem, and anxiety. These comorbidities not only share overlapping symptoms, but they also exacerbate the difficulties that dysgraphia patients confront, affecting their academic, social, and emotional health (Asselborn, et al. (2020). [79]) (Asselborn, et al. (2020). [80]). The occurrence of associated diseases emphasizes the importance of complete evaluations that go beyond detecting individual writing issues (Mekyska, et al. (2023). [81]). To deliver successful assistance, interventions must address the specific needs of these overlapping diseases, combining tactics for physical, cognitive, and emotional difficulties. A multidisciplinary approach is necessary.

5. CURRENT STATUS & NEW RELATED ISSUES:

Handwriting has long been an important part of early childhood education, helping with motor skill development, cognitive organization, and self-expression. However, the COVID-19 pandemic and subsequent reliance on digital tools have reduced the emphasis on handwriting teaching, making it more difficult to detect dysgraphia early and restricting possibilities for children to develop important writing skills. This transition has underlined the importance of balancing conventional handwriting instruction and technology integration to achieve holistic learning (Rishitha & Subramanian. (2022). [82]) (Ghanamah, et al. (2024). [83]).

Dysgraphia poses significant challenges across academic, social, and professional domains, further complicated by the increased use of digital devices, which hinders early identification, especially in children (Golzar Aziz, et al. (2024). [84]). Undiagnosed cases in adults often lead to difficulties at work and psychological effects like anxiety, low self-esteem, and depression, compounded by common comorbidities such as ADHD, dyslexia, and developmental coordination disorder. Addressing these challenges requires standardized diagnostic tools, balanced educational strategies, longitudinal research, and equitable access to interventions (Rokade, et al. (2024). [85]).

The psychological toll of dysgraphia, including anxiety, low self-esteem, and depression, intensifies its challenges, further exacerbated by comorbidities such as ADHD, dyslexia, and developmental coordination disorder. Addressing these difficulties requires prioritizing standardized diagnostic tools, balanced educational strategies, longitudinal research, and equitable access to interventions. A multidisciplinary approach is essential to mitigate both immediate and long-term effects, fostering improved academic, social, and professional outcomes for individuals with dysgraphia.

6. IDEAL SOLUTION, DESIRED STATUS & REQUIRED IMPROVEMENTS:

An ideal solution for dysgraphia requires a comprehensive and multidisciplinary approach that addresses its neurological, cognitive, motor, and psychological aspects. Early identification is critical, supported by standardized diagnostic tools that ensure accurate and timely assessment across all age groups (Shevchenko, et al. (2024). [86]). These tools should integrate technology, such as AI-based assessments and neuroimaging, to enhance diagnostic precision. Interventions should focus on multisensory strategies that combine visual, auditory, kinaesthetic, and tactile methods to improve motor coordination and writing fluency Bhandari, et al. (2024). [87].

The ideal dysgraphia management strategy anticipates a future in which people can achieve academically, socially, and professionally without encountering additional obstacles. Early and precise identification during childhood should become standard practice, allowing for tailored interventions that address unique requirements. It is vital to ensure fair access to high-quality resources and services, regardless of socioeconomic position (Kaushik. (2024). [88])

To effectively serve students, schools should implement evidence-based teaching strategies that combine handwriting instruction with digital resources, as well as comprehensive educator and administrative training. Normalizing accommodations like extra time, alternate formats, and assistive technologies is critical for creating inclusive learning and working environments. Given the increasing influence of technology on learning patterns and abilities, continuous study and adaptation of intervention strategies are crucial. Longitudinal research is necessary to understand dysgraphia's progression over the lifespan and to refine support strategies, particularly for adults (Ceccacci, et al. (2024). [89]).

As the prevalence of dysgraphia rises, schools must proactively develop and implement comprehensive intervention plans aligned with the curriculum to support students in need effectively (Lafitte, et al. (2025). [90]).

Achieving the ideal solution and desired status for dysgraphia requires a concerted effort across educational, medical, and technological fields. By prioritizing early diagnosis, fair access to resources, and a balance between traditional and digital methods, individuals with dysgraphia can overcome challenges and reach their full potential (Lomurno, et al. (2023). [91]).

7. RESEARCH GAP:

Dysgraphia, a specific learning disability, has a substantial impact on writing efficiency and coherence, yet it remains underdiagnosed and poorly recognized. Present study identifies limitations in diagnostic tools and intervention strategies, limiting the ability to successfully treat this illness. While advances in neuroscience have given new insight into the brain correlates of dysgraphia, there is still no universally accepted diagnostic approach. This diversity leads to inconsistencies in recognizing and managing dysgraphia, leaving many people without sufficient support (Aiswarya & Joseph Ponniah. (2024). [92]). Cognitive mechanisms including working memory deficits are strongly linked to handwriting difficulties in individuals with dysgraphia. However, the exact pathways connecting these deficits to poor writing performance remain unclear. Vanjari & Shete (2025) emphasized the need for further research into these cognitive impairments, as targeted interventions may yield significant improvements in writing fluency and motor coordination. Additionally, the lack of attention to dysgraphia in adults represents a major gap in the literature. Adults often face challenges in professional and personal contexts due to undiagnosed dysgraphia, yet research and support remain primarily focused on children (Vanjari & Shete. (2025). [93]) (Wissell, et al. (2025). [94]).

