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Using the Cattell-Horn-Carroll (CHC) Model in Educational Therapy to identify and support a Primary School Learner with Dysgraphia: A Case Study Approach

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Abstract

This paper explores how the Cattell-Horn-Carroll (CHC) theory of cognitive abilities can be applied to understand and support a Primary 4 student with dysgraphia. Through a case study conducted at Merlion Pediatric Clinic, the student's cognitive profile was assessed using the WISC-V and interpreted through the CHC framework. The findings revealed a distinct pattern of strengths in verbal comprehension and fluid reasoning, alongside weaknesses in processing speed and working memory, which is consistent with common features of dysgraphia. Educational therapy strategies were then developed to align with these cognitive domains and were implemented across both home and school settings. This approach demonstrates how individualized, CHC-informed interventions can improve access to learning, reduce writing-related stress, and promote meaningful participation in the classroom. All personal identifiers have been removed in accordance with the Personal Data Protection Act 2012 (with Amendments in 2020).

Keywords: *Cattell-Horn-Carroll (CHC) Theory, Cognitive Abilities, Dysgraphia, Educational Therapy, Learning disorder, Inclusive Education*

1. Introduction

Writing is a fundamental skill that enables children to express thoughts, acquire knowledge, and communicate emotions. When children struggle with written expression, it can disrupt their academic progress and also affect their confidence and limit future educational and career opportunities (Chung et al., 2020). Studies show that around 10% of students in Grades 3 and 4 encounter difficulties with writing speed and legibility, making it hard for them to complete assignments on time (Högemann et al., 2021).

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One condition that contributes to these challenges is dysgraphia: a neurological learning disorder that affects the ability to translate thoughts into written language (National Institute of Neurological Disorders and Stroke, 2023). Dysgraphia is estimated to affect about 10% of children (Kunhoth, Al-Maadeed, Kunhoth, Akbari, & Saleh, 2024). However, more recent research suggests that the prevalence may be higher. A study involving children aged 7-12 years found that approximately 27% met the criteria for dysgraphia, with boys being more commonly affected than girls (Abed, 2024).

Dysgraphia is considered a transcription-related disorder, meaning it affects the physical act of writing. It often involves difficulties with motor coordination, especially in controlling fine motor movements like finger sequencing, as well as challenges with orthographic coding - remembering and producing correct letter patterns (Berninger, 2009). These underlying issues can make a capable child seem as if they are underachieving when in fact their cognitive abilities remain intact.

Unfortunately, dysgraphia and related learning disorders is often overlooked or misinterpreted, particularly when signs are mistaken for general academic weakness or behavioral issues. Without timely educational intervention, children may face unnecessary academic struggles and social setbacks (Baggett, Diamond, & Olszewski, 2023).

2. Medical and Non-medical Aspects of Dysgraphia

Being a a neurological disorder that affects writing abilities, dysgraphia involves difficulties with spelling (as well as transcribing), handwriting (or penmanship), and organizing thoughts (relevant to executive functioning) on paper. The disorder has both medical and non-medical aspects, and it is crucial for educational therapists to be able to distinguish for comprehensive understanding and providing appropriate support.

2.1 Medical Aspects of Dysgraphia

The author of the paper has identified the following medical aspects of dysgraphia:

1. Neurological basis: Stemmed from neurological dysfunction (Rapp et al., 2016) in those cortical areas of the brain responsible for language processing, motor control, and working memory, dysgraphia is often associated with developmental disorders such as ADHD or dyslexia.
2. *Motor control impairment:* In dysgraphia, fine motor skills are often underdeveloped, affecting pencil grip, pressure control, and hand coordination (Deuel, 1995). In addition, the condition also leads to slow, inconsistent, or illegible handwriting.
3. *Cognitive processing deficits:* Children with dysgraphia often face executive functioning challenges, especially in planning, organizing, and sequencing of information (Döhla, Willmes, & Heim, 2018). As a result, they find difficulty in translating their thoughts into written words efficiently.
4. *Comorbid conditions:* Morevoer, dysgraphia also commonly co-occurs with other disorders, e.g., ADHD (i.e., attention and impulsivity issues; Adi-Japha et al., 2007); autism (Mayes et al., 2019); dyslexia (i.e., reading and spelling difficulties; Döhla, & Heim, 2016; also known as dyslexic dysgraphia; see Pierangelo & Giuliani, 2007, for detail); motor skills disorder or dyspraxia (Deuel, 1995); and language disorders with serious problems with grammar, syntax, or vocabulary (Berninger, Richards, & Abbott, 2015).

