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Visual and auditory processing deficits in developmental Dyslexia: A CHC-theoretical perspective

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Abstract
Dyslexia is a specific learning disability of neurobiological origin, characterized by persistent difficulties in accurate and fluent word recognition, spelling, and decoding. This paper explores the cognitive foundations of dyslexia through the Cattell-Horn-Carroll (CHC) theory of cognitive abilities, focusing on Visual Processing (Gv) and Auditory Processing (Ga). Weaknesses in Gv, e.g., deficits in visualization, spatial scanning, visual memory, and closure speed, are linked to letter reversals, poor orthographic mapping, and slow word recognition. These difficulties may stem from disruptions in the visual neural system (VNS), including the magnocellular, parvocellular, and koniocellular pathways. In particular, magnocellular dysfunction affects motion detection and visual timing, impeding fluent reading. Similarly, weaknesses in Ga, including phonetic coding, sound discrimination, and auditory memory, contribute to phonological deficits, decoding issues, and spelling challenges. Together, these impairments hinder the integration of orthographic and phonological systems, essential for reading fluency. Beyond cognitive factors, the paper considers the emotional impact of dyslexia, noting how repeated academic struggles can lead to anxiety, low self-esteem, and depression. Applying CHC theory enables more targeted, strengths-based interventions that support both academic growth and mental wellness. This integrative approach underscores the value of CHC theory in fostering cognitive insight and holistic support for students with dyslexia.

Keywords: Dyslexia, chc theory, phonological processing, visual neural system (VNS), visual processing

Introduction

Among the many specific learning disabilities (SLD), dyslexia is the most common language-based learning disability. According to the U.S. Department of Education (2004), based on the prevalence of disabilities under the Individuals with Disabilities Act (IDEA) passed by the U.S. Congress in 2004, SLD constituted 47.2% of the American school-age population, aged between six and 21, at that time. Today, dyslexia affects approximately 780 million people worldwide, including over 40 million adults in the United States alone, most of whom remain undiagnosed. It has impacted 15-20% of school-age children and accounted for 70-80% of reading difficulties. In fact, dyslexia occurs equally across genders, ethnicities, and economic backgrounds, though children in poverty and minority-populated schools are found to be more likely to struggle with reading. A significant portion of students and adults read below grade level, with 25% of adults reading at an elementary level and 5% functionally illiterate. Despite misconceptions, dyslexia is not linked to intelligence or intellectual disability (previously known as mental retardation under the disability category listed in IDEA 2004).

The International Dyslexia Association (IDA) has defined dyslexia as "a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge" (Lyon, G. R., Shaywitz, S. E., & Shaywitz, 2003, p. 1) [38].

However, there are many different specific types of dyslexia (Pierangelo & Giuliani, 2006) [47]. According to the *Educator's Diagnostic Manual of Learning Disabilities and Disorders* (EDM; Pierangelo & Giuliani, 2007) [48], which is generally used by special education professionals (e.g., special education teachers, resource teachers, and educational therapists), there are 10 specific types of dyslexia (see Table 1), classified under the EDM Level I code LD. It is further categorized under EDM Level II code LD4.00-Dyslexia (Reading Disorder), which is further differentiated into the following specific types of dyslexia as follows (Pierangelo & Guiliani, 2007, pp. 24-31) [48]:

Table 1: EDM Classification of Dyslexia Types

Level	Diagnostic Code	Disorder
EDM Level 1	LD	Specific Learning Disability
EDM Level 2	LD-4.00	Dyslexia (also known as Reading Disorders)
EDM Level 3	LD-4.01	Auditory-Linguistic Dyslexia
EDM Level 3	LD-4.02	Direct Dyslexia
EDM Level 3	LD-4.03	Dysnomia
EDM Level 3	LD-4.04	Dyseidetic Dyslexia (also known as Visual Dyslexia, Dyseidesia or Surface Dyslexia
EDM Level 3	LD-4.05	Dysnemkinesia Dyslexia
EDM Level 3	LD-4.06	Alexic Dyslexia (also known as Mixed Dyseidetic-Dysphonetic Dyslexia)

EDM Level 3	LD-4.07	Dysphoneitc Dyslexia (also known as Dysphonesia or Auditory Dyslexia)
EDM Level 3	LD-4.08	Neglect Dyslexia
EDM Level 3	LD-4.09	Phonological Dyslexia
EDM Level 3	LD-4.10	Other types of Dyslexia (Reading Disorders)

For decades, with nearly 100 studies (e.g, Hulme & Snowling, 1988; Licht, 1994; Satz & Morris, 1981) conducted between the 1960s and 1990s (see Hooper & Swartz, 1994, for details) as well as between the 1950s and 2020s (see Helland, 2022, for details) [27], researchers (e.g., Chalmpe & Vlachos, 2025; Koifman, 2023; Kristanto et al., 2024) [12, 32, 33] are still studying dyslexia subtypes today. These past and present studies reveal that dyslexia is highly diverse, which has significant implications for both treatment strategies and understanding its causes (Edwards & Hogben, 2007). However, most research on the causes of dyslexia fails to account for differences within dyslexic groups. This is likely due to the challenges in establishing a clear and consistent method for identifying subtypes. Edwards and Hogben (2007) explained that the "[D]ifficulty in determining if subtypes result from one or many causes arises partly from problems associated with classifying children based on their current reading performance" (p. 38). Moreover, "[A]part from difficulties in developing a classification scheme, the concept of subtyping has been challenged by questions concerning what it is that subtyping systems resolve" (Edwards & Hogben, 2007).

