ESIC2024 Posted: 17/12/2024

Cognitive Functions for Students with Learning Disabilities: Practical Implications

Farah Faisal Alsakhen - Co-author: Prof. Rogayah A Razak - UCSI University
Email: rogayah@ucsiuniversity.edu.my

Abstracts

Learning disabilities (LD) are neurological disorders that impair the cognitive capacity to process information necessary for the development of skills, such as reading, writing, and mathematics. This narrative review examined the cognitive functions underlying different types of learning disabilities, mainly dyslexia, dyscalculia, and ADHD, from 2014 to 2024. This review discusses deficits in academic performance based on hampering cognitive functions such as memory, attention, and executive functions. The evidence demonstrates that with children with cognitive deficits, sensory and metacognitive strategies to enhance learning are found to be successful. For instance, dyslexic learners rely on phonological processing, whereas dyscalculic learners rely on visual-spatial reasoning. The invaluable personal and integrative approaches in which cognitive and sensory interventions are combined in the review to cater to the needs of children with these conditions. Longitudinal studies should be the focus of in-depth research to understand the long-term effects of these customized interventions and examine the role of environmental factors in cognitive development.

Keywords: Learning Disorders, Cognitive Functions, Cognitive Intervention, Dyslexia, Dyscalculia, ADHD, Quality Education

1. Introduction

Learning disabilities (LD) are defined as neurological disorders that affect a person's ability to gain knowledge in areas such as reading, writing, or mathematics. According to the Learning Disabilities Association of America, learning disabilities are quite separate from intellectual disabilities; they do not lower overall intelligence but rather affect specific cognitive processes absolutely vital for learning (Learning Disabilities Association of America, 2020). Common categories of learning disabilities include dyslexia, dyscalculia, and dysgraphia, as well as attention-deficit/hyperactivity disorder (ADHD), which refers to the impairment of attention and impulse control; these four conditions interfere with diverse cognitive domains (American Psychiatric Association, 2013).

Given the significant impact of LDs, their prevalence in educational settings is substantial. Indeed, some studies estimate that 5-15% of school-age children suffer from some kind of LD worldwide (American Psychiatric Association, 2013; World Health Organization, 2021). About seven million students—or about 14% of all public school students in the United States—receive special education services under the Individuals with Disabilities Education Act, although learning disabilities are the most common category (U.S. Department of Education 2021).

This prevalence underscores the importance of studying cognitive function in students with learning disabilities, as these functions are central to learning and academic achievement. Cognitive functions are defined as mental operations through which individuals engage in all kinds of tasks, from perception, memory, and attention to executive functions that involve planning and problem-solving (Diamond, 2013). This kind of cognitive process is fundamental to learning and academic achievement. Impairment in selective cognitive functions in students with learning disabilities will cause impairment in effective information processing that will result in academic failure and lower educational attainment (Swanson, Harris, & Graham, 2013).

Cognitive functions include crucial mental activities such as memory, attention, processing speed, and executive functions, all of which are essential for acquiring knowledge and skills (Diamond, 2013). These processes are core in learning and provide the ability to understand and store information, control tasks, and adapt to new ones (Swanson, Harris, & Graham, 2013).

Further research has revealed significant differences in cognitive function among students with various learning disabilities. For instance, phonological processing and working memory of students with dyslexia are usually compromised, but those diagnosed with dyscalculia might be unable to handle visual-spatial reasoning or numerical processing appropriately (Alloway, Gathercole, & Elliott, 2010). That is, students with ADHD have a deficit in the regulation of attention and executive control, which affects task performance related to focus, organization, and execution of tasks (Willcutt et al., 2017).

The main focus of this review is on three types of LDs: dyslexia, dyscalculia, and ADHD. Dyslexia is a learning disability that primarily affects the skills involved in accurate and fluent word reading and spelling (Jing et al., 2023). It is characterized by issues with verbal processing speed, verbal memory, and phonological awareness skills. Dyslexia occurs across a range of intellectual abilities (American Psychiatric Association, 2013).

Dyscalculia is defined as difficulty in understanding concepts concerning numbers and the inability to perform mathematical operations. It has been found that the two major cognitive disabilities associated with dyscalculia are visual-spatial reasoning deficits and numerical processing (Butterworth, Varma, & Laurillard, 2011). These deficits might interfere with understanding and working with numeric information, which underlies long-term mathematical difficulties (Geary 2011).

Finally, ADHD involves a pattern of persistent inattention, hyperactivity, and impulsivity. Other studies have indicated that people with ADHD tend to show executive function deficits in functions such as working memory, inhibition, and cognitive flexibility (Willcutt et al., 2017). These deficits may result in an inability to attend to information, plan, or organize one's activities, and even control behavior, all of which will interfere with academic functioning (Barkley, 2014). All three LDs are usually diagnosed based on academic underachievement, despite adequate intelligence and educational opportunities (Fletcher et al., 2018).

Studies on the correlation between cognitive functions and learning disabilities have shown distinct patterns of cognitive deficits related to different types of LDs. Dyslexia is a condition in which a person has difficulty recognizing words, spelling, and decoding. In fact, phonological processing deficits that affect sound manipulation in language are considered one of the hallmarks of dyslexia, and many studies have proven this over the years (Vellutino et al., 2004; Jing et al., 2023). In addition, individuals with dyslexia have working memory deficits, especially when tasks involve manipulating and storing verbal information (Swanson, Zheng, & Jerman, 2009).

Consequently, among all the various learning disabilities, one finds executive function deficits. Such deficits may manifest in goal setting, planning, and problem solving, thus limiting the more complex academic requirements placed on students (Meltzer, 2018). Another widely found deficit is processing speed, which implies that the rate of information processing is slow in students with LDs (Fletcher et al., 2019).

In light of these findings, this narrative review aims to summarize previous findings from research studies conducted between 2014 and 2024 on cognitive functions for students with learning disabilities. This review synthesizes insights from recent research, with a particular focus on improved understanding in this field and areas that remain open to further inquiry.

2. Methods

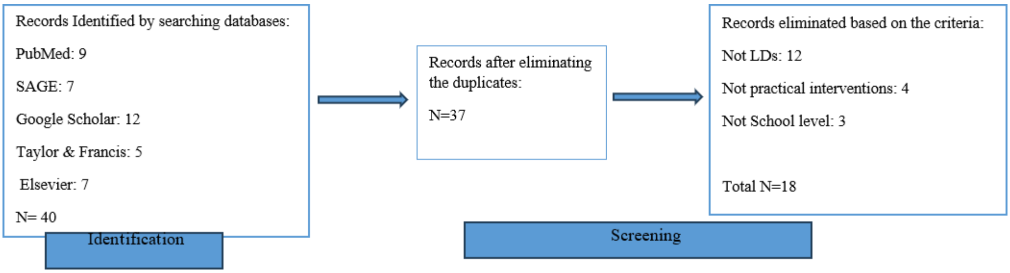
This narrative review examines research findings from 2014 to 2024 on cognitive function among students with learning disabilities. Systematic searches were conducted across major academic sources with inclusion criteria to identify relevant high-quality studies. The literature search used the following databases: PubMed, Google Scholar, SAGE, Taylor and Francis, and Elsevier. Search terms included combinations like "learning disabilities," "cognitive functions," "academic performance," and "neurocognitive assessments." Boolean operators refined search results, while filters limited publications to those released between January 1, 2014, and December 31, 2024.

