47

Learning Disabilities

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For additional material related to the content of this chapter, please see Chapters 46, 86, and 113.

VIGNETTE

Lucas is a 9-year-old boy who was born after an uncomplicated, full-term pregnancy and delivery. He has experienced no health problems. Lucas lives at home with his parents and three siblings. His parents completed high school. His mother is a schoolbus driver and his father works for a landscaping company. There is no known diagnosis of a learning disability in his family, but his father had an individualized education plan (IEP) for part of his K-12 education through which he received reading support.

Lucas presents with a longstanding history of challenges with reading. His parents first became concerned about his development in preschool when his teacher noted that while he had a firm grasp of prenumeric concepts, he had difficulty learning the alphabet and its associated letter sounds. As a result, his parents continued to monitor his development closely. In kindergarten Lucas' parents noted deficits in phonological awareness skills despite ongoing work to strengthen these skills in school and at home. Due to these challenges, as well as concerns regarding immaturity, Lucas was retained in kindergarten.

In the first grade Lucas began receiving response to intervention (RTI) reading support, with which he made modest progress. Due to concerns about inattention in the school setting, his pediatrician also started Lucas on extended-release methylphenidate; while this has improved his focus, to some degree, his parents report that Lucas' reading skills remain below grade level.

Lucas parents question whether Lucas has a learning disability and how they can best advocate for him in the school setting. A friend has recommended vision training, so his family would also like a referral to a provider who can address eye tracking.

BACKGROUND, DEFINITIONS, AND SYMPTOMATOLOGY OF LEARNING DISORDERS

Education attainment, which is highly dependent on proficiency in reading, writing, and/or mathematics, is a strong predictor of overall health and longevity (Johnston, 2019; Sanfilippo et al., 2020). These basic academic skills are recognized determinants of health outcomes and have been linked to mental health and indices of educational, vocational, economic, and social success (Irwin, Siddiqi, & Hertzman, 2007). Learning disorders/disabilities (LDs) are commonly referred to as a category of disorders that affect the acquisition, understanding, and/or retention of information taught in formal education settings and can affect both verbal and nonverbal information. This chapter will provide an overview about LDs, including definitions, epidemiology, etiology, coexisting conditions, treatment, prevention, laws impacting a child's education, and the transition to postsecondary education and adult life.

Unfortunately, among the various stakeholders working with individuals with LDs there are numerous different labels in use for the identification and classification of the various LDs. Furthermore, research studies often use a variety of different labels, and therefore the behavioral characteristics/symptomatology of the research participants is often unclear. For the purposes of this chapter, we will use the *Diagnostic and Statistical Manual of Mental Disorders*, fifth edition (*DSM-5*; American Psychiatric Association [APA], 2013) nosology, but Table 47.1 gives an overview of the various labels used to characterize/categorize a child's struggle in the domain of learning. In addition, for the purposes of this chapter we will use the terms *learning disorder* and *learning disability* interchangeably.

The *DSM-5* classifies specific LDs as neurodevelopmental disorders, defined as "a group of conditions with onset in the developmental period" that result in impairment in "personal, social academic, or occupational functioning" (APA, 2013, p. 7). LDs have a neurobiological etiology and are heritable; however, behavioral/psychosocial and environmental factors can significantly influence their clinical manifestation. Children are not diagnosed with LD if their learning challenges are caused by intellectual impairment, sensory deficits, or lack of instruction. To fulfill all of the diagnostic criteria, the symptoms that define LD must be present for more than 6 months despite academic interventions. LD can be classified by impairment in reading, writing, and/or mathematics.

Specific Learning Disorder/Disability With Impairment in Reading

Specific LD with impairment in reading (LD-R) is the most common type, accounting for 80% of LDs (Shaywitz, 2004). Despite its neurobiological etiology, reading is not a typical biological process; it must be taught explicitly. Reading can be generally described as the ability to perceive a series of written symbols and decode their meaning. Gough and Tunmer

TABLE 47.1 Common Labels for Children and Adults With Learning Disabilities

SLD With Impairment in Reading (*DSM-5*)	SLD with Impairment in Written Expression (*DSM-5*)	SLD With Impairment in Mathematics (*DSM-5*)
Note use the term *disability* and *disorder* interchangeably.		
Word reading Accuracy/developmental dyslexia	Spelling	Numerosity, memorization of arithmetic facts, accurate or fluent calculation Developmental dyscalculia
• Word reading deficit • Word blindness • Word-level reading disability • Alexia		• SLD in arithmetic calculation • Acalculia
Reading rate or fluency	Grammar and punctuation accuracy, clarity, or organization	Accurate math reasoning
Reading comprehension	• Specific learning disorder in written expression • Specific written expression disability	
• Specific reading comprehension deficit • Reading difficulty • Reading disorder		
	Developmental coordination disorder	
	• Dysgraphia • Agraphia	

DSM-5, Diagnostic and Statistical Manual of Mental Disorders, fifth edition; *SLD*, specific learning disability.

(1986) summarized the process of successful reading development with a mathematical formula called the Simple View of Reading. This formula describes the required functions for reading. The equation reads as follows: D × LC = R. In this formula, D indicates decoding; LC, linguistic comprehension; R, reading. Decoding can be described as the mechanics of reading and requires a variety of skills such as phonological/phonemic awareness, which is the ability to manipulate sounds of the language of instruction (e.g., deciding whether two words rhyme, deleting a phoneme, or blending phonemes), grapheme-phoneme correspondence, and the recognition of sight words. Over the time course of learning to read, these mechanics of learning to read become increasingly automatic, leading to reading fluency. However, a child who has mastered the mechanics of reading can still struggle with reading fluency and comprehension due to inadequate language skills. To comprehend the decoded words and to read sentences fluently, vocabulary, listening comprehension, and other language skills are required. These oral language skills are critical for successful reading development and become increasingly strategic over the developmental time course. This concept of two essential strands important for successful reading development has been outlined by Scarborough's (2001) reading rope (Fig. 47.1).