It is, therefore, not surprising to note that not all dyslexia professionals and researchers agree with the EDM nosology of dyslexia mentioned above. For instance, Westman (1996) [57] identified and classified dyslexia into four types: (i) Vestibulo-cerebellar or dysmetric dyslexia (Antonis, 2021; Caldani et al., 2021; Frank & Levinson, 1973) [5, 9, 24], with motor difficulty in visually tracking words, and possibly a syndromic form of dyslexia observed in individuals with Schmahmann Syndrome (Devita et al., 2025) [21]; (ii) Visuo-spatial dyslexia (Du & Zhang, 2023; Lipowska, Czaplewska, & Wysocka, 2011) [22, 36], with cognitive difficulty in recognizing words; (iii) Auditory-linguistic dyslexia (Ashidiqi, Widaningrum, & Karaman, 2023; Bohren, 2019) [6, 7], with language difficulty in comprehending the meaning of words; and (iv) Articulo-graphic dyslexia (Chia, 2000b; Westman, 1996) [13, 14, 57], with motor difficulty in spelling and writing accurately. In another example, Chia (2000a) [13, 14] categorized dyslexia into four types: (i) Developmental dyslexia (Chia, 2016) [16]; (ii) Acquired dyslexia (Coslett & Turkeltaub, 2016) [20] or alexia (also known as alexic dyslexia; Alduais, Alarifi, & Alfadda, 2024; Kerkhoff & Kraft, 2024) [2, 30]; (iii) Pseudo- or induced dyslexia (Hytowitz, 2025) [28]; and (iv) Idiopathic dyslexia (Conrad, 2019) [19]. Koifman (2023) [32] argued that "[A]s for the types of dyslexia, we can classify them according to their origin or according to the pathways that affect learning time" (p. 129).

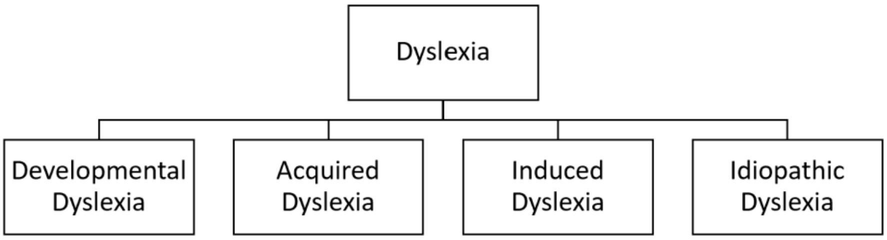

Fig 1: The Four Types of Dyslexia (Chia, 2000a) [13, 14]

Connections Between CHC Narrow Abilities (Gv & Ga), Visual Neural Pathways And Dyslexia Symptoms

The Cattell-Horn-Carroll (CHC) theory of cognitive abilities (Schneider & McGrew, 2018) [49] provides a comprehensive framework to understand the structure of human intelligence. By applying the CHC theory to dyslexia, this offers a scientifically grounded way to evaluate the specific cognitive strengths and weaknesses that underlie reading difficulties. In fact, the two most implicated general (G) or broad abilities (also known as G-code) are Gv (Visual Processing) and Ga (Auditory Processing).

the application of ga (auditory processing) and gv (visual processing) from the chc theory helps to bridge the cognitive assessment with neurobiological models of dyslexia, particularly involving three visual neural pathways (vnps) which are (i) magnocellular [m] (leung, cheong, & chan, 2022; müller-axt et al., 2025) [35, 43]; (ii) parvocellular [p] (ali et al., 2021; leung, cheong, & chan, 2022; masri, grünert, & martin, 2020) [4, 35, 40]; and koniocellular [k]) (solomon, 2021) [51] (see figure 2 and table 2).

Table 2: The Three Visual Neural Pathways

VNP	Characteristics
[M]	✧ Fast conduction, low spatial resolution, high temporal resolution. ✧ Sensitive to motion, flicker, & coarse visual patterns. ✧ Provides timing & sequencing information (critical for saccades, eye movements in reading).
[P]	✧ Slower conduction, high spatial resolution, low temporal resolution. ✧ Sensitive to fine detail, color, & static visual information. ✧ Provides detailed letter/word recognition in reading.
[K]	✧ Intermediate properties, less studied. ✧ Involved in color contrast (especially blue-yellow), some role in visual attention & integrating information from M & P pathways. ✧ May support higher-level integration of visual cues during reading

The visual neural system (VNS) also includes the eyes, optic nerves, chiasm, tracts, lateral geniculate nucleus(LGN) of the thalamus, radiations, striate cortex, and extrastriate association cortices, all are responsible for receiving, relaying, and processing visual information.

