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SPECIAL EDUCATION FOR STUDENTS WITH DISABILITIES

Learning Disabilities

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Abstract

Approximately 5% of all public school students are identified as having a learning disability (LD). LD is not a single disorder, but includes disabilities in any of seven areas related to reading, language, and mathematics. These separate types of learning disabilities frequently co-occur with one another and with social skill deficits and emotional or behavioral disorders. Most of the available information concerning learning disabilities relates to reading disabilities, and the majority of children with learning disabilities have their primary deficits in basic reading skills.

An important part of the definition of LD is its exclusions: learning disabilities cannot be attributed primarily to mental retardation, emotional disturbance, cultural difference, or disadvantage. Thus, the concept of LD focuses on the notion of a *discrepancy* between a child's academic achievement and his or her apparent capacity to learn.

Recent research indicates, however, that disability in basic reading skills is primarily caused by deficits in phonological awareness, which is independent of any achievement-capacity discrepancy. Deficits in phonological awareness can be identified in late kindergarten and first grade using inexpensive, straightforward testing protocol. Interventions have varying effectiveness, depending largely on the severity of the individual child's disability.

The prevalence of learning disability identification has increased dramatically in the past 20 years. The "real" prevalence of LD is subject to much dispute because of the lack of an agreed-upon definition of LD with objective identification criteria. Some researchers have argued that the currently recognized 5% prevalence rate is inflated; others argue that LD is still underidentified. In fact, it appears that there are both sound and unsound reasons for the increase in identification rates.

Sound reasons for the increase include better research, a broader definition of disability in reading, focusing on phonological awareness, and greater identification of girls with learning disabilities. Unsound reasons for the increase include broad and vague definitions of learning disability, financial incentives to identify students for special education, and inadequate preparation of teachers by colleges of education, leading to overreferral of students with any type of special need.

There is no clear demarcation between students with normal reading abilities and those with mild reading disability. The majority of children with reading disabilities have relatively mild reading disabilities, with a smaller number having extreme reading disabilities. The longer children with disability in basic reading skills, at any level of severity, go without identification and intervention, the more difficult the task of remediation and the lower the rate of success.

Children with extreme deficits in basic reading skills are much more difficult to remediate than children with mild or moderate deficits. It is unclear whether children in the most severe range can achieve age- and grade-approximate reading skills, even with normal intelligence and with intense, informed intervention provided over a pro-

tracted period of time. Children with severe learning disabilities are likely to manifest an increased number of and increased severity of social and behavioral deficits. When children with disabilities in reading also manifest attention deficit disorder, their reading deficits are typically exacerbated, more severe, and more resistant to intervention.

While severe reading disorders are clearly a major concern, even mild deficits in reading skills are likely to portend significant difficulties in academic learning. These deficits, too, are worthy of early identification and intervention. Even children with relatively subtle linguistic and reading deficits require the expertise of a teacher who is well trained and informed about the relationships between language development and reading development. Unfortunately, such teachers are in short supply, primarily because of a lack of professional certification programs providing this training.

This article focuses primarily on deficits in basic reading skills, both because of their critical importance to academic success and because relatively more is known about these deficiencies. However, other academic, social, and behavioral manifestations of learning disability are also important and cannot be assumed to be adequately addressed by programs to improve basic reading skills. While early intervention is necessary, it should not be assumed to be sufficient to address the multiple manifestations of learning disability.

Approximately one-half of all children receiving special education services nationally, or about 5% of the total public school population, are identified as having a learning disability (LD) when the federal definition of LD is used by schools to formulate identification criteria.[1] At the same time, LD remains one of the least understood and most debated disabling conditions that affect children. Indeed, the field continues to be beset by pervasive, and occasionally contentious, disagreements about the definition of the disorder, diagnostic criteria, assessment practices, treatment procedures, and educational policies.[2-6]

Learning disability is not a single disorder, but is a general category of special education composed of disabilities in any of seven specific areas: (1) receptive language (listening), (2) expressive language (speaking), (3) basic reading skills, (4) reading comprehension, (5) written expression, (6) mathematics calculation, and (7) mathematical reasoning. These separate types of learning disabilities frequently co-occur with one another and also with certain social skill deficits and emotional or behavioral disorders such as attention deficit disorder. LD is not synonymous with reading disability or dyslexia although it is frequently misinterpreted as such.[7,8] However, most of the available information concerning learning disabilities relates to reading disabilities, and the majority of children with LD have their primary deficits in reading.[2]

Box 1 shows the statutory definition of learning disabilities contained in the Individuals with Disabilities Education Act (IDEA). An important part of

Box 1

Definition of Learning Disability Under the Individuals with Disabilities Education Act

"Specific learning disability" means a disorder in one or more basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in an imperfect ability to listen, speak, read, write, spell, or to do mathematical calculations. The term includes such conditions as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. The term does not apply to children who have learning problems that are primarily the result of visual, hearing, or motor disabilities, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage.

Source: Code of Federal Regulations, Title 34, Subtitle B, Chapter III, Section 300.7(b)(10).

the definition of learning disabilities under the IDEA is the exclusionary language: learning disabilities cannot be attributed primarily to mental retardation, emotional disturbance, cultural difference, or environmental or economic disadvantage. Thus, the concept of learning disabilities embedded in federal law focuses on the notion of a discrepancy between a child's academic achievement and his or her apparent capacity and opportunity to learn. More succinctly, Zigmond notes that "learning disabilities reflect unexpected learning problems in a seemingly capable child."[9]

Although poverty and disability are often found together and each tends to exacerbate the other (see the article by Wagner and Blackorby in this journal issue), Congress has established separate programs to serve children with disabilities (the IDEA) and children in poverty (Title 1). Title 1 of the Elementary and Secondary Education Act provides funding for supplemental programs in schools serving large numbers of economically disadvantaged children. Because individual children with disabilities have strong entitlements to services under the IDEA, Congress's intent was that the IDEA serve only children with "true disabilities" and that the IDEA specifically exclude those students whose underperformance is primarily attributable to poverty. However, in the category of learning disability, and perhaps also in the category of mental retardation, this distinction is difficult or impossible to draw, and no empirical data exist to support this exclusionary practice.

While there is some agreement about these general concepts, there is continued disagreement in the field about diagnostic criteria, assessment practices, treatment procedures, and educational policies for learning disabilities. A number of influences have contributed to these disagreements which, in turn, have made it difficult to build a generalizable body of scientific and clinical knowledge about learning disabilities and to establish reliable and valid diagnostic criteria.[4,5] While some progress has been made during the past decade in establishing more precise definitions and a theoretically based classification system for LD, [8–10] it is useful to understand these historical influences because of their continuing impact on diagnostic and treatment practices for children with learning disabilities.

The next section of this article reviews briefly the historical events that have molded the field of learning disabilities into its present form. Subsequent sections address issues related to the prevalence of learning disabilities, the validity of current prevalence estimates, impediments to the identification and teaching of the child with LD, advances in identification, classification, intervention practices in the area of reading disability, comorbidity of types of learning disabilities (reading, written expression, mathematics disabilities) with disorders of attention and social skills deficits, outcomes for individuals with learning disabilities, and the implications for teacher preparation and school policies.

Historical Influences

The study of learning disabilities was initiated in response to the need (1) to understand individual differences among children and adults who displayed *specific* deficits in spoken or written language while maintaining integrity in *general* intellectual functioning and (2) to provide services to these students, who were not being adequately served by the general educational system.[6,9,10] Overall, the field of learning disabilities emerged primarily from a social and educational need and currently remains a diagnostic practice that is more rooted in clinical practice, law, and policy than in science. Advocates for children with learning disabilities have successfully negotiated a special education category as a means to educational protection at the same time that the schools have seen an increase in the identification of LD.[6]

The unexpected pattern of *general* strengths and *specific* weaknesses in learning was first noted and studied by physicians during the early twentieth century, thus giving the field its historical biomedical orientation.[10] Doctors noted that children with learning disabilities were similar to adults and children with focal brain damage in that specific impairments in some areas of learning could occur without diminishing strengths in general cognitive ability.

Although the clinical work conducted during the first half of the twentieth century recognized the existence of learning disabilities, such information had little influence on public school policies until the mid-1960s. At this time, behavioral scientists, educators,[11] and parents expressed concern that some children had learning handicaps that were not being served effectively by general educational practices.[9] At the same time, these children were ineligible for special education services because their characteristics did not correspond to any recognized categories of disability. This disenfranchisement stimulated an advocacy movement to provide special educational services to students with learning disabilities,[4,6,9] leading many states to establish a special education category for LD during the late 1960s and 1970s.

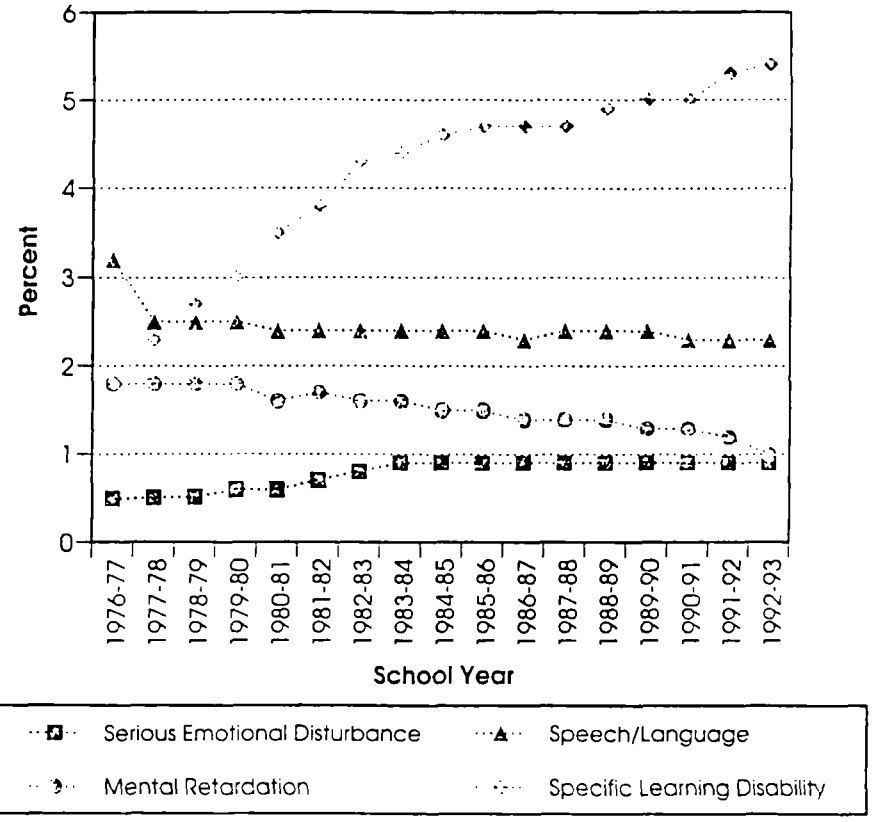
Prevalence

The influence of advocacy has, in turn, contributed to a substantial proliferation in the number of children who have been identified with learning disabilities relative to other handicapping conditions (see Figure 1). Clearly, the prevalence of LD identification has increased dramatically.

The "real" prevalence of learning disabilities is subject to much dispute because of the lack of an agreed-upon definition of LD and objective diagnostic criteria.[4,5,12] Some have argued that the currently recognized 5% prevalence rate is excessive and is based on vague definitions, leading to inaccurate identification. On the other hand, research efforts to identify objective early indicators of LD in basic reading skills have concluded that virtually all children scoring below the 25th percentile on standardized reading tests can meet the criteria for having a reading disorder.[12] While less is known about LD in written expression, researchers estimate its true prevalence at between 8% and 15% of the school population.[13] Research also indicates that approximately 6% of the school population has difficulties in mathematics which cannot be attributed to low intelligence, sensory deficits, or economic deprivation.[14]

Figure 1

Percentage of Children Identified as Manifesting the Most Common Disabilities in the Years 1977 through 1993



Source. Office of Special Education Programs. *Implementation of the Individuals with Disabilities Education Act: Fifteenth Annual Report to Congress.* Washington, DC: U.S. Department of Education, 1993.

Increase in Identification

The substantial increase in the identification of children with learning disabilities shown in Figure 1 has led many to question the validity and reliability of LD as a diagnostic category or its "realness" as a handicapping condition.[15] In fact, it appears likely that there are both sound and unsound reasons for the increase, as is discussed later.

It should be made clear that difficulties in the identification of children with learning disabilities do not make the disabilities any less "real" to the student who cannot learn to read, write, or understand mathematics despite good intelligence, an adequate opportunity to learn, and ostensibly good teaching. However, such an anecdotal understanding of learning disability and its prevalence seems inadequate now, given the increase in diagnoses of LD, the consequences of learning failure in children, and the tremendous financial resources that are applied to the identification and teaching of children with learning disabilities. Given what is at stake, it is critical that the construct of learning disability and procedures for identifying children and adults with LD be valid and accepted by the scientific and clinical communities.

The question remains, however, of how to go about increasing the ability to identify individuals with LD accurately. Valid prevalence estimates depend upon a set of criteria for identification that are clear, observable, measurable, and agreed upon.

The Discrepancy Standard

There is currently no universally accepted test, test battery, or standard for identifying children with LD. While a discrepancy

between intelligence quotient (IQ) and achievement has been a widely accepted criterion for the identification of LD and still serves as the driving clinical force in the diagnosis of LD, there is considerable variation in how the discrepancy is derived and quantified.[9,16] Federal regulations and extant clinical criteria[17] do not specify particular formulas or numerical values to assess discrepancy objectively. The effect of this lack of specification on both clinical and research practices is substantial. From a clinical standpoint, a child can be identified as having a learning disability in one school district but not in a neighboring district because of differences in the measure of discrepancy used. From a research perspective, different approaches to the discrepancy measurement lead to substantially different sample characteristics and different prevalence estimates, which undermine the ability to replicate and generalize findings.[5,6,8,9]

For the individual child, use of the discrepancy standard clearly promotes a wait-to-fail policy because a significant discrepancy between IQ and achievement generally cannot be detected until about age eight or nine. In fact, most school districts do not identify children with learning disabilities until a child is reading well below grade level, generally in third or fourth grade.[18] By this time the child has already experienced at least a few years of school failure and probably has experienced the common attendant problems of low self-esteem, diminished motivation, and inadequate acquisition of the academic material covered by his classmates during the previous few years.

It is clear that the longer children with learning disabilities, at any level of severity, go without identification and intervention, the more difficult the task of remediation becomes and the harder it is for the children to respond. Specifically, the data strongly suggest that children at risk for reading failure should be identified before the age of nine if successful intervention results are to be anticipated.[13] For example, a longitudinal investigation of 407 students[19] found that 74% of the children whose disability in reading was first identified at nine years of age or older continued to read in the lowest quintile throughout their middle and high school years. In addition, the longer children, at all severity levels, are faced with failure in reading in the classroom setting, the greater the probability that comorbid learning and behavioral difficulties will arise, further complicating the remediation task.

Developing a Diagnostic Standard

If current definitions of learning disability are not useful and if the discrepancy standard is a poor one, why have schools not adopted other means of defining and identifying LD? There are a number of conceptual and methodological barriers to the accurate identification of learning disabilities, and these impediments lead to confusion about definitions, diagnostic issues, and rising prevalence rates.

Multidisciplinary Nature of the Field

Opinions about what constitutes a learning disability vary[6,10] in part because LD is the concern of many disciplines and professions, including education, psychology, neurology, neuropsychology, optometry, psychiatry, and speech and language pathology, to name a few. Each of these disciplines has traditionally focused on different aspects of the child or adult with learning disability, so divergent ideas and contentious disagreements exist about the importance of etiology, diagnostic methods, intervention methods, and professional roles and responsibilities.[10] It is not surprising that so many children are identified because each professional may view the child through his or her own idiosyncratic clinical lens. For example, optometrists may identify a child as having a learning disability if the youngster displays difficulties in visual tracking. Speech and language pathologists, on the other hand, become concerned if the child's vocabulary and syntactic development are not commensurate with expectations. Educators become concerned primarily when development in reading, writing, and mathematics is deficient.

Lack of Specific Identification Criteria

Probably the most significant and persistent problem in the field is the lack of a precise definition and a theoretically based classification system that would allow (1) the identification of different types of learning disabilities and (2) a means of recognizing distinctions and interrelationships between types of learning disabilities and other learning disorders such as mental retardation, attention deficit disorder, speech and lan-

guage difficulties, and general academic underachievement.[20] At present, the field continues to construct and use vague and ambiguous definitions that rely heavily on the exclusion of alternative diagnoses, such as the IDEA definition shown in Box 1.

Overly Broad Label

Some observers argue that the term "learning disability" is too broad to be of any diagnostic value. Stanovich,[16] a leading proponent of this view, proposes that the general term learning disabilities be abandoned and that definitional and research efforts focus on the specific types of disabilities that are now identified in ambiguous terms.

As noted earlier, the generic term learning disabilities encompasses disabilities in seven categories: (1) listening, (2) speaking, (3) basic reading skills, (4) reading comprehension, (5) written expression, (6) mathematical calculation, and (7) mathematical reasoning. Given the complexity and heterogeneity of each of these disabilities, it seems unrealistic to expect that any definitional clarity can be achieved by grouping them together under one label. To do so only obscures the critical features of each disability and makes research findings difficult to interpret.

Definitions of specific learning disabilities can be more easily and successfully operationalized than generic definitions, as the research on disability in basic reading skills shows.[8] To establish valid prevalence estimates for the number of individuals with learning disabilities, the first step should be to establish explicit diagnostic criteria for *each* of the seven specific disability domains. At present, the greatest progress toward this goal has been in the area of disability in basic reading skills.[8]

LD as a Sociological Phenomenon

The simplest explanation for the increasing numbers of children identified with learning disabilities and for the difficulty in understanding and defining LD is that "LD" is not a distinct disability, but an invented category created for social purposes. Some argue that the majority of students identified as having learning disabilities are not intrinsically disabled but have learning problems because of poor teaching, lack of educational opportunity, or limited educational resources.[15] In addition, because the label of LD is not a stigmatizing one, parents and teachers may be more comfortable with a diagnosis of LD than with labels such as slow learner, minimal brain dysfunction, or perceptual handicap. A diagnosis of LD does not imply low intelligence, emotional or behavioral difficulties, sensory handicaps, or cultural disadvantage. Thus, more positive outcomes are expected for children with learning disabilities than for those with mental retardation or emotional disturbance.

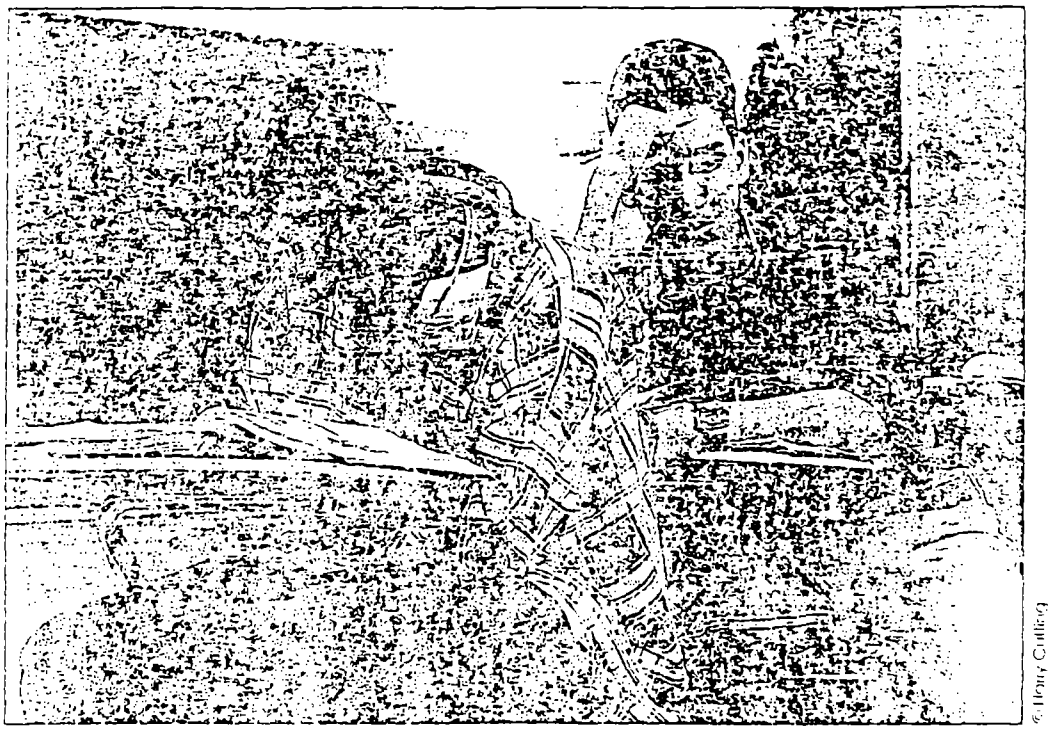
Reasons for Increase in Identification of LD

As pointed out, the substantial increase in the identification of LD, as shown in Figure 1, has caused many researchers to question the validity of the data. No doubt, the failure to develop an agreed-upon, objective, operational definition of learning disability gives credence to the concern about the validity of the identification process. Thus, it seems reasonable to assume that at least some of the increase in prevalence can be linked to conceptual, methodological, social, and political factors that spuriously inflate the identification of children with learning disabilities.[5] However, despite the conceptual and methodological shortcomings that have plagued the field with respect to definition and identification practices, there exist a number of possibly sound reasons that could account for an increase in the number of children identified with LD.

Some Sound Reasons

As knowledge about learning disabilities grows, some academic difficulties not previously recognized as LD can be identified as such. Greater knowledge also affects the behavior and practices of teachers and parents. Sound reasons for the increase in identification rates are described and discussed in the sections that follow.

- *Better Research.* Research in the past decade measures underachievement in reading as it occurs naturally in large population-based samples[12,13] rather than as identified by schools, which use widely varying criteria. In addition, much of this new research is longitudinal and has been replicated, providing the necessary foundation for epidemiological studies.[2,12,13,19,21-24] Finally, many of these



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studies have been specific to LD in reading, rather than LD in general, allowing greater precision.

▫ *Broader Definitions.* Prevalence is directly linked to definition. LD in reading has been defined in recent research as *significant difficulties in reading single words accurately and fluently, in combination with deficits in phonological awareness.*[2] Using this definition and stronger longitudinal research methods outlined above, the prevalence for reading disability alone has increased from estimates of less than 5% in 1976 to approximately 17% in 1994.[12]

Phonological awareness is a critical attribute in learning to read, and children who lack this awareness can be identified in late kindergarten and early first grade. Typical diagnostic questions for kindergartners or first graders involve rhyming skills (for example, "Tell me three words that rhyme with 'cat'") and phoneme deletion skills (for example, "Say 'cat' without the /t/ sound"). The majority of children pick up phonological awareness skills easily by six to seven years of age, but a large minority of children (about 17%) have significant difficulty with these skills and will have great difficulty learning to read, regardless of their intelligence, unless these skills are acquired.

▫ *Identification of LD in Girls.* A substantial portion of this increase can be attributed to the fact that females have been found to manifest reading disabilities at rates equal to males, in contrast to previous reports that males with reading disabilities outnumbered females with reading disabilities at a ratio of four to one.[25] This finding necessarily increases the prevalence rate.

▫ *Increased Awareness.* Information disseminated in the past decade, particularly concerning the characteristics of reading disability, has increased the number of children referred for assessment of a learning disability.[26]

▫ *Understanding of the Impact.* There has been an increase in the recognition that even "mild" deficits in reading skills are likely to portend significant difficulties in academic learning and are, therefore, worthy of early identification, diagnosis, and intervention.[26,27]

Some Unsound Reasons

There is no shortage of horror stories about the misidentification of LD and reports that the category serves as a "catch all" for any youngster who is not meeting the expectations of parents and teachers. Are there legitimate reasons for these criticisms? The

answer appears to be yes. Examples are described and discussed in the sections that follow.

