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Children with specific learning disorder often find it difficult to keep up with their peers in certain academic subjects, whereas they may excel in others. Academic skills that may be compromised in specific learning disorder include reading single words and sentences fluently, written expression and spelling, and calculation and solving mathematical problems. Specific learning disorder results in underachievement that is unexpected based on the child's potential as well as the opportunity to have learned more. Specific learning disorder in reading, spelling, and mathematics appears to aggregate in families. There is an increased risk of four to eight times in first-degree relatives for reading deficits, and about five to ten times for mathematics deficits, compared to the general population. Specific learning disorder

occurs two to three times more often in males than in females. Learning problems in a child or adolescent identified in this manner can establish eligibility for academic services through the public school system. The American Psychiatric Association's Fifth Edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM5), combines the DSM-IV diagnoses of reading disorder, mathematics disorder, and disorder of written expression and learning disorder not otherwise specified into a single diagnosis: Specific learning disorder. Learning deficits in reading, written expression, and mathematics in the DSM-5 are designated using specifiers. DSM-5 notes that the term dyslexia is an equivalent term describing a pattern of learning difficulties, including deficits in accurate or fluent word recognition, poor decoding, and poor spelling skills. Dyscalculia is noted to be an alternative term referring to a pattern of deficits related to learning arithmetic facts, processing numerical information, and performing accurate calculations. Specific learning disorder of all types affects approximately 10 percent of youth. This represents approximately half of all public school children who receive special education services in the United States. In 1975, Public Law 94–142 (the Education for All Handicapped Children Act now known as the Individual with Disabilities Education Act [IDEA]) mandated all states to provide free and appropriate educational services to all children. Since that time, the number of children identified with learning disorders has increased, and a variety of definitions of learning disabilities have arisen. To meet the criteria for specific learning disorder, a child's achievement must be significantly lower than expected in one or more of the following: reading skills, comprehension, spelling, written expression, calculation, mathematical reasoning, and/or the learning problems interfere with academic achievement or activities of daily living. It is common for specific learning disorder to include more than one area of skills deficits. Children with specific learning disorder in the area of reading can be identified by poor word recognition, slow reading rate, and impaired comprehension compared with most children of the same age. Current data suggest that most children with reading difficulties have deficits in speech sound processing skills, regardless of their intelligence quotient (IQ), and in DSM-5, there is no longer a diagnostic criterion for specific learning disorder comparing the specific deficit to overall IQ. Current consensus is that children with reading impairment have trouble with word recognition and "sounding out" words because they cannot efficiently process and use phonemes (the smaller bits of words that are associated with particular sounds). A recent epidemiologic study found four profiles including (1) weak reading, (2) weak language, (3) weak math, or (4) combined weak math and reading, accounting for 70 percent of children with specific learning impairments. Low scores in short-term memory for speech sounds characterized the profile with weak language, whereas, low speech sound awareness was associated with the weak reading group, but not the weak language group. Finally, in another recent study it was found that the weak math group did not show speech sound deficits, Severe specific learning disorder may make it agonizing for a child to succeed in school, often leading to demoralization, low self-esteem,

chronic frustration, and compromised peer relationships. Specific learning disorder is associated with an increased risk of comorbid disorders, including attention-deficit/hyperactivity disorder

(ADHD), communication disorders, conduct disorders, and depressive disorders. Adolescents with specific learning disorder are at least 1.5 times more likely to drop out of school, approximating rates of 40 percent. Adults with specific learning disorder are at increased risk for difficulties in employment and social adjustment. Specific learning disorder often extends to skills deficits in multiple areas such as reading, writing, and mathematics. Moderate to high heritability is believed to contribute to specific learning disorder, and furthermore, it appears that many cognitive traits are polygenic. In addition, there is pleiotropy, that is, the same genes may affect skills necessary for diverse learning tasks. Factors such as perinatal injury and specific neurological conditions may contribute to the development of specific learning disorder. Conditions such as lead poisoning, fetal alcohol syndrome, and in utero drug exposure are also associated with increased rates of specific learning disorder. SPECIFIC LEARNING DISORDER WITH IMPAIRMENT IN READING Reading impairment is present in up to 75 percent of children and adolescents with specific learning disorder. Students who have learning problems in other academic areas most commonly experience difficulties with reading as well. Reading impairment is characterized by difficulty in recognizing words, slow and inaccurate reading, poor comprehension, and difficulties with spelling. Reading impairment is often comorbid with other disorders in children, particularly, ADHD. The term developmental alexia was historically used to define a developmental deficit in the recognition of printed symbols. This was simplified by adopting the term dyslexia in the 1960s. Dyslexia was used extensively for many years to describe a reading disability syndrome that often included speech and language deficits and right–left confusion. Reading impairment is frequently accompanied by disabilities in other academic skills, and the term dyslexia remains as an alternate term for a pattern of reading and spelling difficulties. Epidemiology An estimated 4 to 8 percent of youth in the United States have been identified with dyslexia, encompassing a variety of reading, spelling, and comprehension deficits. Three to four times as many boys as girls are reported to have reading impairments in clinically referred samples. In epidemiological samples, however, rates of reading impairments are much closer among boys and girls. Boys with reading impairment are referred for psychiatric evaluation more often than girls due to comorbid ADHD and disruptive behavior problems. No clear gender differential is seen among adults who report reading difficulties. Comorbidity Children with reading difficulties are at high risk for additional learning deficits