The VNS consisting of the M/P/K neural pathways (see Figure 2; see You et al., 2021, for details) [58] is connected to CHC theory (Ga and Gv abilities), where both M and P are heavily implicated in the reading process.

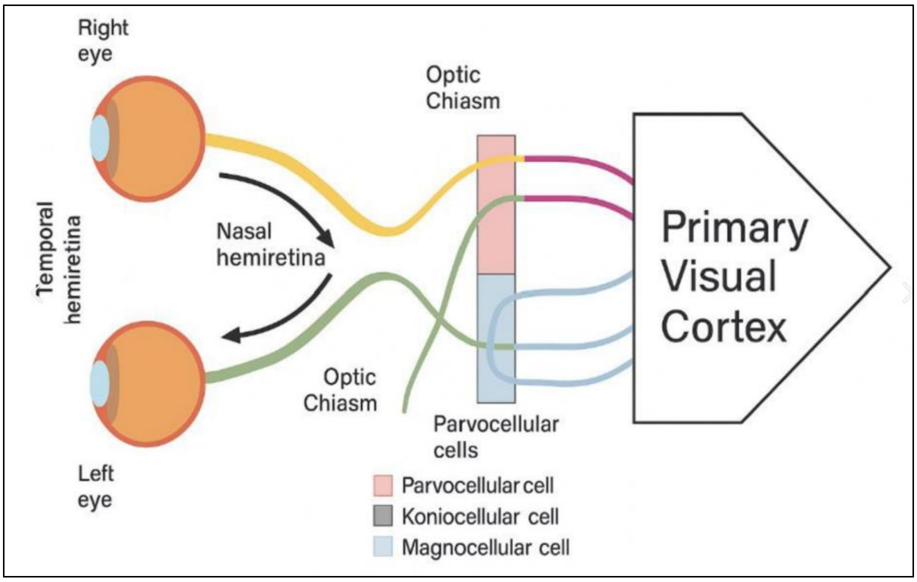

Fig 2: The Three Visual Transneuronal Pathways (You et al., 2021) [58]

The CHC theory groups visual and auditory processing under Gv (visual processing) and Ga (auditory processing). Both broad Gv and Ga abilities are crucial for the reading process. Their respective narrow abilities linked to these neural pathways are included in Table 3 below:

Table 3: The Link between VNPs and CHC Broad Abilities (Gv & Ga)

VNP → CHC Broad Abilities	CHC Narrow Abilities
[M] → Gv & Ga	✧ Gv-Vz (Visualization), Gv-SR (Speeded Rotation), & Gv-P (Perceptual Speed): These narrow Gv abilities rely on the rapid, sequential visual input → tied to the magnocellular timing. ✧ Ga-PC (Phonetic Coding) & Ga-US (Speech Sound Discrimination): Timing deficits in the [M] pathway → cascade into phonological awareness issues (link between visual timing and auditory segmentation in reading).
[P] → Gv	✧ Gv-CS (Closure Speed), Gv-CF (Flexibility of Closure), & Gv-Vz (Visualization): These are needed for detailed letter and word recognition. ✧ Gv-MV (Visual Memory): This narrow Gv ability holds detailed orthographic patterns.
[K] → Gv (& cross-modal integration)	✧ Gv-CF (Flexibility of Closure) & Gv-SS (Spatial Scanning): The K-pathway contributes to color and contrast sensitivity, supporting attention in cluttered text environments. It may also contribute indirectly to learning efficiency (by aiding visual comfort and attentional focus).

In summary, the M/P/K neural pathways in the VNS are each associated with distinct CHC narrow Gv and Ga abilities (more so with Gv), and they play important parts in the process of reading. The [M] pathway is responsible for processing motion, timing, and sequencing, engages narrow Gv and Ga abilities, e.g., Gv-P, Gv-SR, Gv-Vz and Ga-PC and Ga-US. Magnocellular deficits can result in poor eye movement control, temporal sequencing difficulties, and increased risk for dyslexia (Leung, Cheong, & Chan, 2022; Stein, 2021) [35]. The [P] pathway processes fine detail, color, and pattern, involving narrow Gv abilities, e.g., Gv-CS, Gv-CF, Gv-MV, and Gv-Vz. Impairments in the [P] pathway may result in challenges with letter and word recognition and, hence, hinder orthographic mapping (Ciavarelli et al., 2021) [18]. Finally, the [K] pathway contributes to color contrast perception and serves an integrative function, drawing on Gv-CF, Gv-SS, Gv-P, and Gv-CS. Disruptions in the [K] system can cause visual discomfort, disrupted attention to text, and difficulty integrating information across lines of print, e.g., color vision impairments in multiple sclerosis (L'Abbate et al., 2024) [34].