2.2 Diagnostic Tools to Identify Dysgraphia

It is necessary to conduct neuropsychological evaluations to assess writing ability, motor coordination, and language processing. One good screener is the Quick Neurological Screening Test-3rd Edition-revised (QNST-3R; Mutti et al., 2017) that educational therapists can administer to find out about the challenges encountered by a child suspected with dysgraphia. Often the condition is diagnosed by psychologists, neurologists, or allied therapists such as occupational therapists and educational therapists.

2.3 Non-Medical Aspects of Dysgraphia

In addition, this author having previously worked with children with dysgraphia has identified the following non-medical aspects of dysgraphia as follows:

1. Educational challenges: Children with dysgraphia often struggles in completing written assignments, taking down notes, or expressing their knowledge on tests. As a result, these academic struggles may lead them to lower academic performance unrelated to actual intelligence.
2. *Emotional and social impact:* These include frustration, low self-esteem, and anxiety due to frequent struggles and comparison with peers for most, if not all, children with dysgraphia (Ponce & Escobar, 2022). It may result in possible serious social withdrawal (that might also cause academic anxiety disorder) or even strong reluctance to participate in class activities.
3. *Behavioral reactions:* Children with dysgraphia often choose to avoid writing tasks (Gargot et al., 2021). Teachers and parents may misinterpret such behavior as being lazy or defiant.
4. *Accommodations and support:* There are ways that educational therapists as well as teachers can tap on to support those children with dysgraphia in school. For example, the application of assistive technology (e.g., keyboards, and speech-to-text gadgets; Rahim, Mokmin, & Wang, 2025). In addition, special acess arrangment can be provided to give these children with dysgraphia, e.g., extra time on tests, alternative assessments, or reduced writing load. Occupational therapy and specialized instruction can also be provided to aid these children in their learning.
5. *Parental and teacher awareness:* It is sad to note that there remains a lack of awareness among parents and teachers about dysgraphia and this may delay diagnosis or effective intervention (see Kalenjuk et al., 2022, for detail). Early identification and tailored teaching strategies can significantly improve learning outcomes for children with dysgraphia (Tebele & Chaka, 2024).

3. The Cattell-Horn-Carroll Model as an Explanatory Framework

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The intersection of cognitive abilities and writing difficulties presents a complex field educational therapists seeking to understand and address dysgraphia. To unpack the cognitive roots of dysgraphia, educational therapists can turn to the Cattell-Horn-Carroll (CHC) theory of intelligence, which looks at human cognitive abilities. The psychological theory integrates works by Cattell and Horn' fluid (Gf) and crystallized (Gc) abilities with Carroll's three-stratum hierarchy (Carroll, 1993; Horn & Blankson, 2005; McGrew, 2005). The model allows Educational Therapists (EdTx) to look beyond surface-level academic challenges and identify the cognitive patterns that underlie learning difficulties. In this model, there are three strata listed as follows:

- ✧ Stratum I comprises narrow, task-specific skills (e.g., letter-pattern recall).
- ✧ Stratum II groups broad domains, such as Verbal Comprehension (Gc), Visual-Spatial Processing (Gv), Fluid Reasoning (Gf), Long-Term Retrieval (Glr), Working Memory (Gwm), and Processing Speed (Gs), that directly map onto the mental processes required for writing (Schneider & McGrew, 2012).
- ✧ Stratum III represents general intelligence ("g"), a higher-order factor whose necessity remains debated (Carroll, 2003; Horn & Noll, 1997)

By aligning cognitive assessment tools such as WISC-V (Wechsler, 2014) and Woodcock-Johnson IV (Schrank, McGrew, & Mather, 2014) with these strata, educational therapists can identify the specific cognitive processes behind a child's writing challenges, With this clear profile in hand, therapists can craft interventions that directly address each learners unique mix of strengths and needs (Flanagan, Fiorello, & Ortiz, 2010).

3.1 Linking CHC Cognitive Abilities to Dysgraphia

The Cattell-Horn-Carroll (CHC) theory provides educational therapists with a useful lens for examining the cognitive processes that influence writing development and contribute to dysgraphia. Rather than relying on diagnostic labels, the CHC model emphasises a child's cognitive profile, allowing therapists to pinpoint specific strengths and weaknesses that shape how writing difficulties emerge (Flanagan, Alfonso, & Mascolo, 2011; Schneider & McGrew, 2012).