including mathematics and written expression. The DSM-5 Language disorder, also known as specific language impairment, has traditionally been viewed as distinct from dyslexia and dyscalculia. Children with language disorder have poor word knowledge, limited abilities to form accurate sentence structure, and impairments in the ability to put words together to produce clear explanations. Children with language disorder may have delayed development of language acquisition, and difficulties with grammar and syntactical knowledge. Specific learning disorder in the areas of reading and mathematics frequently occur comorbidly with language disorder. In one study, it was found that among dyslexic samples, 19 percent to 63 percent also have language impairment. Conversely, reading impairment has been found in 12.5 percent to 85 percent of individuals with language disorder. In twin studies, reading impairments were found to be significantly higher in those children with specific learning impairment and in family members of children with the disorder. There are also high rates of comorbidity between reading impairment

and mathematics impairment; in some studies the comorbidity has been reported to be up to 60 percent. It appears that children with both reading and math impairment may perform more poorly in mathematics; however, the reading skills of the comorbid children were no different from children who had only reading disorder and not math disorder. Comorbid psychiatric disorders are also frequent, such as ADHD, Oppositional Defiant Disorder, Conduct Disorders, and Depressive Disorders, especially in adolescents. Data suggest that up to 25 percent of children with reading impairment may have comorbid ADHD. Conversely, it is estimated that between 15 and 30 percent of children diagnosed with ADHD have specific learning disorder. Family studies suggest that ADHD and reading impairment may share some degree of heritability. That is, some genetic factors contribute to both reading impairment and attentional syndromes. Youth with reading impairments have higher than average rates of depression on self-report measures and experience higher levels of anxiety symptoms than children without specific learning disorder. Furthermore, children with reading impairment are at increased risk for poor peer relationships and exhibit less skill in responding to subtle social cues. Etiology Data from cognitive, neuroimaging, and genetic studies suggest that reading impairment is a neurobiological disorder with a significant genetic contribution. It reflects a deficiency in processing sounds of speech sounds, and thus, spoken language. Children who struggle with reading most likely also have a deficit in speech sound processing skills. Children with this deficit cannot effectively identify the parts of words that denote specific sounds, leading to difficulty in recognizing and “sounding out” words. Youth with reading impairment are slower than peers in naming letters and numbers. The core deficits for children with reading impairment include poor processing of speech sounds and deficits in comprehension, spelling, and sounding out words. Because reading impairment typically includes a language deficit, the left brain has been hypothesized to be the anatomical site of this dysfunction. Several studies using

magnetic resonance imaging (MRI) studies have suggested that the planum temporale in the left brain shows less asymmetry than the same site in the right brain in children with both language disorders and specific learning disorder. Positron emission tomographic (PET) studies have led some researchers to conclude that left temporal blood flow patterns during language tasks differ between children with and without learning disorders. Cell analysis studies suggest that in reading impaired individuals, the visual magnocellular system (which normally contains large cells) contains more disorganized and smaller cell bodies than expected. Studies indicate that 35 to 40 percent of firstdegree relatives of children with reading deficits also have reading disability. Several studies have suggested that phonological awareness (i.e., the ability to decode sounds and sound out words) is linked to chromosome 6. Furthermore, the ability to identify single words has been linked to chromosome 15. Impairment in reading and spelling has now been linked to susceptibility loci on multiple chromosomes, including chromosomes 1, 2, 3, 6, 15, and 18. Although a recent research study identified a locus on chromosome 18 as a strong influence on single word reading and phoneme awareness, generalist genes have also been implicated as responsible for learning disorders. Many genes believed to be associated with specific learning disorder, may also influence normal variation in learning abilities. In addition, genes that affect abilities in reading, for example, are hypothesized to also affect written expression and potentially mathematics skills. Several historical hypotheses about the origin of reading deficits are now known to be untrue. The first myth is that reading impairments are caused by visual–motor problems, or what has been termed scotopic sensitivity syndrome. There is no evidence that children with reading impairment have visual problems or difficulties with their visual–motor system. The second false theory is that

allergies can cause, or contribute to, reading disability. Finally, unsubstantiated theories have implicated the cerebellar–vestibular system as the source of reading disabilities. Research in cognitive neuroscience and neuropsychology supports the hypothesis that encoding processes and working memory, rather than attention or long-term memory, are areas of weakness for children with reading impairment. One study found an association between dyslexia and birth in the months of May, June, and July, suggesting that prenatal exposure to a maternal infectious illness, such as influenza, in the winter months may contribute to reading disabilities. Complications during pregnancy and prenatal and perinatal difficulties are common in the histories of children with reading disabilities. Extremely low birth weight and severely premature children are at higher risk for specific learning disorder. Children born very preterm have been noted to be at increased risk of minor motor, behavioral, and specific learning disorder. An increased incidence of reading impairment occurs in intellectually average children with cerebral palsy and epilepsy. Children with postnatal brain lesions in the left occipital lobe, resulting in right visual-field blindness, as well as youth with lesions in the splenium of the corpus callosum that blocks transmission of visual information from the intact right hemisphere to the language areas of the left hemisphere experience reading impairments.