The inclusion criteria ensured relevance and quality, and included articles published in English or translated into English to reach a wide audience. The focus was on studies involving students diagnosed with learning disabilities including dyslexia, ADHD, and specific learning disorders. Priority was given to articles examining cognitive functions, such as memory, attention, executive function, and processing speed, concerning learning disabilities. This review considered both qualitative and quantitative studies, including longitudinal, cross-sectional, and controlled trials.

The exclusion criteria were also considered. Studies focusing on learning disabilities secondary to other neurological or psychiatric conditions were excluded, as were research articles that were not based on empirical data, such as opinion pieces or theoretical papers. The data extraction process involved identifying key themes and findings related to cognitive functions in students with learning disabilities, including gathering information about the study design, population characteristics, cognitive assessments used, and major findings. The extracted data were organized into a narrative synthesis, highlighting trends, gaps, and implications for further research and educational practice.

The review acknowledges potential limitations such as publication bias and the exclusion of non-English studies. Additionally, variations in the diagnostic criteria and assessment tools across studies may affect the generalizability of the findings. Despite these limitations, this narrative review aims to synthesize knowledge related to the influence of cognitive functions on students with learning disabilities, providing insights for educators, policymakers, and researchers to develop effective interventions and support strategies.

The filtering process of the study is shown in the figure below.



3. Results

Table 1: Studies on Cognitive Functions in Students with Learning Disabilities

No.	Reference	Type of LD	Participants	Measures and instruments	Cognitive Processes	Results
1	Agostini, F., Zoccolotti, P. and Casagrande, M. (2022) 'Domain-general cognitive skills in children with mathematical difficulties and dyscalculia: A systematic review of the literature', Brain Sciences, 12(2), p. 239.	Dyscalculia	46 studies were analyzed.	Systematic review using PRISMA.	Processing speed Phonological awareness Memory Executive functions Attention	- Children diagnosed with mathematical difficulties, which includes dyscalculia, exhibit deficiencies in executive functions, attention, and processing speed, among other cognitive domains. - Working memory, cognitive flexibility, and inhibition were found to be specifically impaired. - Assessment of general cognitive abilities is necessary to customize interventions during diagnosis. - More studies are required to determine how cognitive abilities related to dyscalculia,

						such as phonological awareness and long-term memory, work. - Developing successful educational strategies for kids with dyscalculia requires thorough cognitive assessment.
2	Castaldi, E., Tinelli, F., Filippo, G., Bartoli, M., & Anobile, G. (2024). Auditory time perception impairment in children with developmental dyscalculia. Research in Developmental Disabilities.	Dyscalculia	37 total children 22 without dyscalculia 15 with dyscalculia	- Auditory categorization task	Time perception	- In all scales, time perception for children with dyscalculia was impaired.
3	Child, A. E., Cirino, P. T., Fletcher, J. M., Willcutt, E. G., & Fuchs, L. S. (2019). A Cognitive Dimensional Approach to Understanding Shared and Unique Contributions to Reading, Math, and Attention Skills. Journal of Learning Disabilities, 52(1), 15–30.	Dyslexia Dyscalculia ADHD	233 students from second grade	- Phonological Awareness was measured using the Elision task. - Numerosity was assessed using the Panamath task. - Working Memory was assessed with three central executive tasks from the Working Memory Test Battery for Children.	Working memory Processing Speed Phonological Awareness	- Working memory and phenological awareness overlap between dyslexia, dyscalculia, and ADHD students. - The processing speed role is very weak among those three disabilities. - Numerosity was strongly related to dyscalculia and ADHD.

				- Processing Speed was assessed using the Cross Out task from the Woodcock-Johnson III Tests of Cognitive Abilities.		
4	Elwan, F., Gaballah, S., & Khalifa, A. G. (2019). Impairment of some cognitive process in children with reading disability in middle childhood, late childhood, and early adolescence. Middle East Current Psychiatry, 26(1), 1.	Dyslexia	180 males between 7 and 15 years old	- The Cognitive Assessment System (CAS) was administered.	Planning Attention	- Children with reading disabilities scored significantly lower in the total, and all subscales of the Cognitive Assessment System (CAS) showed significant correlations with Planning, Attention, Simultaneous, and Successive. - The children with reading disabilities performed significantly poorer than the control group in nearly all of the subtests of the Comprehensive Assessment of Spoken Language (CAS).
5	Fernández-Andrés, M. I., Tejero, P., & Vélez-Calvo, X. (2021). Visual Attention, Orthographic Word Recognition, and Executive Functioning in Children With ADHD, Dyslexia, or ADHD + Dyslexia. Journal of Attention Disorders, 25(7), 942–953.	Dyslexia ADHD	140 children from 8-10 years old 35 with only dyslexia (DD) 35 with the combined type of attention deficit and hyperactivity disorder (ADHD-C) 35 with dyslexia and ADHD (DD + ADHD-C)	- The Conners-3 parents' version for ADHD detection was administered to the parents. - The teachers' version of the same test was administered to the teachers, as well as an academic information questionnaire and the BRIEF (Behavior Rating Inventory of Executive Function) questionnaire to	Selective attention Executive functions	- Attention: Typically The developing (TD) group outperformed all other groups. The group with dyslexia (DD) outperformed both groups with ADHD-C (ADHD-C alone or comorbid with DD). - The TD group outperformed both ADHD-C groups on all measures, as reported by teachers, in terms of executive functions. The DD group outperformed the ADHD-C group in all measures and achieved higher scores than the DD + ADHD-C group in all measures except for "shift."

			35 typical developmental children (TD)	evaluate executive functioning.		
6	Geary, D. C., Hoard, M. K., Nugent, L., & Bailey, D. H. (2015). Mathematical cognition deficits in children with learning disabilities and persistent low achievement: A five-year prospective study. Journal of Educational Psychology, 107(1), 197-207.	Dyscalculia	Mathematical Learning Disability (MLD): 16 children Persistent Low Achievement (LA): 29 children Typical Achievement: 132 children	- Intelligence, Working Memory, Processing Speed, In-Class Attention: Assessed in 2 or more grades. - Mathematical Cognition: Assessed with experimental tasks across all grades.	Working memory Processing speed	MLD Group: - Characterized by low school-entry mathematics achievement and poor word reading skills. - Poor mathematical fluency and slow automatized naming mediated these deficits. MLD and LA Groups: - Showed slow growth in mathematics achievement across grades.
7	Habib, M., et al. (2016). Music and dyslexia: A new musical training method to improve reading and related disorders. Frontiers in Psychology, 7, 26.	Dyslexia	12 dyslexic children, ages 8-11	- To test the efficacy of a specially designed Cognitivo-Musical Training (CMT) method for children with dyslexia.	Phonological awareness	- The study provides evidence supporting the use of musical training as a therapeutic tool for dyslexic children. - Musical training can lead to significant improvements in both linguistic and non-linguistic abilities in dyslexic children. - The results advocate for incorporating music into systematic therapeutic and instructional practices for teaching dyslexia.
8	Jafarlou, M., et al. (2022). Effects of oculomotor rehabilitation on	Dyslexia	50 children with dyslexia between 8 and 12 years	- Oculomotor rehabilitation Those with	Motor function	- The correct scores of cognitive tests in the case group posttest increased significantly compared to the control group