Another issue to consider is the effect of cultural and linguistic variation in the presentation of dysgraphia. Dysgraphia can present differently depending on the complexity of a language's orthography, but these factors are understudied (Boukrina, et al. (2025). [95]). Almaghlouth and colleagues (2025) noted that cultural differences in handwriting instruction can influence how the issue is identified and addressed (Almaghlouth, et al. (2025). [96]). Furthermore, while digital tools have given useful accommodations for dysgraphia, excessive dependence on them, particularly during the COVID-19 pandemic, may have hampered the development of fine motor skills required for handwriting (Nwikpo. (2024). [97]).

Integrated intervention strategies for dysgraphia remain a significant challenge, as current treatments often focus on isolated aspects like motor coordination or cognitive function, neglecting its

multifactorial nature. This highlights the need for multidisciplinary approaches that integrate educational, therapeutic, and technological solutions. The lack of longitudinal studies further limits understanding of how dysgraphia evolves across the lifespan and the long-term effectiveness of interventions (Truxius, et al. (2025). [98]). Future research must prioritize standardized diagnostic criteria, culturally sensitive assessments, and adaptive tools for early and accurate identification (DeBono, et al. (2025). [99]). Additionally, holistic approaches to treatment, as emphasized by Ziyen & Kadri (2025), are essential for addressing the academic, emotional, and social challenges faced by individuals with dysgraphia, ensuring effective and sustained support (Ziyen & Kadri. (2025). [100]).

8. RESEARCH AGENDA:

1. Evaluate the incidence of dysgraphia and how technology has affected the current situation.
2. Investigate the cognitive and neurological mechanisms that contribute to dysgraphia and its relationship with other conditions.
3. Evaluate the long-term and short-term effects of dysgraphia on academic, professional, and personal aspects.
4. Create and evaluate interdisciplinary and integrated intervention programs to treat the underlying causes of dysgraphia.
5. Evaluate how digital technologies can help with dysgraphia and their impact on the signs and symptoms.
6. Identify diagnostic and intervention barriers and develop cost-effective dysgraphia solutions.
7. Develop an integrated assessment tool for dysgraphia

9. ANALYSIS OF RESEARCH AGENDAS:

The selected research agendas address critical gaps in dysgraphia by focusing on its prevalence in the current scenario, underlying mechanisms, and effects on academic, professional, and personal domains. Evaluating the prevalence of dysgraphia and the impact of digital technology sheds light on how modern educational tools reshape handwriting practices, particularly after COVID-19. Researching on the cognitive and neurological systems sheds light on the underlying causes and comorbidities, such as ADHD and dyslexia, facilitating more comprehensive intervention techniques. Assessing the long- and short-term effects of dysgraphia underscores its multifaceted nature and the importance of lifetime assistance. The development of interdisciplinary and integrated intervention programs addresses its multifaceted nature by combining educational, therapeutic, and technical approaches, whilst evaluating digital tools investigates their role in symptom management and skill development. Addressing barriers to diagnosis and intervention provides equitable and cost-effective solutions, especially in underprivileged areas. Finally, creating an integrated evaluation tool would simplify the diagnostic process by encouraging early and accurate detection. While these agendas are extensive, accomplishing their objectives requires combining technological reliance with conventional handwriting practice, prioritizing equity and accessibility, and performing longitudinal research to assure long-term effects for people with dysgraphia.

10. RESEARCH TOPIC:

"Developing Integrated Assessment Tools for Dysgraphia: Addressing Multifactorial Barriers"

11. THE RESEARCH PROPOSAL'S ABCD ANALYSIS:

ABCD analysis is a strong method with a high degree of subjectivity developed by P. S. Aithal et al. in 2015 that may be used to evaluate a wide range of models and procedures. ABCD refers to Advantages, Benefits, Constraints, and Disadvantages. It is a straightforward and scientific method for examining diverse models along with systems (Aithal, et al. (2015).[101]), (Aithal, et al. (2016).[102]), (Aithal, et al. (2015).[103]).

Advantage: The study offers a revolutionary approach to diagnosing dysgraphia by incorporating neurological, cognitive, motor, and psychological dimensions into a standardized and flexible framework. It enhances early detection, fosters tailored interventions, and ensures cultural and linguistic relevance. By leveraging advanced technology and promoting multidisciplinary collaboration, the study addresses diagnostic inconsistencies and barriers, particularly in underserved communities. Its focus on

cost-effective and globally scalable solutions not only improves accessibility but also reduces stigma, paving the way for equitable and effective support for individuals with dysgraphia worldwide.

Benefits: The current study enhances dysgraphia diagnosis by combining symptoms into a comprehensive framework. It ensures that actions are customized to meet the needs of diversified populations. Using sophisticated technologies such as AI, the study contributes to diagnostic accuracy while being cost-effective and accessible to marginalized regions. It tackles inequities, removes stigma, and lays the way for internationally scalable solutions that help people with dysgraphia in academic, social, and emotional domains by encouraging multidisciplinary collaboration and inclusion.