For instance, research has shown that in the early years of schooling, Learning Efficiency (Gl) has a stronger impact on writing ability. As children progress beyond Grade 4, this influence begins to taper off, and Crystallized Ability (Gc), which includes vocabulary knowledge and verbal reasoning, becomes a more significant predictor of writing success (Hajovsky et al., 2018). This developmental shift is important for educational therapists to understand that writing skills evolve with age.

One of cognitive challenges among children with dysgraphia is reduced Processing Speed (Gs). These children often write slowly, with handwriting that appears labored or inconsistent. To support them, educational therapists can recommend tools such as pencil grips, slant boards, or raised-line paper. As mentioned earlier, extended time during writing tasks (recommended via access arrangement) can also reduce performance anxiety and help with written output (Chung, Patel, & Nizami, 2020). For children who continue to struggle with handwriting, structured keyboarding programs, e.g., *Touch Type Read and Spell* (TTRS) or *Typing.com*, can offer a multisensory approach that improves both spelling and fluency. These platforms have been shown to boost confidence and typing ability of children with dysgraphia (Aremu & Adewunmi, 2023).

Children with dysgraphia also display weaknesses in Working Memory (Gsm). They may find it hard to plan, hold, and organize their thoughts while writing. Such children can benefit from scaffolding strategies that reduce cognitive load. Educational therapists can break writing tasks into smaller, manageable steps and use tools such as sentence starters, graphic organizers, and checklists to guide the sequencing of ideas (New York State Dyslexia and Dysgraphia Task Force, 2024).

When a child with dysgraphia shows difficulty with Long-Term Retrieval (Glr) - the ability to access stored information such as vocabulary or spelling patterns - educational therapists can introduce repeated practice using word banks, personal dictionaries, and spelling folders. These strategies help strengthen connections to language and support more fluent writing (Van Doren, 2018).

Some children with dysgraphia may also present challenges in *Visual Processing* (Gv) or fine motor coordination. This can affect how they form letters and manage spatial organization on the page. Tactile aids, e.g., handwriting guides, slant boards, or raised-line worksheets, can improve the physical layout of their writing and make tasks more accessible (Chung, Patel, & Nizami, 2020). This can be supplemented with haptic training on graphomotor skills to learn the direction of letter formation (Rizzo et al., 2024). In addition, software like Write-Rite (Rahim & Jamaludin, 2019) has been developed to support children with dysgraphia through targeted activities that strengthen visual-spatial skills related to letter formation, slant, size, proportion, alignment, spacing, and line quality.

At the same time, many children with dysgraphia have well-developed Verbal Comprehension (Gc). They are often articulate speakers but struggle to express those same ideas in writing. Educational therapists can use this strength by encouraging oral rehearsal, dictation, and voice recordings as pre-writing strategies. Where appropriate, oral assessments or storytelling can also be used as alternatives to written output (Flanagan, Fiorello, & Ortiz, 2010).

Berninger (2009) has emphasized the importance of deciding early whether a child with dysgraphia should continue to build handwriting skills or shift to keyboarding as a primary mode of expression. While handwriting can support motor development, keyboarding often provides a more efficient and less frustrating path for students with persistent transcription difficulties. However, Berninger & Wolf (2009) also recommends that all school-age children with dysgraphia should learn to read as well as write in cursive handwriting, as it remains common in classroom materials despite the shift toward digital learning. One excellent program is the intervention program - *A Hand for Spelling* (Cripps, 1998; also see Cripps & Cox, 1987).

By integrating CHC-informed strategies into classroom instruction, therapists can enhance the effectiveness of differentiated instruction, which is a model that adapts the content, process, and product of learning to meet diverse needs (Tomlinson, 2014). For instance, students might access reading materials through audiobooks (content), process information through visual or tactile activities (process), and express understanding through oral presentations or digital formats (product). When these teaching

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strategies are tailored to a learner's cognitive profile, they not only improve academic outcomes but also foster self-esteem and emotional well-being (Abu-Hamour & Al Hmouz, 2018).