	the cognitive performance of dyslexic children with concurrent eye movement abnormalities. Neuroscience Letters, 768, 136325.		old.	oculomotor abnormalities (n = 30) were randomly assigned to two groups (case and control) matched for age. - The case group received oculomotor rehabilitation. Children in the control group received no intervention.	Visual processing Working memory	(p = 0.028).
9	Lawton, T. (2016). Improving dorsal stream function in dyslexics by training figure/ground motion discrimination improves attention, reading fluency, and working memory. Frontiers in Human Neuroscience, 10(397), 1–16.	Dyslexia	58 dyslexic children in second grade, 7.4 ± 0.4 years of age	- Motion discrimination training - Two interventions targeted the temporal dynamics (timing) of either the auditory or visual pathways, with a third reading intervention (control group) targeting linguistic word building.	Attention Working memory Processing speed	- Visual pathway training in dyslexics to improve direction - discrimination of moving test patterns relative to a stationary background (figure/ground discrimination) significantly improved attention, reading fluency, both speed and comprehension, phonological processing, and both auditory and visual working memory relative to controls. - Auditory training to improve phonological processing did not improve these academic skills significantly more than found for the control group.
10	Leloup, G., et al. (2021). Improving reading skills in children with dyslexia: Efficacy studies on a newly proposed remedial intervention—	Dyslexia	200 children with dyslexia, ages 9-14	- Repeated reading with vocal music masking - A 5-week program of	Phonological Awareness Skills	- Enhanced reading skills and phonological awareness skills. - RVM may help rebalance the phonological and orthographic coding procedures necessary for

	Repeated reading with vocal music masking (RVM). Journal of Learning Disabilities, 54(3), 191-203.			intensive RVM training in a pre-post-test clinical paradigm - as well as a longitudinal paradigm where it is compared to 8 months of the standard remediation program (SRP).		efficient reading. - Demonstrated efficacy of integrated auditory interventions.
11	Liang, F., & Li, P. (2019). Characteristics of Cognitive in Children with Learning Difficulties. Translational Neuroscience, 10, 141–146.	Various learning disabilities, including ADHD and dyslexia	185 participants. 142 males 43 females	- The self-made general information questionnaire is to be completed by the parents.	Working memory Processing speed	- Children with learning difficulties generally have lower intelligence levels compared to their peers. This difference is even more pronounced in children with movement retardation. - Many children with learning difficulties also exhibit attention deficit issues, suggesting a biological basis for their challenges.
12	Liu, S., Cheng, C., Wu, P., Zhang, L., Wang, Z., Wei, W., Chen, Y., & Zhao, J. (2022). Phonological Processing, Visuospatial Skills, and Pattern Understanding in Chinese Developmental Dyscalculia. *Journal of Learning Disabilities*, *55*(6), 499–512.	Dyscalculia	190 Chinese children ages 8 to 11 years 97 children with dyscalculia 93 without dyscalculia	- Arithmetic ability was assessed using the arithmetic subset (MT1) of the C-RSPMA. - Phonological processing was assessed using Digit RAN, onset and rime deletion, and phoneme	Phonological awareness skills Visuospatial skills	- Observing that phonological retrieval, pattern understanding, visual–spatial attention, and phonological awareness could predict dyscalculia significantly. - Among those predictors, phonological retrieval manifested by RAN had the highest effect.

				deletion. - Visual spatial skills were assessed using C-RSPMA test and Standardized Ravens Progressive Matrices.		
13	Luoni, C., Scorza, M., Stefanelli, S., Fagiolini, B., & Termine, C. (2023). A Neuropsychological Profile of Developmental Dyscalculia: The Role of Comorbidity. Journal of Learning Disabilities, 56(4), 310–323.	Dyscalculia	380 children 176 males and 204 females Between the ages of 8.17 and 9.33 years	- Short-term memory was assessed using the Neuropsychological Evaluation Battery for digit span forward and verbal span forward. - Visuospatial memory was assessed using the Corsi Block-Tapping Task. - Visuospatial abilities were assessed using The Shortened VisuoSpatial Questionnaire.	Working memory Visuospatial memory Visuospatial abilities	- Children with developmental dyscalculia (DD) exhibit significant impairments in memory and visuospatial abilities. - Deficits in short-term and working memory are critical for mathematical tasks. - Children with DD struggle with retaining and manipulating numerical information, indicating weaknesses in these memory domains. - Visuospatial processing difficulties are common among children with DD.

14	Mohamed, S. M. H., Butzbach, M., Fuermaier, A. B. M., Weisbrod, M., Aschenbrenner, S., Tucha, L., et al. (2021). Basic and complex cognitive functions in Adult ADHD. PLOS ONE, 16(9), e0256228.	ADHD	48 people with ADHD in the experimental group compared to 48 in the controlled group	Basic and complex cognitive functions were assessed using Vigilance and Sustained Attention, Selective Attention, N-Back, Tower of London, Trail Making Test, Word Fluency, and Verbal Learning and Memory.	Working memory Processing speed Attention	- Patients with ADHD exhibited slow processing speed and increased distractibility, with medium effect sizes. - Significant differences were found in reaction time variability between the groups. - Impairments were also observed in selective attention and memory functions.
15	Morte-Soriano, M. R., Begeny, J. C., & Soriano-Ferrer, M. (2021). Parent and Teacher Ratings of Behavioral Executive Functioning for Students With Dyslexia. Journal of Learning Disabilities, 54(5), 373–387.	Dyslexia	160 children and adolescents 78 with dyslexia 82 without dyslexia	- Behavior Rating Inventory of Executive Function, second edition.	Executive Functions	- Parents and teachers rated children and adolescents with dyslexia as experiencing more frequent cognitive, behavioral, and emotional executive function difficulties at home and school, compared to their typically developing peers. - Teachers frequently observed more pronounced impairments compared to parents in various executive function domains, potentially indicating a distinct pattern of executive function challenges between the home and school environments.
16	Vainieri, I., Michelini, G., Cheung, C. H. M., Oginni, O. A., Asherson, P., Rijsdijk, F., & Kuntsi, J. (2023). The Etiological and Predictive Association Between ADHD and Cognitive Performance From Childhood to Young Adulthood.	ADHD	Total 391 99 participants with persistent ADHD and 100 unaffected siblings (69 full sibling pairs, 61 singletons), 23 remitters (5 full sibling pairs, 13	- Measures included IQ, short-term and working memory measures, and response speed and variability from a four-choice reaction-time task.	Working memory Executive functions	- An ADHD diagnosis during childhood is a strong predictor of impaired working memory during adolescence and young adulthood. This relationship remains significant even when considering their previous connection during childhood. - Having ADHD during childhood has a detrimental effect on future working memory performance.