Children malnourished for long periods during early childhood are at increased risk of compromised performance cognition, including reading. Diagnosis Reading impairment is diagnosed when a child’s reading achievement is significantly below that expected of a child of the same age (Table 31.7-1). Characteristic diagnostic features include difficulty recalling, evoking, and sequencing printed letters and words; processing sophisticated grammatical constructions; and making inferences. School failure and ensuing poor self-esteem can exacerbate the problems as a child becomes more consumed with a sense of failure and spends less time focusing on academic work. Students with reading impairment are entitled to an educational evaluation through the school district to determine eligibility for special education services. Special education classification, however, is not uniform across states or regions, and students with identical reading difficulties may be eligible for services in one region, but ineligible in another. Table 31.7-1 DSM-5 Diagnostic Criteria for Specific Learning Disorder

Clinical Features Children with reading disabilities are usually identified by the age of 7 years (second grade). Reading difficulty may be apparent among students in classrooms where

reading skills are expected as early as the first grade. Children can sometimes compensate for reading disorder in the early elementary grades by the use of memory and inference, particularly in children with high intelligence. In such instances, the disorder may not be apparent until age 9 (fourth grade) or later. Children with reading impairment make many errors in their oral reading. The errors are characterized by omissions, additions, and distortions of words. Such children have difficulty in distinguishing between printed letter characters and sizes, especially those that differ only in spatial orientation and length of line. The problems in managing printed or written language can pertain to individual letters, sentences, and even a page. The child’s reading speed is slow, often with minimal comprehension. Most children with reading disability have an age-appropriate ability to copy from a written or printed text, but nearly all spell poorly. Associated problems include language difficulties: discrimination and difficulty in sequencing words properly. A child with reading disorders may start a word either in the middle or at the end of a printed or written sentence. Most children with reading disorder dislike and avoid reading and writing. Their anxiety is

heightened when they are confronted with demands that involve printed language. Many children with specific learning disorder who do not receive remedial education have a sense of shame and humiliation because of their continuing failure and subsequent frustration. These feelings grow more intense with time. Older children tend to be angry and depressed and exhibit poor self-esteem. Jackson, a 10-year-old boy, was referred for evaluation of failing to complete inclass assignments and homework, and failing tests in reading, spelling, and arithmetic. For the past 2 years (grades 5 and 6), he had been attending a special education class every morning in the local community school, based on an assessment from the second grade. A subsequent psychoeducational assessment by a clinical psychologist confirmed reading problems. Jackson was eligible for a full-day special education class, whereupon he started attending a program with eight other students ranging from 6 to 12 years of age. Clinical interview with his parents revealed a normal pregnancy and neonatal period, and a history of language delay. In preschool and kindergarten, Jackson was reported to have had difficulty with rhyming games and showed a lack of interest in books and preferred to play with construction toys. In the first grade, Jackson had more difficulty learning to read than other boys in his class and continued to have problems pronouncing multisyllabic words (e.g., he said “aminals” for “animals” and “sblanation” for “explanation”). Family history was positive for reading deficits and ADHD. Jackson’s father disclosed a history of his own reading problems, and Jackson’s older brother, 15 years of age, had ADHD, which was well controlled with stimulant medication. Jackson’s parents were concerned about his poor focus in school, and wondered whether he had ADHD. In the clinical interview with Jackson, he rarely made eye contact, mumbled a lot, and struggled to find the right words

(e.g., manifested many false starts, hesitations, and nonspecific terms, such as “the thing that you draw . . . um . . . pencil—no . . . um . . . lines with”). He admitted to disliking school, adding “Reading is boring and stupid—I’d rather be skateboarding.” Jackson complained about how much reading he was given—even in math—and commented, “Reading takes so much time. By the time I figure out a word, I can’t remember what I just read and so have to read the stuff again.” Psychoeducational assessment included the Wechsler Intelligence Scale for ChildrenIV, Clinical Evaluation of Language Fundamentals-IV (CELF-IV), the Wechsler Individual Achievement Test-II, and self-ratings of anxiety, depression, and selfesteem. Results indicated low-average verbal and above average performance IQ, poor word attack and word identification skills (below 12th percentile), poor comprehension (below 9th percentile), poor spelling (below 6th percentile), weak comprehension of oral language (below 16th percentile), elevated but subthreshold scores on the Children’s Depression Inventory, and low self-esteem. Although Jackson manifested symptoms of inattention, restlessness, and oppositional behavior (particularly at school), he did not meet criteria for ADHD. Jackson met DSM-5 criteria for specific learning disorder, with deficits in reading and written expression. Recommendations included continuation in special education plus attendance at a summer camp specializing in children with reading disorder, as well as ongoing monitoring of self-esteem and depressive traits. At 1-year follow-up, Jackson and his parents reported striking improvements in his reading, overall school performance, mood, and self-esteem. Both Jackson and his family felt that the specialized instruction provided during the summer camp was very helpful. The program had provided one-on-one focused and explicit instruction for 1 hour a day for a total of 70 hours. Jackson explained that he had been taught “like a game plan” to read, and challenged the clinician to give him a “really tough long word to read.” He demonstrated strategies that he had learned to read the word “unconditionally” and also explained what it meant. To boost his fluency in reading and comprehension, he was provided with assignments to read along with

audiotaped versions of books, use of graphic organizers to facilitate reading comprehension, and continued participation in the summer camp reading program. (Adapted from Rosemary Tannock, Ph.D.) Pathology and Laboratory Examination No specific physical signs or laboratory measures are helpful in the diagnosis of reading deficits. Psychoeducational testing, however, is critical in determining these deficits. The diagnostic battery generally includes a standardized spelling test, written composition, processing and using oral language, design copying, and judgment of the adequacy of pencil use. The reading subtests of the Woodcock-Johnson Psycho-Educational BatteryRevised, and the Peabody Individual Achievement Test-Revised are useful in identifying reading disability. A screening projective battery may include human-figure drawings,