Although the VNS involves more of Gv than Ga, it is Ga that is closely associated with the phonological (auditory includes aural=listening and oral=speaking) processing that can be impacted by dysfunctions in auditory timing and sequencing, and, hence, potentially reflecting the issues in temporal resolution akin to auditory [M] pathway deficits. On the other hand, Gv is very much concerned with the ability of the brain to process visual-spatial information (printed marks and print background) and any Gv-related problem is often associated with [M] pathway dysfunction

(Leung, Cheong, & Chan, 2022) [35], which, in turn, affects motion detection, visual tracking, and rapid visual processing (Werth, 2021) [56], which are essential skills for fluent reading. Both [M] auditory and visual pathways are most affected in individuals with dyslexia (Ali et al., 2021; Ciavarelli et al., 2021) [4, 18].

In contrast, the [P] pathway, which is responsible for detail and color, and the [K] pathway, which is involved in integrating visual signals, are less directly implicated in dyslexia. However, the [P] and [K] pathways may still contribute to broader visual-auditory sensory integration challenges (Ciavarelli et al., 2021; Solomon, 2021) [18, 51]. By evaluating Ga and Gv, CHC-based assessments (e.g., Woodcock-Johnson IV and Wechsler Intelligence Scale for Children V) indirectly reflect how underlying sensory processing anomalies (particularly, the magnocellular dysfunction) may impair the auditory-visual integration needed for reading, offering a cognitive lens on the neural underpinnings of dyslexia.

Involvement of Gv in Dyslexia and Its Impact on Reading

The broad Gv (Visual Processing) ability relates to how an individual perceives, analyzes, and mentally manipulates visual patterns. Its narrow Gv abilities are variably involved in the connection between reading and the condition of dyslexia. As mentioned in the previous section, dyslexia is primarily a phonological-based disorder, and some of its visual-spatial and perceptual processing weaknesses can contribute to or exacerbate difficulties in reading and spelling for individuals with dyslexia. Below is a critique of how each of the narrow Gv abilities may be involved in or affected by dyslexia, with attention to their functional relevance to reading processes. It has been found that weak narrow Gv abilities contribute to letter reversals, poor orthographic mapping, and slow visual word recognition as observed in individuals with dyslexia. Table 2 below shows the narrow Gv abilities in relation to dyslexia in terms of the respective levels of their involvement with a brief explanation for each of them.

Table 4: Narrow Gv Abilities in Relation to Dyslexia

Gv Ability	Name	Relevance to Dyslexia	Level of Involvement	Explanation
Gv-Vz	*Visualization*	Involves mentally manipulating visual patterns; may help or hinder decoding.	*Moderate*	Weakness in this area may affect orthographic mapping and visual memory of words.
Gv-SR	*Speeded Rotation*	May affect the mental manipulation of letters (e.g., b/d, p/q confusion).	*Moderate*	Some individuals with dyslexia struggle with left-right orientation.
Gv-IM	*Imagery*	May support comprehension or memory, especially compensatory strategies.	*Low to Moderate*	Not a core deficit, but can support comprehension.
Gv-CF	*Flexibility of Closure*	Helps isolate letters/symbols from the background, aiding print discrimination.	*Moderate*	Weakness may impair efficient visual scanning of text.
Gv-CS	*Closure Speed*	Facilitates quick recognition of familiar words/letters.	*Moderate to High*	Key to developing automaticity in reading.
Gv-MV	*Visual Memory (Memory for Visual Stimuli)*	Supports retention of orthographic patterns (e.g., sight words, spelling).	*High*	Commonly affected; directly impacts reading and spelling.
Gv-SS	*Spatial Scanning*	Important for following lines of text and locating information visually.	*Moderate*	Deficits may lead to line-skipping or inefficient reading.
Gv-PI	*Serial Perceptual Integration*	Involves perceiving a coherent sequence of letters or symbols.	*Moderate*	Can impact fluent decoding of orthographic patterns.
Gv-LE	*Length Estimation*	Limited relevance to reading or phonological processes.	*Low*	Possibly involved in spatial organization on a page, but not central.
Gv-IL	*Perceptual Illusions*	Unrelated to core reading skills; may reflect visual-perceptual anomalies.	*Low to Negligible*	No strong empirical link to dyslexia.
Gv-PN	*Perceptual Alternations*	May support flexibility in interpreting visual stimuli, but not directly involved.	*Low*	Theoretical connection only.
Gv-P	*Perceptual Speed*	Essential for fluent word/letter recognition; commonly weak in dyslexia.	*High*	Strongly impacts fluency and accuracy.

All these narrow cognitive abilities of Gv (as briefly described below, in terms of their respective roles, in relation to dyslexia, and their involvement in the reading process) can also contribute to higher order cognitive-social abilities of mentalization [1] (also known as Theory of Mind), which can draw on both visual inputs (e.g., facial expression, body language and eye gaze) and auditory inputs (e.g., prosody, speech content and pacing and pauses) (see Özyurt et al, 2024, for details) [46].

Gv-Viz (Visualization)

This narrow cognitive ability involves mental manipulation of visual patterns.

- **Role in reading:** Supports reading by enabling the mental manipulation of letters, words, and spatial orientation on the page.

- **Impact in dyslexia:** Encounter difficulties with visualization that can hinder letter recognition, sequencing, and spatial organization of text.