	Journal of Attention Disorders, 27(7), 709–720.		singletons), and 169 control siblings (76 full sibling pairs, 17 singletons).			
17	Saga, M. et al. (2021) ‘Developmental dyscalculia: The progress of cognitive modeling in the field of numerical cognition deficits for children’, Applied Neuropsychology: Child, 11(4), pp. 904–914.	Dyscalculia	81 studies were analyzed.	Systematic review of 81 studies.	All cognitive functions	- Dyscalculic children struggle greatly with both the exact and approximate number systems, which hinders their comprehension and manipulation of quantities. - Studies on neuroimaging indicate that parietal deficiencies in the processing of numerical information may be present in dyscalculic individuals, as evidenced by the reduced sensitivity of certain brain regions, such as the intraparietal sulcus, to variations in numbers. - Dyscalculia affects a variety of cognitive abilities, including executive function and short-term visual memory, highlighting the complexity of the disorder and the need for a thorough understanding.
18	Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2017). Validity of the executive function theory of ADHD: A meta-analytic review. Biological Psychiatry, 57(11), 1336-1346. doi:10.1016/j.biopsych.2012.02.019	ADHD	Total Participants: 6,703 individuals ADHD Group: 3,734 participants Control Group: 2,969 participants Sample Types: Both clinic-referred and community samples.	- Meta-analysis of 83 studies that administered EF measures	Executive Functions Working memory	- Groups with ADHD showed significant challenges across all EF tasks. - Effect sizes for EF measures were in the medium range (0.46–0.69). - The strongest and most consistent deficits were found in response inhibition, vigilance, working memory,

						and planning tasks. - Difficulties with EF are an important component of the complex neuropsychology of ADHD, but not the sole cause.

Cognitive Functions and Students with LD

Working Memory

Working memory is a cognitive system that is crucial for temporary storage and manipulation of information necessary for complex cognitive tasks. However, long-term memory is responsible for long-term information retention (Willcutt et al., 2017; Liang and Li, 2019). It also encompasses visuospatial memory, which is the capacity to retain and retrieve visual and spatial data, such as the arrangement of items in a space or visual characteristics of an environment. It entails keeping track of the locations and arrangements of objects, which is useful for tasks requiring spatial reasoning and navigation (Luoni, 2023).

Efficient working memory is crucial for achieving academic success, as it is necessary for various cognitive functions such as learning, reasoning, and comprehension. Agostini et al. (2022) and Geary et al. (2015) suggest that students with learning disorders frequently demonstrate a diminished working memory capacity in comparison to their peers without disabilities. This limitation restricts their ability to retain and process multiple pieces of information simultaneously.

Moreover, Agostini et al. (2022) claimed that the effectiveness of working memory is greatly influenced by executive functions, such as attention and information processing. Students with learning disabilities often struggle to sustain their attention and process new information effectively, which can easily overwhelm their limited working memory capacity. This lack of efficiency hampers their capacity to meet academic requirements.

According to Jafarlou et al. (2022) and Lawton (2016), another significant distinction is the level of automaticity exhibited by cognitive processes. Over time, average students develop automaticity in many cognitive tasks, allowing them to save working memory resources for more complex tasks. On the other hand, students with learning disabilities frequently need to consciously focus on tasks that their classmates complete effortlessly, which use up a larger portion of their working memory capacity. For example, a student with dyslexia may have to dedicate a substantial amount of their working memory to decipher words, resulting in a lower capacity for understanding the entire text. In contrast, students with average abilities possess the capacity to identify words effortlessly, allowing their cognitive resources to be directed towards more advanced comprehension tasks (Child et al., 2019).

Processing Speed

Processing speed refers to the time it takes for an individual to perceive, process, and respond to the information. This cognitive function consists of three main components: visual processing, auditory processing, and motor speed. Students with LDs often demonstrate reduced cognitive processing speeds compared with their peers without LD (Lawton, 2016).

Liang and Li (2019) mention a notable consequence of reduced processing speed in students with learning disabilities is the challenge of comprehending verbal instructions or information during lessons, resulting in difficulties in grasping concepts and keeping up with classroom activities. In addition, students with learning disabilities frequently exhibit reduced reading speed, which presents difficulties in reading and understanding academic materials such as textbooks within a specified timeframe. This constraint hampers their capacity to accomplish reading tasks and to actively participate in the curriculum.

Even when they are knowledgeable about the material, students with learning disabilities frequently struggle to complete timed assignments and assessments. Their incomplete judgments, which may not fairly represent their understanding, may result from their desire for more time to think about things through and reply. Even when they are familiar with the material, some students may find it difficult to quickly retrieve knowledge, which hinders their ability to participate fully in class discussions and activities (Mohamed et al., 2021). Furthermore, it might be difficult for students to keep up with classes that move quickly because the amount of information delivered so quickly may be more than their cognitive processing capacity, which lowers their understanding and interest. Falling behind their peers creates feelings of inadequacy and a developing dislike for academic pursuits, which can lead to dissatisfaction, low self-esteem, and a negative link with learning (Geary et al., 2015).

Attention

Attention deficits observed in students with learning disabilities (LD) result from a complex interplay of neurological, cognitive, and psychological factors. Neurologically, variations in the structure and function of the brain, as well as an imbalance in neurotransmitters, affect the ability to regulate attention (Agostini et al., 2022). Cognitively, impairments in working memory and slow processing speed hinder the ability to maintain focus and respond quickly. Psychologically, increased anxiety, avoidance of tasks, and decreased self-esteem contribute to decreased attention, as students may develop a sense of learned helplessness and reduced motivation (Elwan et al., 2019).

Attention difficulties can present themselves as a lack of focus, being easily distracted, and acting impulsively, which can hinder students' ability to concentrate on tasks, maintain attention, and ignore distractions. Students with attention deficits may struggle to maintain concentration during lessons, complete assignments without being easily distracted, and sustain their focus on tasks that demand prolonged mental exertion. This can lead to unfinished tasks, negligent mistakes, and challenges in maintaining focus on educational materials (Fernández-Andrés et al., 2021).

Executive Functions

Executive functioning encompasses a collection of cognitive processes that are crucial for the control and regulation of behavior, facilitating goal-oriented actions and handling intricate tasks. The processes encompassed in this set include working memory, cognitive flexibility, inhibitory control, planning, problem solving, and self-monitoring. Executive functioning plays a vital role in both academic performance and daily life activities. It enables individuals to effectively organize their thoughts, prioritize tasks, efficiently manage time, and adapt to dynamic situations (Vainieri et al., 2023; Willcutt et al., 2017).

A study by Sage et al. (2021) suggests that executive functioning is often impaired in students with learning disabilities (LD), manifesting in various ways. Inhibitory control problems were prevalent among the students with LD. Inhibitory control is the ability to suppress irrelevant or distracting information and impulses. These students may struggle to maintain concentration on a task, resist distractions, and regulate impulsive behaviors, which can result in difficulties in classroom environments that require sustained attention and self-discipline.

Students with LD face additional challenges in their learning experiences owing to cognitive inflexibility. Cognitive flexibility refers to the ability to seamlessly transition between different tasks, adjust to novel information, and engage in the simultaneous consideration of multiple concepts. Students with LD may struggle with transitioning from one activity to another, adjusting to changes in routines, or approaching problems from different perspectives. This inflexibility can impede their ability to solve problems and make them adaptable (Vainieri et al., 2023).