■ *Ambiguous Definitions.* The ambiguity inherent in the general definitions of LD (see Box 1) leaves the identification process open for wide interpretation and misinterpretation. Flexible identification decision making allows some children to be identified as having learning disabilities when they do not, while others with learning disabilities may be overlooked.[5] This latitude can be manipulated to increase prevalence rates in response to financial incentives (for example, to qualify for increased state funding), to decrease prevalence rates in response to political movements (for example, inclusion), or to abandon programs that appear too costly.[28]

■ *Social and Political Factors.* Social and political factors also contribute to the inflation of prevalence rates for learning disabilities. In 1976–77, the first year of full implementation of Public Law 94–142, 2.16% of all schoolchildren were served in programs for children with mental retardation (MR) and 1.80% in programs for children with learning disabilities (Figure 1). By the 1992–93 school year, placements for children with MR had decreased to 1.1% while placements for children with LD had increased to 5.4% of the total school population (Figure 1). While these reversed trends mask substantial variations among states, the dramatic changes in identification rates of the two types of disability suggest that attempts to apply less stigmatizing labels may be influencing the identification process.

Both market and legal forces can stimulate the development of new professional specialties whose members have financial incentives to diagnose students with learning disabilities.

■ *Number of Professional Specialties Involved.* The large number of professional specialties involved in the identification process provides fertile ground for the overidentification of LD because each specialty brings its own set of diagnostic assumptions, theories, and measures to the assessment task. Inconsistent identification practices allow prevalence rates to escalate. This is a significant problem when there are financial incentives to encourage identification (see the article by Parrish and Chambers in this journal issue). Both market and legal forces can stimulate the development of new professional specialties (such as language/learning disorder specialist) whose members have financial incentives to diagnose students with learning disabilities, which the specialists will often be employed to treat. Although it may be uncomfortable to mention these factors, they exist and play some role in the increase of prevalence of LD. At the same time, the majority of professionals serving children with learning disabilities appear well intentioned and well informed.

■ *Inadequate Preparation of Teachers.* Unfortunately, a major factor contributing to invalid prevalence estimates may be the inadequate preparation of teachers by colleges of education. Recent studies have found that a majority of regular classroom teachers feel that they are not prepared to address individual differences in learning abilities within classroom settings.[29] Even more alarming, research suggests that special educators themselves do not possess sufficient content knowledge to address the language and reading needs of children with learning disabilities.[30] Without adequate preparation, teachers have a tendency to overrefer children for specialized assistance because they feel ill-equipped to provide the necessary services.[31]

Interpreting Prevalence Rates

The prevalence of learning disabilities is completely dependent upon the definition used. In most areas, the identification of LD is based largely upon the discrepancy standard and, thus, provides a count of the number of older elementary students (third grade and above) who are achieving significantly below expectations based on IQ. This is, at best, an incomplete definition of LD and one that, for the majority of students with learning disabilities, is based upon an invalid criterion, namely, the discrepancy standard.

Clearly, current definitions allow both overidentification and underidentification of LD. Depending upon the magnitude of

financial incentives and upon unrelated factors (for example, class size, goals for increasing test scores) that often shape the decisions of classroom teachers to refer students with special needs, an individual school district may drastically overidentify or underidentify students with learning disabilities. Therefore, local or national statistics on identification rates for students with LD must be interpreted with caution.

Efforts to Improve Identification

To improve the diagnosis and remediation of learning disabilities, a classification system is needed to identify different types of learning disabilities as well as the distinctions and interrelationships among types of LD and other childhood disorders.[2,20,32] Prospective longitudinal studies are one of the most powerful means to study the different types of LD and their relationships to other disorders and to obtain data for a focused and succinct definition.

Prospective, longitudinal studies of LD can serve as a platform to (1) identify critical learning and behavioral characteristics that may be manifested in different ways at different developmental periods, (2) develop early predictors of underachievement for different academic domains (for example, reading, written language, math), (3) map the developmental course of different types of learning disabilities, (4) identify commonly co-occurring disorders and secondary behavioral consequences that develop in response to failure in school, and (5) assess the efficacy of different treatment and teaching methods for different types of learning disabilities.

To address this compelling need to establish a valid classification system and definition for LD, Congress enacted the Health Research Extension Act of 1985 (Public Law 99-158). This act called for the development of an Interagency Committee on Learning Disabilities (ICLD), under the lead of the National Institute of Child Health and Human Development (NICHD), to identify critical research needs in LD and to implement comprehensive studies to address issues relevant to identification, prevention, etiology, and treatment.

New Knowledge of Reading Disabilities

Since the inauguration of the NICHD Learning Disability Research Network in 1987, researchers have learned the most about learning disabilities that affect linguistic, reading, and spelling abilities and the least about learning disabilities in mathematics.[2] A number of new findings have also been obtained in the area of attention deficit disorder (ADD) and its relationship to different types of LD, particularly disorders in reading.[12] For brevity, the major discoveries made during the past several years are presented in Table 1. Selected findings are reviewed here. The reader should note that many findings have been replicated by multiple research groups, as cited in Table 1, and that the findings are primarily based on large longitudinal samples. Finally, readers should note that studies being conducted in Canada by Stanovich and Siegel at the Ontario Institute for Studies in Education are included in Table 1 because of their impact on the field and because Stanovich and Siegel serve as consultants to the Yale Learning Disability Research Center (LDRC).

Approximately 80% of children identified as having learning disabilities have their primary difficulties in learning to read.

As Table 1 shows, a majority of discoveries made during the past decade have been in the area of reading disabilities. This is appropriate. As Lerner pointed out from her analysis of public school referral data in 1989,[33] approximately 80% of children identified as having learning disabilities have their primary difficulties in learning to read. This high rate of occurrence of reading difficulties among youngsters with LD has also been reported by Kavale in his meta-analytic studies.[34] More recent longitudinal and cross-sectional studies have supported the high rate of reading difficulty among children with learning disabilities, but have also found that reading deficits frequently co-occur with other academic and attentional difficulties. For example, Fletcher and his associates at the Yale Center for the Study of Learning and Attention have, as part of a

Table 1

Major Findings from Research Programs Supported by the National Institute of Child Health and Human Development

Research Domain	Findings	Research Group*
Definition of learning disabilities	Definitions that measure the discrepancy between IQ and achievement do not adequately identify learning disabilities, particularly in the area of basic reading skills.	Yale Ontario
Reading processes	Disabled readers with and without an IQ-achievement discrepancy show similar information processing, genetic, and neurophysiological profiles. This indicates that the existence of a discrepancy is not a valid indicator of disability in basic reading skills.	Colorado Bowman Gray Yale Ontario
Reading processes	Epidemiological studies indicate that as many females as males manifest dyslexia; however, schools identify three to four times more boys than girls.	Bowman Gray Colorado Yale
Reading processes	Reading disabilities reflect a persistent deficit rather than a developmental lag. Longitudinal studies show that, of those children who are reading disabled in the third grade, approximately 74% continue to read significantly below grade level in the ninth grade.	Yale Ontario
Reading processes	Children with reading disability differ from one another *and* from other readers along a continuous distribution. They *do not* aggregate together to form a distinct "hump" separate from the normal distribution.	Yale Bowman Gray Colorado Ontario
Reading processes	The ability to read and comprehend depends upon rapid and automatic recognition and decoding of single words. Slow and inaccurate decoding are the best predictors of deficits in reading comprehension.	Yale Bowman Gray Colorado Johns Hopkins Florida Houston
Reading processes	The ability to decode single words accurately and fluently is dependent upon the ability to segment words and syllables into phonemes. Deficits in phonological awareness reflect the core deficit in dyslexia.	Yale Colorado Bowman Gray Miami Johns Hopkins Florida Houston
Reading processes	The best predictor of reading ability from kindergarten and first-grade performance is phoneme segmentation ability.	Bowman Gray Yale Florida Houston
Attention	A precise classification of disorders of attention is not yet available; however, operational definitions are emerging.	Yale
Attention	Approximately 15% of students with reading disability also have a disorder of attention. Approximately 35% of students with disorders of attention also have reading disability. However, the two disorders are distinct and separable.	Bowman Gray Yale

*See the related endnote at the end of this article for a detailed description of research groups.

Table 1 (continued)

Major Findings from Research Programs Supported by the National Institute of Child Health and Human Development

Research Domain	Findings	Research Group*
Attention	Disorders of attention exacerbate the severity of reading disability.	Bowman Gray Miami
Genetics	There is strong evidence for a genetic basis for reading disabilities, with deficits in phonological awareness reflecting the greatest degree of heritability.	Colorado Bowman Gray
Neurology	Regional blood studies indicate that deficient word recognition skills are associated with less than normal activation in the left temporal region.	Bowman Gray
Neurology	PET studies indicate that dyslexic adults have greater than normal activation in the occipital and prefrontal regions of the cortex.	Miami
Intervention	Disabled readers do not readily acquire the alphabetic code because of deficits in phonological processing. Thus, disabled readers must be provided highly structured programs that explicitly teach application of phonological rules to print.	Bowman Gray Florida Houston
Intervention	Longitudinal data indicate that systematic phonics instruction results in more favorable outcomes for disabled readers than does a context-emphasis (whole language) approach.	Bowman Gray Florida Houston

*See the related endnote at the end of this article for a detailed description of research groups.

larger classification effort, studied 216 children, 7.5 to 9.5 years of age, who were identified as normal readers, reading disabled, math disabled, both reading and math disabled, normal reading with ADD, and reading disabled with ADD.[21,35] From this sample of children with a variety of learning disabilities, only 25 youngsters were reading at age-appropriate levels.

Research indicates that reading disorders reflected in deficient decoding and word-recognition skills are primarily caused by deficiencies in the ability to segment syllables and words into constituent sound units called phonemes.[16,22,36–38] For example, in a large study of 199 seven- to nine-year-old children who had significant difficulties in decoding and word recognition, more than 85% of the youngsters manifested deficits on measures of phonological awareness. In this investigation, children with and without IQ-reading-achievement discrepancies appeared equally impaired on both the phonological and reading measures.[21] This extremely high frequency of phonological awareness deficits in children with reading disabilities has led Share and Stanovich to conclude: "We know unequivocally that less-skilled readers have difficulty turning spellings into sounds. . . . This relationship is so strong that it deserves to be identified as one, if not the defining, feature of reading disability."[39]

Biological Bases

Several NICHD investigations have indicated that these phonologically based reading disabilities are linked to neurobiological and genetic factors.[2,8,13,40] Functional and structural neuroimaging studies indicate that the poor phonological skills, which limit the development of basic reading abilities, are highly related to aberrant neurophysiological processing.[22,40] Moreover, there is increasing evidence from behavioral and molecular genetic studies that the phonological deficits observed in reading disability are heritable.[41,42] Taken together, longitudinal studies of the linguistic, neurobiological, and genetic factors in reading disabilities provide strong and converging

evidence that reading disability is primarily caused by deficits in phonological processing and, more specifically, phonological awareness.[8,13,30,37,38,40]

Likewise, the data derived from genetic and neurobiological studies suggest that some reading disabilities are associated with subtle chromosomal[42] and neurological differences,[22,40] indicating that such disabilities are biologically "real" rather than sociopolitically created.

Discrepancy Standard

In addition to the previously discussed problems of the discrepancy standard, Table 1 indicates that the use of a discrepancy formula, which calculates differences between IQ and reading scores, is not a valid indicator of reading disability; that is, children with reading disabilities both with and without such discrepancies have similar deficits in phonological awareness and similar genetic and neurophysiological characteristics.[36] At this time, it is not clear whether children with higher IQs respond more favorably to intervention.[7]

Persistent Deficit

Unfortunately, as Table 1 indicates, reading disabilities appear to reflect a persistent deficit rather than a developmental lag. That is, children with delays in understanding phonological concepts in first grade are unlikely to catch up later without explicit and informed teaching. Longitudinal studies show that, of the youngsters who are identified in the third grade, approximately 74% remain reading disabled through the ninth grade.[19,43] This appears to be true even when special education has been provided. It should be made clear, however, that interventions applied *after* a child has failed in reading for two or three years may not be effective for several reasons, including the student's declining motivation and impaired self-concept. Instructional difficulties in later intervention abound. For example, the teacher carrying out the interventions may not be properly trained, the interventions may not include explicit and informed instruction in the development of phonological awareness and sound-symbol relationships, the interventions may not be consistently applied and/or may be limited in intensity and duration, and there may be insufficient follow-up or explicit instruction to enable the student to generalize the specific concepts learned to material presented in regular classroom settings.

Interventions applied after a child has failed in reading for two or three years may not be effective for several reasons, including the student's declining motivation and impaired self-concept.

Distribution of Severity

A significant finding from the Yale LDRC is that reading disability represents the extreme of a normal distribution of reading ability so that there is an unbroken continuum from reading ability to reading disability.[43] The finding that reading disability is part of a continuum now places the disorder in the context of other biologically based disorders such as hypertension and obesity.[43] The discovery that reading disability is best conceptualized as occurring along a normal distribution of reading skills underscores the fact that children will vary in their level of severity of the disorder running along a mild-to-severe spectrum, with the majority of children with reading disabilities falling at the mild end. This finding has significant implications. For example, what are the criteria for identifying a child as having a *severe* reading disability, and does this degree of disability warrant entitlement to a greater intensity and duration of specialized interventions?

To answer such questions, the NICHD is embarking on a series of studies to identify the most valid points along the distribution of reading scores that distinguish levels of severity. In part, the validity of different cut-off points for mild, moderate, and severe reading disability is being determined by how children in each severity group respond to different types and intensities of intervention. At this writing, some initial results derived from the Florida State Intervention Project show that children with scores at the extreme lower end of the distributions for both phonological awareness skills and basic reading skills are much more difficult to remediate than children who fall along the distribution in the mild and moderate

ranges.[44–46] It is as yet unclear whether children in the more severe range can achieve age- and grade-approximate reading skills, even with intense, informed intervention provided over a protracted period of time.

While children with severe reading disabilities will most likely require a greater amount of time in high-impact intervention programs than children with less severe deficits, as discussed earlier, it is clear that the longer children *at any level of severity* go without proper identification and intervention, the more difficult the task of remediation and the harder it becomes for the children to respond. It is also clear that even children with relatively subtle linguistic and reading deficits require the expertise of a teacher who is well trained and informed about the relationships between language development and reading development.[30] Unfortunately, such teachers are in short supply, primarily because of a lack of programs providing this training.[31]

Co-occurring Disorders

As noted, most children with learning disabilities have more than one of the seven subtypes of learning disabilities. It is also not unusual to find LD co-occurring with certain behavioral or emotional disorders. The most common co-occurring combinations are discussed briefly below.

Reading and Attention Disorders

Attention deficit disorder (ADD) is an increasingly common diagnosis recognized in medicine[47] and psychology[17] although it is not a category of disability recognized under the IDEA. Like LD, ADD is the subject of considerable controversy, and diagnostic criteria for ADD continue to evolve. There is no litmus test for ADD, which is diagnosed on the basis of persistent and maladaptive behavior patterns (inattention, impulsivity, and hyperactivity) that are inappropriate for the child's age. The number of diagnoses of ADD has increased dramatically in the past decade,[48] and one study[12] found 7% of a survey sample of 445 kindergarten students qualifying as "inattentive" on the Multigrade Inventory for Teachers.

Figure 2[12] indicates that a child identified with reading disabilities is twice as likely as a member of the general population to also meet the diagnostic criteria for inattention (15% versus 7%). Similarly, an individual diagnosed with ADD is at higher risk than a member of the general population of having a reading disability/phonological awareness deficit (36% versus 17%). Despite this co-occurrence, recent studies have indicated that reading disabilities and ADD are distinct and separable disorders.[12,22,49]

Unfortunately, when children with disabilities in reading also manifest ADD, their reading deficits are typically exacerbated, more severe, and more resistant to intervention.[22] In contrast to reading disabilities, ADD is more prevalent in males. Given the frequent co-occurrence of ADD with reading disabilities and given the tendency of boys with ADD to attract considerable attention from teachers, this combination may make boys with disabilities in reading much more likely than girls with disabilities in reading to come to the attention of teachers and to be referred for testing.

Even children with relatively subtle linguistic and reading deficits require the expertise of a teacher who is well trained.

Social Adjustment Problems

In a broad sense, data indicate that learning disability, no matter what the specific type, has a tendency to co-occur with social adjustment problems.[50] Bruck,[51] in her review of the literature related to social and emotional adjustment, concluded that children with learning disabilities are more likely to exhibit increased levels of anxiety, withdrawal, depression, and low self-esteem compared with their nondisabled peers. This comorbidity is persistent. For example, Johnson and Blalock[52] found that, of the 93 adults studied in an LD clinic sample, 36% continued to receive counseling or psychotherapy for low self-esteem, social isolation, anxiety, depression, and frustration. In many instances, it appears that such emotional problems reflect adjustment difficulties resulting from academic failure.[13] Deficits in social skills have also been found to exist at significantly high rates among children with learning disabilities.[53] In general, social skill deficits include difficulties interacting with people in an appropriate fashion (for

example, lack of knowledge of how to greet people, how to make friends, and how to engage in playground games or a failure to use knowledge of such skills in these situations). While not all children with learning disabilities exhibit deficits in social skills, there are certain common characteristics among those who do. For example, Bruck[51] reported that children with more severe manifestations of LD are likely to manifest both an increased number of and increased severity of social skills deficits. Moreover, the gender of the child appears to be a factor, with evidence suggesting that girls with LD are more likely to have social adjustment problems.[51]

Reading Disorders with Other Learning Disabilities

There is abundant evidence that it is rare for a child with learning disabilities to manifest only one specific type of learning disability.[3,53] The co-occurrence of learning disorders should be expected given the developmental relationships between listening, speaking, reading, spelling, writing, and mathematics. For example, it is clear that deficits in phonological awareness lead to difficulties in decoding and word recognition which, in turn, lead to deficits in reading comprehension.[16,37,38] Likewise, children with disabilities in reading frequently experience persistent difficulties in solving word problems in math for the obvious reason that the printed word is difficult for them to comprehend.[14]

An important conclusion to draw from the literature on co-occurring disorders is that any intervention or remediation effort must take into account the range of deficits a child may have. More specifically, while an intensive reading intervention may consist of explicit instruction in phonological awareness, sound-symbol relationships, and contextual reading skills, the child may also require elements essential to bolstering self-esteem, and to fostering reading in other content areas such as mathematics, social studies, and science. One cannot expect the intervention for the reading deficit to generalize serendipitously to other domains of difficulty.

LD in Written Expression

Typically, children who display LD in written expression have difficulties in spelling, formulation and expression of ideas, handwriting, and knowledge of grammar and syntax. Unfortunately, well-designed research investigating disorders of written expression is relatively meager. Definitions for disorders of written expression remain vague.[54] Therefore it is not surprising that estimates of the prevalence of such disorders range from 8% to 15%.[13] What is known is that boys and girls display written language deficits at relatively equal rates.[54] Despite the lack of objective and detailed identification criteria, a number of excellent studies have been conducted to identify effective assessment and intervention programs for problems in written expression.[55-57]

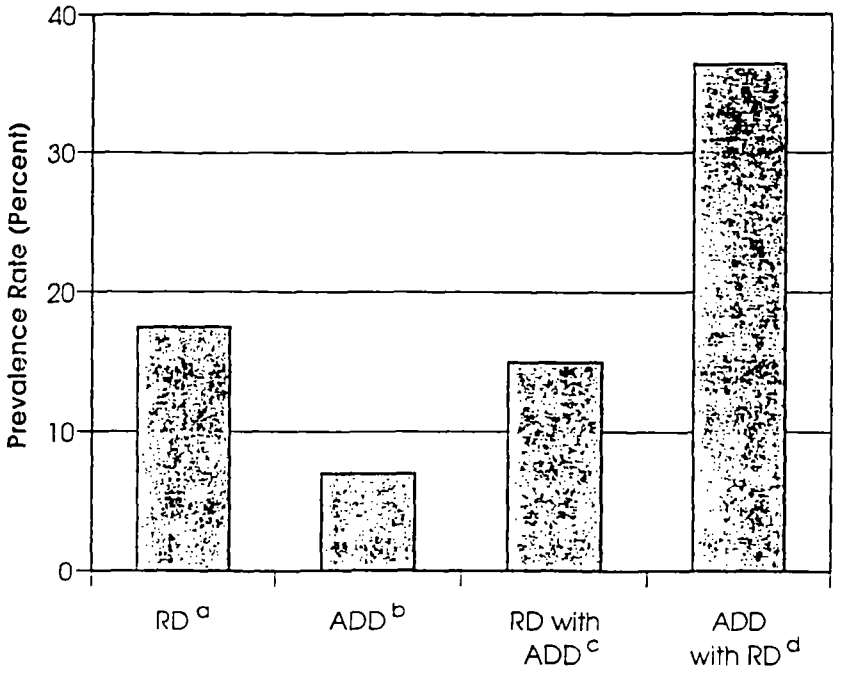
The most successful programs tend to ensure that clear linkages are drawn between oral language, reading, and written language. Successful programs also ensure that basic skills development in spelling and writing (graphomotor production) are explicitly taught and/or accommodated and that the student is also taught how to employ strategies to guide the formulation of ideas for writing and the organization of these ideas in writing. These elements are common to many writing programs; however, successful instruction for students with disabilities in written expression depends upon their intensity and explicitness.

LD in Mathematics

Children identified as manifesting LD in mathematics can demonstrate deficits in arithmetic calculation, mathematics reasoning, or both. In general, authorities agree that approximately 6% of the school population have difficulties in mathematics that cannot be attributed to low intelligence, sensory deficits, or economic deprivation.[14,58] While the data are sparse at this time, it appears that deficits in arithmetic calculation skills are more frequently identified than deficits in arithmetic reasoning.[14] However, common sense would suggest that attempts to reason mathematically would be constrained by limitations in calculations skills. Unfortunately, a major difficulty in identifying math learning disabilities accurately is that, like learning to read, learning mathematics concepts is dependent upon the teacher's knowledge of the concepts and ability to present them.[13]

Figure 2

Co-occurrence of Reading Disability with Attention Deficit Disorder in a Sample of 445 Students at Ninth Grade



Study population: 445 children recruited through a random sample of those attending Connecticut public kindergarten during the 1983–84 school year. This cohort was followed for several years. This chart reflects measures taken during the subjects' ninth-grade year.

[a] **RD** is defined as either an ability-achievement discrepancy (based on a regression formula) or a reading standard score below the 25th percentile.

[b] **ADD** is defined as a score of greater than or equal to 1.5 above the mean on the inattention scale of the Multigrade Inventory for Teachers.

[c] **RD with ADD** is the percentage of all students meeting the criteria for RD in this study who also met the criteria for ADD.

[d] **ADD with RD** is the percentage of all students meeting the criteria for ADD in this stucy who also met the criteria for RD.

Source: Adapted with permission from Shaywitz, S.E., Fletcher, J.M., and Shaywitz, B.A. Issues in the definition and classification of attention deficit disorder. *Topics in Language Disorders* (1994) 14.1–25.

Interventions for Learning Disabilities

Space does not permit an extended review of research on intervention methods for different types of learning disabilities. However, high-quality prospective longitudinal research methods are now being applied to the study of treatment methods for reading disabilities, and that research is summarized here.

Research attempting to identify effective treatment methods for different types and severity levels of reading deficits has been enormously difficult. This is because typical treatment studies have not been able to reliably determine whether the outcomes seen were attributable to the treatment method, the child's general development, the child's previous instruction, the concurrent instruction being provided in the regular classroom, or combinations of these factors. In addition, a majority of treatment studies have been hampered by not having control over teacher expertise and training. Thus, if a treatment method does or does not work effectively, one does not know if it is because of the characteristics of the method, the

characteristics of the teacher, or the characteristics of the child.