- **Involvement in reading:** Moderate, especially in decoding and word recognition, when readers have to mentally represent and compare letter patterns.

Gv-SR (Speeded Rotation)
This concerns the narrow cognitive ability to rotate and perceive objects.
- **Role in reading:** May support the ability to mentally manipulate letters or words (e.g., distinguishing b/d, p/q).

- **Impact in dyslexia:** Some individuals with dyslexia show weaknesses in left-right orientation or mental rotation, though not universally. Difficulty mentally rotating letters may contribute to confusion with letter reversals in early reading stages.

- **Involvement in reading:** Moderate, particularly in orthographic coding and spatial letter discrimination.

Gv-IM (Imagery)
This is the narrow cognitive ability to form mental images.
- **Role in reading:** Visual imagery may aid in word recognition, comprehension, and memory (e.g., associating visual images with words).

- **Impact in dyslexia:** Some individuals may rely more on visual imagery as a compensatory strategy when phonological decoding is impaired. However, evidence for deficits in this area is mixed.

- **Involvement in reading:** Low to moderate; more relevant in reading comprehension than decoding.

Gv-CF (Flexibility of Closure)
This narrow cognitive ability concerns finding a figure embedded in a complex visual pattern.
- **Role in reading:** Helps with identifying individual letters or graphemes in complex visual arrays (e.g., parsing text or distinguishing visually similar letters).

- **Impact in dyslexia:** Weaknesses here may contribute to visual confusion, clutter processing, and difficulty with scanning print efficiently.

- **Involvement in reading:** Moderate, especially in early visual recognition and attention to detail.

Gv-CS (Closure Speed)
This narrow cognitive ability involves a quick identification of a familiar visual object from incomplete information.
- **Role in reading:** Important for rapid letter and word recognition, especially under time pressure or when letters are partially obscured (e.g., cursive or unusual fonts).

- **Impact in dyslexia:** A deficit in closure speed can slow reading fluency and impair automatic recognition of words.

- **Involvement in reading:** Moderate to high, particularly in automaticity of visual word recognition.

Gv-MV (Visual Memory)
This narrow cognitive ability supports retention of orthographic patterns.
- **Role in reading:** Supports reading by helping individuals retain and recall the visual appearance of letters, words, and spelling patterns.

- **Impact in dyslexia:** Weaknesses in visual memory can make it difficult to remember the shape and order of letters, leading to errors in word recognition and spelling.

- **Involvement in reading:** High, contributes to fluent reading by allowing readers to store and retrieve familiar word forms quickly and accurately.

Gv-SS (Spatial Scanning)
This narrow cognitive ability involves following lines of text and locating information visually.
- **Role in reading:** Aids reading by enabling the efficient tracking of text across a page from left to right and line to line.

- **Impact in dyslexia:** Deficits in spatial scanning can lead to difficulties with maintaining visual focus, tracking lines of text, and maintaining reading flow.

- **Involvement in reading:** Moderate, supports visual attention and eye movement control, both of which are essential for smooth and accurate reading.

Gv-PI (Serial Perceptual Integration)
This narrow cognitive ability entails perceiving a coherent whole from visual sequences.
- **Role in reading:** May relate to processing the sequential visual aspects of text (e.g., seeing words as a whole, integrating letters into a word).

- **Impact in dyslexia:** Deficits may affect orthographic processing and ability to parse letter sequences quickly.

- **Involvement in reading:** Moderate, especially in developing fluent word recognition.

Gv-LE (Length Estimation)
This narrow cognitive ability requires estimating visual distances or lengths.
- **Role in reading:** Limited, but might have a peripheral role in tasks like line tracking or spacing perception.

- **Impact in dyslexia:** Not commonly implicated. Potential minor issues in spatial organization on a page, but largely irrelevant to core reading deficits.

- **Involvement in reading:** Low.

Gv-IL (Perceptual Illusions)
This narrow cognitive ability concerns susceptibility to misleading visual stimuli.
- **Role in reading:** Theoretical at best; no clear connection to literacy.

- **Impact in dyslexia:** Some anecdotal claims (e.g., letters “moving” on the page), but evidence is weak and often related to co-occurring visual stress or attentional issues.

- **Involvement in reading:** Low to negligible.

Gv-PN (Perceptual Alternations)
This narrow cognitive ability engages in shifting between different visual interpretations.

- **Role in reading:** May support cognitive flexibility in interpreting ambiguous stimuli (e.g., words with multiple pronunciations or meanings).

- **Impact in dyslexia:** Minimal direct impact, but may relate to difficulty shifting visual attention or adapting to unfamiliar fonts/layouts.

- **Involvement in reading:** Low.

Gv-P (Perceptual Speed)
This narrow cognitive ability involves the speed of comparing and processing visual symbols.

- **Role in reading:** Highly relevant. Supports rapid letter/word recognition and affects reading fluency.

- **Impact in dyslexia:** Often impaired. Slower perceptual speed may contribute to poor automaticity, slower reading rates, and difficulties with timed tasks.