Furthermore, students with LD often exhibit shortcomings in their ability to plan and organize. Efficient planning and organization are crucial for successfully completing assignments, effectively managing time, and establishing goals. These students frequently demonstrate inadequate organizational abilities, struggle to divide tasks into manageable stages, and face difficulties in creating and executing plans. This can lead to failure to meet deadlines, unfinished tasks, and a general lack of organization in academic matters (Morte-Soriano et al., 2021).

Fernández et al. (2021) mentioned that difficulties with self-monitoring pose a significant problem. Self-monitoring entails evaluating one's own performance and making the necessary adjustments. Students with learning disabilities may experience difficulties in assessing their work, identifying mistakes, and implementing necessary revisions. This can have an impact on the caliber of their work and capacity to derive knowledge from errors.

Phonological Awareness

The fundamental cognitive ability of phonological awareness is the recognition and manipulation of spoken language's sound structures. This includes the following essential skills: phoneme segmentation, phoneme blending, rhyme recognition, and sound discrimination. The ability to recognize and differentiate between various phonemes, such as the difference between the sounds /b/ and /p/, is known as sound discrimination. Phoneme segmentation is the process of dissecting words into phonemes that make them up. For example, "cat" can be divided into the phonemes /k/, /æ/, and /t/. In phoneme blending, separate phonemes are combined to form a single word. For example, /k/, /̦/, and /t/ are blended to form "cat." Rhyme recognition involves identifying words that share the same ending sounds, such as recognizing that "cat" and "hat" rhyme (Liu et al., 2022; Leloun et al., 2021; and Habib et al., 2016).

Child et al. (2019) found that phonological awareness can be significantly impaired in students with dyslexia, dyscalculia, and ADHD. These students may experience difficulties in distinguishing between sounds and similar phonemes. Their capacity to distinguish and modify specific sounds within words may be affected by this. These students may experience difficulties breaking down words into their constituent phonemes due to issues with phoneme segmentation, which hinders their comprehension of various sounds. Their ability to combine phonemes into words can be hampered by problems with phoneme mixing, which can impair their ability to interpret and read new words. Additionally, phonological processing skills, which are essential for spelling and fluency in reading, can be impacted by issues with rhyme identification.

Consequently, Agnostini et al. (2022) found that these deficits in phonological awareness can have a major impact on the development of literacy because they limit the capacity to interpret words, spell correctly, and read fluently. Specialized interventions are frequently needed to help learning-disabled students improve their phonological skills and assist their overall reading development.

Perception

As a cognitive process, perception is the brain's capacity to decipher and arrange sensory data from the outside world into a meaningful understanding. This procedure involves the senses of sight, hearing, touch, taste, and smellreceiving stimuli, and then processing the resulting sensory data to identify patterns, objects, and events. Because perception serves as the basis for other cognitive processes, it is essential for many cognitive processes, such as attention, memory, and decision-making. Visuospatial perception and temporal perception are two crucial components of perception (Castadi et al., 2024; and Saga et al., 2021).

The ability to process and understand visual information about spatial relationships between objects is known as visuospatial perception. Using spatial thinking, this cognitive ability enables people to read maps, put puzzles together, navigate their surroundings, and comprehend the locations of items. On the other hand, time perception refers to the capacity to comprehend and gauge the passage of time, allowing people to plan their activities and behaviors in accordance with temporal restrictions. Effective management of spatial and temporal information is made possible by both visuospatial and temporal perceptions, which are essential for day-to-day functioning and academic achievement (Mohamed et al., 2021).

Perceptual processing, which includes visuospatial and temporal perception, can be abnormal or compromised in students with any type of learning disability, posing a serious challenge. Reading, writing, and comprehending geometric concepts can all be impacted by these children's potential challenges by appropriately recognizing the difference between visual and spatial relationships. For instance, a student with poor visuospatial perception may find it difficult to distinguish similar letters or numerals, misread spatial layouts, or struggle to align text when writing. These obstacles may cause problems in disciplines such as geometry and mathematics, in which spatial comprehension is essential (Luoni et al., 2023).

Similarly, problems with time perception might hinder a student's capacity to manage their time efficiently, making it harder for them to complete assignments that call for organization, timing, and sequencing. It may be difficult for students with LDs to manage deadlines, predict how long tasks will take, or adhere to routines that call for a sense of time. This may lead to problems adhering to schedules, managing time, and finishing work on time (Castadi et al. 2024).

Practical Interventions to Enhance Cognitive Functions for Students with LDs

Interventions targeting the enhancement of cognitive function in students with LD are necessary to improve educational outcomes. Some promising strategies identified by research include universal design for learning, multisensory learning, explicit instruction, peer-assisted learning, and technology integration.

The study by Lawton (2016) focused on sensory training to assist in developing the reading and cognitive skills of 58 children with dyslexia. The study compared three interventions that targeted the auditory and visual pathways and a control group that focused on linguistic word-building skills. Visual pathway training improved the ability to discriminate the direction of moving patterns against a stationary background and significantly enhanced attention, reading fluency, phonological processing, and both auditory and visual working memory compared to controls. Auditory training aimed at improving phonological processing did not result in any gains that were significantly higher than those in the control group. These findings show that sensory, especially visual, training to enhance the cognitive and reading abilities of children with dyslexia is feasible.

Moreover, Leloup et al. (2021) developed an innovative intervention that involved repeated Reading with Vocal Music masking or RVM. Two hundred children with dyslexia participated in this research, which was a five-week program. The program was assessed with reference to both a pre-post clinical paradigm and compared over eight months to normal remediation programs. The findings showed that RVM significantly enhanced phonological awareness and reading. It is suggested that the role of rebalancing phonological and orthographic coding in the vocal music-masking condition could be significant for fluent reading. The results of this study highlight the effectiveness of combining auditory interventions with reading in children with dyslexia.

In support of this study, Habib et al. (2016) studied musical training in children with dyslexia. The study focused on the effects of the Cognitivo-Musical Training program on a small study size of 12 children with dyslexia. Strong differences were observed in the performance in categorical perception, auditory perception of temporal speech components, auditory attention, phonological awareness, reading skills, and pseudo-word repetition. These results would support the claim that music should be administered within the treatment and education process, as musical interventions might offer important improvements not only in the linguistic but also in the non-linguistic abilities of dyslexic children.

Jafarlou et al. (2022) explored the effects of oculomotor rehabilitation on the cognitive activity of children with dyslexia who presented with coexisting abnormalities in eye movement. The improvement rate in the results of cognitive testing of the experimental group who underwent treatment was substantially higher than that in the control group without treatment. Oculomotor improvement in dyslexic children from these studies implies that cognitive performance could be enhanced for the betterment of these children, since targeted rehabilitation programs that can ameliorate actual reading processes should be appropriate.

For students with dyscalculia, Geary et al. (2015) examined mathematical cognition deficits in children with mathematical learning disabilities and low achievement over a five-year period. The investigation consisted of an assessment of intelligence, working memory, processing speed, and mathematical cognition. Their results showed that the MLD group had low school-entry math achievement and poor word-reading skills, mediated by poor mathematical fluency and slow automated naming. The math achievement rates of growth were also very slow for both, indicating underlying deficits in fluency, memory retrieval, and problem-solving for students diagnosed with MLD as well as LA. Such a study underlines the management of these deficits directly for positive mathematical outcomes among children with learning impairments.