Since the late 1980s, a number of well-designed longitudinal treatment studies have been conducted. Because these studies have the capability to intervene with children early on and follow them over time, many of the methodological problems described above have been addressed. These intervention studies have provided information about how to prevent reading disabilities as well as how to address reading disabilities once they are detected at later ages.

For example, Blachman and her colleagues[59-61] have shown that instruction in phonological awareness at the kindergarten level has significant positive effects on reading development during the first grade. Within this context, research has demonstrated that proper instruction carried out by informed teachers can prevent reading failure both for children with inherent LD in basic reading skills and for children whose lack of exposure to "language rich" environments and language development activities during the first five years of life places them at risk for reading deficits. For instance, in a series of studies, Blachman[60,61] provided 84 low-income, inner-city children with 11 weeks of intensive instruction, 20 minutes per day, with one teacher instructing a small group of four to five students in several aspects of phonological awareness. Prior to instruction, classroom teachers also received 14 hours of intensive training. At the end of the 11 weeks, children receiving the interventions significantly ($p < 0.0001$) outperformed control children at reading phonetically regular words and at related tasks. A follow-up study conducted in February and May of the first-grade year showed that the gains were maintained if the first-grade curriculum continued the same emphasis on phonological skill development. Similar studies of kindergarten and first-grade children conducted by other researchers[62-64] have yielded similar results.

Instruction in phonological awareness at the kindergarten level has significant positive effects on reading development during the first grade.

Unfortunately, not all children with reading disabilities have the benefit of appropriate early interventions. As discussed earlier, most children whose reading disability is not recognized until third grade or later and who receive standard interventions fail to show noticeable improvement. However, intensive instruction of appropriate duration provided by trained teachers can remediate the deficient reading skills of many children. For example, in one study, Alexander and her colleagues[65] provided 65 severely dyslexic children with 65 hours of individual instruction in addition to group instruction in phonemic awareness and synthetic and analytic skills. This intensive treatment approach improved the reading skills of the children from an initial reading score of 77 to an average of 98.4 (mean = 100) on a measure of alphabetic reading skills. Longitudinal studies continue to demonstrate the efficacy of intensive and informed multidimensional treatment programs.[64,66]

Several additional findings have emerged from these longitudinal treatment studies. It is clear that children with severe phonological deficits, leading to poor decoding and word recognition skills, respond to treatment at slower rates than youngsters with mild to moderate deficits.[44,67] In addition, instruction and interventions for reading failure, which focus primarily on context and reading comprehension without commensurate attention paid to phonological awareness, decoding, and word recognition, show limited results.[67-69] Finally, the success of even the best-designed reading intervention program is highly dependent upon the training and skills of the teacher.[22,29-31,38]

Disability in basic reading skills has been a prime candidate for treatment studies because it is the most common form of LD, it is the most objectively identifiable, and more knowledge is available concerning its causes and developmental course. Interventions for other types of learning disabilities have been developed but not studied as extensively and not studied in prospective, longitudinal research. There is as yet no solid indication whether early, effective interventions for disability in basic reading

skills will affect the developmental course of other forms of learning disability.

Outcomes

Learning disabilities, sometimes inappropriately conceptualized as a "mild" disorder, may be anything but—they may be persistent and may not respond to general instruction or to inappropriate (for example, whole language) instruction. Unless identified early on and taught by expert teachers using detailed and intensive approaches emphasizing teaching both in phonological awareness and phonics instruction, children who learn poorly in the third grade can be expected to learn poorly throughout middle- and high-school grades. Unfortunately, the majority of children with learning disabilities are still not identified until the third or fourth grade and do not receive appropriate and timely reading instruction. In turn, those students with learning disabilities who graduate from high school are destined for few postschool opportunities. The minority of children with LD who received appropriate early intervention have not been identified for long-term follow-up so their long-term outcomes are speculative, but there is reason for optimism in their significantly improved short-term outcomes.

At present, the long-term outcomes for the majority of individuals with learning disabilities who did not receive appropriate early reading instruction are frequently bleak. It is known from the epidemiological data cited earlier that 75% of the children with disabilities in reading who are not identified until the third grade continue to have reading disabilities in the ninth grade.[24] In a recent review, Martin[70] reported that a considerable percentage (26.7%) of high school students identified as having learning disabilities drop out of school prior to graduation. Another 16% of students with learning disabilities exit school for "unknown" reasons without a diploma. Equally disturbing, Fairweather and Shaver[71] found that only 17.1% of the individuals with learning disabilities whom they followed for three to five years after high school were enrolled in any postsecondary course, including vocational courses. Only 6.7% of the students with learning disabilities participated in two-year higher education programs, and only 1.8% participated in four-year programs.

While these data suggest that individuals with learning disabilities do not markedly improve their academic skills (particularly reading skills) and face limited educational and vocational opportunities, it should not be concluded that individuals with LD cannot be taught. They can, but, as stated throughout this paper, interventions are most likely to be successful if applied early and carried out by expert teachers.

Conclusions

The past decade has witnessed a significant improvement in the quality of research on learning disabilities. Much of this recent research has been longitudinal in nature, thus opening the door to the identification of better predictors of different types of LD, their prevalence, their developmental course, and their response to intervention. Specifically,

Learning disabilities, sometimes inappropriately conceptualized as a "mild" disorder, may be anything but–they may be persistent and may not respond to general instruction.

- The definitional issues addressed in this article continue to be the single greatest impediment to understanding learning disabilities and how to help children and adults with LD.

- Maintaining the term "learning disabilities" makes little sense for scientific purposes, clinical purposes, or school policy purposes. Instead, the field must grapple with the clear need to address each type of learning disability individually to arrive at clear definitional statements and a coherent understanding of etiology, developmental course, identification, prevention, and treatment.

- Reading disability in the form of deficits in phonological awareness is the most prevalent type of learning disability and affects approximately 17% of school-age children to some degree.

- While other factors will, no doubt, be identified as contributing to reading disability, deficits in phonological awareness will most likely be found to be the core deficit.

Research during the past decade has shown that deficits in phonological awareness can be identified in late kindergarten and first grade using inexpensive, straightforward testing protocols, and the presence of these deficits is a strong indicator that reading disability will follow.

■ Although it is now possible to identify children who are at-risk for reading failure, and some of the instructional conditions that must be in place from the beginning of formal schooling are understood, it is still true that the majority of LD children are not identified until the third grade. Therefore, policy initiatives should focus on the dissemination of existing early identification and early intervention programs.

■ Interventions for reading disability must consist of explicit instructional procedures in phonological awareness, sound-symbol relationships, and meaning and reading comprehension, and should be provided by expert teachers in the kindergarten and first-grade years.

■ In general, teachers remain seriously unprepared to address individual differences in many academic skills but particularly in reading. However, teachers cannot be expected to know what they have not been taught, and clearly colleges of education have let students down. Regrettably, being unprepared takes a toll on teachers. Many teachers worry about their failures with hard-to-teach students, become frustrated, lose confidence, and leave the profession, or discontinue attempting to teach children with special needs. This cycle of events calls for honest and aggressive reform in higher education.

■ While early intervention is *necessary*, it should not be assumed to be *sufficient* to address the multiple manifestations of learning disability. Even those students who receive appropriate phonological instruction at a young age may require continuous and intensive support to deal with other co-occurring disorders.

■ When policymakers consider "inclusionary" models of instruction, they must consider carefully whether those models can provide the critical elements of intensity and the appropriate duration of instruction, along with teacher expertise in multiple teaching methods and in accommodating individual learning differences.

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The Florida State University Research Group

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The principal investigator for the University of Miami Learning Disabilities Program Project is Dr. Herbert Lubs, professor of pediatrics and genetics, University of Miami School of Medicine, MCCD, P.O. Box 16820, Miami, FL 33101. The Miami group also consists of Drs. Ranjan Duara, Bonnie Levin, Bonnie Jallad, Marie-Louis Lubs, Mark Rabin, Alex Kushch, and Karen Gross-Glenn, all from the University of Miami.

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Research Initiatives in Learning Disabilities: Contributions From Scientists Supported by the National Institute of Child Health and Human Development

G. Reid Lyon, PhD

Learning disabilities encompass a wide range of disorders in listening, speaking, reading, writing, and mathematics that are frequently accompanied by comorbid deficits in attention and social behavior. Current estimates indicate that children with learning disabilities compose between 10% and 15% of the school-aged population and represent over half of the children who receive special education services in the United States.[1] Despite this frequency of occurrence, learning disabilities remain one of the least understood yet most disabling array of conditions that affect both children and adults. This is unfortunate because learning disabilities are extremely deleterious to the development of children in general, and the negative effects of learning disabilities go well beyond school failure. For example, poor peer relationships, decrements in self-concept, poor postschool adjustment, and limited placed occupational opportunities are some of the known outcomes of learning disabilities.

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A number of influences have contributed to persistent difficulties in diagnosing and treating learning disabilities. In fact, until research programs supported by the National Institute of Child Health and Human Development and the Natural Sciences and Engineering Council of Canada to study learning disabilities began to lead to major discoveries during the past decade, the consensus of thought in the biologic and behavioral sciences was that the field of learning disabilities lacked scientific validity and clinical utility.[2,3] To better understand the difficulties that have plagued the learning disabilities field and the National Institute of Child Health and Human Development's programmatic response to alleviate them, a brief review of both problems and progress in the field is presented in the following sections. An emphasis will be placed on discussing the role of the National Institutes of Health in general, and the National Institute of Child Health and Human Development in particular, in stimulating and supporting systematic, prospective longitudinal research to best understand how to classify, define, and treat learning disabilities. As mentioned above, additional reference will also be made to the outstanding work of Stanovich and Siegel in learning disabilities and reading disorders at the Ontario Institute for Studies in Education that is supported by the Canadian government.[3] Readers should note that comprehensive sources on these topics have recently been published.[4,5]

IMPEDIMENTS TO SCIENTIFIC DEVELOPMENTS IN LEARNING DISABILITIES: A HISTORICAL PERSPECTIVE

Historically, a number of influences have contributed to difficulties in validating scientifically the construct of learning disabilities.[1,2] First, the field's limitations as a clinical science can be related to its brief tenure as a recognized category of disability. Specifically, learning disabilities as a federally designated category of handicap, has been in existence only since 1968.[3] Thus, there has not been time to collect and consolidate the necessary observations under experimental conditions that could lead to a better understanding of the critical diagnostic markers and treatment interventions that have a known probability of success.

Second, many different theoretical and conceptual views are offered to explain learning disabilities, and these views clearly reflect the multidisciplinary nature of the field.[2] Learning disabilities are considered the legitimate concern of many disciplines and professions, including education, psychology, neurology, neuropsychology, optometry, psychiatry, and speech and language pathology, to name a few. Each of these professions has focused on different aspects of the child or adult with learning disabilities, so that there exist highly divergent ideas and, frequently, contentious disagreements about the importance of etiology, diagnostic methods, intervention methods, and professional roles and responsibilities. Unfortunately, from the perspective of developing a valid definition and classification system for learning disabilities, such variation in views and beliefs results in differences in the numbers of children identified and their characteristics. In turn, conducting research on samples of children with putative learning disabilities who vary widely in diagnostic and demographic characteristics provides little opportunity for the replication and generalization of findings—the cornerstones of scientific inquiry.

Third, many diagnostic and treatment decisions about individuals with learning disabilities have been based on technically inadequate tests and measures. Recent comprehensive reviews[4] suggest that fewer than one third of the psychometric tools used in the diagnosis of learning disabilities meet criteria for adequate norms, reliability, and validity. As importantly, the valid assessment of change over time, and change as a function of treatment, is very difficult to accomplish at present because few instruments have the scaling properties to satisfy conditions for the measurement of individual growth curves.[4]

Fourth and by far the most significant and persistent problem impeding progress in the field of learning disabilities has been the difficulty in establishing a precise inclusionary definition and a theoretically based classification system that provides (1) a framework for the identification of different types of learning disabilities and (2) a framework for recognizing distinctions and interrelationships (comorbidities) between learning disabilities and other learning disorders to include attention deficit disorders, general academic underachievement, mental retardation, and emotional disturbance. The precise characterization of learning disabilities has been hindered on the one hand by associating learning disabilities with the concept of aptitude-achievement discrepancy and, on the other hand, by conducting "single-shot" studies on "school-identified" or "clinic-referred" samples of children.[1,4] The assumption that a discrepancy between achievement and aptitude (typically assessed using intelligence tests) is a clear diagnostic marker for learning disabilities or can be considered a pathognomonic sign is at best premature, and at worst invalid.[2,5] Such an assumption is based on the premise that individuals who display an IQ-achievement discrepancy are indeed different from individuals who do not with respect to phenotypic variables such as information-processing characteristics and response to intervention, and genotypic features such as differences in the heritability of the disorder or its neurophysiologic signature. As will be pointed out later, a major thrust of the National Institute of Child Health and Human Development's efforts in the study of learning disabilities has been to evaluate the efficacy of discrepancy in defining learning disabilities by systematically comparing "discrepant" versus "nondiscrepant" low-achieving children on both phenotypic and genotypic variables.[5]

The study of individuals identified a priori as learning disabled by school or clinic criteria within the context of single investigations or cross-sectional designs has also significantly hampered efforts to develop a valid definition and classification system for learning disabilities. It has been pointed out many times that schools and clinics lack consistency in the way in which learning disabilities are diagnosed. A child can literally be "cured" of a learning disability simply by moving across state boundaries or by changing schools within the same community.[1,2] Such variability in sample characteristics prohibits replication and generalization of findings—a severe impediment to the development of any clinical science. Moreover, "single-shot" investigations that compare children achieving normally with children with learning disabilities on one or more dependent variables of interest at one point in time ignores the developmental nature of learning and change over time, and how such change interacts with information processing characteristics, teacher characteristics, different interventions, and classroom climates. As such, limited information is available on the developmental course of learning disabilities and how children may display different characteristics at different points in time.

The foregoing brief review provides the rationale for the development of the National Institute of Child Health and Human Development research programs in learning disabilities. Before the initiation of the programs, much of our research-based thinking about learning disabilities was predicated on information obtained from ambiguously defined school-identified samples of children who were administered technically inadequate tests. Frequently, the research problem was further confounded by the tendency to interpret these test data in the context of invalid theoretical and conceptual frameworks. Finally, the majority of studies carried out with individuals with learning disabilities were not informed by a longitudinal, developmental perspective. It has been within this context of scientific need that the National Institute of Child Health and Human Development has systematically developed a portfolio of individual research initiatives, program projects and learning disability research centers to define and classify learning disabilities and to obtain new knowledge related to etiologies, developmental trajectories, and interventions for learning disabilities. The next sections of this paper provide a review and analysis of the major findings of the research supported by the National Institute of Child Health and

Human Development, with an eye toward identifying additional future research needs and directions.

THE ROLE OF THE NATIONAL INSTITUTE OF CHILD HEALTH AND HUMAN DEVELOPMENT IN THE PLANNING AND CONDUCT OF RESEARCH IN LEARNING DISABILITIES

By way of background, the Health Research Extension Act of 1985 (PL 99-158) mandated the establishment of an Interagency Committee on Learning Disabilities for the express purpose of addressing the persistent problems in identifying a valid classification system and a definition for learning disabilities. More specifically, the Interagency Committee on learning disabilities was charged with the task of reviewing and assessing federal research priorities, activities, and findings regarding learning disabilities. The National Institute of Child Health and Human Development was designated the lead agency for this congressional initiative. With respect to legislative and administrative action, the Interagency Committee on Learning Disabilities was required to make recommendations to increase the effectiveness of research on learning disabilities and to improve the dissemination of findings, and to prioritize research efforts in the causes, diagnosis, treatment, and prevention of learning disabilities. After a comprehensive review of extant data and information related to the study of learning disabilities,[8] the Interagency Committee on Learning Disabilities concluded that

> collaborative, integrated, and coordinated multidisciplinary approaches to research questions, such as could be undertaken on university campuses in large program projects and in specialized research centers of excellence, would be the most appropriate way to increase the effectiveness of this research.... A major goal of this research should be the development of a classification system that more clearly defines and diagnoses learning disabilities, conduct disorders, and attention deficit disorders, and their interrelationships. Such information is prerequisite to the delineation of homogeneous subgroups and the delineation of more precise and reliable strategies for treatment, remediation, and prevention that will increase the effectiveness of both research and therapy.[8]

Within this context, the National Institute of Child Health and Human Development proceeded to develop requests for applications for program projects in 1985,[8] learning disability research centers in 1987,[9] and treatment/intervention research projects in 1993. By way of background, the program project research award is a National Institutes of Health funding mechanism that can support at least three discrete, yet closely related and synergistic, projects. The learning disability research centers are funded via specialized research center grants that provide support for both the synergistic research projects *and* supporting core service projects. This type of mechanism is used to stimulate research in a given field by encouraging collaborative, interdisciplinary research.

In response to the program project request for applications, five program projects were awarded by the National Institute of Child Health and Human Development. The recipients were John DeFries and his research group at the University of Colorado, Frank Wood and his team at the Bowman Gray School of Medicine, Herbert Lubs and his colleagues at the University of Miami, Bennett Shaywitz and his collaborators at Yale University and the University of Houston (led by Jack Fletcher), and Albert Galaburda and his group at Beth Israel Hospital and Harvard University. In response to the learning disability research center request for applications, three centers were established: one at Johns Hopkins University under the leadership of Martha Denckla, another at Yale University (also directed by Shaywitz), and one at University of Colorado (also directed by DeFries). In response to the treatment/intervention research request for applications, one research program was established at Florida State University under the direction of Joseph Torgesen and one at the University of Houston led by Barbara Foorman. These longitudinal intervention studies are in the beginning phases and data are not yet available.

A brief overview of the major goals and objectives of the National Institute of Child Health and Human Development program projects and learning disability research centers is provided in the following sections. Individual program projects (Bowman Gray, Miami, and Beth Israel/Harvard) will be summarized first, followed by a review of the research programs that have been awarded a learning disability research center (Johns Hopkins) and both a program project and a learning disability research center (Colorado and Yale). This overview will be followed by brief sections that provide a synthesis of the major discoveries made by the research programs in targeted areas of inquiry (ie, classification/definition, reading and language related processes, attention, genetics, neurophysiology/neuroimaging, and treatment/intervention). Readers should note that comprehensive reviews of the goals and findings from each of the projects and centers, written by each of the principle investigators and their research teams, can be found in Duane and Gray,[5] Lyon et al,[1] Fletcher et al,[7] and Lyon.[4]

THE NATIONAL INSTITUTE OF CHILD HEALTH AND HUMAN DEVELOPMENT RESEARCH PROGRAMS IN LEARNING DISABILITIES

Program Projects

The *Bowman Gray Program Project* is designed to study childhood reading disability, with an eye toward developing a definition and subtyping system for dyslexia.[5] Within this context, research studies have been, and continue to be, conducted to (1) identify an appropriate combination of measures in the first grade that can define dyslexia and predict reading performance throughout the later grades; (2) determine whether attention deficit disorder has an independent impact on reading development and disorders; (3) develop the most powerful combination of linguistic (eg, phonologic and naming) tasks that can be used to chart the developmental course of reading and reading disability; (4) identify the efficacy of code-emphasis reading approaches versus context-based reading approaches with well-defined groups of reading-disabled children; (5) study regional cerebral blood flow and positron-emission tomographic activation signatures that are correlated with specific linguistic and cognitive parameters in a unique sample of adult dyslexics, first seen as children by June Orton, the wife of Samuel Torrey Orton, a noted pioneer in the study of dyslexia; and (6) externally validate distinctions between dyslexia and attention deficit disorder using event-related potential electrophysiology.

The *University of Miami Program Project* has completed its first 5 years of investigations to identify inherited subtypes of specific dyslexia via both behavioral genetic studies and genetic linkage analyses, and to further characterize these subtypes by psychophysical, behavioral, and neuroimaging studies. More specifically, Lubs and his group have attempted to define the chromosomal location of the several genes that produce autosomal dominantly inherited dyslexia. Project goals were addressed through scientific experiments in three major areas[5]: in the first area, the Miami group designed and conducted linkage studies to delineate the location of chromosomes and chromosome bands of several genes that could be specifically related to a different phenotypic expression of dyslexia. In the second area of investigation, psychophysical and neuropsychological tasks were administered to dyslexic subjects to delineate information processing and cognitive profiles that could be used to validate genetically different subtypes. In the third area, magnetic resonance imaging and positron-emission tomographic studies were carried out in an attempt to identify unique neurophysiologic signatures for dyslexic subtypes.

The *Beth Israel/Harvard Program Project* has as a primary goal the development of an understanding of the relationships between subtle abnormalities of brain development and specific childhood learning disabilities to include dyslexia. The ultimate goal of the research is to identify the causes of such neural anomalies and thus the neurobiologic causes of learning disabilities and dyslexia.[5] Within this context, Galaburda and his colleagues have sought to develop an animal model of brain development that provides a window on how cortical abnormalities occur during ontogenesis and how such abnormalities affect behavior. Major efforts have also been deployed to delineate the cytoarchitectonic organization and the chemoarchitectonics of those brain regions implicated in developmental dyslexia. In addition, several investigations are underway to specify immunologic variables responsible for anatomic and behavioral anomalies in human and animal brain.

The *Johns Hopkins Learning Disability Research Center* represents a multidisciplinary research effort designed to understand the neurodevelopmental bases of learning disabilities. Denckla and her associates pursue this complex research task through four major lines of research.[4,9] In one project, the Johns Hopkins group is attempting to discover the causes of nonverbal learning disabilities via behavioral, neuropsychological, and neuroimaging studies of learning-disabled individuals and individuals with neurofibromatosis. A second project is designed to examine the spectrum and severity of social deficits in female children who are heterozygous for the fragile X genetic anomaly and to investigate the relationship of these deficits to specific cognitive, linguistic, and neuropsychological problems observed in learning-disabled individuals without fragile X syndrome. A third line of research is designed to investigate the relationship between Tourette syndrome and attention deficit disorder using both genetic and neuropsychological procedures. The fourth project is designed to develop assessment methods to differentiate between hard-to-remediate dyslexic children and children who respond to intervention. This project is also designed to identify the most powerful predictors of dyslexia and intervention approaches that have a high probability of success with disabled readers.

The *Colorado Program Project* has been composed of four interrelated projects designed (1) to assess the genetic etiology of reading disability, and, in particular, the heritability of phonologic and orthographic skills; (2) to identify the specific language and perceptual skills that are critical for the development of fluent reading skills; (3) to determine whether reading disability is correlated with deficiencies in the immunologic system; and (4) to conduct genetic linkage analyses to localize, if possible, specific genes implicated in the expression of reading disability.[4,5,9]

With the *Colorado Learning Disability Research Center*, DeFries and his group extend the research carried out in the Program Project by increasing sample sizes and developing creative behavioral genetic analytic methodologies to assess the genetic and environmental etiologies of deficient component phonologic, orthographic, reading skills in reading disability. Within this context, genetic linkage analysis is being employed to search for major genes and quantitative trait loci that influence learning disabilities. In addition, a treatment/intervention project is being conducted with 100 twin pairs of disabled readers in an effort to discover reading subtype/dimension by treatment interactions.

The *Yale University Program Project* is designed to address major questions related to the definition, etiology, developmental course, and biologic/neurophysiologic bases for dyslexia.[4,5,9] The Yale studies are unique in that they are being carried out with the largest longitudinal cohort of reading-disabled children in North America. As such, Shaywitz and his associates are continuing to obtain major findings that are not biased by the vagaries of studying school-identified or clinic-referred samples. In Project 1 of the Program Project, the longitudinal cohort is studied to identify (1) whether distinct subtypes of dyslexia exist; (2) whether subtypes are stable over time; (3) whether dyslexia constitutes a developmental lag versus a fixed deficit in reading, neurolinguistic, and cognitive skills; (4) whether deficits in single-word reading are attributable to a combination of deficits in phonologic and orthographic processes; and (5) whether positive or negative outcomes of dyslexia are associated with sociodemographic factors, the nature and severity of the reading disability, comorbidity, and self-esteem.