picture-story tests, and sentence completion. The evaluation should also include systematic observation of behavioral variables. Course and Prognosis Children with reading disability may gain knowledge of printed language during their first 2 years in grade school, without remedial assistance. By the end of the first grade, many children with reading problems, in fact, have learned how to read a few words; however, by the third grade, keeping up with classmates is exceedingly difficult without remedial educational intervention. When remediation is instituted early, in milder cases, it may not be necessary after the first or second grade. In severe cases and depending on the pattern of deficits and strengths, remediation may be continued into the middle and high school years. Differential Diagnosis Reading deficits are often accompanied by comorbid disorders, such as language disorder, disability in written expression, and ADHD. Data indicate that children with reading disability consistently present difficulties with linguistic skills, whereas children with ADHD only, do not. Children with reading disability, without ADHD, however, may have some overlapping deficits in cognitive inhibition, for example, they perform impulsively on continuous performance tasks. Deficits in expressive language and speech discrimination along with reading disorder may lead to a comorbid diagnosis of language disorder. Reading impairment must be differentiated from intellectual disability syndromes in which reading, along with most other skills, are below the achievement expected for a child’s chronological age. Intellectual testing helps to differentiate global deficits from more specific reading difficulties. Poor reading skills resulting from inadequate schooling can be detected by comparing a given child’s achievement with classmates on reading performance on standardized reading tests. Hearing and visual impairments should be ruled out with screening tests. Treatment Remediation strategies for children with reading impairments focus on direct instruction that leads a child’s attention to the connections between speech sounds and spelling. Effective remediation programs begin by teaching the child to make accurate associations between letters and sounds. This approach is based on the theory that the core deficits in reading impairments are related to difficulty recognizing and remembering the associations between letters and sounds. After individual letter-sound associations have been mastered, remediation can target larger components of reading such as syllables and words. The exact focus of any reading program can be determined only after accurate assessment of a child’s specific deficits and weaknesses. Positive coping strategies include small, structured reading groups that offer individual attention and make it easier for a child to ask for help.

Children and adolescents with reading difficulties are entitled to an individual education program (IEP) provided by the public school system. Yet, for high school students with persistent reading disorders and ongoing difficulties with decoding and work identification, IEP services may not be sufficient to remediate their problems. A study of students with reading disorders in 54 schools

indicated that, at the high school level, specific goals are not adequately met solely through school remediation. It is likely that high schoolers with persisting reading difficulties may have greater benefit from individualized reading remediation. Reading instruction programs such as the Orton Gillingham and Direct Instructional System for Teaching and Remediation (DISTAR) approaches begin by concentrating on individual letters and sounds, advance to the mastery of simple phonetic units, and then blend these units into words and sentences. Thus, if children are taught to cope with graphemes, they will learn to read. Other reading remediation programs, such as the Merrill program, and the Science Research Associates, Inc. (SRA) Basic Reading Program, begin by introducing whole words first and then teach children how to break them down and recognize the sounds of the syllables and the individual letters in the word. Another approach teaches children with reading disorders to recognize whole words through the use of visual aids and bypasses the sounding-out process. One such program is called the Bridge Reading Program. The Fernald method uses a multisensory approach that combines teaching whole words with a tracing technique so that the child has kinesthetic stimulation while learning to read the words. SPECIFIC LEARNING DISORDER WITH IMPAIRMENT IN MATHEMATICS Children with mathematics difficulties have difficulty learning and remembering numerals, cannot remember basic facts about numbers, and are slow and inaccurate in computation. Poor achievement in four groups of skills have been identified in mathematics disorder: linguistic skills (those related to understanding mathematical terms and converting written problems into mathematical symbols), perceptual skills (the ability to recognize and understand symbols and order clusters of numbers), mathematical skills (basic addition, subtraction, multiplication, division, and following sequencing of basic operations), and attentional skills (copying figures correctly and observing operational symbols correctly). A variety of terms over the years, including dyscalculia, congenital arithmetic disorder, acalculia, Gerstmann syndrome, and developmental arithmetic disorder have been used to denote the difficulties present in mathematics disorder. Core deficits in dyscalculia are in processing numbers, and good language abilities are skills needed for accurate counting, calculating, and understanding mathematical principles. Mathematics deficits can, however, occur in isolation or in conjunction with language and reading impairments. According to the DSM-5, the diagnosis of specific learning disorder with impairment in mathematics consists of deficits in arithmetic counting and calculations, has difficulty remembering mathematics facts, and may count on fingers instead. Additional deficits include difficulty with mathematic concepts and reasoning,

leading to difficulties in applying procedures to solve quantitative problems. These deficits lead to skills that are substantially below what is expected for the child’s chronological age and cause significant interference in academic success, as documented by standardized academic achievement testing. Epidemiology Mathematics disability alone is estimated to occur in about 1 percent of school-age children, that is about one of every five children with specific learning disorder. Epidemiological studies have indicated that up to 6 percent of school-age children have some difficulty with mathematics, and prevalence estimates of 3.5 to 6.5 percent have been reported for impairing forms of dyscalculia. Although specific learning disorder overall occurs two to three times more often in males, mathematics deficits may be relatively more frequent in girls than reading deficits. Many studies of learning disorders in children have grouped reading, writing, and mathematics disability together, which makes it more difficult to ascertain the precise prevalence of mathematics disability. Comorbidity Mathematics deficits are commonly found to be comorbid, with deficits in both reading and written expression. Children with mathematics difficulties may also be at higher risk for expressive language problems, and developmental