Willcutt et al. (2017) conducted a meta-analytic review of 6,703 participants in executive function theory of ADHD. There were significant impairments in executive functioning across the domains of response inhibition, vigilance, working memory, and planning with medium effect sizes. However, these deficits are moderate and non-universal in their effect sizes; thus, they do not fully explain ADHD. This study highlights the complexity of ADHD. In this respect, while executive function deficits are part of this condition, it is definitely not the whole phenomenon.

4. Discussion

This review covers studies that shed light on interventions and cognitive processes related to various types of developmental disorders, including ASD, dyslexia, LD, ADHD, and general cognitive development. These results are supported by a growing body of literature that emphasizes the complex interplay of cognitive skills with the effectiveness of targeted interventions.

The review studies present some effective interventions for cognitive and reading skill improvements in children with dyslexia. Lawton (2016) justified his work in sensory training, particularly visual pathway training, with evidence that training in enhanced sensory processing provides gains in reading and phonological skills (Tallal, 2004). In line with this, a study by Leloup et al. (2021) indicated that in repeated reading with vocal music masking, or RVM, similar to the findings of other studies involving auditory interventions, the improvement shown was related to gains in phonological processing and fluent reading (Cogo-Moreira et al., 2013). Importantly, the work by Jafarlou et al. (2022) further demonstrated the benefits of oculomotor rehabilitation and added to the findings of studies that have been said to underscore the importance of visual processing within reading (Bucci et al., 2012). Habib et al.'s (2016) study on musical training added additional evidence to music's therapeutic potential and linked nicely with a body of work in which it has been considered an area of interest in dyslexia research for several years (Overy, 2003).

Indeed, Geary et al. (2015) believe that metacognitive strategies in the solution of math problems are rather important, while other researchers agree that with metacognitive interventions, the performance of a student with LDs would greatly improve academically, particularly Swanson (1990). Bernini et al. (2023) also support this view, stating that their findings have shown the differential impact of cognitive training on cognitive profiles and provide further evidence to see the issue through the prism of a broader literature on tailored educational strategies and interventions (Fuchs et al., 2008).

Geary et al. (2015) found number-processing and memory-retrieval deficits, which are in line with the existing understanding of mathematical learning disabilities, often involving specific cognitive deficits that affect the child's overall mathematical cognition (Geary, 2004). Furthermore, Wang (2023) identified potential neural biomarkers for dyscalculia, a finding highly consistent with recent neuroimaging research showing different patterns of brain activation during calculations in children with mathematical difficulties (Rotzer et al., 2009).

Willcutt et al. (2017) also conducted a very well-done analysis of EF deficits in ADHD, showing that those deficits are at the core of the disorder. This is further supported by other studies that indicate difficulties in response inhibition, working memory, and planning in subjects with ADHD (Barkley, 1997; Willcutt et al., 2008). However, the moderate effect sizes suggest that, while executive function is a contributory factor, it is not the sole cause of ADHD, which reinforces the concept of the multifaceted nature of the disorder with genetic, neurobiological, and environmental factors converging in complex ways that become behaviorally expressed. 27 of Twenty-seven Epidemiologic samples (Faraone et al., 2005).

The study of Alloway & Alloway (2018) strongly illustrated the role of working memory as a strong predictor of academic attainment, and it is supported by substantial evidence that working memory capacity is a strong determinant of learner outcomes, often far stronger than IQ (Gathercole & Alloway, 2008; St Clair-Thompson & Gathercole, 2006). Furthermore, Liang et al. (2023) demonstrated that physical activity, through an exercise intervention but more specifically through open skill exercises, supports cognitive functions, among which functions such as cognitive flexibility and working memory are related to executive functions (Best, 2010; Diamond & Lee, 2011).

In a research article on RAN and reading fluency, Papadopoulos et al. (2016) continued to show additional value regarding RAN as a relevant predictor of oral reading skills. This is in line with prior evidence indicating that RAN is the most robust predictor of reading development, especially in transparent orthographies such as Greek (Lervåg and Hulme 2009). The fact that RAN is mediated by phonological awareness and orthographic processing further supports the dual-route theory of reading: both phonological and visual routes contribute to reading ability (Coltheart et al., 2001).

Overall, these findings support the importance of understanding and targeting specific cognitive and neuropsychological factors related to developmental disorders. An integrative, multifaceted approach to sensory, cognitive, and metacognitive intervention strategies is posited to be advantageous for developing tailored interventions. Future research should investigate these complex interactions to develop personalized and effective educational and therapeutic practices.

Integrating insights from neuroimaging, cognitive science, and educational psychology will be the key to advancing our understanding and treatment of developmental disorders.

5. Limitations

One of the common limitations present in a good number of them is the small sample size. For instance, the studies by Habib et al. (2016) and Jafarlou et al. (2022) had few participants (12-50 students) and limited generalization of the findings to a broad and diverse population. Small samples increase the chance of statistical error and do not capture the broad demographic variance. There is also a scarcity of reports on the diversity of participants in terms of their social class, ethnicity, and language background, which may impact the generalization of results across different cultural contexts. (Henrich et al., 2010).

A closely related issue is that most studies had an extremely short period of follow-up. Interventions such as oculomotor rehabilitation and cognitive training tend to result in immediate gains, but it is challenging to determine the long-term sustained effects. Longitudinal studies are needed to check the permanence of the effects of these interventions and their long-term influence on developmental trajectories.

6. Conclusion

Yet, with all those limitations taken as a whole, the studies point out that the interventions should be specifically tailored and multidimensional in the case of developmental disorders. It is demonstrated that the best practice in intervention can usually be performed by individualization, taking into account different cognitive profiles and problems. For example, training in sensory function in dyslexia and training in cognitive function in learning disabilities seem quite promising.

However, the studies also highlight the critical importance of the role of cognitive and sensory processing is in enhancing academic and cognitive functioning. Effective targeted interventions to enhance working memory, sensory processing, and metacognitive strategies are beneficial, which is a clear indication that the cognitive domains should be well addressed to foster better learning outcomes.

Early intervention is a common underlying theme, for example, in research by Alloway & Alloway (2018), showing how early cognitive skills, such as working memory, can predict later academic achievements. The earlier these disorders are identified, the better the interventions will be to reduce long-term impact. A very useful for integration are the multimodal approaches that combine auditory, visual, and motor trains. These more comprehensive strategies, addressing many underlying deficits and including the much broader cognitive enhancement, that are characteristic of interventions for dyslexia and ADHD.

Although the findings are promising, further research is needed on the long-term effects of the interventions, the influences of individual differences, and the relationship between neuroimaging and cognitive assessments. Further research will deepen our understanding and improve the refinement of intervention strategies so that they can effectively help individuals with diverse needs.