Constraints: Accessibility barriers, such as cost and technology constraints in low-resource regions, compound its limitations. Furthermore, the instrument requires substantial training for educators and therapists, and its use of new technologies raises concerns about privacy and overreliance on digital procedures. Time-consuming development limits longitudinal data collection, and stakeholder resistance hinders implementation. Addressing these limitations is crucial for ensuring the tool's effectiveness and global accessibility (Mekyska, et al. (2024). [104]).

Disadvantages: Its complex design requires significant time, funding, and specialized training, which may limit accessibility, especially in low-resource settings. The reliance on advanced technologies raises concerns about affordability, privacy, and overdependence on digital methods. Adapting the tool for diverse cultural and linguistic contexts adds further challenges. Ethical issues, the risk of misinterpretation, and resistance from institutions due to perceived costs or complexity also hinder implementation. Additionally, the focus on diagnosis might overshadow efforts to develop effective interventions. Addressing these issues is crucial for the tool's success and broad adoption (Bhushan, et al. (2024). [105]).

12. SUGGESTIONS TO IMPLEMENT RESEARCH ACTIVITIES:

We need to approach the study from a multidimensional perspective. This multidisciplinary approach ensures that the tool addresses all aspects of dysgraphia in detail. Pilot testing in several scenarios is essential for fine-tuning the tool based on real-world feedback, resulting in improved accuracy and adaptability. Cost-effective design is critical to ensuring accessibility, particularly in low-income regions. Combining sophisticated technologies such as AI with traditional methods allows for a balance of innovation and affordability. Structured training programs for educators and clinicians will assure the tool's proper usage and interpretation, lowering the chance of misdiagnosis. The tool will become globally relevant through validation studies conducted in several cultural and language contexts. To assess its impact on intervention results and long-term efficacy, longitudinal research is also required. Protecting sensitive data requires a high priority on ethical procedures and privacy protections, particularly when using AI or neuroimaging (Tushar, et al. (2024). [106]) (Marino, et al. (2024). [107]). Securing funds and support for execution requires active engagement with institutions and policymakers. Adoption in clinics and schools can be boosted by showcasing the tool's advantages and cost-effectiveness. Increasing public knowledge of dysgraphia and the value of early diagnosis will help ensure that the instrument is widely accepted and used (Aremu & Lawal. (2024). [108]).

Through validation tests carried out in various linguistic and cultural situations, the instrument will gain global relevance. Additionally, longitudinal research is needed to evaluate its effect on intervention outcomes and long-term efficacy. Particularly when employing AI or neuroimaging, protecting sensitive data necessitates giving ethical practices and privacy concerns top emphasis (Rokade, et al. (2024). [109]).

13. LIMITATIONS OF THE STUDY:

An integrating cognitive, motor, neurological, and psychological factors into a single tool is complex and resource-intensive, requiring significant time and effort. Adapting the tool for diverse cultural, linguistic, and educational contexts adds further challenges, demanding extensive validation studies for global applicability.

The reliance on advanced technologies like AI and neuroimaging limits accessibility in low-resource settings, while the need for specialized training for educators and clinicians may hinder widespread adoption. Ethical concerns around data privacy and security, especially for children, pose additional challenges. Moreover, the tool's focus on diagnosis may overshadow the equally critical need for effective intervention strategies (Subbey, et al. (2022). [110]) (Alzahrani & Algahtani. (2025). [111]). Financial constraints and resistance from institutions or policymakers due to perceived complexity or costs could further delay implementation. Addressing these limitations through iterative refinement, stakeholder collaboration, and cost-effective design is essential to ensure the tool's success and widespread adoption (Rosenblum, et al. (2004). [112]).

14. CONCLUSIONS:

Dysgraphia is a category of learning impairment that results in problems with writing, including problems with spelling, organizing ideas on paper, and unreadable handwriting. A neurological disorder that affects the ability to express oneself in writing is how it is described. A comprehensive picture of the complex nature of dysgraphia is provided by this study, which provides a thorough grasp of the neurological, cognitive, motor, psychological, and environmental components that contribute to the condition. To properly address the difficulties caused by dysgraphia, the results emphasize the need for early detection, standardized diagnostic instruments, and integrated therapeutic techniques.

The study highlights the importance of a multidisciplinary approach that combines traditional handwriting training with advanced technologies like artificial intelligence and neuroimaging. This integration can enhance diagnostic accuracy, promote tailored interventions, and ensure accessibility for marginalized communities. It also identifies critical gaps, such as the lack of culturally sensitive methods, limited focus on adult dysgraphia, and the need for longitudinal research to assess long-term outcomes. The study stresses the importance of resource equity, comprehensive teacher training, and increased public awareness while providing a roadmap for further research and practical solutions. With sustained efforts to address these challenges, individuals with dysgraphia can achieve greater academic, social, and professional success in a more inclusive and supportive environment.

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