In Project 2, a well-defined group of children with early language disorders is studied to assess the development of reading-related language skills (eg, phonologic awareness) and to determine how particular early language impairments relate to the emergence of different types of reading disability. In Project 3, dyslexic, mathematics-disabled, and nondisabled boys and girls are followed and studied as they pass through puberty in order to assess the effects of specific endocrinologic influences on reading, cognitive, and neurolinguistic skills. Finally, in Project 4 of the Program Project, the Yale group is employing state-of-the-art functional magnetic resonance neuroimaging technology to examine brain structures and brain functions in well-defined groups of dyslexic children as the children carry out tasks designed to assess reading, phonologic awareness, orthographic decision making, and phonologic decision-making skills.

The *Yale University Learning Disability Research Center* has been charged with the complex task of developing a comprehensive classification system for the range of common disorders that can influence school performance. A major focus of the Center is the development of a classification system for children with

attention and oppositional/conduct disorders with and without learning disabilities. In addition, one large project within the Center is tasked with the continued in-depth epidemiologic study of 414 reading-disabled children, now entering the ninth grade, who were originally identified during kindergarten. This ongoing investigation continues to provide data relevant to the stability and generalizability of learning disability subtypes over time.

MAJOR FINDINGS AND CONCLUSIONS

A number of independent and replicated discoveries relevant to learning disabilities in general, and dyslexia in particular, have been obtained through the research efforts at each of the National Institute of Child Health and Human Development's program projects and learning disability research centers, as well as through the Stanovich and Siegel research programs at the Ontario Institute for Studies in Education funded by the Canadian government. It should be noted here that the Ontario group is collaborating with the Yale Learning Disabilities Research Center in selected studies of reading disabilities. Selected important discoveries are highlighted in Table 1 and described according to major domains of study, major findings obtained, and the group of scientists responsible for the research. References are provided for each of the major findings. However, due to limitations in the number of references that could be used for this paper, readers are encouraged to peruse the edited sources cited for an overview of the research, an analysis of other important discoveries, and citations for the specific findings reported in Table 1.

As can be seen in Table 1, a number of major discoveries have been made, particularly in reference to the epidemiology of dyslexia and the identification of the core linguistic deficits observed in dyslexia. In turn, these findings have led to the development of tasks and measures that can be used with preschool and first-grade children to predict the onset of reading disabilities during the primary grades. As Table 1 further indicates, if the prediction leads to early intervention before the third grade, the learning-disabled child has a much greater chance of developing appropriate reading skills. If reading-disabled children are not identified until the third grade or beyond, the majority (75%) will continue to manifest reading deficits throughout their school and adult years.

Exciting new developments in neuroimaging and genetics are presented in Table 1 and clearly reinforce the hypothesis that reading and other learning disabilities have a biologic basis. However, ongoing treatment/intervention studies demonstrate that learning-disabled children can improve their language, reading, and written language abilities if the appropriate teaching methodology is employed.

FUTURE RESEARCH DIRECTIONS IN LEARNING DISABILITIES

In addition to the research initiatives and programs described above, the National Institute of Child Health and Human Development is developing and expanding programs and plans in the area of treatment/intervention for learning-disabled children and in the area of cognitive neuroscience and neuroimaging. Each of these areas of inquiry are described briefly.

Treatment/Intervention

Review of the literature related to reading disabilities and other learning disabilities indicates that no single treatment/intervention approach or method is likely to yield clinically significant, long-term, therapeutic gains with children diagnosed with learning disabilities.[12] Unfortunately, to date, there exists scant scientific support for the use of particular interventions or combinations of interventions with different types of learning disabilities. Because of this, the National Institute of Child Health and Human Development has recently launched a major research effort to determine which treatment methods or combinations of methods, provided in which setting, have the most effective impact on well-defined domains of child functioning, for how long, and for what reasons. Within this context, two highly controlled and well-designed longitudinal prospective intervention studies with learning-disabled children are now being supported at the Florida State University under the direction of Joseph Torgesen and at the University of Houston under the direction of Barbara Foorman. Additional treatment/intervention initiatives are being planned at this time.

Cognitive Neuroscience and Neuroimaging

There exists a critical need to understand how the human brain is organized for complex behaviors and to know more specifically how the child with learning disabilities and the normal learner differ with respect to central nervous system functioning. In addition, it is important for us to understand how such physiologic and neuroanatomic differences are related to indices of heritability and environmental influences. Our ability to assess brain-behavior relationships in an accurate, yet noninvasive, manner is improving significantly as we begin to employ dramatic new advances in neuroimaging technology. For instance, the Shaywitz group at Yale is moving forward with the application of functional magnetic resonance imaging studies with reading-disabled and normal children. In addition, Allen Reiss and his colleagues at Johns Hopkins are designing imaging software that will allow different sites to compare neuroimaging data and determine how best to register functional brain information with structural brain information. These projects, as well as initiatives being planned, should serve to provide the empirical foundation necessary not only to understand the limits of individual variability in brain structure and function but to identify the neurobiologic underpinnings of learning disabilities.

SUMMARY

The National Institute of Child Health and Human Development has been, and will continue to be, responsive to the critical research needs in learning disabilities and related disorders. As an index of the heightened research activity in this arena, consider that National Institute of Child Health and Human Development's support for projects related to learning and language disabilities has increased from 1.75 million dollars in 1975 to over 15 million dollars in 1993—a cumulative total of approximately 80 million dollars. Given the significant discoveries made by the program projects, learning disability research centers, and individual research grants supported through these increases, the money clearly has been well spent. Within the past 10 years, National Institute of Child Health and Human Development research programs have identified the major cognitive mechanisms underlying

Table 1. Major Findings From NICHHD-Supported Research Programs

Research Domain	Findings	Research Group
Definition of learning disabilities	A definition must be developed within a longitudinal developmental perspective unbiased by a priori assumptions reflected in current definitions.[1,4,5,7]	Bowman Gray School of Medicine, Yale University
	Exclusionary definitions using discrepancy criteria appear invalid, particularly in the area of basic reading skills.[1,5,7]	Yale University, Ontario Institute for Studies in Education
Reading and language-related processes	Reading disabilities affect at least 10 million children in the United States.[9–11]	Yale University
	Epidemiologic studies indicate as many females as males manifest dyslexia; however, schools identify four times as many boys as girls.[2,4,5,11]	Bowman Gray School of Medicine, University of Colorado, Yale University
	Reading disabilities reflect a persistent deficit rather than a developmental lag. Longitudinal studies show that of those children who are reading disabled in the third grade, approximately 74% remain disabled in the ninth grade.[1,3,4,7,10]	Yale University, Ontario Institute for Studies in Education
	Distinguishing between disabled readers with and without an IQ-achievement discrepancy appears invalid. Children with and without discrepancies show similar information processing, genetic, and neurophysiologic profiles.[1,3,4,7]	University of Colorado, Bowman Gray School of Medicine, Yale University, Ontario Institute for Studies in Education
	Children with reading disability differ from one another *and* from other readers along a continuous distribution. They do not aggregate together to form a distinct "hump" separate from the normal distribution.[7,10]	Yale University, Bowman Gray School of Medicine, University of Colorado, Ontario Institute for Studies in Education
	The ability to read and comprehend depends on rapid and automatic recognition and decoding of single words. Slow and inaccurate decoding are the best predictors of deficits in reading comprehension.[1,3,4,5,7,12]	Yale University, Bowman Gray School of Medicine, University of Colorado, Johns Hopkins School of Medicine
	The ability to decode single words accurately and fluently is dependent on the ability to segment words and syllables into phonemes. Deficits in phonologic awareness reflect the core deficit in dyslexia.[4,5,7,12]	Yale University, University of Colorado, Bowman Gray School of Medicine, University of Miami, Johns Hopkins School of Medicine
	The best predictor of reading ability from kindergarten and first-grade performance is phoneme segmentation ability.[5]	Bowman Gray School of Medicine, Yale University
Attention	A precise classification of disorders of attention is not yet available. A classification methodology that assesses internal and external validity of dimensional *and* categorical models must be applied to this issue.[1,4]	Yale University
	Disorders of attention and reading disability often coexist, but the two disorders are distinct and separable.[4,5,9]	Bowman Gray School of Medicine, Yale University
	Disorders of attention occur more frequently and exacerbate the severity and cognitive morbidity of reading disabilities. Because disorders of attention and reading disabilities often co-occur, more males are typically identified as reading disabled, spuriously inflating the sex ratio in favor of males.[5,9]	Bowman Gray School of Medicine, University of Miami
Genetics	A multiple regression procedure has been developed that allows for the analysis of the genetic etiology of individual differences in component language and reading skills. This methodology can assess differential genetic and environmental effects.[4,5]	University of Colorado
	There is strong evidence for genetic etiology of reading disabilities, with deficits in phonologic awareness reflecting the greatest degree of heritability.[4,5,13]	University of Colorado
	There appears to be at least one type of reading disability that can be linked to the HLA region of chromosome 6, reflecting a possible association with autoimmune disorders.[5,13]	University of Colorado, University of Miami
Neuroanatomy, neurophysiology, neuroimaging	Several types of brain pathology, including microdysgenesis (ectopias), cell loss, and abnormalities of the corpus callosum are present in a number of strains of mice. There is a similarity between the brain lesions seen in the mouse model and in humans with dyslexia.[5,9]	Beth Israel Hospital and Harvard Medical School
	At the microscopic level, atypical neural organization in dyslexic individuals is suggested by absence of the normal left-greater-than-right asymmetry in the region of the posterior temporal planum.[5,9]	Beth Israel Hospital and Harvard Medical School
	The phenotypic expression in dyslexia is related to anomalous organization of tissue and processing systems subserved within the posterior left hemisphere.[5,9]	Beth Israel Hospital and Harvard Medical School, Bowman Gray School of Medicine
	Regional blood studies indicate that deficiency in word recognition skills is associated with less-than-normal activation in the left temporal region.[5,9]	Bowman Gray School of Medicine
	PET studies indicate that dyslexic adults have greater-than-normal activation in the occipital and prefrontal regions of the cortex.[5,9]	University of Miami
Intervention	Disabled readers do not readily acquire the alphabetic code due to deficits in phonologic processing. Thus, disabled readers must be provided highly structured programs that explicitly teach application of phonologic rules to print.[5,9]	Bowman Gray School of Medicine
	Longitudinal data indicate that systematic phonics instruction results in more favorable outcomes for disabled readers than does a context-emphasis (whole-language) approach.[5,9]	Bowman Gray School of Medicine

NICHHD = National Institute for Child Health and Human Development; PET = positron-emission tomography.

dyslexia and other learning disabilities and how the assessment of these mechanisms can help to predict the onset, developmental course, and outcomes of such disorders. Moreover, scientists supported by the National Institute of Child Health and Human Development have contributed substantially to an understanding of how genes, the brain, and the environment interact to produce individual variations in learning. Given this knowledge, we are hopeful that the newly funded treatment/intervention projects will provide guidance with respect to ameliorating the devastating effects of learning disabilities on both children and adults.

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Wanted: Teachers with knowledge of language

Research on the nature of reading and spelling disability (dyslexia) indicates unequivocally that most dyslexic individuals do not process language accurately or fluently at the level of phonology and that they may experience disorders in syntax and semantics as well. Simultaneously, intervention research clearly demonstrates that individuals who are taught language structure explicitly progress more readily than those who are not. Given the consistency of research findings, the paucity of teachers skilled in teaching language explicitly to dyslexic children is of more concern than ever. Surveys of teacher knowledge, reviews of the literature on teacher education, and policy statements indicate that many teachers are underprepared to teach language content and processes to children whose learning problems are language based. Even motivated and experienced teachers typically understand too little about spoken and written language structure to be able to provide sufficient instruction in these areas. A new approach to teacher education is needed that emphasizes the importance of language knowledge for literacy instruction, as well as its skilled application to instructional planning. Key words: *dyslexia, language, literacy, teacher education*

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AS EVIDENCE mounts that reading and spelling disability (dyslexia) originates from insufficient language processing capability, the need for language-focused instruction for the millions of children with insufficient reading skills is an increasingly urgent problem. Formally trained language clinicians typically are unable to assume primary responsibility for the instructional needs of dyslexic children, who need teaching throughout the day that integrates both oral and written language. Conversely, teachers of reading, classroom teachers, and special educators are often lacking the depth of language knowledge necessary for effective reading and writing instruction with dyslexics. Although research continues to document that basic language processes are deficient in cases of reading failure, such research is unlikely to influence literacy education unless large numbers of classroom teachers, reading specialists, and learning specialists can interpret and apply it. The common ground on which to build professional training across disciplines is knowl-

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edge of language structure and the principles of language learning. Such knowledge is critical to intervention with children and adults with dyslexia.

DYSLEXIA IS A DISORDER OF LANGUAGE

The community of reading researchers has reached consensus that most reading and spelling disabilities originate with a specific impairment of language processing, not with general visual perceptual deficits, inability to construct meaning from context, or other more general problems with attention or memory (Adams, 1990; Goswami & Bryant, 1990; Gough, Ehri, & Treiman, 1992; Stanovich & Siegel, 1994; Vellutino, Scanlon, & Tanzman, 1994). Dyslexic students, those who constitute the large majority of those identified as having learning disabilities (Lyon, 1995), are unable to process efficiently and accurately the phonological building blocks of language and the units of print that represent them (Rack, Snowling, & Olson, 1992). Although many of those with reading disabilities demonstrate varying degrees of deficit in semantic and syntactic processing (Gillon & Dodd, 1995; Scarborough, 1990), most people with reading disability demonstrate a core deficit in phonological processing (Bryant & Bradley, 1983; DeFries, Olson, Pennington, & Smith, 1991; Ehri, 1993; Felton & Wood, 1989; Goswami & Bryant, 1990; Liberman & Shankweiler, 1985; Shaywitz, Fletcher, & Shaywitz, 1995; Stanovich & Siegel, 1994; Wagner & Torgesen, 1987; Vellutino et al., 1994).

Although phonological processing encompasses a number of linguistic skills (Catts, this issue), the most researched characteristic is a lack of *phonemic awareness*; that is, lack of explicit awareness of the phoneme constituents of words. Phonemic awareness is measured by performance on a variety of tasks, including phoneme counting (e.g., "How many sounds are in *box*?"), phoneme identification (e.g., "What is the last sound in *cab*?"), phoneme matching (e.g., identifying words that end with the same sound), phoneme reversal (e.g., say *funny* backwards), and phoneme deletion (e.g., "Say *smack* without the /m/".) Although learning to read enhances phonemic awareness, this linguistic skill is distinct from phonic knowledge and reading ability. Importantly, it can be measured and taught without reference to written language symbols.

Many beginning readers and most children with dyslexia or specific reading disability have significant difficulty on such tasks (Adams, 1990). In addition, children with specific spelling disability, possibly a milder form of dyslexia, also show deficits on tests of phoneme awareness and measures of phonetic spelling accuracy (Goswami, 1992; Lindamood, 1994; Moats, 1995; Tangel & Blachman, 1994). Insufficient phonological processing ability results in an incomplete and degraded phonological template on which to link associations to an alphabetic writing system. To be a skilled reader, one needs to appreciate that words are made up of individual speech sounds that are more or less represented by letters. Explicit awareness of speech sounds allows the accurate and complete match of symbols to sounds during the encoding of printed words.

A second area of limited structural awareness for the beginning or poor reader/speller is appreciation of the *morphemic structure*

of words (Henry, 1993; Moats & Smith, 1992; Templeton, 1992). These units of sound and meaning, of course, may be whole words with one or more syllables (e.g., *foot, finger*) or may be parts of words (e.g., *ac+com+mod+ate, un+teach+able, medic+al*). Awareness of the morphemes in words facilitates both reading and spelling, and not only for the advanced reader. For example, beginning writers and poor spellers often spell inflections, especially plurals and past tense forms, as they sound (e.g., *dogz, wakt*), before they have grasped the plural concept represented by the consistent spelling *s* or the past tense concept represented by the consistent spelling *ed*. Further, to progress to more advanced stages of reading and spelling, the learner must become aware that the spelling of meaningful word parts often stays constant even when pronunciation changes from one word form to another, as in *credible* and *credulous, compete* and *competition, resign* and *resignation, define* and *definition*.

EFFECTIVE INSTRUCTION TEACHES THE STRUCTURE OF LANGUAGE

Theoretical, experimental, and clinical evidence points to the necessity of helping unskilled readers and spellers acquire explicit knowledge of language structure, beginning with phonemic awareness, so that alphabetic print can be deciphered. If children are lacking in phonological skills, they can be taught directly as a precursor to and along with instruction in letter-sound relationships (Ball & Blachman, 1991; Bryant & Bradley, 1983; Yopp, 1992). Kindergarten, early elementary, and remedial classes need to incorporate direct instruction in phonological skills in order to give children the linguistic foundation to become skilled readers and spellers (Brady, Fowler, Stone, & Winbury, 1994), and students with severe deficits benefit from explicit, intense instruction in phonology no matter what their age (Alexander, Andersen, Heilman, Voeller, & Torgesen, 1991; Truch, 1994).

A related key finding in reading research is the importance of code-emphasis instruction for students who do not automatically learn to read and spell. Although a full discussion of the methods debate in reading education is beyond the scope of this article, two points need to be made: (1) inclusion of code-based instruction does not preclude well-designed instruction in comprehension, and (2) code-based instruction is not necessarily the "phonics" of old that was largely workbook oriented. When it is skillfully implemented by a knowledgeable teacher, systematic code instruction is most effective for beginning and for problem readers (e.g., see Adams & Bruck, 1993; Chall, 1989; Liberman & Liberman, 1990; Mather, 1992; and Williams, 1987, for thoughtful, comprehensive reviews of the evidence). "Skillful implementation" assumes the integration of decoding skills into meaningful contexts, with eventual emphasis on higher-level reasoning. Effective instruction for beginning and for problem readers initially emphasizes phonemes, onsets and rimes, and syllables and how they are represented in the writing system (i.e., spelling-sound rules, syllable patterns). Onsets and rimes are subsyllabic units intermediate between phonemes and syllables. The onset of a syllable is the initial consonant or consonant cluster, and the rime is the vowel plus any consonants that follow (e.g., *dr + ink*). See Treiman (1991) for the role of

these units in reading and spelling acquisition. As students are ready, effective instruction teaches the meaningful units (morphemes) and their spelling patterns. These word-level skills in turn become part of a broader focus on language structure at the sentence, paragraph, and discourse levels as students progress.

Even more specifically, there is evidence that dyslexic students are confused by some linguistic constructions more than others, and not all aspects of phonology, morphology, semantics, and syntax are equally problematic. For example, spelling error research that examines the confusions of dyslexic students at older ages indicates that plural and past tense inflections, unaccented vowels in multisyllable words, and the spellings of liquids /l/ and /r/ after vowels account for a high number of persistent errors (Bailet, 1990; Moats, 1995). Teachers charged with remediating or treating dyslexia must first be able to recognize such specific linguistic problems before interventions can address such problems directly and systematically (Lindamood, 1994).

Certainly, knowledge of the structure of language and the alphabetic writing system that represents it is not all that teachers must know in order to teach reading well. Nevertheless, given the evidence such as that cited above, it is critical that teachers have this knowledge to address the needs of dyslexic children. The informed teacher will be able to interpret errors, present linguistic concepts accurately and with appropriate examples, and relate spoken to written language. Unambiguous presentation of information for the poor reader in turn requires the teacher to be familiar with phonology, phoneme-grapheme correspondences, the organization of the spelling system and other levels of language structure. Are we currently requiring teachers to have such a command of their language and how to teach it? Both indirect and direct evidence regarding teacher training suggests that we are not.

THE CURRENT STATE OF TEACHER PREPARATION

Poorly conceived and inadequate requirements

The insufficiency of teacher education in the area of reading and learning disabilities has been discussed elsewhere in general terms. Nolen, McCutchen, and Berninger (1990), for example, concluded after surveying general teacher preparation in reading and writing instruction that program requirements and state certification standards must be upgraded nationwide. Teachers could not, in their estimation, be prepared to meet the diverse needs of students who are at risk for reading/writing failure on the basis of current, minimal requirements in literacy education, which range from no course work in reading to an average of three to six credit hours. In some states, special educators are not even required to take courses in reading, and in most, no courses in language study are required for any discipline outside speech and language pathology, where a minimum of 40 to 80 course hours in language acquisition and 80 more course hours in language disabilities plus practicum are necessary.

A recent survey of several hundred learning specialists in one midwestern state suggests the gaps that may exist between the content knowledge held by learning specialists and the language knowledge needed for teaching reading and writing (Kavale & Reese, 1991). Although 73% acknowledged

that reading was the basic problem in most students categorized as learning disabled (LD), only 22% attributed the core deficit to linguistic processing. Endorsements of vague terms for the underlying nature of reading/learning disability included problems with "information processing," "memory," "attention," and "faulty learning strategies." Further, teachers surveyed believed we should teach to strengths, not deficits, and that teachers should enhance learning strategies, but a specific orientation toward language-based remediation for children with language-based deficits was not endorsed.

As one might expect, the beliefs and practices of professors and other experts seem to reflect teachers' beliefs. Reynolds, Wang, and Walberg (1992) surveyed a broad field of over 100 "experts" in learning disabilities, including university faculty, to determine by consensus the requisite knowledge and skills that should distinguish teachers of children with learning handicaps. The most important aspects of remedial teaching valued by the experts consulted included such procedural basics as time on task, time spent in direct instruction on basic academic skills, provision of direct feedback, appropriate error correction, monitoring of task difficulty, and individualization. Although these principles of instruction are certainly important and constitute some of the "good teaching" skills necessary for success, mastery of structural language elements (phonemes, syllables, morphemes), the way they are represented in print, and how children learn them were not designated as critical for teacher competence. It is thus easy to see why teachers may obtain certification without acquiring knowledge of the language content and processes critical to reading and spelling acquisition.

Diffuse, nonspecific expectations for competency

Encouraging this lack of content specificity are the noncategorical certification practices of more than half the states in the United States. Teachers take three-hour courses such as "Teaching Students with Learning Problems" rather than specific and more extensive courses on the remediation of reading disability (Cranston-Gringas & Mauser, 1992). Admittedly, categorical training programs giving certificates in learning disabilities and other handicaps have not been shown to benefit children with handicapping conditions more than noncategorical preparation (Marston, 1987); however, their content may be no more specific than that of the general certification programs. Certificate programs in learning disabilities, and often in reading, usually do not require teachers to be versed in language structure or the way print corresponds to speech. At present, motivated teachers are often left to obtain specific skills in teaching phonetics, phonics, word structure, and other language skills on their own by seeking out workshops or specialized instructional manuals.

Professional organizations such as the International Reading Association (International Reading Association, 1978) and the Division for Learning Disabilities of the Council for Exceptional Children have issued competency lists for teachers of children with reading/spelling difficulty to guide professional preparation, but these seem to contribute to the diffusion of teacher education. These lists usually include, among many other skills, the expectation that teachers have an overview of language development and language disorders, but not its specific relationships to reading.

spelling, and writing. Typically there is no designated level of competence in knowledge of oral and written language itself. Further, the lists of competencies are so extensive as to discourage intensive focus and study in depth (Anderson, Heibert, Scott, & Wilkinson, 1985). The level of language knowledge necessary for teaching a person with language processing difficulties, however, exceeds what can be learned from casual or cursory training.