TABLE 47.2 US Organizational Resources for Learning Disability for Clinicians, Educators, and Families

The National Joint Committee on Learning Disabilities	www.NJCLD.org
The International Dyslexia Association	www.dyslexiaida.org
Learning Disability Association of America	www.ldaamerica.org
National Center for Learning Disabilities	www.NCLD.org
National Center on Improving Literacy	www.improvingliteracy.org
National Center for Intensive Intervention	www.intensiveintervention.org

Furthermore, there are numerous international and country-specific organizations.

Children who are struggling with reading are broadly classified under LD-R. Among these, developmental dyslexia affects the mechanics of reading and is characterized by difficulties with accurate and/or fluent word reading, as well as

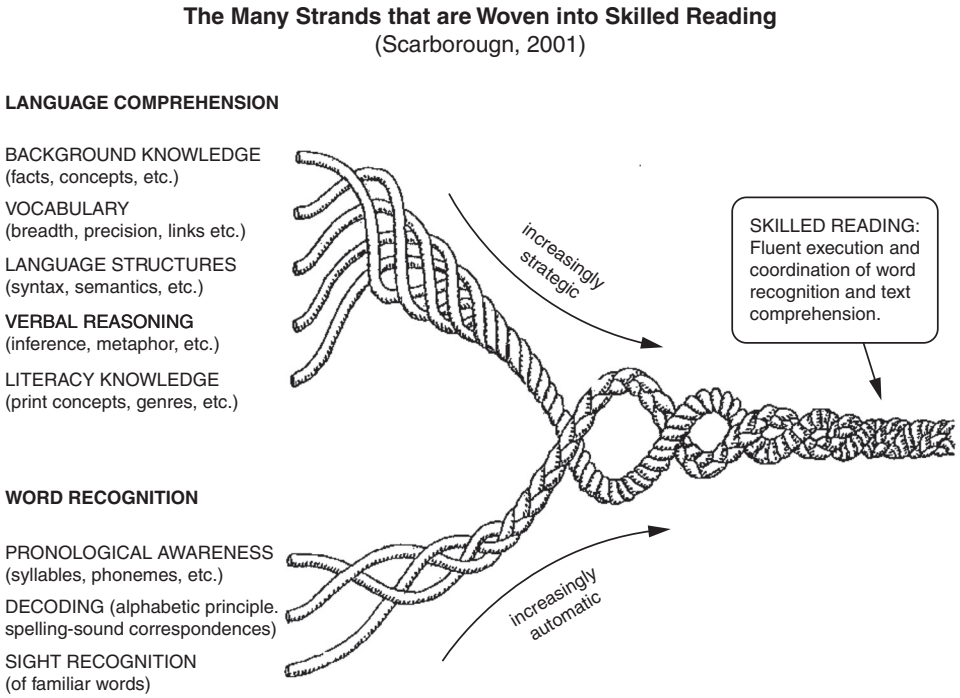

Fig. 47.1 The Scarborough reading rope.

poor spelling and decoding abilities (International Dyslexia Association, 2002). Children who show average word reading abilities but struggle with reading fluency or reading comprehension are usually not considered as having a diagnosis of developmental dyslexia, but they certainly fit the criteria for LD-R. However, children with dyslexia can show secondary deficits in fluency and comprehension that primarily stems from their underlying word reading deficits. Furthermore, dyslexia or LD-R cannot be explained by vision or hearing deficits, lack of motivation, or educational opportunities.

Specific Learning Disorder/Disability With Impairment in Written Expression

Children can also suffer from LD with impairment in written expression (LD-W), characterized by specific deficits in spelling accuracy, grammar and punctuation accuracy, and clarity or organization of written expression. Like reading disorders, children with LD-w can manifest impairment at the word level (spelling), at the content/language level (generating text), or both. Children with difficulty in spelling are likely to experience difficulties with word attack skills as they require similar skills. Spelling (encoding) and word attack skills (decoding) are two sides of the same coin, and they are usually present together in individuals diagnosed with dyslexia. Handwriting difficulties may also impact written output in children with LD-W. Although such children would more appropriately be classified as having a developmental coordination disorder, they are also often diagnosed with dysgraphia. A child who is experiencing difficulties with language skills will likely have challenges with written expression skills (e.g., semantics, general and topical knowledge, and genre and text structure).

Specific Learning Disorder/Disability With Impairment in Mathematics

Children who are exhibiting an LD with impairment in mathematics (LD-M) can be broadly characterized as having difficulties with the mechanics of mathematical skills, namely computational skills (arithmetic) and/or problem-solving abilities (mathematics). The latter tends to be strongly associated with difficulties in language and executive functioning (Bull & Lee, 2014). As with other LDs, *DSM-5* categorizes LD-M by the impairment associated with specific functions such as number sense (numerosity), memorization of math facts, accurate or fluent calculation, and accurate mathematical reasoning. The skill deficits in mathematics disorders can impact computation (e.g., numerosity, memorization, and fluency) and the application of those skills. Numerosity, or number sense, allows us to quantify elements in our environment without counting, estimate, and understand concepts such as more or less, big and small, etc. (De Smedt, Noël, Gilmore, & Ansari, 2013). Developmental dyscalculia is a specific mathematics LD, which mainly affects the acquisition of grade-level arithmetic skills (computation). It is defined as an impairment in learning basic arithmetic facts and performing accurate and fluent arithmetic operations (Kucian & von Aster, 2015). Cognitive difficulties may further include visual-spatial deficits or deficits in working memory or attention. It is important to note that language and reading skills are also strongly linked to academic performance in arithmetic and mathematics (e.g., for word problems or for understanding instructions) and can affect the acquisition of these skills (Moll, Landerl, Snowling, & Schulte-Körne, 2019).

In the past LDs were diagnosed in the context of a discrepancy model. For dyslexia this required that the assessed

reading ability be at least 1 SD below a child's general cognitive ability index (e.g., IQ). A similar model was in place for dyscalculia. However, research has shown that dyslexia can occur independently of general cognitive abilities and that the discrepancy model should not be considered when making diagnostic decisions.

Furthermore, there is a misconception that individuals with LDs all exhibit certain strengths unique to individuals with LDs (such as entrepreneurship, above-average visuospatial skills). There is no evidence for such a common shared strength, and this myth can significantly exacerbate social-emotional problems (e.g., "I am not even good at having an LD"). It is important to emphasize that all children are unique and all have their individual strengths and weaknesses.