- **Involvement in reading:** High, especially in fluency and efficiency.

Among the 12 narrow Gv abilities that are most consistently involved in dyslexia are: (i) Gv-P (Perceptual Speed) which affects fluency and efficiency; (ii) Gv-MV (Visual Memory) affects word recognition and spelling; (iii) Gv-CS (Closure Speed) affects word/letter recognition under time pressure; (iv) Gv-Vz (Visualization) is involved in letter-sequence processing and spelling; and (v) Gv-SS (Spatial Scanning) affects tracking and visual attention while reading.
While phonological deficits remain the hallmark of dyslexia, certain narrow Gv abilities, especially perceptual speed and closure speed, can meaningfully influence reading fluency and accuracy (Werth, 2021) [56]. However, not all individuals with dyslexia show deficits in Gv abilities, and visual factors are generally considered secondary or compounding, rather than primary causes.

Involvement of Ga in Dyslexia and Its Impact on Reading
In addition to the broad and narrow Gv abilities, the broad Ga (Auditory Processing) ability is just as critical for phonological awareness, a core weakness in dyslexia. In other words, weak narrow Ga abilities cause phonological deficits, inaccurate decoding, and poor spelling, which are central to developmental dyslexia (Chalmpe & Vlachos, 2025; Habib, 2021; Koifman, 2023) [12, 26, 32].
In the CHC theory (Schneider & McGrew, 2018) [49], Ga (Auditory Processing) refers to the ability to analyze, discriminate, and synthesize auditory stimuli, particularly the skills of phonemic awareness, sound discrimination, and temporal sequencing. For individuals with dyslexia, Ga deficits are commonly observed and strongly associated with difficulties in decoding written language. Children with weak auditory processing often struggle to distinguish between similar speech sounds (e.g., /b/ vs. /d/), to segment words into phonemes, or to blend sounds into whole words, i.e., skills that are essential for the ability to read as well as to spell accurately (Carroll, 1993; Schneider & McGrew, 2018; Stanton, 1995) [10, 49, 52].
The impact of Ga weaknesses on reading/spelling can be profound. Both cognitive processes depend heavily on phonological knowledge and awareness. Hence, poor or weak auditory processing interferes with the development of phonological awareness, which is the hallmark of dyslexia (Chia & Houghton, 2011; Wagner & Torgesen, 1987) [17, 55]. As a result, learners with dyslexia may exhibit slow, inaccurate, and effortful reading, limited word recognition, and difficulty with spelling patterns (Snowling, 2013) [50]. Moreover, reduced efficiency in processing auditory information affects working memory for sounds, making it challenging to retain and manipulate phonological codes during reading tasks. This explains why interventions for dyslexia often target auditory processing and phonemic awareness, using structured, multi-sensory approaches (e.g., Orton-Gillingham-based programs, the Lindamood Phonemic Sequencing Program, and the Alpha-Omega Phonics Program) to strengthen the connection between sounds and symbols, thereby compensating for Ga-related weaknesses (Mather & Wendling, 2012) [41]. Table 3 below shows the narrow Ga abilities in relation to dyslexia in terms of their respective levels of involvement, with a brief explanation for each of them.

Table 5: Narrow Ga Abilities in Relation to Dyslexia

Ga Ability	Name	Relevance to Dyslexia	Level of Involvement	Explanation
Ga-PC	*Phonetic Coding*	Analyzes and blends phonemes	*High*	Trouble sounding out words
Ga-US	*Speech Siund Discrimination*	Distinguishes subtle differences between phonemes	*High*	Leads to inaccurate decoding
Ga-UR	*Resistance to Auditory Stimulus Distortion*	Sustains comprehension and fluency when auditory input is degraded/less clear	*High*	Combined with phonological deficits only exacerbates comprehension problems
Ga-U8	*Maintaining & Judging Rhythm*	Recognizes rhythm, stress, and intonation	*Moderate*	Synchronizes auditory-visual input to aid phonemic decoding and fluency
Ga-UM	*Memory for Sound Patterns*	Short-term recall of sound sequences	*High*	Difficult to retain verbal instructions or spelling words by sound
Ga-U1/U9	*Musical Discimination & Judgment*	Distinguish subtle auditory differences during phonological processing	*Moderate*	Supports the accurate perception of speech sounds and rhythmic patterns essential for decoding and reading fluency
Ga-UP	*Absolute Pitch*	Minimal direct role in reading	*Low*	Little involvement in reading process
Ga-UL	*Sound Localization*	Noises interfere attention during reading to comprehend	*Low*	Environmental noises interfere reading

All these narrow cognitive abilities of Ga (as briefly described below, in terms of their respective roles, in relation to dyslexia, and their involvement in the reading process) are crucial to the abilities of raiding[1] (Carver, 1977) [11].

Ga-PC (Phonetic Coding)

The ability to code, discriminate, and retain phonetic information in short-term memory. It includes phonological awareness (analyzing and manipulating the sound structure of language).

- **Role in reading:** Central to decoding; allows readers to connect graphemes (letters) to phonemes (sounds).