Teacher surveys

Surveys of teachers' perceptions of the strengths and weaknesses of their undergraduate and graduate education programs reveal a disconcerting and somewhat embarrassing array of findings. For example, Lyon, Vaasen, and Toomey (1989) asked 440 teachers (250 regular educators and 190 special educators) in grades one through seven about the effectiveness of the training programs from which they graduated. Teachers responding to the survey represented three New England states, four midwestern states, and three southeastern states. In general, only 20% of regular educators and 10% of special educators felt they had had adequate content preparation in reading and reading instruction. In addition, only 2% of regular educators and 6% of special educators reported that they were provided teaching experiences with diverse groups of learners during their training. Regardless of the type of teaching experience provided during student teaching, only 16% of the regular educators and 20% of the special educators reported that they received systematic and frequent feedback regarding their instructional practices.

Two additional findings provide some further indication of why general and special education teachers feel underprepared to address individual learning differences in reading and content areas. First, an alarming finding was that less than 10% of regular educators and special educators had ever observed their professors of education model and demonstrate different teaching methods with children with different learning needs. Second, less than 5% of teachers surveyed could ever recall that theories presented in undergraduate and graduate education courses were explicitly and directly linked via demonstration and modeling to the development and use of teaching methods for reading and other content areas.

The discovery that teachers are routinely presented theories of learning and teaching in an isolated and decontextualized manner, rarely have the opportunity to observe and model master teachers in instructional settings, and rarely receive direct and explicit feedback for their teaching practices violates every known principle of how people learn and generalize complex information. Unfortunately, it is unlikely that these trends in teacher preparation practices will abate given the culture of mediocrity and indifference that exists in many colleges of education.

Direct measures of language knowledge

Another major impediment to teacher effectiveness is inadequate knowledge of the structure of language. Teacher knowledge of phonetics, phonology, morphology, phonics, and the organization of the spelling system of English is surprisingly low even in experienced teachers of literacy (Moats, 1994b). Contrary to expectation, teachers do not naturally develop explicit awareness of spoken language structure and its relationship to writing just because they them-

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selves are literate or because they are teachers of reading. In fact, the acquisition of explicit linguistic awareness useful in teaching challenges many adults even though they themselves had no pronounced difficulty learning to read. A survey given at the outset of a series of teachers' classes has shed some light on the reasons why.

The information about teachers' knowledge of language has been obtained from a survey given to over 100 teachers in seven groups at the first meeting of a course entitled "Reading, Spelling, and Phonology." The survey was designed to assess the knowledge teachers have of speech sounds and syllables, correspondence between sounds and symbols, concepts of language organization, and presence of morphemic units in words. The survey assessed the specificity and depth of teachers' knowledge, in order to reveal misconceptions or unfocused concepts as well as outright absence of information. The course the teachers were entering was designed to teach this material, and by the conclusion of the class, most students had mastered it at a satisfactory level. The test is presented in the box entitled "Informal Survey of Linguistic Knowledge."

The 103 teachers surveyed were a diverse group, educated at a variety of colleges and graduate schools and experienced in classroom teaching. They included—in approximately equal distribution—reading teachers, classroom teachers, special education teachers, speech-language pathologists, classroom teaching assistants, and graduate students. The average length of time in teaching was five years, with a range of zero to 20 years of experience. Subjects reported that they were, or were going to be, responsible for teaching language, writing, or reading to students from kindergarten to adulthood. Because this course was not required for certification but was taken out of interest, these teachers were among the more motivated and informed of professionals, and the results of the survey may therefore be overly optimistic as a reflection of teachers' knowledge in general.

This test revealed insufficiently developed concepts about language and pervasive conceptual weaknesses in the very skills that are needed for direct, systematic, language-focused reading instruction, such as the ability to count phonemes and to identify phonic relationships (see the box entitled "Teacher Survey of Language Knowledge: Items on Which Less Than One Third of 103 Teachers Were Proficient").

Terminology

Descriptive terminology about morphology, such as inflection and derivation was foreign, as was the distinction between a compound and an affixed word form. Teachers were unaware of the difference between phonetics, phonology, and phonics, and although they had heard of phonological awareness, they themselves were typically unsure of the identity or number of component phonemes in words. Many subjects were unsure of what was meant by the term speech sound or phoneme, as they believed that letters were equivalent to speech sounds.

Phonic knowledge

The term *phonics* refers to the predictable correspondences between *phonemes* (speech sounds) and *graphemes* (letters and letter combinations that represent speech sounds) in our written language. It does not refer to a particular teaching method. Knowledge of

Informal Survey of Linguistic Knowledge

(Answers are shown in italics.)

1. From the list below, find an example of each of the following:

	Answers
inflected verb _____	*impeached*
compound noun _____	*scarecrow*
bound root _____	*phonograph*
derivational suffix _____	*nameless*

scarecrow nameless terrible phonograph
impeached tables weakly

2. For each word on the left, determine the number of syllables and the number of morphemes:

	Syllables	Morphemes
salamander	*4*	*1*
crocodile	*3*	*1*
attached	*2*	*3*
unbelievable	*5*	*3*
finger	*2*	*1*
pies	*1*	*2*
gardener	*3*	*2*
psychometrics	*4*	*3*

3. How many speech sounds are in the following words?

ox	*3*
boil	*3*
king	*3*
thank	*4*
straight	*5*
shout	*3*
though	*2*
precious	*6*

4. What is the third speech sound in each of the following words?

boyfriend	/f/	prayer	/e/
thank-you	/ŋ/	higher	/r/ or /y/
squabble	/w/	chalk	/k/
educate	/y/ or /yu/	witchcraft	/č/
stood	/ʊ/	badger	/j/

5. Underline the schwa vowels:
   about melody sofa effect difficult definition
6. Underline the consonant blends:
   doubt known first pumpkin squawk scratch
7. Underline the consonant digraphs:
   wholesale psychic doubt wrap daughter think
8. When is a *ck* used in spelling?
   immediately after a short, stressed vowel

continues

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9. What le
   e.
10. List all
    c.
11. List all
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12. What a
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13. When a
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9. What letters signal that a *g* is pronounced /j/?
   e, i, y
10. List all the ways you can think of to spell "long a":
    a, ai, ae, ey, ay, eigh
11. List all the ways you can think of to spell */k/*:
    c, k, ck, ch (Note: qu *and* x *also correspond to /kw/ and /ks/)*
12. What are six common syllable types in English?
    open, closed, r controlled, vowel team, silent e, consonant le
13. When adding a suffix to a word ending with *y*, what is the rule?
    When a root word ends in a y *preceded by a consonant, change* y *to* i *when adding a suffix except* -ing. *If the root word ends in a* y *preceded by a vowel, just add the suffix.*
14. How can you recognize a word of Greek origin?
    presence of y *for* [I] *as in gym,* ch *for [k] as in chorus,* ph *for [f] as in sphere, or a Greek combining form such as psych+ology*
15. Account for double *m* in *comment* or *commitment*:
    The first m *closes the syllable to make it short;* com *is a Latin morpheme as are* ment *and* mit.

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phonics was surprisingly weak. Typically, about 10% to 20% of all subjects tested could consistently identify consonant blends in written words. Although they knew, for example, that *str* was a blend, many also thought the *tch* in *stretch* and the *bt* in *doubt* were blends because the concept of a blend as a representation of a spoken consonant cluster was not differentiated from the occurrence of consonant letters adjacent in spelling. Almost no one in any group could reliably identify a consonant digraph. Less than half of those tested could identify the reduced vowel *schwa* consistently. Only

Teacher Survey of Language Knowledge: Items on Which Less Than One Third of 103 Teachers Were Proficient

Identification of an inflection such as *ed* in *instructed*
Identification of the number of morphemes in common words such as *television*
Identification of consonant blends in printed words
Identification of consonant digraphs in written words
Accurate counting of number of phonemes in *ox, precious,* and *thank*
Knowledge of six basic syllable types
Knowledge of spelling rules such as "change *y* to *i*" or why a letter is doubled
Identification of word forms and spellings originating from Greek
Identification of the third speech sound in words such as *thank, educate, squabble,* and *higher*

30% could explain when *ck* was used in spelling.

Phoneme and morpheme awareness

At the level of morpheme structure, only 27% of subjects were able to identify the component morphemes of transparent words. Many teachers remarked they had never been asked to analyze words at this level. Words with an indirect relationship between spelling and speech sounds were particularly difficult on the phoneme counting and phoneme identification tasks. For example, only 25% of this group knew that the word *ox* contains three speech sounds, although it has only two letters (*x* corresponds to /k/+/s/).

Additional examples of the confusion between speech sounds and symbols were elicited by words whose spellings do not correspond directly to their speech sound constituents. In these items, when teachers were asked about the identity of specific speech sounds, the presence of the nasal /ŋ/, the glides /w/ and /y/, and the fricative /ž/ were typically not recognized when the spellings of words obscured their presence. The spelling of words with silent letters, such as *comb*, *calm*, and *folk*, and spelling of words with doubled letters, such as *accommodate*, also elicit confusion about what sounds really are in the word.

Interpretation of the survey results

As the data suggest, teachers who are literate and experienced generally have an insufficient grasp of spoken and written language structure to teach it explicitly to those with reading/spelling difficulties. Usually teachers are not trained or required to have such knowledge to be certified. Further, the errors of adult literacy educators on tasks such as those reported here indicate that explicit knowledge of speech-to-print relationships is not learned through incidental exposure.

There is also evidence (Lindamood, 1994) that complete and explicit awareness of phonemes in syllables is an underdeveloped metalinguistic skill in many people, even speech-language pathologists, although they have learned to read. About one third of the average adults Lindamood tested had trouble identifying what phonemes had changed when a spoken syllable like *lisp* was changed to *lips*. She also reported that college students who had trouble comparing the speech sounds in words were those who tended to have greater difficulty with spelling. Thus, many average adults may have acquired linguistic awareness sufficient for their own reading development that is not sufficient for teaching language elements directly to children. Development of phonemic awareness in these individuals, who have a diminished "ear" for phonology, might depend on explicit teaching of how speech sounds are produced motorically and cultivation of the ability to compare speech-sound differences in words (see Truch, 1994, for a review of the Lindamood approach).

In addition, many adults, even experienced teachers of reading and writing, conceptualize words in their written rather than their spoken form unless they are taught to pay attention specifically to speech-sound structure. For example, when asked to count speech sounds in known words, they will count letters rather than phonemes (e.g., *yellow* will be viewed as having six speech sounds; *pitch* will be viewed as having an extra /t/ that is not present in *rich*). Explicit phonemic awareness in many adults may

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even be limited because of their knowledge of print. Children who are first learning the alphabetic principle show in their creative spellings the capacity to analyze words phonetically (e.g., they will spell *dragon* as *jragn* and *use* as *yuz*). However, as they become familiar with print and decoding becomes more automatic, children begin to judge what sounds are in words by their letters (Ehri, 1984), a tendency that appears even stronger in adults. Teachers in training usually need formal instruction and many examples to think beyond print while analyzing speech before they can clarify these relationships for students.

RECOMMENDATIONS FOR TEACHER EDUCATION

In conclusion, several changes are recommended for the preparation of teachers responsible for teaching those with language-based learning disorders or dyslexia. It is likely that speech-language pathologists will not typically be responsible for basic reading instruction with language-learning disabled children, although much in their training should be relevant for conducting language therapy with dyslexics and they can contribute vital collaboration and support for teachers of literacy.

Teachers who are to work with dyslexic students must themselves be well versed in language, including the identity and categories of speech sounds, the nature of sound-symbol correspondence, historical changes in English spelling and pronunciation, and the organization of the English spelling system. Their training must also include working knowledge of syntax, semantics, and discourse organization so that instruction can integrate language systems for the four areas of listening, speaking, reading, and writing (Moats, 1994a).

Our competency lists and licensing practices should state clearly that certified teachers of literacy education must themselves demonstrate phonemic awareness and have a working knowledge of the speech-sound system and how our orthography represents spoken English. Moreover, the opportunity to learn this information in depth, through study of basic linguistics and application of the concepts in clinical teaching practice, must be part of every teacher training program in literacy education. Activities that promote such learning include discovering and classifying the speech sounds of the language, performing broad phonetic transcriptions of English words using the International Phonetic Alphabet, and recognizing the linguistic significance of spelling errors. The concept of the morpheme and the principles by which words are constructed from meaningful units can be explored by dividing words, identifying derivational relationships, and studying word origin in English. Intensive study and practice must be devoted to these levels of language, using a linguistics text (e.g., Fromkin & Rodman, 1993) and other material, to ensure that teachers are secure with them.

When language concepts are firmly entrenched, teachers are then ready to study English spelling and the manner in which it represents speech. The specific content of "phonics" should be learned (Hull, 1985) but extended to include understanding of sound-symbol correspondences for both spelling and reading, syllable patterns and syllabication, and the effect of word meaning and word origin on spelling. This knowledge can then be applied to discovering error patterns in the work of students.

designing lesson plans, critiquing published materials, and creating diagnostic instruments. Such a course would be distinct in format and content from traditional introductory language courses taught in departments of communication science or speech-language pathology because the emphasis would be on the relationships between spoken and written language learning. The speech-language pathologist must be trained in specialty areas such as voice, fluency, phonology, language, and hearing impairments, but the literacy educator must be an expert in reading and writing acquisition. Although the professional territory of both disciplines includes the common ground of language structure and language acquisition, and similar content might be included in the introductory training of both, the literacy educator who works with dyslexics needs course work focused on multisensory structured language teaching for written language learning. The language clinician and teacher of reading disabilities should be able to collaborate more effectively if such background concepts are shared.

Course work in understanding lower-level language organization (i.e., phonetics, phonology, morphology, sound-symbol correspondence) and how it is learned by beginning readers requires at least one semester; two would be preferable. It takes time for teachers to acquire knowledge of word structure and to adjust their views about the relationships between speech and print, even if they have the prerequisite linguistic analysis skills to do so. Certainly other courses are needed to address topics in higher-level language processing, including reading comprehension, written expression, and study strategies.

It would be hard to find disagreement in the educational community that the direction and fabric of teacher education programs must change. No doubt, however, bringing about changes in the colleges of education will be difficult. As Graham (1988) and Lyon et al.(1989) have found, many professors of education and special education have limited teaching experience themselves and obviously may be challenged to demonstrate the application of instructional principles with students. Moreover, those who have a thorough knowledge of language structure themselves and who are skilled at teaching it to educators are uncommon.

A number of additional barriers to change must be addressed if teacher preparation is to improve. Currently, within a majority of higher-education settings, there is an inherent tension between the need to conduct and publish research and the need to teach and supervise students, with greater reinforcement provided to professors for research than for teaching. More specifically, the nature of university settings requires professors of education to emulate the principles and practices of faculty members in the arts and sciences. Thus scholarship, usually and unfortunately decontextualized from the act of teaching in classes or in clinical settings, constitutes the major activity of professors, with the business of teaching teachers given over to junior faculty, adjunct faculty, or supervising teachers within local school systems. Without a doubt, scholarship is a critical and valued activity that must be conducted. However, research should bear forcefully and directly on critical content as well as the principles and practices of teaching. We must begin to integrate theory and practice in an explicit manner, and we must

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do this in classrooms and under the conditions that teachers will ultimately face.

Finally, if teacher preparation in the area of language and reading is expected to become more thoughtful and systematic, change in how teaching competencies and certification requirements are developed and implemented is a must. Currently, in many states, the certification offices within state departments of education do not maintain a formal and collaborative relationship with academic departments within colleges of education. Thus, the requirements that a student may be expected to satisfy for his or her college degree may bear little relationship to the requirements necessary for a teaching certificate. Given these realities, it is not surprising that teacher preparation and practice is frequently viewed as a fragmentary and irrelevant enterprise. Our teachers deserve better, as it is they and their students who bear the burden of limitations in teacher preparation practices.

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Toward a Definition of Dyslexia

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Bethesda, Maryland

INTRODUCTION

A precise and *inclusionary* definition of dyslexia is sorely needed for at least three reasons. First, accurate identification of dyslexia requires that the key symptoms and characteristics be specified. Second, treatment of dyslexia, including early intervention and general teaching methods, must be based on an informed understanding of what difficulties impede reading development and reading mastery for children and adults with reading disabilities. Third, an operational definition is essential for research purposes. More specifically, to investigate the causes and consequences of dyslexia, to examine whether there are different types of reading problems, and to explore how dyslexia relates to other disorders, it is crucial to study individuals who meet well-specified selection criteria. A number of recent papers and books address, in detail, this need for an operational and inclusionary definition of dyslexia and are recommended for those who wish to pursue more in-depth reviews of the definitional issues in dyslexia (Fletcher and Morris 1986; Lyon and Moats 1993; Lyon et al. 1993; Morris 1988, 1993; Morris, Lyon, Alexander et al. 1994; Shaywitz, Shaywitz, Liberman et al. 1991).

BACKGROUND: EARLIER DEFINITIONS

Despite the significant role that a definition should play in the scientific and clinical understanding of dyslexia, the field has constructed numerous vague, ambiguous, and nonvalidated descriptions of the disorder. For example, dyslexia or learning disability (LD) in reading often has been cast within the very general framework of *exclusionary* definitions of LD. That is, dyslexia is identified if reading disability exists in the absence of other problems that could lead to the reading difficultly. Consider the definition incorporated into the Education for All Handicapped Children Act (Public Law 94-142) in 1968:

> The term "specific learning disability" means a disorder in one or more basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in an imperfect ability to listen, speak, read, write, spell, or do mathematical calculations. The term includes such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, *DYSLEXIA* (italics added), and developmental aphasia. Such terms do not include children who have learning disabilities which are primarily the result of visual, hearing, or motor handicaps, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage (U.S. Office of Education [USOE] 1977, p. 65083).

This early definition failed to provide objective guidelines and criteria for distinguishing individuals with dyslexia from those with other primary handicaps or generalized learning difficulties (Moats and Lyon 1993). Further, as Rutter (1978) pointed out more than two decades ago, "A negative definition of this kind not only fails to aid conceptual clarity, but also implies that dyslexia cannot be diagnosed in a child in a poor or unconventional background. In short, it suggests that if all the known causes of reading disability can be ruled out, the unknown (in the form of dyslexia) should be invoked." More recent hybrid exclusionary definitions of LD have the same weaknesses (e.g., see the NJCLD definition, Hammill et al. 1981). Concerns about the limitations of exclusionary definitions have prompted many scholars to call for a moratorium on the development of broad definitions. For example, Stanovich (1993) stated the following:

> Scientific investigations of some generically defined entity called "learning disability" simply make little sense given what we already know about heterogeneity across various learning domains. Research investigations must define groups specifically in terms of the domain of deficit (reading disability, arithmetic disability).

The development of inclusionary criteria for two recent definitions of reading disorder demonstrate some progress toward meeting the goal of identifying and defining a specific domain of difficulty. Specifically, both the Diagnostic and Statistical Manual of Mental Disorders-IV (DSM-IV) (American Psychiatric Association 1994) (see table I) and the ICD-10 Classification of Mental and Behavioural Disorders (ICD-10) (World Health Organization 1993) (see table II) definitions focus on reading failure per se. Yet these definitions are also problematic and make clear that domain specificity, though necessary, is not sufficient. For example, the criteria in each definition are vague (e.g., "significantly interferes with academic achievement") and difficult to operationalize. Further, both rely on a discrepancy between IQ and reading achievement, a requirement that recent research suggests is invalid. (This issue will be discussed in a following section).

TABLE I. DSM-IV (1994) DIAGNOSTIC CRITERIA FOR THE DIAGNOSIS OF READING DISORDER

A. Reading Achievement, as measured by individually administered standardized tests of reading accuracy or comprehension, is substantially below that expected given the person's chronological age, measured intelligence, and age-appropriate education.
B. The disturbance in Criterion A significantly interferes with academic achievement or activities of daily living that require reading skills.
C. If a sensory deficit is present, the reading difficulties are in excess of those usually associated with it.

Adapted from the American Psychiatric Association (APA) 1994. *Diagnostic and Statistical Manual of Mental Disorder* (4th ed.). Washington, DC: American Psychiatric Association.

TABLE II. ICD-10 (1993) DIAGNOSTIC CRITERIA FOR THE DIAGNOSIS OF SPECIFIC READING DISORDER

A. Either of the following must be present:

(1) a score on reading accuracy and/or comprehension that is at least 2 standard errors of prediction below the level expected on the basis of the child's chronological age and general intelligence, with both reading skills and IQ assessed on an individually administered test standardized for the child's culture and educational system;

(2) a history of serious reading difficulties, or test scores that met criterion A(1) at an earlier age, plus a score on a spelling test that is at least 2 standard errors of prediction below the level expected on the basis of the child's chronological age and IQ.

B. The disturbance described in Criterion A significantly interferes with academic achievement or with activities of daily living that require reading skills.

C. The disorder is not the direct result of a defect in visual or hearing acuity, or of a neurological disorder.

D. School experiences are within the average expectable range (i.e., there have been no extreme inadequacies in educational experiences).

E. Most commonly used exclusion Clause. IQ is below 70 on an individually administered standardized test.

Adapted from the ICD-10 Classification of Mental and Behavioural Disorders 1993. *Diagnostic Criteria for Research*. Geneva: World Health Organization

The negative consequences of inadequate definitions are serious. On the applied side, the basis for assigning support services for children with reading problems usually are not clear or are not justified by research findings, leading to numerous inequities in who does and who does not receive special education. Similarly, the typically vague descriptions of the nature of the reading difficulty given in current definitions

fail to provide guidance about which component(s) of skilled reading are impaired and require remedial attention. Unfortunately, the lack of emphasis on the relevance of particular language or reading skills necessary for reading mastery, in turn, contributes to inadequate training for most teachers and other professionals concerned with children's reading performance (e.g., classroom teachers, special education personnel, school psychologists, etc.) (see Moats 1994a; Moats and Lyon in press).

On the research side, at least two related problems stemming from the lack of an appropriate definition have occurred. First, the lack of substance in existing definitions (i.e., the reliance on exclusionary criteria) has meant that research on the cognitive processes involved in reading disability has proceeded independently, without benefit of clear selection criteria for those being studied. Second, the majority of research investigations seeking to elucidate the characteristics of dyslexia and other types of LD and conducted with poorly defined samples have yielded findings that are difficult to interpret, replicate, and generalize (Lyon 1987, in press; Moats and Lyon 1993; Stanovich 1993).

A NEW RESEARCH-BASED DEFINITION

Clearly then, there is a critical need to have a valid and operational definition of dyslexia. In attempting to delineate the important criteria for such a definition, a number of guidelines are proposed:

1. The definition must be theory driven. That is, the components of the definition should be based on a theoretical framework (see Fletcher and Morris 1986, Morris and Fletcher 1988; Stanovich 1993) that is informative vis-a-vis the skills critical for becoming a skilled reader and that identifies candidate sources of difficulty for poor readers (e.g., Adams 1990; Bradley and Bryant 1983; Chall 1967; Colheart 1981; Ehri 1985; Gough and Tunmer 1986; Jorm and Share 1983; LaBerge and Samuels 1974; Liberman and Shankweiler 1979, 1985; Perfetti 1985; Rayner and Pollatsek 1989; Rummelhart and McClelland 1982; Samuels and Kamil 1984; Shankweiler and Crane 1986; Snowling 1990; Stanovich 1980, 1990, 1992; Vellutino, Scanlon, and Tanzman 1994; Venezky 1970; Wagner and Torgessen 1987).

2. This theory or combination of theories and the resulting definition should be supported by a substantial body of convergent research *and* clinical information (see Adams 1990).
3. The evidence for this theory should be based on studies of well-described samples of subjects. Within this context, it is important to avoid confounding causes of reading disability common in referred samples (For discussion see Fletcher, Francis, Rourke, et al. 1993; Lyon 1987; Morris 1993; Shaywitz, Fletcher, and Shaywitz 1995; Vellutino 1979).
4. The definition must be based on constructs that are relevant to the theory, that are internally valid, and that can be measured objectively. Specifically, inclusionary statements about the characteristics of dyslexia provided in the definition must be measured directly and consistently by those doing the measuring (Fletcher and Morris 1986; Morris 1993).
5. The definition must be externally valid and useful. For instance, the definition should provide clear indications of how to identify whether a person is dyslexic (Fletcher and Morris 1986; Fletcher et al. 1994; Stanovich and Siegel 1994), what to assess as predictors of later reading achievement in young children (Adams 1990; Blachman 1991; Bradley and Bryant 1983), and what to address in instruction or remediation (Lyon 1985; Lyon and Flynn 1991; Lyon and Moats 1988; Lyon, Moats, and Flynn 1989; Morris 1993).