4. A Case Study: Rationale and Purpose

While the CHC theory is widely used in cognitive assessment, its application in everyday classroom support for students with dysgraphia remains under explored. This case study addresses that gap by examining Ethan[1], a nine-year-old student with ongoing handwriting difficulties (also known as cacographia) despite receiving standard accommodations. Using a CHC-aligned assessment, his cognitive strengths and challenges in processing speed, working memory, and verbal comprehension were identified. Tailored interventions were then developed to address the underlying causes of his writing difficulties. This study demonstrates how linking CHC abilities of learners with dysgraphia to educational therapy approaches can potentially enhance both academic outcomes and student confidence.

4.1 The Case Profile of Ethan

Ethan[2], a 9-year-old Primary 4 student in a mainstream public school, was referred to a pediatric therapy clinic, where this author is working, for a psychoeducational assessment and educational therapy due to ongoing difficulties with handwriting, spelling, and written expression. His class teachers described him as bright, expressive and socially integrated boy. He actively contributes to class discussions and demonstrates strong oral language However, both his parents and teachers noted that his written work falls well below age expectations. Ethan writes slowly and the handwritten work is difficult to read. He avoids writing unless supported and performs better in oral tasks than written ones. Despite receiving weekly occupational therapy for fine motor support, he is has not shown much improvement.

4.2 Method and Materials

Ethan was assessed using the Wechsler Intelligence Scale for Children-5th Edition (WISC-V; Wechsler, 2014), administered by a licensed educational psychologist trained in psychoeducational evaluation. The WISC-V is a standardized cognitive assessment tool that aligns with the Cattell-Horn-Carroll (CHC) Theory of Cognitive Abilities, making it a suitable instrument for identifying key cognitive strengths and weaknesses relevant to educational therapy.

Assessment results were shared with the educational therapist at the pediatric therapy clinic to inform individualized intervention planning. Ethan's cognitive profile was examined across five key CHC domains: *Verbal Comprehension* (Gc), *Visual-Spatial Processing* (Gv), *Fluid Reasoning* (Gf), *Working Memory* (Gwm), and *Processing Speed* (Gs). To gain a holistic understanding of his learning profile, these findings were supplemented by qualitative data which include parent and teacher interviews, classroom observations, and samples of his written work.

By interpreting Ethan's results through the CHC framework, the educational therapist was able to pinpoint the cognitive processes contributing to his writing difficulties. This integrative method supports the development of targeted educational therapy strategies and is grounded in current research and best practices (Flanagan, Alfonso, & Mascolo, 2011; Schneider & McGrew, 2012; New York State Dyslexia and Dysgraphia Task Force, 2024).

4.3 Results and Discussion

Ethan's cognitive profile demonstrates a distinct pattern of strengths and challenges (see Table 1). He shows superior ability in Verbal Comprehension (Gc/VCI=120), reflecting well-developed vocabulary and strong oral reasoning skills. This is consistent with classroom observations, where he is able to verbally express ideas clearly during discussions. His Fluid Reasoning (Gf/FRI=110) falls in the high average range, suggesting he is capable of abstract thinking has the ability to problem solve.

In contrast, Ethan's Processing Speed (Gs/PSI=75) is in the borderline range. This indicates that he struggles with tasks requiring quick visual-motor coordination, such as handwriting, copying, and recognizing symbols efficiently - skills essential for fluent written expression. These issues are consistent with dysgraphia, which is characterized by slow, effortful handwriting and difficulty translating ideas into written form. Ethan also has average Working Memory (Gwm/WMI=90), which may affect his ability to juggle multiple pieces of information during writing tasks. His Visual-Spatial Skills (Gv/VSI=95) are also average, allowing him to benefit from visual learning aids when appropriately scaffolded.

This cognitive profile which consists *high Gc and Gf, average Gwm and Gv, and low Gs,* is typical of learners with dysgraphia. Observations from parents and teachers corroborate these findings: Ethan avoids writing, experiences fatigue during writing tasks, and demonstrates a strong discrepancy between verbal expression and written output.

Table 1: Cognitive Assessment (WISC-V and CHC Broad Ability Mapping)

Index	Score	Subtests	CHC Broad Ability
Verbal Comprehension (VCI)	120 (Superior)	Similarities (14), Vocabulary (15)	Gc – Crystallized Intelligence
Visual Spatial (VSI)	95 (Average)	Block Design (9) Visual Puzzles (10)	Gv – Visual Processing
Fluid Reasoning (FRI)	110 (High Avg)	Matrix Reasoning (12) Figure Weights (11)	Gf – Fluid Intelligence
Working Memory (WMI)	90 (Average)	Digit Span (9) Picture Span (8)	Gwm – Working Memory
Processing Speed (PSI)	75 (Borderline)	Coding (5) Symbol Search (6)	Gs – Processing Speed
Full Scale IQ [g] (FSIQ)	**103 (Average)**	Composite of core subtests	Composite of CHC abilities

[1]*Personal identifiers have been removed in accordance with the Personal Data Protection Act 2012 (amended 2020).*

[2]Not the child's real name to protect his identity and ensure personal privacy and confidentiality. Informed consent has been obtained from the child's supporting parents.