coordination disorder. Etiology Mathematics deficiency, as with other areas of specific learning disorder, has a significant genetic contribution. High rates of comorbidity with reading deficits have been reported in the range of 17 percent up to 60 percent. One theory proposed a neurological deficit in the right cerebral hemisphere, particularly in the occipital lobe areas. These regions are responsible for processing visual–spatial stimuli that, in turn, are responsible for mathematical skills. This theory, however, has received little support in subsequent neuropsychiatric studies. Causes of deficits in mathematics are believed to be multifactorial, including genetic, maturational, cognitive, emotional, educational, and socioeconomic factors. Prematurity and very low birth weight are also a risk factor for specific learning disorder, including mathematics. Compared with reading abilities, arithmetic abilities seem to depend more on the amount and quality of instruction. Diagnosis The diagnosis of specific learning disorder in mathematics is made when a child’s skill in mathematical reasoning, or calculation, remain significantly below what is expected for that child’s age, for a period of at least 6 months, even when remedial interventions have been administered. Many different skills contribute to mathematics proficiency.

These include linguistic skills, conceptual skills, and computational skills. Linguistic skills involve being able to understand mathematical terms, understand word problems, and translate them into the proper mathematical process. Conceptual skills involve recognition of mathematical symbols and being able to use mathematical signs correctly. Computational skills include the ability to line up numbers correctly and to follow the “rules” of the mathematical operation. The DSM-5 diagnostic criteria for specific learning disorder with impairment in mathematics are provided in Table 31.7-1. Clinical Features Common features of mathematics deficit include difficulty learning number names, remembering the signs for addition and subtraction, learning multiplication tables, translating word problems into computations, and performing calculations at the expected pace. Most children with mathematics deficits can be detected during the second and third grades in elementary school. A child with poor mathematics abilities typically has problems with concepts, such as counting and adding even one-digit numbers, compared with classmates of the same age. During the first 2 or 3 years of elementary school, a child with poor mathematics skill may just get by in mathematics by relying on rote memory. But soon, as mathematics problems require discrimination and manipulation of spatial and numerical relations, a child with mathematics difficulties is overwhelmed. Some investigators have classified mathematics deficiencies into the following categories: difficulty learning to count meaningfully; difficulty mastering cardinal and ordinal systems; difficulty performing arithmetic operations; and difficulty envisioning clusters of objects as groups. Children with mathematics difficulty have trouble associating auditory and visual symbols, understanding the conservation of quantity, remembering sequences of arithmetic steps, and choosing principles for problem-solving activities. Children with these problems are presumed to have good auditory and verbal abilities; however, in many cases, the mathematics deficits may occur in conjunction with reading, writing, and language problems. In these cases, the other deficiencies may compound the impairment of the poor mathematics skill. Mathematics difficulty, in fact, often coexists with other disorders affecting reading, expressive writing, coordination, and language. Spelling problems, deficits in memory or attention, and emotional or behavioral problems may be present. Young grade-school children may exhibit specific learning problems in reading and writing, and these children should also be evaluated for mathematics deficits. The exact relationship between mathematics deficits and the deficits in language and dyslexia is not clear. Although children with language disorder do not necessarily experience mathematics deficiencies, these conditions often coexist, and both are associated with impairments in decoding

and encoding processes. Lena, an 8-year-old girl, was referred for evaluation of impairing problems in

attention and academic achievement, which were first noted in kindergarten but were now causing difficulty at home and school. Lena attended a regular third-grade class in a local public school, which she had been attending since midway through kindergarten. Lena's history included a mild delay in speech acquisition (e.g., first words at approximately 18 months of age and short sentences at approximately 3 years of age), but otherwise she had no major developmental problems until kindergarten, when her teacher had raised concerns about inattentiveness, difficulty following instructions, and her difficulty in mastering basic number concepts (e.g., inaccurate counting of sets of objects). A speech, language, and hearing assessment completed at the end of kindergarten revealed mild language problems that did not warrant specific intervention. School reports from grades 1 and 2 noted ongoing concerns about inattention, poor reading skills, and difficulty mastering simple arithmetic facts, and "making careless mistakes in copying numbers from the board and in doing addition and subtraction." These problems continued through grade 2, despite some in-school accommodations (e.g., moving Lena's seat closer to the teacher) and modifications (e.g., providing her with printed sheets of arithmetic problems so she did not need to copy them herself). Lena's parents reported a 3-year history of losing things, fidgeting at the dinner table, and difficulty concentrating on games and homework, and forgetting to bring notes to and from school. Psychological assessment included the Wechsler Intelligence Scale for Children-III, Clinical Evaluation of Language Fundamentals-IV, Comprehensive Test of Phonological Processing, and the Woodcock-Johnson Psycho-Educational Battery–III. Results indicated average intelligence, with relatively weaker performance on tests of perceptual organization, weak phonological (speech sound) awareness, mild deficits in receptive and expressive language, and reading and arithmetic abilities that were well below grade level. Parent and teacher ratings on a standardized behavior questionnaire (Conners' Rating Scales-Long Form) were above clinical threshold for ADHD. Lena was given a diagnosis of ADHD, predominantly inattentive type, and specific learning disorder with impairment in reading, based on the history, school achievement, and standardized assessment. She did not meet criteria for communication disorder, and it was speculated that her mathematics problems did not cause impairment like her reading disorder and ADHD did. Recommendations included the following: family psychoeducation clarifying the ADHD and specific learning disorder, remedial interventions for reading, and treatment of her ADHD with a long-acting stimulant agent. At 1-year follow-up, Lena and her parents reported noticeable improvement with inattention, but ongoing problems with reading and more significant deficits in mathematics. Mathematics remediation was added to her weekly schedule. Two years later, when Lena was 11 years of age, her parents called for an "urgent reevaluation" due to a sudden worsening of her difficulties at home and school. Clinical evaluation revealed adequate stimulant treatment response of her ADHD, more marked deficits in reading speed accuracy compared to others her age, and significant deficits in