In an effort to respond to the need for an improved definition for research purposes, a working definition was constructed by The Orton Dyslexia Society Research Committee in collaboration with leaders from the National Center for Learning Disabilities, with scientists from the National Institute of Child Health and Human Development, and with scientists and clinicians from universities in the United States and Canada. The characterization of the proposed definition as a *working* definition reflects the recognition that the definition may need to be, and probably will be, altered in light of continuing advances in research and clinical knowledge. The proposed working definition presented in this paper is meant to serve as an example of a research-based definition that will hopefully generate productive discussion among clinicians, researchers, teachers, and parents about how we study and communicate about dyslexia.

THE WORKING DEFINITION

"Dyslexia is one of several distinct learning disabilities. It is a specific language-based disorder of constitutional origin characterized by difficulties in single word decoding, usually reflecting insufficient phonological processing. These difficulties in single word decoding are often unexpected in relation to age and other cognitive and academic abilities; they are not the result of generalized developmental disability or sensory impairment. Dyslexia is manifest by variable difficulty with different forms of language, often including, in addition to problems with reading, a conspicuous problem with acquiring proficiency in writing and spelling" (The Orton Dyslexia Society Research Committee April, 1994).

RATIONALE FOR THE INCLUSION OF DEFINITIONAL STATEMENTS

This proposed working definition of dyslexia is composed of several distinct inclusionary statements that were adopted on the basis of their clinical importance, their conceptual and empirical support in the clinical and research literature, and their ability to be operationalized via objective study. Each of the statements is discussed in turn.

DEFINITIONAL CONTEXT

"Dyslexia is one of several distinct learning disabilities."

This opening statement is designed to indicate that dyslexia is one of several learning disabilities that affect children and adults and is *not synonymous* with the general term *learning disabilities*. This is because the LD category encompasses a wide range of disorders in listening, speaking, reading, writing, and mathematics as indicated in the USOE (1977) definition presented earlier. In addition, this statement incorporates the thinking of several leading scholars (Shepard 1988; Stanovich 1993; Torgesen 1988) that the field should discontinue the use of the broad term *learning disabilities* when discussing reading disabilities and should instead discuss *specific* disabilities defined in terms of coherent and operational domains. While keeping in mind the distinctiveness of dyslexia within the general category of LD, it is important to note that reading disabilities affect at least 80% of the LD population and thus constitute the most prevalent type of LD (Lerner 1989; Lyon 1995; Lyon in

dyslexia evidence co-occurring or comorbid deficits in other cognitive and academic areas such as attention (Shankweiler, Crain, Katz, et al. 1995; Shaywitz et al. 1994), mathematics (Fletcher and Loveland 1986), and/or spelling and written expression (Lindamood 1994; Moats 1994b). These observations of comorbidity do not detract from the specificity of the proposed working definition of dyslexia since the cognitive characteristics of deficits in attention and mathematics are quite different from the cognitive characteristics associated with deficits in basic reading skills (for further discussion see Shankweiler et al. 1995, and Wood et al. 1991). Thus, while disorders of attention as well as mathematics deficits frequently co-occur with reading problems, their inclusion in the definition of dyslexia would not be empirically sound and would limit its focus and its application to research and clinical practice.

BASIC DEFINITION

"It is a specific language-based disorder of constitutional origin characterized by difficulties in single word decoding, usually reflecting insufficient phonological processing abilities."

This statement contains several important conceptual observations that have strong empirical support. An examination of these observations follows.

Dyslexia is a specific language-based disorder ... usually reflecting insufficient phonological processing abilities. This observation reflects research evidence that strongly indicates dyslexia represents a disorder of language, and more specifically an impairment in phonological processing ability (Adams 1990; Adams and Bruck 1995; Brady and Shankweiler 1991; Gough and Tunmer 1986; Gough, Ehri, and Treiman 1992; Goswami and Bryant 1990; Liberman 1989, Liberman, Shankweiler, and Liberman 1989; Perfetti 1985; Share and Stanovich 1995). At this point, a definition of terms might be helpful.

A *phoneme* is the smallest unit of discernable sound and our apprehension of these segments within running speech (syllables and words) is made possible by our ability to process phonological information. The term *phonological processing* has been conceptualized as encompassing at least three different components or skills: phonological awareness; phonological recoding in lexical access; and phonetic recoding in working memory (for comprehensive reviews, see Adams 1990; Torgesen in press; Wagner in press; Wagner and Torgesen 1987). The development of phonological awareness can be assessed by

asking the child or adult to rhyme or perform phoneme deletion tasks (e.g., say cat without the /t/ sound). The ability to access phonological information rapidly from a lexical store is assessed typically by tasks requiring rapid retrieval and naming of objects, letters, and colors. Phonetic recoding in working memory is usually assessed by observing performance on digit span, word span, and sentence repetition tasks. Of these three major phonological processing skills, it is phonological awareness that appears to be the most deficient linguistic skill in disabled readers. More specifically, there is a wealth of evidence that deficits in phonological awareness not only co-occur with deficits in basic reading skills (Pratt and Brady 1988; Vellutino and Scanlon 1987), but that the relationship is, in fact, a causal one, with deficits in phonological awareness impeding the acquisition of reading skills (Blachman 1991; Catts 1986; Gough and Tunmer 1986; Kahmi, Catts, and Mauer 1990; Liberman and Shankweiler 1979; Lundborg, Oloffson, and Wall 1980; Stanovich 1993; Torgesen in press; Wagner in press; Wagner and Torgesen 1987). Indeed, the nature of the English orthography and its alphabetic characteristics relies on this linguistic ability that allows the reader to segment words into their constituent phonemes. The beginning reader must be conscious of the sound segments in syllables and words and must be able to manipulate them on demand. Such awareness is critical if one wishes to rhyme words, speak in "pig-latin," break words into syllables and syllables into sounds, and most importantly, to read in an automatic and fluent fashion. Underdeveloped awareness of the speech-sound constituents of words and the consequent inability to associate them with symbols leads to slow and inaccurate decoding and word recognition (Adams and Bruck 1995; Beck and Juel 1995; Liberman and Shankweiler 1979). For current reviews of the prominent role that phonological awareness plays in reading acquisition, the reader is referred to Adams (1990), Brady and Shankweiler (1991), Olson et al. (1994), and Vellutino et al. (1994).

It should be made clear that the role of phonological processing in general, and phonological awareness in particular, in this working definition of dyslexia *does not* preclude the possibility that future research will reveal additional candidate processes, and deficits, if they exist, in the areas of temporal processing, semantic knowledge, grammatical and derivational morphology, and syntactic usage. As future research findings emerge the definition described here will be revised to reflect the state of the science. In fact, some evidence is now accruing

that indicates that other skills, not strictly phonological, may interact with or contribute to the development of phonological awareness, as well as to the reading process. For example, Tallal and her colleagues (Tallal 1980; 1988; Tallal and Piercy 1973) have suggested that the same verbal and nonverbal temporal processing deficits that appear to impede linguistic development in language impaired children may also be related to the reading deficits observed in dyslexics. However, the reader is referred to Studdert-Kennedy and Mody (in press) and Mody, Studdert-Kennedy, and Brady (submitted) for an explanation of some of the difficulties with this research. It should also be noted that even if Tallal's thesis were supported, the idea that general temporal processing difficulties contribute to phonological deficits and to reading deficits need not detract from the claim that the phonological deficits themselves are the proximal cause of reading disability.

In other recent work, there is an indication that phonological deficits may have consequences leading to both morphological deficits (Fowler and Liberman 1995) and syntactic difficulties (Fowler 1988; Shankweiler and Crain 1986), and that interactions among these linguistic deficits may compromise reading development in different ways at different stages of development. Yet another potential challenge to a strictly phonological account of reading disability derives from Scarborough's (1990) important study, which showed that children who manifest reading deficits by the second grade can be distinguished from their normal reading age-mates at 30 months of age on a variety of language production tasks that assessed, among other abilities, sentence length and grammatical complexity. Scarborough's findings suggest that dyslexia may be related to a broader language-based deficit that exceeds the boundaries of a phonological core definition.

While deficits in temporal processing and deficiencies in the semantic, syntactic, and morphological domains of language may ultimately be found to exert some independent influence on the developmental reading process, the current evidence regarding these candidates remains suggestive. More to the point, the precise role that these linguistic deficits play in dyslexia, outside of their association with phonology, is unknown. For operational purposes, therefore, they are not included as causal deficits in the working definition. It should also be noted that research suggests that a subgroup of dyslexics may have difficulties accessing the lexicon on a visual/orthographic basis (Lovegrove, Martin, and Slaghuis 1986; Martin

and Lovegrove 1988). These data remain controversial (see Hulme 1988; Vellutino et al. 1994). As such, the working definition emphasizes that deficits in phonological processing, rather than deficits in visual orthographic processing, constitute the core or central deficit in most cases of dyslexia (Shaywitz et al. 1994; Stanovich and Siegel 1994). In summary, the proposed working definition is primarily constructed on the basis of replicated empirical findings. Definitional statements regarding the role of deficiencies in temporal processing, semantic processing, syntactic processing, morphology, and visual orthographic processing in dyslexia will be incorporated into the definition, if they emerge from studies characterized by methodological rigor.

Dyslexia is ... of constitutional origin. This statement is included in the definition because substantial evidence suggests that dyslexia aggregates in families, is heritable, and probably reflects autosomal dominant transmission (for review see Pennington 1995). In addition, recent studies utilizing genetic linkage analyses suggest that there appear to be effects of major genetic loci on the transmission of phonological deficits and subsequent reading problems (Cardon et al. 1994; Pennington 1995).

The specific mechanisms by which genetic factors operate to predispose someone to dyslexia are not yet clear. As Pennington (1995) suggests, it is possible that genetic alterations in dyslexia alter or constrict the range of neural development, as well as possibly produce "hardwired" aberrations in the tissue substrate (for examples of the neuroanatomical correlates of dyslexia see Galaburda 1988, 1991; Galaburda and Kemper 1979; Hynd, Semrud-Clikeman, and Lyytinen 1991; Rumsey, Dorwat, Vermess, et al. 1986). It has been hypothesized that such changes in dynamic neural development can compromise emerging neural networks, typically within the left cerebral hemisphere, that are involved in accessing and interpreting linguistic information. For instance, previous and ongoing work has indicated that poor performance on tasks demanding phonological awareness is associated with atypical cortical activation in the left temporal region as indicated in studies of regional cerebral blood flow (see Wood 1990; Wood et al. 1991). More recent functional neuroimaging work conducted by Shaywitz and colleagues at Yale (Shaywitz, Shaywitz, Pugh et al. 1995; Shaywitz, Shaywitz, Pugh et al., in press) has demonstrated that specific regions of the brain are activated during the performance of phonological tasks related to reading and that dyslexics show different activation patterns than normals

(Shaywitz in preparation). While the current neuroimaging research should be interpreted with caution at this time, tremendous advances in neuroimaging technology are now being applied specifically to the study of dyslexia in a number of NICHD funded Centers and projects (see Lyon 1995; Lyon and Rumsey in press). As mentioned, preliminary data clearly indicate that phonologically based reading deficits are correlated with differences in local brain function.

Due to the tentative nature of the findings derived from the genetic and neurobiological studies of dyslexia, a note of caution is extended to the researcher and the clinician. Until the next generation of studies addressing the constitutionality of dyslexia are published, the inclusion of this statement within this definition reflects a working hypothesis. As such, one should not be convinced as yet that all cases of dyslexia have a biological basis. However, while awaiting these findings, one can be certain that dyslexia casts its formidable shadow across the life span. Among others, Scarborough (1990) and Shaywitz et al. (1995) report that the linguistic precursors of dyslexia can be identified before entering school and Bell and Perfetti (1994), Bruck (1990, 1992), and Pennington et al. (1990) find that the disorder continues to manifest itself throughout adulthood.

Dyslexia is ... characterized by difficulties in single word decoding. Adams (1990), Adams and Bruch (1995), and Beck and Juel (1995) make the essential point that while reading is a meaning-driven activity, the key to meaning for proficient readers starts with the immediate and accurate recognition of a single written word. Their point is underscored by a wealth of research indicating that the major academic deficits of children with dyslexia are difficulties in decoding and reading single words in an accurate and fluent fashion (Beck and Juel 1995; Olson et al. 1994; Stanovich 1986, 1993). Therefore, this statement occupies a central position in the definition. While this statement may appear at odds with the argument that reading comprehension is the most salient ability in reading development (Goodman 1986; Smith 1971), one should note that comprehension depends on the ability to decode and recognize single words rapidly and accurately (Stanovich 1993). Stanovich (1994) places the substantial importance of word recognition vis-a-vis reading comprehension within the following context:

> Reading for meaning [comprehension] is greatly hindered when children are having too much trouble with word recognition. When word recognition processes demand too much cognitive capacity, fewer cognitive resources are left to allocate to higher-level process of text integration and comprehension.

Although it is undeniable that comprehension is the very purpose of reading, the paramount importance given to single word decoding is based on a significant number of converging studies that find that rapid and accurate word recognition is a prerequisite to understanding what is read (for reviews see Olson et al. 1994; Shankweiler and Liberman 1989; Stanovich 1990; Stanovich and Siegel 1994; Vellutino et al. 1994).

UNEXPECTED UNDERACHIEVEMENT

"These difficulties in single word decoding are often unexpected in relation to age and other cognitive abilities;"

Unexplained difficulty in acquiring reading skills is basic to almost all definitions of dyslexia (Orton 1937; Shaywitz et al. 1995). By the use of the word *unexplained;* it is meant that the observed reading deficits are "unexpected" or can not be predicted by the child's age, other academic and cognitive abilities, exposure to instruction, or sociocultural opportunities. It is important to note that while the current working definition preserves the concept of unexpected underachievement, it *DOES NOT* embrace the idea that basic deficits in decoding and word recognition must be significantly lower than IQ as specified in typical discrepancy formulae. Rather, the data suggest that "unexpectedness" should be assessed via comparisons of reading age with chronological age and/or by comparing reading ability to academic performance in other domains (i.e., listening comprehension, verbal expression, mathematics, written expression) (Stanovich 1993).

The issue of IQ-reading discrepancy. There are two major reasons that an IQ-reading achievement discrepancy is seen as an inappropriate and invalid marker and why it is not employed in this working definition of dyslexia. First, at present, it is extremely difficult to define and operationalize the concept of an IQ-reading achievement discrepancy from either a conceptual or a statistical perspective (Aaron 1989; Lyon 1988; Share, McGee, and Silva 1989; Zigmond 1993). Second, and more importantly, reading disabled children with high IQ scores (discrepant poor readers) do not differ from reading disabled children with lower intellectual aptitudes (nondiscrepant poor readers) on measures assessing decoding and word recognition skills (Fletcher 1992; Fletcher et al. 1994;

Francis et al. 1994; Olson et al. 1989; Siegel 1989; Stanovich and Siegel 1994), phonological skills (Fletcher et al. 1994; Shankweiler et al. 1995; Stanovich and Siegel 1994), genetic characteristics (Pennington, 1995; Pennington et al. 1992) or neurological characteristics (Lyon in press; Stanovich and Siegel 1994).

More specifically, a series of studies by Shaywitz and his colleagues (Fletcher et al. 1994; Fletcher et al. 1992; Shaywitz et al. 1992) have not supported the use of discrepancy based definitions for dyslexia. For example, Shaywitz et al. (1992) reported the results of a longitudinal study that followed a cohort of good and poor readers from kindergarten through the fifth grade. The sample was large enough to study children who were diagnosed as dyslexic according to regression-based discrepancy criteria, children matched for level of reading deficit without a discrepancy with IQ, and children with age appropriate reading skills. The Shaywitz group found minimal differences between the discrepant and non-discrepant ("garden variety") poor reader groups on measures of linguistic function, manual dexterity, visual perception, and teacher's assessment of learning and behavior at any time within the developmental trajectory. Similarly, in a recent study, Fletcher et al. (1994) compared dyslexic children with IQ-reading achievement discrepancies with a group of non-discrepant poor readers on 9 cognitive variables related to reading proficiency. The groups did not differ with respect to performance on visual, vocabulary, memory, or phonological measures. In addition, measures of phonological awareness were the most robust indicators of differences between children with impaired reading and children without impaired reading, *regardless* of how reading disability was defined. Finally, Stanovich and Siegel (1994) reported compelling data that showed no differences between discrepant and non-discrepant poor readers on measures of word recognition skills, phonology, and orthography. In summarizing their findings, the authors stated:

> ... neither the phenotypic nor genotypic indicators of poor reading are correlated in any reliable way with IQ discrepancy. If there is a special group of children with reading disabilities who are behaviorally, genetically, or neurologically different, it is becoming increasingly unlikely that they can be easily identified by using IQ discrepancy as a proxy for the genetic and neurological differences themselves .... (p. 48)

Thus, converging data from several studies show that an IQ-achievement discrepancy does not differentiate the reading

impairment of a dyslexic reader with average to above average intelligence from a dyslexic reader whose intelligence is commensurate with his low reading ability. These findings have significant clinical and conceptual impact on the understanding and diagnosis of dyslexia. From a conceptual standpoint, the fact that IQ-reading achievement discrepancies do not differentiate discrepant and non-discrepant poor readers supports recent findings that dyslexia represents the extreme of a normal distribution of reading ability so that there..."is an unbroken continuum from reading ability to disability..." (Shaywitz et al. 1992; Shaywitz and Shaywitz 1994). Thus, conceptually, dyslexia is not a discrete categorical entity that is discontinuous with other cases of reading disability (Shaywitz et al. 1995; Stanovich and Siegel 1994). From a diagnostic standpoint, the findings have significant implications for those individuals who are reading disabled, but who have typically been excluded from a diagnosis of dyslexia because of IQs below 85.

The lack of validity demonstrated for IQ-reading achievement discrepancies does not, however, obviate completely the conceptual notion that the poor reading skills of dyslexics can be characterized as "unexpected." As Stanovich (1991) points out, the critical task will be to identify the most valid predictor of one's potential to read. Thus, it is quite possible that dyslexia may be characterized by poor reading skills against a background of other cognitive and academic strengths, but not expressed as an IQ-achievement discrepancy. It is also important to keep in mind that the studies consulted in the development of the working definition all used decoding and/or word recognition as the measure of reading ability and disability. It remains to be seen whether differences exist between discrepant and non-discrepant poor readers on measures of reading comprehension or response to instruction (Lyon 1989, in press; Moats and Lyon 1993).

EXCLUSIONARY CRITERIA

"[T]hey are not the result of generalized developmental disability or sensory impairment."

To date the majority of definitions for dyslexia have relied heavily on numerous exclusionary criteria (see the USOE [1977] definition and tables 1 and 2). Given the primary role of these exclusion statements in the identification of dyslexic individuals, children have been frequently diagnosed on the basis of what they were not, rather than what they were (Fletcher and Morris 1986, Lyon 1994, in press; Moats and Lyon 1993). It is

now clear, however, that excluding children from the diagnosis of dyslexia because of cultural differences, inadequate instruction, or co-morbid attentional, social, and behavioral deficits has no empirical basis (Stanovich 1993). Moreover, the current research addressing discrepant and non-discrepant disabled readers does not indicate a natural break in the IQ and/or reading distributions that successfully predict the presence or absence of dyslexia; the severity of dyslexia; the developmental course of dyslexia; or the genetic and neurophysiological correlates of dyslexia. The current working definition proposed in this article excludes only those conditions that could serve as *primary* causes of difficulties learning to read (i.e., blindness, deafness, moderate to severe mental retardation).

FUNCTIONAL IMPACT

"Dyslexia is manifest by variable difficulty with different forms of language, often including, in addition to problems reading, a conspicuous problem with acquiring proficiency in writing and spelling."

As pointed out throughout this paper, a number of converging studies have shown that the linguistic abilities causally related to learning to read involve phonology, with deficits in phonological awareness best predicting poor reading behavior at the single word level (Ball and Blachman 1988; Catts 1989; Cunningham 1990; Juel 1988; Kahmi et al. 1990; Snowling 1990; Torgesen 1988; Wagner and Torgesen 1987; Wolf, Bally, and Morris 1986). Similarly, phonological deficits may influence other linguistic skills: reading deficits frequently co-occur with deficiencies in word recognition skills, spelling, and written expression (Bruck 1988; Ehri 1989, Fowler and Liberman 1995; Frith and Frith 1983; Lindamood 1994; Moats 1994). Moreover, deficits in written expression (Bain, Bailet, and Moats 1991; Johnson and Myklebust 1967; Liberman and Shankweiler 1985) typically share some of the same core deficiencies in phonology (Lindamood 1994; Moats 1994). It is important to note that it is common for dyslexic individuals to also experience variable difficulties in many levels of oral language (Johnson 1994; Scarborough 1990). The inclusion in the definition of a statement explicitly highlighting these interrelationships among levels of spoken and written language underscores the critical nature of the phonological deficit at all levels of linguistic functioning as well as the fact that the primary manifestations of childrens' reading and writing problems may change as they grow older (Moats 1994).

SUMMARY

A working operational definition of dyslexia has been presented that evolved from the substantial amount of evidence that indicates that reading disability is most precisely measured at the single word level and causally associated with phonological deficits. In contrast to other definitions of dyslexia, this definition does not specify that an IQ-reading achievement discrepancy be present and does not exclude any conditions or handicaps where a specific phonological deficit could exert a primary causal influence on subsequent reading development. All statements within the definition have an empirical basis and it has been noted that converging data relevant to genetic and neurobiological factors are emerging. The objective nature of the criteria included within the definition should both aid in clinical diagnosis and help researchers.

Very importantly, the criteria specified in this definition are dynamic and subject to modification as new data become available. Certainly the central role of phonological deficits in dyslexia will be further explicated in future studies as will other candidate etiological factors such as orthographic processing, temporal processing, and interrelationships among these and other skills. It should also be made clear that the validity of certain statements within the definition are not yet fully established and require further study. For example, to establish that dyslexia has a known and specific constitutional basis will require more advanced neuroimaging and genetic studies than those presently available. The first step has been taken in that we are now able to isolate and localize phonological processing in the brain (see Shaywitz, Shaywitz, Pugh et al. 1995; Shaywitz, Shaywitz, Pugh et al. in press). In addition, while the available data clearly show that differentiating children according to IQ-reading achievement discrepancies is invalid, it is unclear how, and to what extent, sole use of a low achievement definition provides an adequate classification of dyslexia. For example, does a difference between a child's age and his or her phonological skill or single word reading ability reflect a reliable and valid marker for dyslexia? If so, how large does the difference have to be and does it vary according to age? As an important aside, it should be noted that a great deal needs to be learned about how the brain recovers phonemes from running speech. As Liberman (1992) has eloquently pointed out, the articulatory gesture, rather than the speech sound, might ultimately prove to be the most basic

mechanism that subserves phonological awareness and basic reading skill.

The search for answers to these basic questions should take on paramount importance in our research programs. Within this context, the proposed working definition put forth by The Orton Dyslexia Research Committee provides an objective and dynamic context to insure that children are selected for study according to operational data-based criteria. The operational nature of the statements in the definition should help to foster communication among clinicians and researchers and to stimulate research studies that can be replicated and generalized.