Nonverbal Learning Disability

The diagnosis of a nonverbal LD is used to describe a developmental profile that is notable for deficits in social interactions, nonverbal problem solving, visuospatial skills, motor coordination, reading comprehension, and math skills (Handler & Fierson, 2011). Individuals with nonverbal LDs often have strengths in their verbal abilities (Handler & Fierson, 2011). Of note, nonverbal LD is not included in the *DSM-5* and is therefore often not recognized in the same way as specific LDs are recognized; however, clinicians in developmental-behavioral pediatrics should be familiar with the general developmental profile associated with a nonverbal LD. At the time of this publication there is some controversy within the field as to the validity and merit of a nonverbal LD as a discrete entity.

EPIDEMIOLOGY AND ETIOLOGY

The National Center for Learning Disabilities (2017) estimates that roughly one in five children are suffering from LD. The National Assessment of Educational Progress (2019) indicated that approximately 60% of US fourth and eighth graders performed below proficient in reading and mathematics skills, but not all of these children meet criteria for a diagnosis of LD. Reading, arithmetic, and writing skills serve many everyday functions and provide a foundation for learning more advanced competencies. LDs are a widely recognized determinant of health and, if untreated, are likely to persist into adulthood. Individuals with LD-R, LD-W, or LD-M are less likely to enroll in college or other postsecondary education programs, have an increased risk of unemployment, and are more likely to be incarcerated. Furthermore, these individuals are at a greater risk for developing internalizing symptoms and externalizing behaviors (Hendren, Haft, Black, White, & Hoeft, 2018). LD-R and LD-M can even influence medical decision making, as comprehending written materials related to an individual's care or understanding of basic arithmetic concepts is often required to make informed decisions (e.g., percentage of risk, calculating medication doses) (Johnston, 2019). In summary, reading, writing, and arithmetic skills have a significant effect on individuals' wellbeing, education, and vocation and are crucial skills for functioning in modern society.

It has been estimated that 7% to 10% of children have dyslexia (Grigorenko et al., 2020). It is important to note that the prevalence of dyslexia is lower for languages that have a higher orthographic transparency (e.g., Spanish and Italian). The prevalence of dyscalculia has been reported to be 3% to 6% (Kaufmann & von Aster, 2012). While some studies claim that more boys are affected by reading disorders, the opposite has been claimed for dyscalculia. However, these gender differences remain controversial, and opposite findings have also been reported. The prevalence of LD-W has been estimated at 6% to 14%, but this is strongly influenced by the different labels and their characterizing symptomatology (Slavica, Katusic, Colligan, Weaver, & Barbaresi, 2009), and the prevalence in boys has been reported to be two to three times higher than for girls.

Learning disabilities are heritable, with a risk of reoccurrence of up to 50% to 60% in families with an affected member (first degree) (Willcutt et al., 2010). Several dyslexia susceptibility genes have been identified, but this remains an active area of research (Grigorenko et al., 2020). Multivariant genetic studies indicate high correlations between reading and arithmetic skills among twins, suggesting a substantial overlap between genes associated with these two skills (Daucourt, Erbeli, Little, Haughbrook, & Hart, 2020). For example, in a sample of twins in which at least one experienced an LD-R, 68% of monozygotic twins and 40% of dizygotic twins showed LD-R in one twin and LD-M in the other twin (Light & DeFries, 1995).

It is important to note that despite the heritability of LDs, their etiology is multifaceted and includes genetic, perceptual, cognitive, neurobiological, and environmental factors (Ozernov-Palchik, Yu, Gaab, & Wang, 2016). Various studies have reported atypical brain characteristics in individuals with dyslexia and/or dyscalculia. For instance, functional MRI (fMRI) studies have indicated that reading is primarily supported by a left hemispheric brain network that includes the inferior frontal, superior temporal, temporoparietal, and occipitotemporal cortices (Ozernov-Palchik & Gaab, 2016; Ozernov-Palchik et al., 2016). As a group, individuals with dyslexia and/or LD-R show structural and functional atypicalities in the reading network. This includes reports of reduced gray matter volume, alterations in white matter tracts, hypoactivation in response to prereading- and reading-related fMRI tasks, and reduced functional connectivity between key areas of the reading network (see Ozernov-Palchik et al., 2016 for a summary). Importantly, these differences in brain structure and function characteristic of LD-R and dyslexia can be observed before the start of formal reading instruction in educational contexts, indicating that at least some of these brain atypicalities are not a result of struggling with learning to read but rather represents a biological disposition (Ozernov-Palchik & Gaab, 2016; Ozernov-Palchik et al., 2016). In other words children are entering their first day of school with a brain that is less equipped to learn to read, which underlines the importance of early identification and intervention to prevent long-term reading impairments. Furthermore, several studies have reported unique brain atypicalities in children

with specific reading comprehension deficits (a deficit within the LD-R category) suggesting unique and shared etiologies between specific word reading and specific reading comprehension difficulties (Bailey, Hoeft, Aboud, & Cutting, 2016).

Studies examining the brain characteristics of LD-M and dyscalculia have shown unique alterations in the brain networks supporting numeric cognition and arithmetic. Activation in bilateral regions of the intraparietal sulcus has been shown to be a key neural correlate of numeric cognition, which has been reported as early as infancy and preschool years (Hyde & Spelke, 2011). Furthermore, studies comparing typically developing children and children with LD-M and dyscalculia during arithmetic performance reported differences in parietal, prefrontal, and occipital-temporal regions with activation patterns modulated by notation, task complexity, and operation (addition vs. subtraction) (Ashkenazi, Rosenberg-Lee, Tenison, & Menon, 2012). Structural imaging studies suggest children with dyscalculia and LD-M have characteristic reductions in gray matter volume in a variety of brain regions, including the parietal cortex, inferior frontal, and parahippocampal gyrus (Matejko & Ansari, 2015), as well as alterations in white matter tracts (Matejko, Price, Mazzocco, & Ansari, 2013). Unfortunately, the neural correlates of LD-W are currently understudied.