WORKS CITED

Alloway, T. P. , & Alloway, R. G. (2018). Investigating the predictive roles of working memory and IQ in academic attainment. Journal of Experimental Child Psychology, 106(1), 20–29. 10.1016/j.jecp.2009.11.003
Alloway, T. P., & Gathercole, S. E. (2006). Working memory and neurodevelopmental disorders. Psychology Press.
American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.). Arlington, VA: American Psychiatric Publishing.
Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. Psychological Bulletin, 121(1), 65. doi:10.1037/0033-2909.121.1.65
Barkley, R. A. (2014). Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment. Guilford Publications.
Best, J. R. (2010). Effects of physical activity on children's executive function: Contributions of experimental research on aerobic exercise. Developmental Review, 30(4), 331-351. doi:10.1016/j.dr.2010.08.001
Bucci, M. P., Nassibi, N., Gerard, C. L., Bui Quoc, E., & Seassau, M. (2012). Postural control and eye movements in dyslexic children. NeuroReport, 23(5), 264-269. doi:10.1097/WNR.0b013e3283517048
Butterworth, B., Varma, S., & Laurillard, D. (2011). Dyscalculia: From brain to education. Science, 332(6033), 1049-1053. doi:10.1126/science.1201536
Cappelletti, M., & Price, C. J. (2014). Cognition and dyscalculia: Neuropsychological perspectives. Current Opinion in Behavioral Sciences, 4, 81-85. doi:10.1016/j.cobeha.2015.03.008
Castaldi, E., Tinelli, F., Filippo, G., Bartoli, M., & Anobile, G. (2024). Auditory time perception impairment in children with developmental dyscalculia. Research in Developmental Disabilities, 149, 104733. https://doi.org/10.1016/j.ridd.2024.104733
Child, A. E., Cirino, P. T., Fletcher, J. M., Willcutt, E. G., & Fuchs, L. S. (2019). A Cognitive Dimensional Approach to Understanding Shared and Unique Contributions to Reading, Math, and Attention Skills. Journal of Learning Disabilities, 52(1), 15–30.
Cogo-Moreira, H., et al. (2013). Music education for improving reading skills in children and adolescents with dyslexia. The Cochrane Database of Systematic Reviews, 2013(9), CD009133. doi:10.1002/14651858.CD009133.pub2
Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. Psychological Review, 108(1), 204-256. doi:10.1037/0033-295X.108.1.204
Diamond, A. (2013). Executive functions. Annual Review of Psychology, 64, 135-168. doi:10.1146/annurev-psych-113011-143750
Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. Science, 333(6045), 959-964. doi:10.1126/science.1204529
Elwan, F., Gaballah, S., & Khalifa, A. G. (2019). Impairment of some cognitive process in children with reading disability in middle childhood, late childhood, and early

adolescence. Middle East Current Psychiatry, 26(1), 1. https://doi.org/10.1186/s43045-019-0001-z
Faraone, S. V., et al. (2005). The worldwide prevalence of ADHD: Is it an American condition? World Psychiatry, 4(2), 104-113. PMID: 16633513
Fernández-Andrés, M. I., Tejero, P., & Vélez-Calvo, X. (2021). Visual Attention, Orthographic Word Recognition, and Executive Functioning in Children With ADHD, Dyslexia, or ADHD + Dyslexia. Journal of Attention Disorders, 25(7), 942–953. https://doi.org/10.1177/1087054719864637
Fletcher, J. M., Lyon, G. R., Fuchs, L. S., & Barnes, M. A. (2018). Learning disabilities: From identification to intervention. Guilford Press.
Fuchs, D., Fuchs, L. S., & Malone, A. S. (2017). The taxonomy of intervention intensity. Teaching Exceptional Children, 50(1), 35-43.
Fuchs, D., Fuchs, L. S., & Vaughn, S. (2008). Response to intervention: A framework for reading educators. Newark, DE: International Reading Association.
Gathercole, S. E., & Alloway, T. P. (2008). Working memory and learning: A practical guide for teachers. SAGE Publications Ltd.
Geary, D. C. (2004). Mathematics and learning disabilities. Journal of Learning Disabilities, 37(1), 4-15. doi:10.1177/00222194040370010201
Geary, D. C. (2011). Cognitive predictors of achievement growth in mathematics: A 5-year longitudinal study. Developmental Psychology, 47(6), 1539-1552. doi:10.1037/a0025510
Geary, D. C., et al. (2015). Mathematical cognition deficits in children with learning disabilities and persistent low achievement: A five-year prospective study. Developmental Psychology, 51(1), 61-75. doi:10.1037/a0038265
Geary, D. C., Hoard, M. K., Nugent, L., & Bailey, D. H. (2015). Mathematical cognition deficits in children with learning disabilities and persistent low achievement: A five-year prospective study. Journal of Educational Psychology, 107(1), 197-207.
Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2002). Behavior rating inventory of executive function. Child Neuropsychology, 6(3), 235-238. doi:10.1076/chin.6.3.235.3152
Habib, M., et al. (2016). Music and dyslexia: A new musical training method to improve reading and related disorders. Frontiers in Psychology, 7, 26. doi:10.3389/fpsyg.2016.00026
Hackman, D. A., & Farah, M. J. (2009). Socioeconomic status and the developing brain. Trends in Cognitive Sciences, 13(2), 65-73. doi:10.1016/j.tics.2008.11.003
Henrich, J., Heine, S. J., & Norenzayan, A. (2010). Most people are not WEIRD. Nature, 466(7302), 29-29. doi:10.1038/466029a
Hill, E. L. (2004). Executive dysfunction in autism. Trends in Cognitive Sciences, 8(1), 26-32. doi:10.1016/j.tics.2003.11.003
Jafarlou, M., et al. (2022). Effects of oculomotor rehabilitation on the cognitive performance of dyslexic children with concurrent eye movement abnormalities. Neuroscience Letters, 768, 136325. doi:10.1016/j.neulet.2021.136325
Jing, W., Yu, E. L. X., & Motevalli, S. (2023). A Comparison Between Cognitive Assessment and Neurobiology Technology Assessment of Dyslexia: A Literature Review. International Journal of Academic Research in Business and Social Sciences, 13(4), 976 – 986.
Kaufmann, L., Mazzocco, M. M., Dowker, A., von Aster, M., Goebel, S., Grabner, R. H., & Kucian, K. (2020). Dyscalculia from a developmental and differential perspective. Frontiers in Psychology, 11, 1274. doi:10.3389/fpsyg.2020.01274