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Drawing on the Cattell-Horn-Carroll (CHC) theory, the educational therapist (EdtX) analysed Ethan's cognitive profile to design targeted interventions. These strategies are tailored to his specific learning needs and closely aligned with the Primary 4 curriculum to support inclusive and meaningful learning.

Educational Therapy Intervention Approaches based on the CHC model

Educational therapy interventions grounded in the Cattell-Horn-Carroll (CHC) model focus on targeting specific cognitive abilities linked to learning challenges. Based on the CHC model, the following interventions are tailored to Ethan's strengths in Verbal Comprehension (Gc) and Fluid Reasoning (Gf), while addressing his difficulties in Processing Speed (Gs), Working Memory (Gwm), and fine motor coordination. This approach moves beyond surface-level difficulties to focus on the underlying factors affecting learning. The following strategies are designed by the child's educational therapist to work collaboratively with parents and teachers, both at home and in school, to ensure consistent support across two different contexts.

A. Home-Based Interventions

Home routines can be adapted to reinforce therapy goals and reduce writing-related stress. To leverage Ethan's strong verbal skills, parents can encourage oral storytelling using apps like *Toontastic or ChatterPix*, and support reflective speaking exercises through voice recording, which can later be typed or written with assistance. Regular discussions about books and shows also promote narrative development without the pressure of writing. For spelling and literacy reinforcement, multisensory tools such as letter tiles, sand trays, and textured paper can help Ethan practise word construction and letter formation while bypassing handwriting fatigue. To address his slow processing speed, Ethan can benefit from typing programs like *TTRS or Typing.com*, as well as grammar and sentence-building games that reduce the physical demands of writing while building core literacy skills. Reading and language apps such as *ReadTheory* or *Nessy* can support his reading fluency and sentence structure. To support working memory, Ethan's parents can use visual checklists and break writing tasks into clear steps with the help of mind maps or picture organizers. Cue cards with sentence starters and sequencing words can also ease the cognitive load during writing activities.

B. School-Based Interventions

In school, Ethan's language lessons should focus on minimizing handwriting demands while allowing him to express his ideas fully. Educational therapist can work with teachers to allow him to use voice-to-text tools or scribe assistance for compositions, permit oral responses during informal assessments, and provide visual scaffolds such as story maps and sentence starters to support planning. In Mathematics, Ethan should be allowed to demonstrate understanding using manipulative and verbal explanations. Worksheets with clearly marked grids (see Figure 1 below) can reduce handwriting effort, and typed or spoken answers can be accepted where appropriate. In Science, he can use labeled diagrams, digital templates, and oral or video-based presentations to show understanding of concepts. Fill-in-the-blank experiment sheets can reduce writing without compromising learning outcomes. For Social Studies, mind maps, comic strips, and visual timelines can help him organize and communicate ideas. Pre-filled notes and visuals reduce copying demands, and verbal contributions during group work should be encouraged and assessed as valid demonstrations of learning. These combined strategies ensure that Ethan receives equitable access to the curriculum while developing his skills and confidence in a way that reflects his cognitive strengths.

Figure 1: An example of clearly marked grid used to fill in numeral and mathematical symbols to reduce cognitive overload.

Conclusion

The Cattell-Horn-Carroll (CHC) model offers a valuable framework for supporting students like Ethan, whose learning difficulties are linked to underlying cognitive factors such as processing speed, working memory, and crystallized intelligence. By applying this model in to idenfity the relevant broad cognitive stratum linked to learners with dysgaphia, educational therapists can designed targeted, evidence-based interventions that accommodate Ethan's strengths and address his specific need which can be applied to both home and school settings.

Through a combination of assistive technologies, multi-sensory approaches, and tailored instructional strategies, Ethan can reduce the cognitive and physical demands of writing and thrive in his academic environment. The CHC model provides a holistic, individualized roadmap that not only supports academic growth but also builds confidence and resilience, ensuring that Ethan's learning experiences are meaningful and successful.

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