- **Impact in dyslexia:** Weakness leads to difficulties in phonological awareness, decoding, and spelling. This is considered the core deficit in dyslexia.

- **Involvement in reading:** High, crucial for mapping sound to symbol, blending sounds, segmenting words, and recognizing rhymes.

Ga-US (Speech Sound Discrimination)

The ability to distinguish speech sounds that differ only slightly (e.g., /p/ vs. /b/).

- **Role in reading:** Supports accurate phoneme recognition and prevents confusion when decoding similar-sounding words.

- **Impact in dyslexia:** Deficits cause misperception of sounds, leading to frequent misreadings and spelling errors.

- **Involvement in reading:** High, ensures fine-grained auditory distinctions necessary for phonics and word recognition.

Ga-UR (Resistance to Auditory Stimulus Distortion)

The ability to understand speech under distorted or noisy conditions.

- **Role in reading:** Supports listening comprehension and oral reading accuracy in noisy environments (e.g., classrooms).

- **Impact in dyslexia:** Weakness here exacerbates comprehension problems, especially when combined with phonological deficits.

- **Involvement in reading:** High, helps sustain comprehension and fluency when auditory input is degraded or less clear.

Ga-U8 (Maintaining & Judging Rhythm)

The ability to perceive, maintain, and judge rhythmic patterns in auditory stimuli.

- **Role in reading:** Supports reading by enhancing temporal processing skills critical for phonological awareness, syllabic segmentation, and prosody.

- **Impact in dyslexia:** Impairs the brain's ability to process the timing and rhythm of speech sounds, leading to difficulties in phonemic decoding and fluency.

- **Involvement in reading:** Moderate, facilitates the synchronization of auditory input with visual text, aiding in the development of fluent and expressive reading.

Ga-UM (Memory for Sound Patterns)

The ability to retain and recall sequences of sounds, such as tones, rhythms, or phoneme sequences.

- **Role in reading:** Supports memory of phoneme sequences in words, word order in sentences, and spelling patterns.

- **Impact in dyslexia:** Deficits lead to problems holding sound sequences in working memory, affecting decoding multi-syllabic words.

- **Involvement in reading:** High, essential for blending phonemes, holding phonological chunks while decoding longer words.

Ga-U1/U9 (Musical Discrimination & Judgment)

The ability to perceive and differentiate musical elements such as pitch, melody, harmony, and rhythm.

- **Role in reading:** Supports reading development by enhancing auditory discrimination skills necessary for phonemic awareness and prosodic sensitivity in language.

- **Impact in dyslexia:** Impairs the ability to distinguish subtle auditory differences in speech sounds, affecting phonological processing.

- **Involvement in reading:** Moderate, contributes to reading by supporting the accurate perception of speech sounds and rhythmic patterns, which are essential for decoding and reading fluency.

Ga-UP (Absolute Pitch)

The ability to identify or produce a specific pitch without an external reference.

- **Role in reading:** Plays a minimal direct role in reading, as absolute pitch is not typically required for phonological processing or decoding written language.

- **Impact in dyslexia:** Unlikely to significantly impact dyslexia, as reading difficulties are more closely related to temporal and phonological auditory processing rather than pitch identification.

- **Involvement in reading:** Low; little involvement in reading processes, though it may support musical training that indirectly benefits auditory discrimination skills used in phonological awareness.

Ga-UL (Sound Localization):

The ability to determine the source or direction of sounds and analyze auditory information spatially.

- **Role in reading:** Supports focus in classroom reading environments; helps distinguish teacher's voice from background noise.

- **Impact in dyslexia:** Not a primary deficit, but weaknesses can add to attentional and comprehension challenges.

- **Involvement in reading:** Low, secondary support, more environmental than cognitive in terms of reading.

Ga-UA (Auditory Closure)
Not found in the official CHC list of narrow Ga abilities is the non-listed narrow Ga-UA (Auditory Closure), which this author describes as the ability to recognize whole words or messages when parts of the auditory signal are missing. This narrow ability is listed under the Quotient-code (or Q-code) of Reading Quotient (RQ) in the non-CHC model (Liu & Xie, 2024) [37].

- **Role in reading:** Supports word recognition and comprehension, especially when readers encounter partially unfamiliar words.
- **Impact in dyslexia:** Weakness limits the ability to use context or partial cues for word recognition.
- **Involvement in reading:** Helps in automaticity and fluency, allowing readers to 'fill in' missing or misread cues from context.

Among the eight officially listed narrow Ga abilities that are most consistently involved in dyslexia are: (i) Ga-PC (Phonetic Coding) and Ga-US (Speech-Sound Discrimination) are core for reading acquisition; (ii) Ga-UM (Memory for Sound Patterns) and the unofficial Ga-UA (Auditory Closure) play strong supportive roles in fluency and comprehension; and (iii) Ga-UR (Resistance to Auditory Stimulus Distortion) and Ga-UL (Sound Localization) are environmental/perceptual supports that are not directly the cause or associated with dyslexia. In fact, dyslexia is most strongly linked to weaknesses in phonological processing, i.e., Ga-PC, Ga-US, and Ga-UM, which disrupt decoding and fluency in the reading process.