mathematics. Lena's parents reported that she had started lying about having mathematics homework or refused to do it, was suspended from mathematics class twice in the past 3 months because of oppositional behavior, and had failed sixthgrade mathematics. Lena acknowledged disliking and worrying about math: "whenever the teacher starts asking questions and looks in my direction, my mind just goes blank and I feel sort of shaky—it's so bad in tests that I have to leave class to get myself together." At this point, an additional component of anxiety was noted to be

contributing to her school impairments. Recommendations were expanded to include increased specific educational remediation for mathematics. At follow-up, Lena reported that the resource teacher had taught her some helpful strategies to address her anxiety about mathematics, as well as ways of classifying word problems and differentiating critical information from irrelevant information. She continued to be a robust responder to long-acting stimulants for her ADHD, and had only minimal difficulties concentrating on homework after school. (Adapted from case material by Rosemary Tannock, Ph.D.) Pathology and Laboratory Examination No physical signs or symptoms indicate mathematics disorder, but educational testing and standardized measurement of intellectual function are necessary to make this diagnosis. The Keymath Diagnostic Arithmetic Test measures several areas of mathematics including knowledge of mathematical content, function, and computation. It is used to assess ability in mathematics of children in grades 1 to 6. Course and Prognosis A child with a specific learning disorder in mathematics can usually be identified by the age of 8 years (third grade). In some children, the disorder is apparent as early as 6 years (first grade); in others, it may not be apparent until age 10 (fifth grade) or later. Too few data are currently available from longitudinal studies to predict clear patterns of developmental and academic progress of children classified as having mathematics disorder in early school grades. On the other hand, children with a moderate mathematics disorder who do not receive intervention may have complications, including continuing academic difficulties, shame, poor self-concept, frustration, and depression. These complications can lead to reluctance to attend school, and demoralization about academic success. Differential Diagnosis Mathematics deficits must be differentiated from global causes of impaired functioning such as intellectual disability. Arithmetic difficulties in intellectual disability are accompanied by similar impairments in overall intellectual functioning. Inadequate schooling can affect a child’s arithmetic performance on a standardized arithmetic test.

Conduct disorder or ADHD can occur comorbidly with specific learning disorder in mathematics and, in these cases, both diagnoses should be made. Treatment Mathematics difficulties for children are best remediated with early interventions that lead to improved skills in basic computation. The presence of specific learning disorder in reading along with mathematics difficulties can impede progress; however, children are quite responsive to remediation in early grade school. Children with indications of mathematics disorder as early as in kindergarten require help in understanding which digit in a pair is larger, counting abilities, identification of numbers, and remembering sequences of numbers. Flash cards, workbooks, and computer games can be a viable part of this treatment. One study indicated that mathematics instruction is most helpful when the focus is on problem-solving activities, including word problems, rather than only computation. Project MATH, a multimedia self-instructional or group-instructional in-service training program, has been successful for some children with mathematics disorder. Computer programs can be helpful and can increase compliance with remediation efforts. Social skills deficits can contribute to a child’s hesitation in asking for help, so a child identified with a mathematics disorder may benefit from gaining positive problemsolving skills in the social arena as well as in mathematics. SPECIFIC LEARNING DISORDER WITH IMPAIMRENT IN WRITTEN EXPRESSION Written expression is the most complex skill acquired to convey an understanding of language and to express thoughts and ideas. Writing skills are highly correlated with reading for most children; however, for some youth, reading comprehension may far surpass their ability to express complex thoughts. Written expression in some cases is a sensitive index of more subtle deficits in language usage that typically are not detected by standardized reading and language tests. Deficits in

written expression are characterized by writing skills that are significantly below the expected level for a child's age and education. Such deficits impair the child's academic performance and writing in everyday life. Components of writing disorder include poor spelling, errors in grammar and punctuation, and poor handwriting. Spelling errors are among the most common difficulties for a child with a writing disorder. Spelling mistakes are most often phonetic errors; that is, an erroneous spelling that sounds like the correct spelling. Examples of common spelling errors are: fone for phone, or beleeve for believe. Historically, dysgraphia (i.e., poor writing skills) was considered to be a form of reading disorder; however, it is now clear that impairment in written expression can occur on its own. Terms once used to describe writing disability include spelling disorder and spelling dyslexia. Writing disabilities are often associated with other forms of specific