COEXISTING CONDITIONS

Children with LD are also at risk for a number of coexisting conditions ranging from attention-deficit/hyperactivity disorder (ADHD) to mental health concerns to a second or third LD. There is significant comorbidity of LD-M with language disorders (25%), dyslexia (30%–70%), and ADHD (18%) (McGrath, Peterson, & Pennington, 2020). Given evidence that reading and arithmetic skills are strongly linked at cognitive, genetic, and neurocognitive levels, it is not surprising that LD-M and LD-R tend to cooccur, and the rates of cooccurrence seem to increase with age and grade level (Moll et al., 2019). Because of the increased risk of various coexisting conditions, it is critical that clinicians assess conditions with LD for these conditions and intervene quickly when they present additional challenges and impairments.

Attention-Deficit/Hyperactivity Disorder

ADHD is a developmental disorder that is notable for impairment related to inattention and/or hyperactivity impulsivity typically at both home and school (see Chapter 46). The connection between ADHD and LD is well established. Recent studies suggest that 20% to 40% of children with ADHD also have dyslexia, and a combination of shared and distinctive brain alterations between dyslexia and ADHD have been identified (Langer, Benjamin, Becker, & Gaab, 2019). Coexisting ADHD is also common with disorders of written expression. It is important to note that a child experiencing ADHD-related impairment in the school setting may experience academic difficulties across multiple subjects and settings, whereas a child with LD might present with an isolated deficit in reading, writing, or math. However, diffuse academic impairment across subjects can also be seen in children with multiple LDs. Nevertheless, inadequate control of ADHD symptoms during the school day should also enter diagnostic consideration.

Lucas, from the chapter-opening vignette, has an undiagnosed LD that may be either causing or contributing to his reported symptoms regarding inattention during the school day. It is important to recognize that undiagnosed or undertreated LDs can result in inattention, causing some to think that ADHD may also be present. It is certainly possible, and perhaps likely, that Lucas may also have ADHD given that they often coexist. Therefore a next clinical step might be to obtain parents' and teachers' reports of ADHD symptoms to clarify his profile.

Speech and Language Disorders

Children with speech and language disorders are at high risk of developing LDs, like LD-R/dyslexia and LD-W (see Chapter 44). The underlying mechanisms are thought to stem from factors related to a common etiology as well as neurocognitive differences. There is significant overlap between children with language disorders and children with dyslexia such that approximately half of children with dyslexia have a cooccurring language disorder and half of children with a language disorder have cooccurring dyslexia. It is also important to note that academic instruction is largely language mediated, which may exacerbate the vulnerabilities experienced by individuals with speech and language disorders. Furthermore, children who are dialect speakers or who are still learning the language of instruction (Hoff, 2013) have an increased risk for developing reading difficulties. This should be strongly considered in the process of early identification, diagnoses, and interventions.

Other Specific Learning Disorders

As mentioned, the presence of one LD does not preclude the possibility of another. In fact, children with dyscalculia and LD-W are more likely to have coexisting dyslexia than children without either of these conditions (Moll et al., 2019). Further, 30% to 47% of children with writing challenges also experience reading challenges (Chung, Patel, & Nizami, 2020). As previously discussed, children with dyslexia may experience math-related challenges due to difficulty reading word problems. This impairment alone would not be consistent with the presence of a coexisting LD in math; rather, this scenario is more indicative of the wide-reaching nature of reading and/or oral language impairment on a child's school functioning.

Autism Spectrum Disorder

Children with an autism spectrum disorder have been reported to be at increased risk of dyslexia. In the author's clinical experience children with autism can also experience deficits in reading comprehension related to challenges consistently understanding what a character might be feeling

or what their motivation may be (e.g., social pragmatics). This likely stems from deficits in theory of mind and pragmatic language skills related to their diagnosis of autism (see Chapter 41). Writing has also been identified as an area in which individuals with autism spectrum disorders are at risk (Chung et al., 2020).

Similar to the diagnostic process associated with ADHD and learning, children with autism may experience learning challenges related to the presence of a comorbid LD or the presence of impairing behaviors that interfere with the process of learning. A careful history elucidating behavioral functioning and need for supports in the school setting may help clarify this potential concern.

Developmental Coordination Disorder

Developmental coordination disorder (DCD) is a condition that is characterized by deficits in motor skills that can result in impairment in areas such as academics (see Chapter 71). These deficits can include motor incoordination, impaired motor planning, and poor handwriting. Around half of children with DCD experience impaired writing skills (Chung et al., 2020). Further, up to 85% of children with dyspraxia/LD-W/DCD also have dyslexia (Pauc, 2005).

Mental Health Conditions

LDs can negatively impact mental health beginning at a young age. Children with dyslexia may be perceived as "lazy" or "stupid" when, in truth, their reading difficulties stem from an underlying disorder. Analogously, children with LD report experiencing lower self-esteem than their peers without LDs (Stein, Blum, & Barbaresi, 2011). Adolescents with LDs are also at increased risk of depression, suicidal ideation and attempts, and general risk-taking behavior (Stein et al., 2011). In general, children with dyslexia have been found to be at increased risk of both generalized anxiety and depression (Hendren et al., 2018). Externalizing conditions that may occur with dyslexia include conduct disorder and oppositional defiant disorder. Congruently, children who are more skilled at reading are less likely to be incarcerated (Cree, Kay, & Steward, 2012). Failure to recognize psychiatric comorbidity and to address coexisting mental health concerns can significantly worsen learning outcomes (Hendren et al., 2018).

Social Impairment

Qualitative studies of individuals with LD have been notable for self-reported social challenges related to factors that include "feeling different" or having "an invisible disability" (Stein et al., 2011). It is also important to recall that children with developmental differences in general are at higher risk of being bullied than their typical peers. Reported bullying rates among children with developmental differences are likely underestimates for a number of reasons, including those related to shame, difficulty perceiving bullying, and challenges with expressive language. Many children may be hesitant to disclose being bullied unless specifically asked.

Genetic Disorders

Well-described genetic syndromes such as Turner syndrome, Klinefelter syndrome, and neurofibromatosis type 1 can also be associated with LD (Karipidis & Hong, 2020).