Kenworthy, L., Yerys, B. E., Anthony, L. G., & Wallace, G. L. (2008). Understanding executive control in autism spectrum disorders in the lab and in the real world. Neuropsychology Review, 18(4), 320-338. doi:10.1007/s11065-008-9077-7
Kofler, M. J., Irwin, L. N., Soto, E. F., Groves, N. B., Harmon, S. L., & Sarver, D. E. (2019). Executive functioning heterogeneity in pediatric ADHD. Journal of Abnormal Child Psychology, 47(2), 273-286. doi:10.1007/s10802-018-0438-2
Lawton, T. (2016). Improving dorsal stream function in dyslexics by training figure/ground motion discrimination improves attention, reading fluency, and working memory. Frontiers in Human Neuroscience, 10(397), 1–16.
Learning Disabilities Association of America. (2020). Types of learning disabilities. Retrieved from https://ldaamerica.org/types-of-learning-disabilities/
Leloup, G., et al. (2021). Improving reading skills in children with dyslexia: Efficacy studies on a newly proposed remedial intervention—Repeated reading with vocal music masking (RVM). Journal of Learning Disabilities, 54(3), 191-203. doi:10.1177/0022219420959094
Lervåg, A., & Hulme, C. (2009). Rapid automatized naming (RAN) taps a mechanism that places constraints on the development of early reading fluency. Psychological Science, 20(8), 1040-1048. doi:10.1111/j.1467-9280.2009.02405.x
Liang, X., et al. (2023). Effects of open and closed skill exercise interventions on executive function in typical children: A meta-analysis. BMC Psychology, 11, 15. doi:10.1186/s40359-023-01090-5
Liu, S., Cheng, C., Wu, P., Zhang, L., Wang, Z., Wei, W., Chen, Y., & Zhao, J. (2022). Phonological Processing, Visuospatial Skills, and Pattern Understanding in Chinese Developmental Dyscalculia. Journal of Learning Disabilities, 55(6), 499–512. https://doi.org/10.1177/00222194211063650
Luoni, C., Scorza, M., Stefanelli, S., Fagiolini, B., & Termine, C. (2023). A Neuropsychological Profile of Developmental Dyscalculia: The Role of Comorbidity. Journal of Learning Disabilities, 56(4), 310–323. https://doi.org/10.1177/00222194221102925
Marino, M. T., Gotch, C. M., Israel, M., Vasquez, E., Basham, J. D., & Becht, K. (2014). Learning disabled students' perceptions of science-based information communication technology: A mixed methods investigation. Computers & Education, 70, 305-319.
McGrath, L. M., & Stoodley, C. J. (2024). Are there shared neural correlates between dyslexia and ADHD? A meta-analysis of voxel-based morphometry studies.
Meltzer, L. (2018). Executive function in education: From theory to practice. Guilford Publications.
Meyer, A., Rose, D. H., & Gordon, D. (2014). Universal Design for Learning: Theory and Practice. CAST Professional Publishing.
Mohamed, S. M. H., Butzbach, M., Fuermaier, A. B. M., Weisbrod, M., Aschenbrenner, S., Tucha, L., et al. (2021). Basic and complex cognitive functions in Adult ADHD. PLOS ONE, 16(9), e0256228. https://doi.org/10.1371/journal.pone.0256228
Morte-Soriano, M. R., Begeny, J. C., & Soriano-Ferrer, M. (2021). Parent and Teacher Ratings of Behavioral Executive Functioning for Students With Dyslexia. Journal of Learning Disabilities, 54(5), 373–387. https://doi.org/10.1177/0022219420981986
Overy, K. (2003). Dyslexia and music: From timing deficits to musical intervention. Annals of the New York Academy of Sciences, 999(1), 497-505. doi:10.1196/annals.1284.060
Ozernov-Palchik, O., & Gaab, N. (2016). Tackling the 'dyslexia paradox': Reading brain and behavior for early markers of developmental dyslexia. Wiley Interdisciplinary Reviews: Cognitive Science, 7(2), 156-176. doi:10.1002/wcs.1383

Papadopoulos, T. C., Spanoudis, G. C., & Georgiou, G. K. (2016). How is RAN related to reading fluency? A comprehensive examination of the prominent theoretical accounts. Frontiers in Psychology, 7, 1217.
Peng, P., Barnes, M., Wang, C., Wang, W., Li, S., Swanson, H. L., ... & Tao, S. (2018). A meta-analysis on the relation between reading and working memory. Psychological Bulletin, 144(1), 48-76. doi:10.1037/bul0000124
Ritchey, K. D., & Goeke, J. L. (2006). Orton-Gillingham and Orton-Gillingham-based reading instruction: A review of the literature. The Journal of Special Education, 40(3), 171-183.
Rotzer, S., Loenneker, T., Kucian, K., Martin, E., Klaver, P., & von Aster, M. (2009). Dysfunctional neural network of spatial working memory contributes to developmental dyscalculia. Neuropsychologia, 47(13), 2859-2865. doi:10.1016/j.neuropsychologia.2009.06.009
Saga, M. et al. (2021) ‘Developmental dyscalculia: The progress of cognitive modeling in the field of numerical cognition deficits for children’, Applied Neuropsychology: Child, 11(4), pp. 904–914. doi:10.1080/21622965.2021.1955679.
Scanlon, D., & Baker, D. L. (2012). An accommodations model for the secondary inclusive classroom. Learning Disabilities Research & Practice, 27(3), 150-158. doi:10.1111/j.1540-5826.2012.00359.x
Schneider, W. J., & McGrew, K. S. (2018). The Cattell-Horn-Carroll theory of cognitive abilities. In D. P. Flanagan & E. M. McDonough (Eds.), Contemporary intellectual assessment: Theories, tests, and issues (pp. 73-163). Guilford Press.
Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.
St Clair-Thompson, H. L., & Gathercole, S. E. (2006). Executive functions and achievements in school: Shifting, updating, inhibition, and working memory. Quarterly Journal of Experimental Psychology, 59(4), 745-759. doi:10.1080/17470210500162854
Swanson, H. L. (1990). Influence of metacognitive knowledge and aptitude on problem solving. Journal of Educational Psychology, 82(2), 306. doi:10.1037/0022-0663.82.2.306
Swanson, H. L., Harris, K. R., & Graham, S. (2013). Handbook of learning disabilities (2nd ed.). New York, NY: The Guilford Press.
Swanson, H. L., Zheng, X., & Jerman, O. (2009). Working memory, short-term memory, and reading disabilities: A selective meta-analysis of the literature. Journal of Learning Disabilities, 42(3), 260-287. doi:10.1177/0022219409331958
Tallal, P. (2004). Improving language and literacy is a matter of time. Nature Reviews Neuroscience, 5(9), 721-728. doi:10.1038/nrn1499
U.S. Department of Education. (2021). Students with disabilities. Condition of education 2021. Retrieved from https://nces.ed.gov/programs/coe/indicator_cgg.asp
Vainieri, I., Michelini, G., Cheung, C. H. M., Oginni, O. A., Asherson, P., Rijsdijk, F., & Kuntsi, J. (2023). The Etiological and Predictive Association Between ADHD and Cognitive Performance From Childhood to Young Adulthood. Journal of Attention Disorders, 27(7), 709–720. https://doi.org/10.1177/10870547231159908
Vellutino, F. R., Fletcher, J. M., Snowling, M. J., & Scanlon, D. M. (2004). Specific reading disability (dyslexia): What have we learned in the past four decades? Journal of Child Psychology and Psychiatry, 45(1), 2-40. doi:10.1046/j.0021-9630.2003.00305.x
Wang, F., & Jamaludin, A. (2023). Investigating the Neural Heterogeneity of Developmental Dyscalculia. bioRxiv. https://doi.org/10.1101/2023.09.12.557321:citation[oaicite:0]{index=0}.

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2017). Validity of the executive function theory of ADHD: A meta-analytic review. Biological Psychiatry, 57(11), 1336-1346. doi:10.1016/j.biopsych.2012.02.019
Willcutt, E. G., et al. (2008). Prevalence of ADHD: A meta-analytic review. American Journal of Psychiatry, 165(6), 749-757. doi:10.1176/appi.ajp.2008.07071047
World Health Organization. (2021). World report on disability 2021. Retrieved from https://www.who.int/teams/noncommunicable-diseases/sensory-functions-disability-and-rehabilitation/world-report-on-disability
Zelazo, P. D., Blair, C. B., & Willoughby, M. T. (Eds.). (2016). Executive function: Implications for education (Vol. 27). National Center for Education Statistics.