learning disorders; however, impaired writing ability may be identified later than other forms because it is generally acquired later than verbal language and reading. In contrast with the DSM-5, which includes specific learning disorder in written expression, the 10th Edition of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) includes a separate specific spelling disorder. Epidemiology The prevalence of specific learning disorder with impairment in written expression has been reported to occur in the range of 5 to –15 percent of school-age children. Over time, specific learning disorder remits in many youth, leading to a persistent rate of specific learning disorder of 4 percent in adults. The gender ratio in writing deficits is two to three to one in boys compared with girls. Impaired written expression often occurs along with deficits in reading, but not always. Comorbidity Children with impaired writing ability are significantly more likely to have language disorder and impairments in reading and mathematics compared to the general population of youth. ADHD occurs with greater frequency in children with writing disability than in the general population. Youth with specific learning disorder, including writing disability, are at higher risk for social skills difficulties, and some develop poor self-esteem and depressive symptoms. Etiology Causes of writing disability are believed to be similar to those of reading disorder, that is, underlying deficits in using the components of language related to letter sounds. Genetic factors are a significant factor in the development of writing disability. Writing difficulties often accompany language disorder, leading an affected child to have trouble with understanding grammatical rules, finding words, and expressing ideas clearly. According to one hypothesis, impairment in written expression may result from combined effects of language disorder, and reading disorder. Hereditary predisposition to writing impairment is supported by the finding that most youth with impaired written expression have first-degree relatives with similar difficulties Children with limited attention spans and high levels of distractibility may find writing an arduous task. Diagnosis The DSM-5 diagnosis of specific learning disorder with impairment in written expression is based on a child's poor ability to use punctuation and grammar accurately in sentences, inability to organize paragraphs, or to clearly articulate ideas in writing. Poor performance on composing written text may also include poor handwriting and

impaired ability to spell and to place words sequentially in coherent sentences, compared to others of the same age. In addition to spelling mistakes, youth with impaired written expression make grammatical mistakes, such as using incorrect tenses, forgetting words in sentences, and placing words in the wrong order. Punctuation may be incorrect, and the child may have poor ability to remember which words begin with capital letters. Additional symptoms of impaired written expression include the formation of letters that are not legible, inverted letters, and mixtures of capital and lowercase letters in a given word. Other features of writing disorders include poor

organization of written stories, which lack critical elements such as “where,” “when,” and “who” or clear expression of the plot. Clinical Features Youth with impairments in written expression struggle early in grade school with spelling words and expressing their thoughts according to age-appropriate grammatical norms. Their spoken and written sentences contain an unusually large number of grammatical errors and poor paragraph organization. Affected children commonly make simple grammatical errors, even when writing a short sentence. For example, despite constant reminders, affected youth frequently fail to capitalize the first letter of the first word in a sentence, and fail to end the sentence with a period. Typical features of impaired written expression include spelling errors, grammatical errors, punctuation errors, poor paragraph organization, and poor handwriting. In higher grades in school, affected youth’s written sentences become more conspicuously primitive, odd, and inaccurate compared to what is expected of students at their grade level. For youth with impaired written expression, word choices are often erroneous and inappropriate, paragraphs are disorganized and not in proper sequence, and spelling accuracy becomes increasingly difficult as their vocabulary becomes larger and more abstract. Associated features of writing impairments may include reluctance to go to school, refusal to do assigned written homework, and concurrent academic difficulties in other areas. Many children with impaired written expression understandably become frustrated and angry, and harbor feelings of shame and inadequacy regarding poor academic achievement. In some cases, depressive disorders can result from a growing sense of isolation, estrangement, and despair. Young adults with impaired written expression who do not receive remedial intervention continue to have writing skills deficits and a persistent sense of incompetence and inferiority. Brett, an 11-year-old boy, was referred for evaluation of increasing problems in school over a 2-year period, including failure to complete assigned schoolwork and homework, inattention and oppositional behavior, and deteriorating grades and test scores. At the time of assessment, he was enrolled in a regular fifth-grade class in a public school, which he had been attending since grade 1.

Clinical interview with parents revealed that Brett had a twin brother (monozygotic) with a history of language problems for which he had received speechlanguage therapy in the preschool years and remedial reading in the primary grades. Brett, however, had not exhibited difficulty in speech or language development, according to parental report and scores on standardized tests of oral language administered in the preschool years. His current and previous school reports indicate that Brett participated well in class discussions and had no difficulty in reading or mathematics; however, his written work was far below grade level. In each of the last 2 years, his teachers had expressed increasing concerns about Brett’s refusal to complete written work, failure to hand in homework, daydreaming and fidgeting in class, and withdrawal from class activities. Brett admitted to an increasing dislike of school and especially writing assignments. He explained, “It’s writing, writing all day long—even in math and science. I know how to do the problems and the experiments, but I hate having to write it all down—my mind just goes blank.” Brett complained “My teacher is always on at me, telling me that I’m lazy and haven’t done enough, and that my writing is atrocious. He tells me, I’ve got a bad attitude—so why would I want to go to school?” Brett and his parents reported that, over the past year, he has been down, increasing frustrated with school, and has refused to do homework. They all agree that Brett has had a few brief episodes of depressed mood. Testing by a clinical psychologist revealed average to high-average scores on the verbal and performance scales of the Wechsler Intelligence Scale for Children-III and average scores on the reading and arithmetic subtests of the Wide Range Achievement Test-3 (WRAT-3). However, scores on the WRAT-3 spelling subtest were below the 9th percentile, which

was significantly below expectations for age and ability. Examination of his spelling errors revealed that, although his spelling was typically phonologically accurate (i.e., could plausibly be pronounced to sound like the target word), it was unacceptable in that he used letter sequences that did not resemble English, regardless of pronunciation (e.g., “houses” was written as “howssis,” “phones” was written as “fones,” and “exact” was written as “egszakt”). Moreover, his performance was well below age and grade on standardized tests of written expression (TOWL-3), as well as on a brief (5-minute) informal assessment of expository text generation on a favorite topic (e.g., newspaper article on recent sports event). During the 5-minute writing activity, he was observed to frequently stare out of the window, to shift positions and to chew on his pencil, to get up to sharpen his pencil and to sigh when he did put pencil to paper, and to write slowly and laboriously. At the end of 5 minutes, he had produced three short sentences without any punctuation or capitalization that were barely legible, containing several misspellings and grammatical errors, and that were not linked semantically. By contrast, later in the assessment, he described the sporting event with detail and enthusiasm. A speech-language evaluation revealed average scores on standard tests of oral language (Clinical Evaluation of Language Fundamentals-IV), but he was noted to omit sounds or syllables in a multisyllabic word in a nonword repetition test, which has been found to be sensitive to mild residual language impairments and