DIAGNOSTIC APPROACH

Clinicians working with children should be alert to signs of learning challenges at various ages. In very young children signs concerning for emerging learning challenges include developmental language delays, delayed letter or number recognition, failure to acquire letter-sound correspondence or phonological processing skills, and difficulty counting with one-to-one correspondence. School-age children with LDs may present with signs of increased learning effort, school distress, or school failure (Rimrodt & Lipkin, 2011). Examples of increased learning effort can include complaints that school is boring, school anxiety, class clown behavior, or requiring more time than their peers to complete academic tasks (Rimrodt & Lipkin, 2011). Children experiencing school distress may present with failing grades, frequent school absences/detentions/suspensions, social disengagement, or bullying. Lastly, signs of school failure include grade retention, expulsion, and/or dropping out (Rimrodt & Lipkin, 2011).

Lucas, in the vignette, demonstrated early challenges with letter recognition and phonological processing, which were unaddressed and led to grade retention.

Medical Assessment of Learning Disability

The medical assessment of a child with a potential LD should begin with a detailed developmental history that includes timing of acquisition of developmental milestones, current school day routines (homework, sleep schedule, possible ADHD symptoms, current learning impairment), and a past school history (grade retention, behavioral challenges in the school setting, teacher feedback, and academic progress over time).

A careful past medical history should query prenatal and birth history, potential genetic disorders, sensory deficits, seizures, chronic conditions that may affect school attendance, and medications that can impact cognitive functioning. In addition to obtaining a social history, the family history should assess parental level of education and relatives with learning challenges that can range from grade retention to academic failure.

The family history from the vignette does not include a frank diagnosis of dyslexia but is highly suggestive of this condition. Given the challenges detecting LDs, especially in those who attended school many years ago, information regarding need for school supports and persistent reading challenges in adulthood can be informative.

The physical exam of a child presenting with learning challenges should include close observation of growth parameters or phenotypic differences that might be suggestive of an underlying genetic syndrome that is known to be associated with LD. Clinicians should also rule out vision and hearing deficits and mental health problems (e.g., anxiety or mood disorders) as potential causes of learning impairment.

Psychological Assessment of Learning Disability

The diagnosis of LD in a medical setting usually includes assessment of a child's intellectual and academic functioning by a psychologist using standardized, individually administered measures (see Chapters 85 and 86).

TREATMENT

Educational intervention of LD can be divided into three main approaches: remediation, accommodations, and modifications. Remediation is intended to reduce the performance gap in basic academic skills between the students diagnosed with LD and their peers by strengthening their weaknesses. This is typically provided through specialized instruction taught by special education teachers, certified therapists, speech-language pathologists, and tutors. Other services, including occupational, and physical therapy, are also part of this approach. Most students receiving this type of intervention have an Individualized Educational Plan (IEP) or are receiving services through a multitier system of support (MTSS). Accommodations are intended to prevent discrimination by providing equal access to educational activities (Dragoo & Cole, 2019). Some accommodations may include extended time, preferential sitting, adaptive equipment (text-to-speech/speech-to-text software, keyboarding, graphic organizers, etc.), and individual support (reading or scribing). These accommodations are often provided under Section 504 of the Rehabilitation Act of 1973 and Title II of the Americans with Disabilities Act (Dragoo & Cole, 2019). However, Section 504 also requires the provision of free and appropriate education (FAPE) in K-12 public schools (Barnes, 2021). Finally, schools can provide modifications, such as reducing the volume of work (e.g., the number of math homework problems or books to read). These are typically offered in the elementary and secondary settings but not in postsecondary facilities as they can impact diploma requirements.

The common tenets of effective intervention can be applied to all LDs, but content will vary depending on the type of impairment (reading, writing, or math). The child's RTI will determine how individualized, comprehensive, differentiated, and intense the instruction must be to address all the contributing factors, including coexisting conditions, impacting a specific skill development (Grigorenko et al., 2020).

Dyslexia and Reading Disorders

The treatment of children with dyslexia centers upon early recognition of the disability and the delivery of evidence-based reading intervention. High-quality, evidence-based reading interventions focus on intensive and explicit instruction in areas of reading, including phoneme awareness, the alphabetic principle and phonics, word analysis, fluency, and reading comprehension (Peterson, Pennington, & McGrath, 2018). The International Dyslexia Association coined the term *structured literacy* to refer to this approach to reading instruction. This type of evidence-based teaching requires systematic, explicit instruction (International Dyslexia Association, n.d.). Structured literacy integrates listening, speaking, reading, and writing. It emphasizes the structure of language, including phonology (speech sound system), orthography (writing system), syntax (sentence structure), morphology (meaningful parts of words), semantics (relationships among words), and discourse (organization of spoken and written language). When describing this integrated approach to instruction, the importance of simultaneously addressing content and methodology is stressed. Thus reading interventions should include the foundational skills necessary for reading along with language skills such as vocabulary and comprehension strategies (Peterson et al., 2018). Lovett et al. (2017) demonstrated that the effects of early intervention (first and second grade) resulted in gains that were double when compared with students who began to receive services in the third grade. Older students with reading problems respond best to remediation that emphasizes language and cognitive skills such as vocabulary and comprehension strategies (Peterson et al., 2018). However, they may still benefit from instruction in basic reading mechanics (e.g., phonics and fluency) if they lack these skills.

Visual impairment can certainly affect learning and academic progress. In addition, conditions such as strabismus, amblyopia, convergence and/or focusing deficiencies, and refractive errors can similarly impact learning (Handler & Fierson, 2011). However, there is no evidence to support the theory that eye problems either cause or increase the severity of LDs in general or dyslexia in particular (Handler & Fierson, 2011). There is also no evidence of treatment benefits for recommendations or techniques involving special balancing exercises, fish oils, vision therapy or glasses with tinted lenses, inner ear–improving medications, or the training of primitive reflexes.

Dyscalculia and Math Disorders

Intervention for children with dyscalculia focuses on the delivery of a research-supported math curriculum. These interventions include explicit instruction, skill modeling, practice, and corrective feedback in arithmetic/computational and mathematics skills, such as problem-solving strategies (Peterson et al., 2018). Typical and LD-M students benefit from this approach to instruction, but the child with LD-M requires greater instructional intensity. Children with dyscalculia often benefit from explicit teacher-led instruction coupled with peer-assisted learning (Soares et al., 2018). In addition, they may benefit from elements of teaching such as controlling task difficulty, more intensive elaboration on some topics, and instruction in the small group setting (Soares et al., 2018). The use of manipulatives, computer-based lessons, videos, and hands-on projects have also been found to support math instruction in this population.