At the same time, the proposed definition and the scientific evidence upon which it is based have clear implications for the development of diagnostic guidelines for dyslexic individuals and for teaching practices. For example, the working definition stresses the fact that phonological deficits can be detected early and that such deficits predict reading difficulties at the single word level. These findings necessitate the development and use of teaching practices that incorporate explicit instruction in phonological awareness and sound-symbol relationships to enhance the speed and accuracy of decoding and single word reading. It is also critical that this instruction be contextualized within a rich meaning-based linguistic framework (Adams 1995; McPike 1995). In short, the data support the development of informed, balanced approaches to the teaching of reading (see Moats 1994a; Moats and Lyon in press). In summary, a valid definition of dyslexia should have value for future research endeavors, for the diagnosis of reading disability, and for the shaping of curricular goals. It is hoped that this working definition of dyslexia takes a step toward meeting these objectives.

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Research in

LEARNING

DISABILITIES

at the

NICHD

CONTRIBUTIONS FROM SCIENTISTS SUPPORTED BY THE
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INTRODUCTION

Learning disabilities (LD) encompass a wide range of disorders in listening, speaking, reading, writing, and mathematics that are frequently accompanied by comorbid deficits in attention and social behavior. Current estimates indicate that children with LD compose between seven to 10 percent of the school-aged population and represent over half of the children who receive special education services in the United States.[1] Despite this frequency of occurrence, LD remains one of the least understood yet most disabling conditions that affect both children and adults. This is unfortunate since learning disabilities are extremely deleterious to the development of children in general, and the negative effects of LD go well beyond school failure. For example, poor peer relationships, decrements in self-concept, poor post-school adjustment, and limited placed occupational opportunities are some of the known outcomes of LD.

A number of influences have contributed to persistent difficulties in diagnosing and treating LD. In fact, until research programs supported by the National Institute of Child Health and Human Development (NICHD) and the Natural Sciences and Engineering Council of Canada to study learning disabilities began to lead to major discoveries during the past decade, the consensus in the biological and behavioral sciences was that the field of LD lacked scientific validity and clinical utility.[2,3] To better understand the difficulties that have plagued the LD field and the NICHD's programmatic response to alleviate them, a brief review of both problems and progress in the field is presented in the following sections. Emphasis is placed on discussing the role of the National Institutes of Health (NIH) in general, and NICHD in particular, in stimulating and supporting systematic, prospective longitudinal research to best understand how to classify, define, and treat LD. As mentioned above, additional reference will also be made to the outstanding work of Stanovich and Siegel in LD and reading disorders supported by the Canadian government.[3] Readers should note that comprehensive sources on these topics have recently been published.[1,4,5]

Impediments to Scientific Developments in Learning Disabilities: An Historical Perspective

Historically, a number of influences have contributed to difficulties in validating scientifically the construct of LD.[1,3] First, the field's limitations as a clinical science can be related to its brief tenure as a recognized category of disability. Specifically, LD as a federally designated condition, has been in existence only since 1968.[6] Thus, there has not been time to collect and consolidate the necessary observations under experimental conditions that could lead to a better understanding of the critical diagnostic markers and treatment interventions that have a known probability of success.

Second, many different theoretical and conceptual views are offered to explain LD and these views clearly reflect the multidisciplinary nature of the field.[2] Learning disabilities are considered the legitimate concern of many disciplines and professions, including education, psychology, neurology, neuropsychology, optometry, psychiatry, and speech and language pathology, to name a few. Each of these professions has focused on different aspects of the child or adult with LD, so that there exist highly divergent ideas, and frequently contentious disagreements about the importance of etiology, diagnostic methods, intervention methods, and professional roles and responsibilities. Unfortunately, from the perspective of developing a valid definition and classification system for LD, such variation in views and beliefs results in differences in the numbers of children identified and their characteristics. In turn, conducting research on samples of children with ostensible LD who vary widely in diagnostic and demographic characteristics provides little opportunity for the replication and generalization of findings – the cornerstones of scientific inquiry.

Third, many diagnostic and treatment decisions about individuals with LD have been based on technically inadequate tests and measures. Recent comprehensive reviews[4] suggest that fewer than one-third of the psychometric tools used in the diagnosis of LD meet criteria for adequate norms, reliability, and validity. As important, the valid assessment of change over time, and change as a function of treatment, is very difficult to accomplish at present because few instruments have the scaling properties to satisfy conditions for the measurement of individual growth curves.[4]

Fourth and by far the most significant and persistent problem impeding progress in the field of LD has been the difficulty in establishing a precise inclusionary definition and a theoretically based classification system that provides (1) a framework for the identification of different types of LD, and (2) a framework for recognizing distinctions and interrelationships (comorbidities) between LD and other learning disorders to include attention deficit disorders, general academic underachievement, mental retardation, and emotional disturbance. The precise characterization of LD has been hindered on the one hand by associating learning disabilities with the concept of aptitude-achievement discrepancy, and on the other hand by conducting "single-shot" studies on "school-identified" or "clinic-referred" samples of children.[1,2,3,4] The assumption that an aptitude (typically assessed using intelligence tests) achievement discrepancy is a clear diagnostic marker for LD or can be considered a pathognomonic sign is at best premature, and at worst invalid.[2,3,7] Such an assumption is based on the premise that individuals who display an IQ-achievement discrepancy are indeed different from individuals who do not with respect to phenotypic variables such as information processing characteristics and response to intervention, and genotypic features such as differ-

ences in the heritability of the disorder or its neurophysiological signature. As will be pointed out later, a major thrust of the NICHD efforts in the study of LD has been to evaluate the efficacy of discrepancy in defining learning disabilities by systematically comparing "discrepant" versus "non-discrepant" low achieving children on both phenotypic and genotypic variables.

The study of individuals identified a priori as LD by school or clinic criteria within the context of single investigations or cross-sectional designs have also significantly hampered efforts to develop a valid definition and classification system for learning disabilities. It has been pointed out many times that schools and clinics lack consistency in the way in which LD is diagnosed. A child can literally be "cured" of an LD condition simply by moving across state boundaries or by changing schools within the same community.[1,2] Such variability in sample characteristics prohibits replication and generalization of findings – a severe impediment to the development of any clinical science. Moreover, "single-shot" investigations that compare children achieving normally with children with LD on one or more dependent variables of interest at one point in time ignores the developmental nature of learning and change over time, and how such change interacts with information processing characteristics, teacher characteristics, different interventions, and classroom climates. As such, limited information is available on the developmental course of LD, and how children may display different characteristics at different points in time.

The foregoing brief review provides the rationale for the development of the NICHD research programs in learning disabilities. Prior to the initiation of the programs, much of our research-based thinking about LD was predicated on information obtained from ambiguously defined school-identified samples of children who were administered technically inadequate tests. Frequently the research problem was further confounded by the tendency to interpret these test data in the context of invalid theoretical and conceptual frameworks. Finally, the majority of studies carried out with individuals with LD were not informed by a longitudinal, developmental perspective. It has been within this context of scientific need that the NICHD has systematically developed a portfolio of individual research initiatives, program projects, and Learning Disability Research Centers (LDRCs) to define and classify LD, and to obtain new knowledge related to etiologies, developmental trajectories, and interventions for learning disabilities. The following sections provide a review and analysis of the major findings of the NICHD-supported research projects with an eye toward identifying additional future research needs and directions.

The Role of the NICHD in the Planning and Conduct of Research in Learning Disabilities

By way of background, the Health Research Extension Act of 1985 (P.L. 99-158) mandated the establishment of an Interagency Committee on Learning Disabilities (ICLD) for the express purpose of addressing the persistent problems in identifying a valid classification system and a definition for LD. More specifically, the ICLD was charged with the task of reviewing and assessing Federal research priorities, activities, and findings regarding LD. The NICHD was designated the lead agency for this congressional initiative. With respect to legislative and administrative action, the ICLD was required to make recommendations to increase the effectiveness of research on LD and to improve the dissemination of findings, and to prioritize research efforts in the causes, diagnosis, treatment, and prevention of learning disabilities. Following a comprehensive review of extant data and information related to the study of LD,[8] the ICLD concluded that:

> "...collaborative, integrated, and coordinated multidisciplinary approaches to research questions, such as could be undertaken on university campuses in large program projects and in specialized research centers of excellence, would be the most appropriate way to increase the effectiveness of this research...A major goal of this research should be the development of a classification system that more clearly defines and diagnoses LD, conduct disorders, and attention deficit disorders, and their interrelationships. Such information is prerequisite to the delineation of homogeneous subgroups and the delineation of more precise and reliable strategies for treatment, remediation, and prevention that will increase the effectiveness of both research and therapy.[8]

Within this context, the NICHD proceeded to develop Requests for Applications (RFA's) for Program Projects in 1985, Learning Disability Research Centers (LDRC's) in 1987,[9] and treatment/intervention research projects in 1993. By way of background, the Program Project research award is an NIH funding mechanism that can support at least three discrete, yet closely related and synergistic projects. The LDRC's are funded via Specialized Research Center Grants that provide support for both the synergistic research projects *and* supporting core service projects. This type of mechanism is used to stimulate research in a given field by encouraging collaborative, interdisciplinary research.

In response to the Program Project RFA, five program Projects were awarded by the NICHD. The recipients were Dr. John DeFries and his research group at the University of Colorado, Dr. Frank Wood and his team at the Bowman Gray School of Medicine, Dr. Herbert Lubs and his colleagues at the University of Miami, Dr. Bennett Shaywitz and his collaborators at Yale University and the University of Houston (led by Dr. Jack Fletcher), and Dr. Albert Galaburda and his group at Beth Israel Hospital and Harvard University. In response to the LDRC RFA, three centers were established; one at Johns Hopkins University under the leadership of Dr. Martha Denckla, another at Yale University (also directed by Shaywitz) and one at University of Colorado (also directed by DeFries). In

response to the treatment/intervention research RFA, one research program was established at Florida State University under the direction of Dr. Joseph Torgesen, and one at The University of Houston lead by Dr. Barbara Foorman. These longitudinal intervention studies are in the beginning phases and data are not yet available.

A brief overview of the major goals and objectives of the NICHD Program Projects and LDRC's is provided in the following sections. Individual Program Projects (Bowman Gray, Miami, Beth Israel/Harvard) will be summarized first followed by a review of the research programs that have been awarded an LDRC (Johns Hopkins) and both a Program Project and an LDRC (Colorado, Yale). This overview will be followed by sections which provide a synthesis of the major discoveries made by the research programs in targeted areas of inquiry (i.e., classification/definition, reading and language related processes, attention, genetics, neurophysiology/neuroimaging, and treatment/intervention). Readers should note that comprehensive reviews of the goals and findings from each of the projects and centers, written by each of the principle investigators and their research teams, can be found in Duane and Gray (1991),[5] Lyon et al.,[1] Fletcher et al.,[7] and Lyon.[4]

The NICHD Research Programs in Learning Disabilities Program Projects

The Bowman Gray Program Project is designed to study childhood reading disability with an eye toward developing a definition and subtyping system for dyslexia.[5] Within this context, research studies have been, and continue to be, conducted to (1) identify an appropriate combination of measures in the first grade that can define dyslexia and predict reading performance throughout the later grades, (2) determine whether Attention Deficit Disorder (ADD) has an independent impact on reading development and disorders, (3) develop the most powerful combination of linguistic (e.g., phonological, naming) tasks that can be used to chart the developmental course of reading and reading disability, (4) identify the efficacy of code-emphasis reading approaches versus context-based reading approaches with well-defined groups of reading disabled children, (5) study regional cerebral blood flow and positron emission tomographic activation signatures that are correlated with specific linguistic and cognitive parameters in a unique sample of adult dyslexics, first seen as children by Mrs. June Orton, and (6) externally validate distinctions between dyslexia and ADD using event-related potential electrophysiology.

The University of Miami Program Project has completed its first five years of investigations to identify inherited subtypes of specific dyslexia via both behavioral genetic studies and genetic linkage analyses, and to further characterize these subtypes by psychophysical, behavioral, and neuroimaging studies. More specifically, Dr. Lubs and his group have attempted to define the chromosomal location of the several genes that produce

autosomal dominantly inherited dyslexia. Project goals were addressed through scientific experiments in three major areas.[4] In the first area, the Miami group designed and conducted linkage studies to delineate the location of chromosomes and chromosome bands of several genes that could be specifically related to a different phenotypic expressions of dyslexia. In the second area of investigation, psychophysical and neuropsychological tasks were administered to dyslexic subjects to delineate information processing and cognitive profiles that could be used to validate genetically different subtypes. In the third area, Magnetic Resonance Imaging and Positron Emission Tomography studies were carried out in an attempt to identify unique neurophysiological signatures for dyslexic subtypes.

The Beth Israel/Harvard Program Project has as a primary goal the development of an understanding of the relationships between subtle abnormalities of brain development and specific childhood learning disabilities to include dyslexia. The ultimate goal of the research is to identify the causes of such neural anomalies, and thus the neurobiological causes of LD and dyslexia.[5] Within this context, Dr. Galaburda and his colleagues have sought to develop an animal model of brain development that provides a window on how cortical abnormalities occur during ontogenesis and how such abnormalities affect behavior. Major efforts have also been deployed to delineate the cytoarchitectonic organization and the chemoarchitectonics of those brain regions implicated in developmental dyslexia. In addition, several investigations are underway to specify immunological variables responsible for anatomical and behavioral anomalies in human and animal brain.

The Johns Hopkins LDRC represents a multidisciplinary research effort designed to understand the neurodevelopmental bases of LD. Dr. Denckla and her associates pursue this complex research task through four major lines of research.[4,9] In one project, the Johns Hopkins group is attempting to discover the causes of nonverbal LD via behavioral, neuropsychological and neuroimaging studies of LD individuals and individuals with neurofibromatosis. A second project is designed to examine the spectrum and severity of social deficits in female children who are heterozygous for the Fragile X genetic anomaly and to investigate the relationship of these deficits to specific cognitive, linguistic, and neuropsychological problems observed in LD individuals without Fragile X. A third line of research is designed to investigate the relationship between Tourette Syndrome and ADD using both genetic and neuropsychological procedures. The fourth project is designed to develop assessment methods to differentiate between hard to remediate dyslexic children versus children who respond to intervention. This project is also designed to identify the most powerful predictors of dyslexia and intervention approaches that have a high probability of success with disabled readers.

The Colorado Program Project and LDRC. The Colorado Program Project has been composed of four interrelated projects designed (1) to assess the genetic etiology of reading disability, and, in particular, the heritability of phonological and orthographic skills, (2) to identify the specific language and perceptual skills that are critical for the development of fluent reading skills, (3) to determine whether reading disability is correlated with deficiencies in the immunological system, and (4) to conduct genetic linkage analyses to localize, if possible, specific genes implicated in the expression of reading disability.[4,5,9]

With the Colorado LDRC, Dr. DeFries and his group extend the research carried out in the Program Project by increasing sample sizes and developing creative behavioral genetic analytic methodologies to assess the genetic and environmental etiologies of defi-

cient component phonological, orthographic, reading skills in reading disability. Within this context, genetic linkage analysis is being employed to search for major genes and quantitative trait loci that influence learning disabilities. In addition, a treatment/intervention project is being conducted with 100 twin pairs of disabled readers in an effort to discover reading subtype/dimension by treatment interactions.

The Yale University Program Project and LDRC. The Yale University Program Project is designed to address major questions related to the definition, etiology, developmental course, and biological/neurophysiological bases for dyslexia.[4,5,9] The Yale studies are unique in that they are being carried out with the largest longitudinal cohort of reading disabled children in North America. As such, Dr. Shaywitz and his associates are continuing to obtain major findings that are not biased by the vagaries of studying school-identified or clinic-referred samples. In Project 1 of the Program Project, the longitudinal cohort is studied to identify (1) whether distinct subtypes of dyslexia exist, (2) whether subtypes are stable over time, (3) whether dyslexia constitutes a developmental lag versus a fixed deficit in reading, neurolinguistic, and cognitive skills, (4) whether deficits in single word reading are attributable to a combination of deficits in phonological and orthographic processes, and (5) whether positive or negative outcomes of dyslexia are associated with sociodemographic factors, the nature and severity of the reading disability, co-morbidity, and self-esteem.

In Project 2, a well defined group of children with early language disorders is studied to assess the development of reading-related language skills (e.g., phonological awareness) and to determine how particular early language impairments relate to the emergence of different types of reading disability. In Project 3, dyslexic, math disabled, and nondisabled boys and girls are followed and studied as they pass through puberty in order to assess the effects of specific endocrinological influences on reading, cognitive, and neurolinguistic skills. Finally in Project 4 of the Program Project, the Yale group is employing state-of-the-art Functional Magnetic Resonance neuroimaging technology to examine brain structures and brain functions in well defined groups of dyslexic children as the children carry out tasks designed to assess reading, phonological awareness, orthographic decision making, and phonological decision making skills.

The Yale University LDRC has been charged with the complex task of developing a comprehensive classification system for the range of common disorders that can influence school performance. A major focus of the Center is the development of a classification system for children with attention and oppositional/conduct disorders with and without learning disabilities. In addition, one large project within the Center is tasked with the continued in-depth epidemiological study of 414 reading disabled children, now entering the ninth grade, who were originally identified during kindergarten. This ongoing investigation continues to provide data relevant to the stability and generalizability of learning disability subtypes over time.

MAJOR FINDINGS AND CONCLUSIONS

A number of independent and replicated discoveries relevant to learning disabilities in general, and dyslexia in particular, have been obtained through the research efforts at each of the NICHD Program Projects and LDRC's, as well as through the Stanovich and Siegel research programs funded by the Canadian government. Selected important discoveries will be highlighted here according to major domains of study, and those programs obtaining the findings will be indicated in parentheses. Due to limitations on the number of references that could be used for this paper, readers are encouraged to peruse the edited sources cited for both an overview of the research, an analysis of other important discoveries, and citations for specific studies.

CLASSIFICATION/DEFINITION

■ The definition and classification of learning disabilities and dyslexia must be accomplished within a longitudinal developmental framework that does not require adherence to a priori assumptions reflected in current definitions. Further a valid definition can best be developed by studies that investigate *representative* groups of children over time and that document how differences among children emerge, change, and influence further development (Bowman Gray,[5] Yale[1,4,5,7]).

■ Current exclusionary definitions of learning disabilities appear to be invalid, particularly in the area of reading disabilities and particularly when discrepancy formulae are used (Yale[7]).

READING AND LANGUAGE RELATED PROCESSES

■ Reading disabilities (dyslexia) affect at least 10 million children, or approximately 1 child in 5 (Yale[9,10]).

■ While schools identify approximately four times as many boys as girls as reading disabled, longitudinal and epidemiological studies show that as many girls are affected as boys (Bowman Gray,[5,9] Colorado,[4,9,11] Miami,[5,9] Yale[2,5,7,12]).

■ Reading disability reflects a persistent deficit rather than a developmental lag in linguistic and reading skills. Longitudinal studies show that of the children who are reading disabled in the third grade, 74 percent remain disabled in the ninth grade (Yale,[1,4,7,10] Stanovich & Siegel[3]).

■ The practice of distinguishing between disabled readers with an IQ-Achievement discrepancy and those without a discrepancy appears invalid.[3,7] More specifically, children with and without a discrepancy do not differ in the information processing subskills (phonological and orthographic coding) that are necessary for the reading of single words.[3] Likewise genetic and neurophysiological studies have not indicated differential etiologies for reading disabled children with and without discrepancies.[1,3,4,7] It remains to be seen whether a discrepancy between achievement and IQ is a worthwhile predictor of choice of, or response to, intervention.

■ Children with reading disability differ from one another and from other readers along a continuous distribution, and do not aggregate together in a distinct "hump" at the tail of the distribution as once thought (Bowman Gray,[5] Colorado,[4,5] Yale,[1,4,7,10] Stanovich & Siegel[3]).

■ The ability to read and comprehend depends upon rapid and automatic recognition and decoding of single words and slow and inaccurate decoding are the best predictors of difficulties in reading comprehension (Bowman Gray,[5] Colorado,[5,11] Johns Hopkins,[4] Yale[1,3,5,7]).

■ The ability to decode single words accurately and fluently is dependent upon the ability to segment words and syllables into abstract constituent sound units (phonemes). Deficits in phonological awareness reflect the core deficit in dyslexia (Bowman Gray,[5] Colorado,[4,5,11] Johns Hopkins,[4] Miami,[5] Yale[4,7]).

■ The best predictor of reading ability/disability from kindergarten and first grade test performance is phoneme segmentation ability (Bowman Gray[5]). However there may be different predictors for different component reading skills. For example, rapid naming ability may predict word identification while tasks assessing phonological awareness best predicts word attack skills (Bowman Gray[5]).

ATTENTION

■ A precise classification of ADD with and without hyperactivity is not yet available. A classification methodology that assesses internal and external validity of dimensional and categorical models must be applied to the issue (Yale[1,4]).

■ ADD and reading disability often co-exist, but the two disorders are distinct and separable (Bowman Gray,[5,9] Yale[4,5,9]).

■ ADD occurs more frequently in males and ADD exacerbates the severity and cognitive morbidity of reading deficits. Since ADD and reading deficits often co-occur, more males are typically identified as reading disabled, spuriously inflating the gender ratio in favor of males (Bowman Gray,[5,9] Miami[9]).

■ The effects of ADD on cognitive functioning are variable with primary deficits in rote verbal learning and memory. ADD appears relatively unrelated to naming and phonemic awareness tasks (Bowman Gray[5,9]).

GENETICS

■ A multiple regression analytic procedure has been developed by DeFries and his colleagues that allows for the analysis of the genetic etiology of individual differences in component language and reading skills. This is a unique and flexible methodology that can be used to assess differential genetic and environmental effects (Colorado[4,5,9,13]).

■ There is strong evidence for genetic etiology of reading disability, with deficits in phonological awareness reflecting the greatest degree of heritability (Colorado[4,5,13]).

■ There appears to be at least one type of reading disability that can be linked to the HLA region of Chromosome 6 reflecting an association with autoimmune disorders (Colorado,[5,9] Miami[9]). Recent evidence obtained from twin and kindred siblings with severe deficits in reading performance show strong evidence for a Quantitative Trait Locus on chromosome 6 (Colorado[13]).

NEUROANATOMY, NEUROPHYSIOLOGY, AND NEUROIMAGING

- Several types of brain pathology, including microdysgenesis (Ectopias), cell loss, and abnormalities of the corpus callosum are present in a number of strains of immune defective mice. There is a similarity between the brain lesions seen in the mouse model and in humans with dyslexia (Beth Israel/Harvard[5,9]).
- At the macroscopic level, atypical neural organization in dyslexic individuals is suggested by absence of the normal left-greater-than-right asymmetry in the posterior temporal planum (Beth Israel/Harvard[5,9]).
- There is converging evidence from anatomical microstructure studies, gross morphology studies, and neuroimaging studies that the phenotypic expression in dyslexia is related to anomalous organization of tissue and processing systems subserved within the posterior left hemisphere (Beth Israel/Harvard,[5,9] Bowman Gray[5,9]).
- Regional Blood Flow studies indicate that the poor reading development in dyslexics is associated with less activation than normal in the left temporal region with atypically increased activation in the region of the angular gyrus (Bowman Gray[5,9]).
- Positron Emission Tomographic studies indicate that dyslexic adults have greater than normal activation in regional metabolic values in the occipital (lingual) and pre-frontal regions of the cortex (Miami[6]).

TREATMENT/INTERVENTION

- Disabled readers do not readily acquire the alphabetic code when learning to read due to deficiencies in the processing of phonological processing. As such, disabled readers must be presented highly structured, explicit and intensive instruction in phonics rules and the application of the rules to print (Bowman Gray[5,9]).
- Longitudinal data indicate that systematic structured phonics instruction results in more favorable outcomes in reading than does a context-emphasis (Whole Language) approach (Bowman Gray[5,9]).
- Dyslexic readers who have been remediated and who are at normal to near normal reading levels in adulthood continue to display atypical neural processing as assessed by regional cerebral blood flow studies. This finding suggests that initial neuropathology remains stable over time, despite remediation, and that compensatory mechanisms may be developed (Bowman Gray[5,9]).