written language impairments. The clinical team formulated a diagnosis of specific learning disorder with impairment in written expression, based on Brett’s inability to compose written text, poor spelling, and grammatical errors, without problems in reading or mathematics or a history of language impairments. He did not meet full diagnostic criteria for any other DSM-5 disorder, including oppositional defiant disorder, ADHD, or mood disorder. Recommendations included the following: psychoeducation, the need for educational accommodations (e.g., provision of additional time for test taking and written assignments, specific educational intervention to facilitate written expression and to teach note taking, and use of specific computer software to support written composition and spelling), and counseling should his depressed mood continue or worsen. (Adapted from case material from Rosemary Tannock, Ph.D.) Pathology and Laboratory Examination Whereas no physical signs of a writing disorder exist, educational testing is used in making a diagnosis of writing disorder. Diagnosis is based on a child’s writing performance being markedly below expected production for his age, as confirmed by an individually administered standardized expressive writing test. Currently available tests of written language include the Test of Written Language (TOWL), the DEWS, and the Test of Early Written Language (TEWL). Evaluation for impaired vision and hearing is recommended. When impairments in written expression are noted, a child should be administered a standardized intelligence test, such as WISC-R to determine the child’s overall intellectual capacity. Course and Prognosis Specific learning disorder with impairment in writing, reading, and mathematics often coexist, and additional language disorder may be present as well. A child with all of the above disabilities will likely be diagnosed with language disorder first and impaired written expression last. In severe cases, an impaired written expression is apparent by age 7 (second grade); in less severe cases, the disorder may not be apparent until age 10 (fifth grade) or later. Youth with mild and moderate impairment in written expression fare well if they receive timely remedial education early in grade school. Severely impaired written expression requires continual, extensive remedial treatment through the late part of high school and even into college. The prognosis depends on the severity of the disorder, the age or grade when the remedial intervention is started, the length and continuity of treatment, and presence or absence of associated or secondary emotional or behavioral problems. Differential

Diagnosis

It is important to determine whether disorders such as ADHD or major depression are interfering with a child’s focus and thereby preventing the production of adequate writing in the absence of a specific writing impairment. If true, treatment for the other disorder should improve a child’s writing performance. Commonly comorbid disorders with writing disability are language disorder, mathematics disorder, developmental coordination disorder, disruptive behavior disorders, and ADHD. Treatment Remedial treatment for writing disability includes direct practice in spelling and sentence writing as well as a review of grammatical rules. Intensive and continuous administration of individually tailored, one-on-one expressive and creative writing therapy appears to effect favorable outcome. Teachers in some special schools devote as much as 2 hours a day to such writing instruction. The effectiveness of a writing intervention depends largely on an optimal relationship between the child and the writing specialist. Success or failure in sustaining the patient’s motivation greatly affects the treatment’s long-term efficacy. Associated secondary emotional and behavioral problems should be given prompt attention, with appropriate psychiatric treatment and parental counseling. REFERENCES Archibald LMD, Cardy JO, Joanisse MF, Ansari D. Language, reading, and math learning profiles in an epidemiological sample of school age children. PLoS One. 2013;8:e77463. DOI: 10.1371/journal.pone.0077463. Badian NA. Persistent arithmetic, reading, or arithmetic and reading disability. Ann Dyslexia. 1999;49:43–70. Bergstrom KM, Lachmann T. Does noise affect learning? A short review on noise effects on cognitive performance in children. Front Psychol. 2013;4:578. Bernstein S, Atkinson AR, Martimianakis MA. Diagnosing the learner in difficulty. Pediatrics. 2013;132:210–212. Bishop DVM. Genetic influences on language impairment and literacy problems in children: Same or different? J Child Psychol Psychiatry. 2001;42:189–198. Butterworth B, Kovas Y. Understanding neurocognitive developmental disorders can improve education for all. Science. 2013;340:300–305. Catone WV, Brady SA. The inadequacy of Individual Educational Program (IEP) goals for high school students with wordlevel reading difficulties. Ann Dyslexia. 2005;55:53. Cragg L, Nation K. Exploring written narrative in children with poor reading comprehension. Educational Psychology. 2006;26:55–72. Endres M, Toso L, Roberson R, Park J, Abebe D, Poggi S, Spong CY. Prevention of alcohol-induced developmental delays and learning abnormalities in a model of fetal alcohol syndrome. Am J Obstet Gynecol. 2005;193:1028. Flax JF, Realpe-Bonilla T, Hirsch LS, Brzustowicz LM, Bartlett CW et al. Specific language impairment in families: Evidence for co-occurrence with reading impairments. J Speech Lang Hear Res. 2003:46:530–543. Fletcher JM. Predicting math outcomes: Reading predictors and comorbidity. J Learn Disabil. 2005;38:308. Gersten R, Jordan NC, Flojo JR. Early identification and interventions for students with mathematics difficulties. J Learn Disabil. 2005;38:305 Gordon N. The “medical” investigation of specific learning disorders. Pediatr Neurol. 2004;2(1):3.

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