Dysgraphia and Writing Disorders

Remediation of writing deficits can vary depending on the age of the child (Chung et al., 2020). For example, intervention for the early school-age child with dysgraphia may focus on development of fine motor skills, including hand coordination, strength, grip control, and writing posture (Chung et al., 2020). These strategies are thought to be most effective in remediating writing challenges when taught in conjunction with orthographic tasks (Chung et al., 2020). Older children and teens with dysgraphia often benefit from explicit instruction in aspects of writing such as planning, drafting, and revising (Chung et al., 2020). In addition to these remedial strategies, students with dysgraphia can benefit from writing accommodations, including keyboarding, spellcheck, and voice-to-text technology as well as writing modifications such as the ability to produce a shorter written product or adjusted grading expectations (Chung et al., 2020).

Children with LD-W can benefit from structured literacy instruction to address their spelling difficulties. Similarly, explicit and systematic instruction in written expression is helpful in addressing these challenges. Reading and writing foundational skills are derived from oral language skills. Strategies that facilitate the development of written expression include structured language activities that are applicable at the word, sentence, and paragraph level (Haynes, Smith, & Laud, 2019). As with other LD interventions, emphasis is placed on developing basic skills combined with higher-level reasoning linguistic concepts (e.g., vocabulary development, syntax, discourse) (Haynes et al., 2019).

LAWS IMPACTING SPECIAL EDUCATION

For more information on the ways that laws impact special eduation, see Chapter 113.

The Individuals With Disabilities Education Act (IDEA)

IDEA is a law that makes a free appropriate public education available to eligible children with disabilities and ensures special education and related services to those children. IDEA regulates the way states and public agencies provide early intervention, special education, and related services. It requires that the local educational agencies (1) evaluate and identify students with LD to ascertain eligibility for services, (2) convene a team, including the parents of the student, to develop an IEP detailing the specific special education and related services to ensure FAPE, and (3) the right to appeal the placement and determination of services through an administrative hearing. In summary, IDEA regulates the educational services provided for eligible students with disabilities and their families and establishes age limits (birth–21 years) (Dragoo & Cole, 2019).

Section 504 of the Rehabilitation Act of 1973

Section 504 provides a broad spectrum of antidiscrimination measures for any qualified individual with a disability, which includes individuals with LD. Thus for students enrolled in K-12 public schools, Section 504 requires that those identified as having a disability are provided with regular and special education services to meet their individual educational needs as adequately as those of typical students. Furthermore, Section 504 provides regulations to ensure adherence to procedures that guarantee FAPE (Barnes, 2021).

Title II of the Americans With Disabilities Act of 1990 (ADA)

ADA provides protection from discrimination similar to Section 504, but unlike Section 504, which applies only to entities receiving federal funds, ADA prohibits discrimination in public and private settings (Dragoo & Cole, 2019). It ensures (1) the provision of accessible facilities and transportation services, (2) delivery of effective communication for persons with disabilities equal to what is provided to the nondisabled population, and (3) available "auxiliary aids and services," such as alternative communication format materials (e.g., braille, sign language interpreters), and assistive technology.

These three laws ensure robust protections and rights for students with disabilities. The major difference between them is that Section 504 and ADA Title II are laws that prohibit the discrimination by ensuring equal access to individuals with disabilities of all ages. In addition, Section 504 ensures that students deemed disabled in K-12 public schools are guaranteed FAPE, procedural safeguards to protect them, and the proper assessment and evaluations to ascertain their disability to develop an educational plan (504 plan, not an IEP). IDEA mandates the provision of special education services (e.g., remediation) to individuals with disabilities from birth through 21 years through an IEP.

PREVENTION

In addition to the neurobiological factors that have been suggested to contribute to the etiology of LDs (see earlier), research studies have focused on the perceptual, language, and cognitive precursors of LDs.

Various longitudinal studies have linked dyslexia to early (and persisting) deficits in phonological and/or phonemic awareness (the ability to manipulate the sounds of language; see earlier). Other identified predictors include mapping sounds onto letters/letter combinations and vice versa (grapheme-phoneme mapping), pseudoword repetition (the ability to repeat orally presented nonsense words), and rapid automatized naming (the ability to quickly retrieve and name a series of highly familiar stimuli arranged in the reading direction), which has been shown to be a strong predictor of later reading fluency (Norton & Wolf, 2012). Furthermore, deficits in oral language comprehension and receptive and expressive vocabulary have been identified as strong predictors of subsequent reading outcomes. These precursors have been detected even before the onset of formal reading instruction (see Ozernov-Palchik & Gaab [2016] for an overview).

Dyscalculia has been related to a core deficit in processing numerosity, but the etiology of dyscalculia has been debated. Similar to dyslexia, several studies suggest a multifactorial approach and not one single cognitive deficit. Precursors of subsequent weaknesses in number recognition and arithmetic have been identified, but these are far less studied than precursors in the domain of reading. These precursors include precision of the approximate number system (ANS), difficulty learning to count, number knowledge, poor memory for numbers, and difficulties with organizing shapes. The ANS has been described as the ability to identify quantities rapidly (e.g., larger/smaller set) (Peterson et al., 2018). Preschoolers' precision of the ANS predicts later school mathematics performance (Mazzocco, Feigenson, & Halberda, 2011), but 6-year-old's number knowledge and not the precision of the ANS has been shown to be the best longitudinal predictor of mathematics performance 1 year later (Göbel, Watson, Lervåg, & Hulme, 2014). A recent metaanalysis reported consistent predictive value for the knowledge of symbolic numbers, but the findings for nonsymbolic formats were very inconsistent (De Smedt et al., 2013). This suggests that the predictive value of the number sense changes over the developmental time course.