Integrating Ga and Gv Weaknesses in Identification of Dyslexia Types
Symptoms of dyslexia emerge when weaknesses in Ga (auditory/phonological processing) prevent accurate mapping of sounds to letters, especially in the following specific types of dyslexia: LD-4.01 Auditory-Linguistic Dyslexia (Knoop-van Campen, Segers, & Verhoeven, 2018) [31], LD-4.07 Dysphonetic Dyslexia (also known as Dysphonesia or Auditory Dyslexia; Chia, 2000a; Johnson & Myklebust, 1967) [13, 14, 29], and LD-4.09 Phonological Dyslexia (Alcalde-Llergo et al., 2025; Bolduc & Guay, 2021) [1, 8]. The weaknesses in Gv (visual processing) that interfere with recognizing and manipulating written symbols are found, particularly in the following specific types of dyslexia: LD-4.04 Dyseidetic Dyslexia (also known as Visual Dyslexia, Dyseidesia or Surface Dyslexia; Chia, 2015; Stein, 2024) [15, 53, 54], and LD-4.05 Dysnemkinesia Dyslexia (McMains, 2002) [42]. Together, these Ga and Gv deficits can result in LD-4.06 Alexic Dyslexia (also known as Acquired Reading Disorder that includes Alexia or Acquired Dyslexia and Hemianopic Dyslexia, Mixed Dyseidetic-Dysphonetic Dyslexia) where the acquired disruption is noted in the orthographic-phonological integration upon which the foundation of fluent reading and spelling depends (Alduais, Alarifi, & Alfadda, 2024; Ali et al., 2021; Kerkhoff & Kraft, 2024) [2, 4, 30]. In other words, from the Ga and Gv weaknesses that have been gathered so far, looking through the lens of the CHC framework, three possible dyslexia types have been identified: the first category is due to Ga weaknesses; the next category is the result of Gv weaknesses; and the third category is the combination of both Ga and Gv weaknesses. In this way, the CHC theory has helped the educational therapists in designing better individualized intervention plans for their clients, by pinpointing the weaknesses or deficits identified in the narrow Ga and Gv abilities that are affected by dyslexia.

CHC Theory, Dyslexia And Mental Wellness
Applying the CHC framework to dyslexia does not only shed light on the cognitive mechanisms underlying reading difficulties but also has significant implications for students' mental wellness and overall health. Students with dyslexia often experience repeated academic failure, slower progress compared to peers, and difficulties meeting school expectations. These struggles, when misunderstood as a lack of intelligence or effort, can lead to frustration, reduced self-esteem, heightened anxiety, and even depressive symptoms (Alexander-Passe, 2015; Georgiadi et al., 2023) [3, 25]. By identifying the specific CHC cognitive domains (e.g., Ga for phonological awareness and Gv for visual-symbol processing) that contribute to their learning challenges, educators and therapists can reframe dyslexia as a neurocognitive profile rather than a personal deficiency. This reframing helps protect students' self-concept, reducing stigma and fostering resilience (Stein, Hoeft, & Richter, 2024) [53, 54].
Furthermore, interventions based on CHC-informed assessments enable more precise and strengths-based approaches, where students learn to build compensatory strategies around intact cognitive abilities. Such an approach enhances their sense of agency and efficacy in learning, reducing the helplessness that often accompanies unaddressed reading struggles. Improved self-efficacy directly supports mental health outcomes, buffering against negative emotional states and fostering motivation to persist with challenging tasks (Nalavany et al., 2017) [44]. In this way, applying the CHC theory to the understanding of dyslexia links academic intervention with emotional well-being, offering a holistic pathway that addresses both the cognitive and psychological needs of students.

Conclusion
Developmental dyslexia can be more clearly understood by examining its relationship with specific cognitive abilities in the CHC framework. Deficits in visual processing (Gv) hinder recognition, sequencing, and memory of written symbols, while deficits in auditory processing (Ga) compromise phonological awareness, sound discrimination, and auditory memory. The interaction between these two domains explains the hallmark difficulties of dyslexia: problems in decoding, spelling, and fluent reading. Recognizing these connections not only strengthens the theoretical foundation of dyslexia research but also charts a roadmap for designing targeted assessments and interventions that address both visual and auditory processing weaknesses.
At the same time, applying the CHC framework to dyslexia also underscores its connection to students' mental wellness and health. When learning challenges are reframed as specific cognitive differences rather than global deficits, the stigma and frustration associated with academic struggles

are reduced. Interventions that leverage strengths while addressing weaknesses help foster self-efficacy, resilience, and a positive sense of identity, all of which protect against anxiety, low self-esteem, and depressive symptoms (Omar, Kirkman, & Babicova, 2024; Zuppardo et al., 2021) [45, 59]. In this way, the CHC theory provides a dual benefit: guiding precise instructional practices while supporting the psychological well-being and long-term development of students with dyslexia.

Competing interests
Author have declared that he has no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

Consent and Ethical approval
It is not applicable.

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