It is important to note that a weakness in any of these tasks indicates an increased probability of subsequently developing LDs. Unfortunately, precursors of LD-W have not been reliably identified yet. The fact that longitudinal research studies have identified reliable precursors of LD as early as preschool and the evidence that the brain characteristics of LDs predate the onset of formal education has strong implications for the early identification and prevention of LDs. While most school districts and pediatricians currently operate under a "wait to fail" or "reactive approach" when it comes to learning disabilities (often referred to as the "dyslexia paradox" in the domain of reading), the evidence speaks for a preventive model where children at risk for LDs are identified early and intervention provided during a time of heightened brain plasticity for some of these skills with goal of preventing LDs or decreasing the severity of symptoms (Ozernov-Palchik et al., 2016; Wanzek & Vaughn, 2007).

These approaches have been shown to be successful for the prevention of reading disabilities. For example, using a metaanalytic approach, Wanzek et al. (2013) reported that word reading interventions were significantly more effective for improving reading outcomes when administered in kindergarten and first grade than when they were when administered during later elementary grades. Furthermore, when at-risk beginning readers receive intensive instruction, 56% to 92% of these children across six studies reached the range of average reading ability (Torgesen, 2004). Overall, converging research points to the importance of early and (often) individualized interventions for at-risk students for improving the effectiveness of remediation (Catts, Nielsen, Bridges, Liu, & Bontempo, 2015).

To move from a reactive to a proactive model when it comes to the early identification of children at risk for learning disabilities, it has been suggested that an effective screening approach followed by evidence-based early intervention is the best prevention method (Ozernov-Palchik et al., 2016; Wanzek & Vaughn, 2007). However, while primary care clinicians often screen for ADHD and autism, they usually do not screen for LDs (Sanfilippo et al., 2020). This approach has been justified by the fact that ADHD and autism often require medical interventions, while LDs require interventions in educational settings. However, given the fact that children with LDs have an increased risk for developing internalizing and externalizing problems and show higher incidences of anxiety, depression, and suicidal thoughts, screening in primary care settings should be strongly considered. Furthermore, the early precursors of a reading disability are primarily related to oral language (which includes phonological awareness), and therefore a referral to a speech-language pathologist can be highly effective in aiding the early intervention approach.

It is important to note that numerous states now have legislation that is directly related to the prevention of LDs. For instance, in 2020 over 35 US states had laws that mandate the screening for language-based LDs as early as kindergarten. For an overview of these laws, consult the National Center on Improving Literacy (NCIL). The advocacy and legislative map for the prevention of developmental dyscalculia is years behind that of developmental dyslexia. While a few screeners exist, the screening for developmental dyscalculia is scarce or even nonexistent to date.

It is also of great importance to include individuals who are bilingual or are still learning the language of their formal instruction (e.g., English language learners) in the screening and early identification process since these children are often overlooked (Hoff, 2013). Children are often not identified early since educators may think that it is their English proficiency that causes their reading problems rather than suspecting a language-based LD.

Response to Intervention

With the reauthorization of IDEA in 2004, funding was provided with the goal of offering early intervention services for students at risk of LD. Response to intervention (RTI) has been the predominant approach used to address assessment, instruction, and intervention services of students considered at risk for LD. RTI offers three tiers of educational support to students experiencing reading and other academic difficulties, assigns school personnel to provide the tiered educational support services, and collects and analyzes data to guide intervention and other educational decisions. An MTSS is more comprehensive in scope than RTI as it provides tiered academic, social, and behavioral supports. RTI's primary focus is the tiered provision of academic support services and can be implemented as a component of MTSS. The RTI model of LD identification involves universal screening of all young students for risk factors that predict academic skill failure. This is then followed by the provision of effective, evidence-based academic intervention to those students who are identified as being at risk. This approach requires repeated brief assessments (progress monitoring) over time to gauge the student's response to the intervention. An RTI model bases the identification of LD on a lack of response to evidence-based instruction/intervention as part of a tiered education/intervention approach. Students

whose rate of progress over time is unsatisfactory and who fail to meet grade- or age-level expectations despite increasingly intensive instruction through a tiered system (often referred as unexpected underachievement) can be identified as or suspected of having an LD. For example, Miciak and Fletcher (2020) proposed a "hybrid dyslexia identification process" implemented through the MTSS process. Their model recommends collecting data using reading and spelling as specific markers for dyslexia in combination with insufficient response to evidence-based interventions. Thus a student who has reading and spelling challenges and who fails to respond to evidence-based intervention can be classified as having dyslexia. A comprehensive LD evaluation within an RTI model should also rule out other factors as the primary reason for a student's unsatisfactory response. These factors include irregular school attendance, limited English language proficiency, intellectual disability, vision/hearing/motor disabilities, classroom behavioral difficulties, or other environmental, economic, and/or cultural factors. Poor instruction or lack of instruction should also be ruled out prior to determining a student has an LD.

While in theory the approach of RTI as it is proposed offers a practical approach to early identification and intervention of students at risk for LD, the way that it is being currently implemented in the United States is not demonstrating a measurable difference. A report on a study published in 2015 revealed that first-grade students assigned to schools providing RTI services showed a worse academic performance than those in schools not using RTI (Balu et al., 2015). Analysis of the data revealed that many schools are not implementing RTI with the necessary fidelity or "in a manner supported by research and policy" (Fuchs & Fuchs, 2017). Thus using progress monitoring when the instruction is not delivered with sufficient intensity or fidelity may lead to the erroneous interpretation that a student's lack of progress is due to LD when it may be the result of poor instruction and remediation, one of the exclusion criteria as listed earlier.

TRANSITION TO POSTSECONDARY EDUCATION AND ADULT LIFE

Postsecondary Education

Every year thousands of students with LDs graduate from high school. As the job requirements of the US economy are increasingly becoming knowledge based, and the possibility of a higher earning potential increases with the person's educational level, pursuing a postsecondary education has become more crucial. The National Longitudinal Transition Study-2 (NLTS2) by the National Center for Education Statistics (NCES, 2011) reported that most young adults with disabilities (60%) continued to postsecondary education. These findings are comparable to those of their non-LD peers (67%) in the general population. The same study revealed that of those diagnosed with LD, 44% attended community colleges, 32% business or technical school, and 19% 4-year colleges and universities. The completion of postsecondary education was lower for students with LD (41%) than for those in the general population (52%). While 57% completed technical, business, or vocational school programs, 41% completed 2-year college programs. Approximately one-third of students with LD finished their 4-year college/university programs within 8 years of graduating from high school, in contrast with 62% of young adults in the general population (NCES, 2019). Studies indicate that students with LD who spent more time in general education classrooms and participated in career and technical education courses in secondary school had higher rates of on-time graduation, college attendance, and employment than students who did not spend as much time in similar school settings (Joshi & Bouck, 2017). When reviewing these data it is important to consider that in 2018 the NCES reported that of the 203,805 students identified as having LD, 14% dropped out of secondary education and only 79% obtained a regular high school diploma (NCES, 2019).

The postsecondary educational environment that students with disabilities will encounter is dramatically different from the primary and secondary (K-12) setting. For example, students with LD in a postsecondary setting who elect to request accommodations will be required to disclose their disability and provide the necessary documentation to the institution's disability services office. These requirements vary from one institution to another. As such, the young adult with LD must become familiar with the types of support services offered by each institution and the specific documentation requirements. For many of these students, this will be the first time that they must advocate for themselves while transitioning into a new environment with unfamiliar systems and supports. Postsecondary institutions are prohibited by law to inquire about any disability or a student's need for accommodations. As such, it is essential for the students and their parents or guardians to understand the legal and practical considerations to access those services and whether the student will choose to disclose a disability. Some of these considerations include where to find information on services for students with disabilities, what accommodations they may be eligible for, and what documentation is needed.

The laws that apply to students with disabilities in postsecondary education are different from those that regulate education at the elementary and secondary level. Section 504 and ADA Title II continue to prohibit discrimination on the basis of a student having a disability. In contrast, IDEA and Section 504 requirements related to providing special education and a free and appropriated education do not apply in postsecondary educational settings. Thus postsecondary educational institutions must offer appropriate accommodations to guarantee equal access to the content material. There are no legal mandates for them to provide modifications regarding course content or work expectations as might be in an IEP. For example, college students with LD may be allowed assistive technology accommodations such as recorded books and voice-to-text technology; however, they are still expected to read the same number of books and write as many papers as their classmates. Changing these requirements would be considered curriculum modifications. It is critical for students to understand they cannot circumvent academic requirements that the institution

deems essential to a specific program by using modifications. In short, postgraduate educational settings will make accommodations, but they will not change expectations.

Employment

The NLTS2 showed that most young adults (63%) with LD were likely to be employed (NCES, 2011). However, their employment status varied depending on their highest level of educational attainment. Those who completed postsecondary education were more likely to be employed (99%) when compared with those who did not finish it (78%) or only completed high school requirements (89%). Most of the young adults with LD work close to 40 hours per week and their wages are comparable to those of their peers in the general population (NCES, 2011). Less than 5% required accommodations by their employers and most (94%) reported being satisfied with their jobs (NCES, 2011).

Criminal Justice System and Learning Disability

It is difficult to obtain prevalence data on children and adults in the criminal justice system diagnosed with LD. However, studies have estimated the rates of LD in the population in juvenile detention facilities as ranging from 13% to 41% (Grigorenko et al., 2015). It is important to remember that 43 million Americans in the general population (21%) are unable to identify information in prose text, follow simple written instructions, or locate numbers to perform simple math operations (NCES, 2019). There are multiple factors beyond LD that can impact literacy, including genetic, environmental (home, school, community), socioeconomic, social competencies, and health problems, and these must be considered when reviewing the statistics.

PRIMARY CARE PROVIDER ROLE AND ESTABLISHING PARTNERSHIPS

Primary care providers (PCPs) are usually the first professionals that parents will consult when their children are experiencing learning problems. Even though learning challenges may seem out of the realm of the traditional PCP role, they can play a significant part in the early identification and management of LD. Health care providers can offer advice to parents/caregivers about further diagnostic and therapeutic measures that may be needed. They can evaluate and manage medical factors that could affect learning such as chronic health conditions, sleep challenges, and common cooccurring conditions (e.g., encopresis and enuresis, ADHD, anxiety, depression). Often, PCPs have established long-term relationships with their patients and their families, which allows them to have a good understanding of the home environment and the community schools that may impact their patients. They can serve in an advocacy role for their patients and their families and assist them in the development of an intervention plan, including the identification of diagnostic and therapeutic measures that may be indicated in addressing the student's needs. To fulfill this role, PCPs should become familiarized with the steps needed to obtain educational support and assessment services through the school system. By developing relationships with key individuals within the local schools, PCPs can establish effective channels of communication to help diagnose and address their patients' learning challenges. Furthermore, such relationships can facilitate the coordination and implementation of the multimodal interventions that many students with LD require. Health care providers should identify other professionals in their community (e.g., psychologists, neuropsychologists, speech-language pathologists, behavior specialists, well-trained tutors, and reading therapists) that can assist with diagnostic, educational, and mental health intervention services that their patients may require.

CONCLUSION

Lucas, the patient in the vignette, presented with a history of early markers of LD including his difficulties learning letter names and sounds. However, his early mathematical skills were developing typically. Additionally, Lucas has a family history of learning difficulties. Lucas was prescribed stimulant medication to address his attention problems. While the attentional symptoms have improved, he continues to struggle with word reading. His history describes classical early markers of LD-R and ADHD. His pediatric practitioner can play a critical role pursing further assessment of Lucas' attention challenges and referring him for evaluation of his learning difficulties. This would identify the skills and functions that may require academic remediation, conduct a more thorough ADHD assessment, and identify potential emotional cooccurring conditions such as anxiety. This approach will ensure the most appropriate intervention. In the vignette it is noted that a friend of Lucas' family recommended vision therapy as an option for treatment of his difficulties. It is important that the pediatric practitioner provides the family information regarding evidence-based interventions for dyslexia and other learning disorders to prevent them from implementing costly and unproven interventions such as vision therapy. The Joint Technical Report on Learning Disabilities, Dyslexia and Vision by Handler and Fierson (2011) is an excellent resource for providers when questioned about vision therapy. Table 47.2 provides a list of US-based organizations that offer information for clinicians, educators, and families on the most appropriate ways to address challenges similar to those described in the vignette.

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