FUTURE RESEARCH DIRECTIONS IN LD

In addition to the research initiatives and programs described above, the NICHD is developing and expanding programs and plans in area of treatment/intervention for LD children and in the area of cognitive neuroscience and neuroimaging. Each of these areas of inquiry are described briefly.

TREATMENT/INTERVENTION

Review of the literature related to reading disabilities and other learning disabilities indicates that no single treatment/intervention approach or method is likely to yield clinically significant, long-term, therapeutic gains with children diagnosed with LD.[1,2] Unfortunately, to date, there exists scant scientific support for the use of particular interventions or combinations of interventions with different types of learning disabilities. Because of this, the NICHD has recently launched a major research effort to determine which treatment methods or combinations of methods, provided in which setting, have the most effective impact on well defined domains of child functioning, for how long, and for what reasons. Within this context, two highly controlled and well designed Longitudinal prospective intervention studies with LD children are now being supported at the Florida State University under the direction of Dr. Joseph Torgesen and the University of Houston under the direction of Dr. Barbara Foorman. Additional treatment/intervention initiatives are being planned at this time.

COGNITIVE NEUROSCIENCE AND NEUROIMAGING

There exists a critical need to understand how the human brain is organized for complex behaviors, and to know more specifically how the child with LD and the normal learner differ with respect to central nervous system functioning. In addition, it is important for us to understand how such physiological and neuroanatomical differences are related to indices of heritability and environmental influences. Our ability to assess brain-behavior relationships in an accurate, yet noninvasive manner, is improving significantly as we begin to employ dramatic new advances in neuroimaging technology. For instance, The Shaywitz group at Yale is moving forward with the application of Functional Magnetic Resonance Imaging studies with reading disabled and normal children. In addition, Dr. Allen Reiss and his colleagues at Johns Hopkins are designing imaging software that will allow different sites to compare neuroimaging data and how best to register functional brain information with structural brain information. These projects, as well as initiatives being planned, should serve to provide the empirical foundation necessary to not only understand the limits of individual variability in brain structure and function, but to identify the neurobiological underpinnings of learning disabilities.

SUMMARY

The NICHD has been, and will continue to be responsive to the critical research needs in LD and related disorders. As an index of the heightened research activity in this arena, consider that NICHD support for projects related to learning and language disabilities has increased from $1.75 million in 1975 to over $15 million in 1993—a cumulative total of approximately $80 million. Given the significant discoveries made by the Program Projects, LDRC's and individual research grants supported through these increases, the money clearly has been well spent. Within the past 10 years, NICHD research has identified the major cognitive mechanisms underlying dyslexia and other learning disabilities and how the assessment of these mechanisms can help to predict the onset, developmental course, and outcomes of such disorders. Moreover, NICHD scientists have contributed substantially to an understanding of how the genome, the brain, and the environment interact to produce individual variations in learning. Given this knowledge, we are hopeful that the newly funded treatment/intervention projects will provide guidance with respect to ameliorating the devastating effects of learning disabilities on both children and adults.

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Message from the National Institute of Mental Health

Research conducted and supported by the National Institute of Mental Health brings hope to millions of people who suffer from mental illness and to their families and friends. In many years of work with animal as well as human subjects, researchers have advanced our understanding of the brain and vastly expanded the capability of mental health professionals to diagnose, treat, and prevent mental and brain disorders.

Now, in the 1990s, which the President and Congress have declared the "Decade of the Brain," we stand at the threshold of a new era in brain and behavioral sciences. Through research, we will learn even more about mental and brain disorders such as depression, bipolar disorder, schizophrenia, panic disorder, obsessive-compulsive disorder, and attention deficit hyperactivity disorder. And we will be able to use this knowledge to develop new therapies that can help more people overcome mental illness.

The National Institute of Mental Health is part of the National Institutes of Health (NIH), the Federal Government's primary agency for biomedical and behavioral research. NIH is a component of the U.S. Department of Health and Human Services.

Attention Deficit Hyperactivity Disorder

Understanding the Problem

Getting Help

Sustaining Hope

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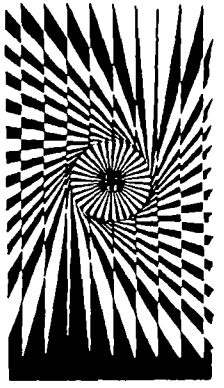
Attention Deficit Hyperactivity Disorder

Imagine living in a fast-moving kaleidoscope, where sounds, images, and thoughts are constantly shifting. Feeling easily bored, yet helpless to keep your mind on tasks you need to complete. Distracted by unimportant sights and sounds, your mind drives you from one thought or activity to the next. Perhaps you are so wrapped up in a collage of thoughts and images that you don't notice when someone speaks to you.



For many people, this is what it's like to have Attention Deficit Hyperactivity Disorder, or ADHD. They may be unable to sit still, plan ahead, finish tasks, or be fully aware of what's going on around them. To their family, classmates, or coworkers, they seem to exist in a whirlwind of disorganized or frenzied activity. Unexpectedly—on some days and in some situations—they seem fine, often leading others to think the person with ADHD can actually control these behaviors. As a result, the disorder can mar the person's relationships with others in addition to disrupting their daily life, consuming energy, and diminishing self-esteem.

ADHD, once called hyperkinesis or minimal brain dysfunction, is one of the most common mental disorders among children. It affects 3 to 5 percent of all children, perhaps as many as 2 million American children. Two to three times more boys than girls are affected. On the average, at least one child in every classroom in the United States needs help for the disorder. ADHD often continues into adolescence and adulthood, and can cause a lifetime of frustrated dreams and emotional pain.

But there is help...and hope. In the last decade, scientists have learned much about the course of the disorder and are now able to identify and treat children, adolescents, and adults who have it. A variety of medications, behavior-changing therapies, and educational options are already available to help people with ADHD focus their attention, build self-esteem, and function in new ways.

In addition, new avenues of research promise to further improve diagnosis and treatment. With so many American children diagnosed as having attention disorder, research on ADHD has become a national priority. During the 1990s—which the President and Congress have declared the "Decade of the Brain"— it is possible that scientists will pinpoint the biological basis of ADHD and learn how to prevent or treat it even more effectively.

This booklet is provided by the National Institute of Mental Health (NIMH), the Federal agency that supports research nationwide on the brain, mental illnesses, and mental health. Scientists supported by NIMH are dedicated to understanding the workings and interrelationships of the various regions of the brain, and to developing preventive measures and new treatments to overcome brain disorders that handicap people in school, work, and play.

The booklet offers up-to-date information on attention deficit disorders and the role of NIMH-sponsored research in discovering underlying causes and effective treatments. It describes treatment options, strategies for coping, and sources of information and support. You'll find out what it's like to have ADHD from the stories of Mark, Lisa, and Henry. You'll see their early frustrations, their steps toward getting help, and their hopes for the future.

The individuals referred to in this brochure are not real, but their stories are representative of people who show symptoms of ADHD.

Understanding the Problem

Mark

Mark, age 14, has more energy than most boys his age. But then, he's always been overly active. Starting at age 3, he was a human tornado, dashing around and disrupting everything in his path. At home, he darted from one activity to the next, leaving a trail of toys behind him. At meals, he upset dishes and chattered nonstop. He was reckless and impulsive, running into the street with oncoming cars, no matter how many times his mother explained the danger or scolded him. On the playground, he seemed no wilder than the other kids. But his tendency to overreact—like socking playmates simply for bumping into him—had already gotten him into trouble several times. His parents didn't know what to do. Mark's doting grandparents reassured them, "Boys will be boys. Don't worry, he'll grow out of it." But he didn't.

Lisa

At age 17, Lisa still struggles to pay attention and act appropriately. But this has always been hard for her. She still gets embarrassed thinking about that night her parents took her to a restaurant to celebrate her 10th birthday. She had gotten so distracted by the waitress' bright red hair that her father called her name three times before she remembered to order. Then before she could stop herself, she blurted, "Your hair dye looks awful!"

In elementary and junior high school, Lisa was quiet and cooperative but often seemed to be daydreaming. She was smart, yet couldn't improve her grades no matter how hard she tried. Several times, she failed exams. Even though she knew most of the answers, she couldn't keep her mind on the test. Her parents responded to her low grades by taking away privileges and scolding, "You're just lazy. You could get better grades if you only tried." One day, after Lisa had failed yet another exam, the teacher found her sobbing, "What's wrong with me?"

Henry

Although he loves puttering around in his shop, for years Henry has had dozens of unfinished carpentry projects and ideas for new ones he knew he would never complete. His garage was piled so high with wood, he and his wife joked about holding a fire sale.

Every day Henry faced the real frustration of not being able to concentrate long enough to complete a task. He was fired from his job as stock clerk because he lost inventory and carelessly filled out forms. Over the years, afraid that he might be losing his mind, he had seen psychotherapists and tried several medications, but none ever helped him concentrate. He saw the same lack of focus in his young son and worried.

What are the symptoms of ADHD?

The three people you've just met, Mark, Lisa, and Henry, all have a form of ADHD—Attention Deficit Hyperactivity Disorder. ADHD is not like a broken arm, or strep throat. Unlike these two disorders, ADHD does not have clear physical signs that can be seen in an x-ray or a lab test. ADHD can only be identified by looking for certain characteristic behaviors, and as with Mark, Lisa, and Henry, these behaviors vary from person to person. Scientists have not yet identified a single cause behind all the different patterns of behavior—and they may never find just one. Rather, someday scientists may find that ADHD is actually an umbrella term for several slightly different disorders.

At present, ADHD is a diagnosis applied to children and adults who consistently display certain characteristic behaviors over a period of time. The most common behaviors fall into three categories: inattention, hyperactivity, and impulsivity.

Inattention. People who are inattentive have a hard time keeping their mind on any one thing and may get bored with a task after only a few minutes. They may give effortless, automatic attention to activities and things they enjoy. But focusing deliberate, conscious attention to organizing and completing a task or learning something new is difficult.

For example, Lisa found it agonizing to do homework. Often, she forgot to plan ahead by writing down the assignment or bringing home the right books. And when trying to work, every few minutes she found her mind drifting to something else. As a result, she rarely finished and her work was full of errors.

Hyperactivity. People who are hyperactive always seem to be in motion. They can't sit still. Like Mark, they may dash around or talk incessantly. Sitting still through a lesson can be an impossible task. Hyperactive children squirm in their seat or roam around the room. Or they might wiggle their feet, touch everything, or noisily tap their pencil. Hyperactive teens and adults may feel intensely restless. They may be fidgety or, like Henry, they may try to do several things at once, bouncing around from one activity to the next.

Impulsivity. People who are overly impulsive seem unable to curb their immediate reactions or think before they act. As a result, like Lisa, they may blurt out inappropriate comments. Or like Mark, they may run into the street without looking. Their impulsivity may make it hard for them to wait for things they want or to take their turn in games. They may grab a toy from another child or hit when they're upset.

Not everyone who is overly active, inattentive, or impulsive has Attention Deficit Hyperactivity Disorder.

Not everyone who is overly hyperactive, inattentive, or impulsive has an attention disorder. Since most people sometimes blurt out things they didn't mean to say, bounce from one task to another, or become disorganized and forgetful, how can specialists tell if the problem is ADHD?

To assess whether a person has ADHD, specialists consider several critical questions: Are these behaviors excessive, long-term, and pervasive? That is, do they occur more often than in other people the same age? Are they a continuous problem, not just a response to a temporary situation? Do the behaviors occur in several settings or only in one specific place like the playground or the office? The person's pattern of behavior is compared against a set of criteria and characteristics of the disorder. These criteria appear in a diagnostic reference book called the DSM (short for the *Diagnostic and Statistical Manual of Mental Disorders*).

According to the diagnostic manual, there are three patterns of behavior that indicate ADHD. People with ADHD may show several signs of being consistently inattentive. They may have a pattern of being hyperactive and impulsive. Or they may show all three types of behavior.

According to the DSM, signs of **inattention** include:

- becoming easily distracted by irrelevant sights and sounds
- failing to pay attention to details and making careless mistakes
- rarely following instructions carefully and completely
- losing or forgetting things like toys, or pencils, books, and tools needed for a task

Some signs of **hyperactivity** and **impulsivity** are:

- feeling restless, often fidgeting with hands or feet, or squirming
- running, climbing, or leaving a seat, in situations where sitting or quiet behavior is expected
- blurting out answers before hearing the whole question
- having difficulty waiting in line or for a turn

Because everyone shows some of these behaviors at times, the DSM contains very specific guidelines for determining when they indicate ADHD. The behaviors must appear early in life, before age 7, and continue for at least 6 months. In children, they must be more frequent or severe than in others the same age. Above all, the behaviors must create a real handicap in at least two areas of a person's life, such as school, home, work, or social settings. So someone whose work or friendships are not impaired by these behaviors would not be diagnosed with ADHD. Nor would a child who seems overly active at school but functions well elsewhere.

Can any other conditions produce these symptoms

The fact is, *many* things can produce these behaviors. Anything from chronic fear to mild seizures can make a child seem overactive, quarrelsome, impulsive, or inattentive. For example, a formerly cooperative child who becomes overactive and easily distracted after a parent's death is dealing with an emotional problem, not ADHD. A chronic middle ear infection can also make a child seem distracted and uncooperative. So can living with family members who are physically abusive or addicted to drugs or alcohol. Can you imagine a child trying to focus on a math lesson when his or her safety and well-being are in danger each day? Such children are showing the effects of other problems, not ADHD.

In other children, ADHD-like behaviors may be their response to a defeating classroom situation. Perhaps the child has a learning disability and is not developmentally ready to learn to read and write at the time these are taught. Or maybe the work is too hard or too easy, leaving the child frustrated or bored.

Tyrone and Mimi are two examples of how classroom conditions can elicit behaviors that look like ADHD. For months, Tyrone shouted answers out in class, then became disruptive when the teacher ignored him. He certainly seemed hyperactive and impulsive. Finally, after observing Tyrone in other situations, his teacher realized he just wanted approval for knowing the right answer. She began to seek opportunities to call on him and praise him. Gradually, Tyrone became calmer and more cooperative.

Mimi, a fourth grader, made loud noises during reading group that constantly disrupted the class. One day the teacher realized that the book was too hard for Mimi. Mimi's disruptions stopped when she was placed in a reading group where the books were easier and she could successfully participate in the lesson.

Like Tyrone and Mimi, some children's attention and class participation improve when the class structure and lessons are adjusted a bit to meet their emotional needs, instructional level, or learning style. Although such children need a little help to get on track at school, they probably don't have ADHD.

What can look like ADHD?

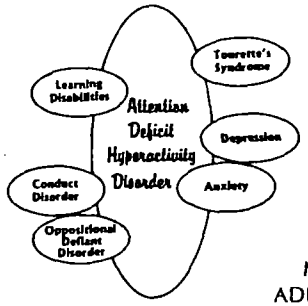
- Underachievement at school due to a learning disability
- Attention lapses caused by petit m seizures
- A middle ear infection that cau an intermittent hearing problem
- Disruptive or unresponsive behavior due to anxiety or depression

It's also important to realize that during certain stages of development, the majority of children that age tend to be inattentive, hyperactive, or impulsive—but do not have ADHD. Preschoolers have lots of energy and run everywhere they go, but this doesn't mean they are hyperactive. And many teenagers go through a phase when they are messy, disorganized, and reject authority. It doesn't mean they will have a lifelong problem controlling their impulses.

ADHD is a serious diagnosis that may require long-term treatment with counseling and medication. So it's important that a doctor first look for and treat any other causes for these behaviors.

Can other disorders accompany ADHD?

One of the difficulties in diagnosing ADHD is that it is often accompanied by other problems. For example, many children with ADHD also have a specific learning disability (LD), which means they have trouble mastering language or certain academic skills, typically reading and math. ADHD is not in itself a specific learning disability. But because it can interfere with concentration and attention, ADHD can make it doubly hard for a child with LD to do well in school.



A very small proportion of people with ADHD have a rare disorder called Tourette's syndrome. People with Tourette's have tics and other movements like eye blinks or facial twitches that they cannot control. Others may grimace, shrug, sniff, or bark out words. Fortunately, these behaviors can be controlled with medication. Researchers at NIMH and elsewhere are involved in evaluating the safety and effectiveness of treatment for people who have both Tourette's syndrome and ADHD.

More serious, nearly half of all children with ADHD—mostly boys—tend to have another condition, called oppositional defiant disorder. Like Mark, who punched playmates for jostling him, these children may overreact or lash out when they feel bad about themselves. They may be stubborn, have outbursts of temper, or act belligerent or defiant. Sometimes this progresses to more serious conduct disorders. Children with this combination of problems are at risk of getting in trouble at school, and even with the police. They may take unsafe risks and break laws—they may steal, set fires, destroy property, and drive recklessly. It's important that children with these conditions receive help before the behaviors lead to more serious problems.

At some point, many children with ADHD—mostly younger children and boys—experience other emotional disorders. About one-fourth feel anxious. They feel tremendous worry, tension, or uneasiness, even when there's nothing to fear. Because the feelings are scarier, stronger, and more frequent than normal fears, they can affect the child's thinking and behavior. Others experience depression. Depression goes beyond ordinary sadness—people may feel so "down" that they feel hopeless and unable to deal with everyday tasks. Depression can disrupt sleep, appetite, and the ability to think.

Every child who has ADHD should be checked for anxiety and depression.

Because emotional disorders and attention disorders so often go hand in hand, every child who has ADHD should be checked for accompanying anxiety and depression. Anxiety and depression can be treated, and helping children handle such strong, painful feelings will help them cope with and overcome the effects of ADHD.

Of course, not all children with ADHD have an additional disorder. Nor do all people with learning disabilities, Tourette's syndrome, oppositional defiant disorder, conduct disorder, anxiety, or depression have ADHD. But when they do occur together, the combination of problems can seriously complicate a person's life. For this reason, it's important to watch for other disorders in children who have ADHD.

What causes ADHD?

Understandably, one of the first questions parents ask when they learn their child has an attention disorder is *"Why? What went wrong?"*

Health professionals stress that since no one knows what causes ADHD, it doesn't help parents to look backward to search for possible reasons. There are too many possibilities to pin down the cause with certainty. It is far more important for the family to move forward in finding ways to get the right help.

Scientists, however, do need to study causes in an effort to identify better ways to treat, and perhaps some day,

prevent ADHD. They are finding more and more evidence that ADHD does not stem from home environment, but from biological causes. When you think about it, there is no clear relationship between home life and ADHD. Not all children from unstable or dysfunctional homes have ADHD. And not all children with ADHD come from dysfunctional families. Knowing this can remove a huge burden of guilt from parents who might blame themselves for their child's behavior.

Over the last decades, scientists have come up with possible theories about what causes ADHD. Some of these theories have led to dead ends, some to exciting new avenues of investigation.

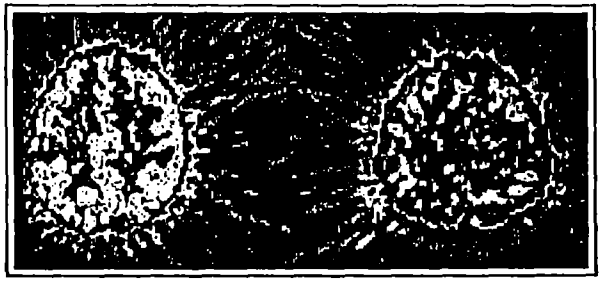
ADHD is not usually caused by:
- too much TV
- food allergies
- excess sugar
- poor home life
- poor schools

One disappointing theory was that all attention disorders and learning disabilities were caused by minor head injuries or undetectable damage to the brain, perhaps from early infection or complications at birth. Based on this theory, for many years both disorders were called "minimal brain damage" or "minimal brain dysfunction." Although certain types of head injury can explain some cases of attention disorder, the theory was rejected because it could explain only a very small number of cases. Not everyone with ADHD or LD has a history of head trauma or birth complications.

Another theory was that refined sugar and food additives make children hyperactive and inattentive. As a result, parents were encouraged to stop serving children foods containing artificial flavorings, preservatives, and sugars. However, this theory, too, came under question. In 1982, the National Institutes of Health (NIH), the Federal agency responsible for biomedical research, held a major scientific conference to discuss the issue. After studying the data, the scientists concluded that the restricted diet only seemed to help about 5 percent of children with ADHD, mostly either young children or children with food allergies.

In recent years, as new tools and techniques for studying the brain have been developed, scientists have been able to test more theories about what causes ADHD.

Using one such technique, NIMH scientists demonstrated a link between a person's ability to pay continued attention and the level of activity in the brain. Adult subjects were asked to learn a list of words. As they did, scientists used a PET (positron emission tomography) scanner to observe the brain at work. The researchers measured the level of glucose used by the areas of the brain that inhibit impulses and control attention. Glucose is the brain's main source of energy, so measuring how much is used is a good indicator of the brain's activity level. The investigators found important differences between people who have ADHD and those who don't. In people with ADHD, the brain areas that control attention used less glucose, indicating that they were less active. It appears from this research that a lower level of activity in some parts of the brain may cause inattention.



Brain scan images produced by positron emission tomography (PET) show difference between an adult wi Attention Deficit Hyperactivity Disord (right) and an adult h of the disease (left)

The next step will be to research *why* there is less activity in these areas of the brain. Scientists at NIMH hope to compare the use of glucose and the activity level in mild and severe cases of ADHD. They will also try to discover why some medications used to treat ADHD work better than others, and if the more effective medications increase activity in certain parts of the brain.

Researchers are also searching for other differences between those who have and do not have ADHD. Research on how the brain normally develops in the fetus offers some clues about what may disrupt the process. Throughout pregnancy and continuing into the first year of life, the brain is constantly developing. It begins its growth from a few all-purpose cells and evolves into a complex organ made of billions of specialized, interconnected nerve cells. By studying brain development in animals and humans, scientists are gaining a better understanding of how the brain works when the nerve cells are connected

correctly and incorrectly. Scientists at NIMH and other research institutions are tracking clues to determine what might prevent nerve cells from forming the proper connections. Some of the factors they are studying include drug use during pregnancy, toxins, and genetics.

Research shows that a mother's use of cigarettes, alcohol, or other drugs during pregnancy may have damaging effects on the unborn child. These substances may be dangerous to the fetus' developing brain. It appears that alcohol and the nicotine in cigarettes may distort developing nerve cells. For example, heavy alcohol use during pregnancy has been linked to fetal alcohol syndrome (FAS), a condition that can lead to low birth weight, intellectual impairment, and certain physical defects. Many children born with FAS show much the same hyperactivity, inattention, and impulsivity as children with ADHD.

Drugs such as cocaine—including the smokable form known as crack—seem to affect the normal development of brain receptors. These brain cell parts help to transmit incoming signals from our skin, eyes, and ears, and help control our responses to the environment. Current research suggests that drug abuse may harm these receptors. Some scientists believe that such damage may lead to ADHD.

Toxins in the environment may also disrupt brain development or brain processes, which may lead to ADHD. Lead is one such possible toxin. It is found in dust, soil, and flaking paint in areas where leaded gasoline and paint were once used. It is also present in some water pipes. Some animal studies suggest that children exposed to lead may develop symptoms associated with ADHD, but only a few cases have actually been found.

Other research shows that attention disorders tend to run in families, so there are likely to be genetic influences. Children who have ADHD usually have at least one close relative who also has ADHD. And at least one-third of all fathers who had ADHD in their youth bear children who have ADHD. Even more convincing: the majority of identical twins share the trait. At the National Institutes of Health, researchers are also on the trail of a gene that may be involved in transmitting ADHD in a small number of families with a genetic thyroid disorder.

Getting Help

Mark

In third grade, Mark's teacher threw up her hands and said, "Enough!" In one morning, Mark had jumped out of his seat to sharpen his pencil six times, each time accidentally charging into other children's desks and toppling books and papers. He was finally sent to the principal's office when he began kicking a desk he had overturned. In sheer frustration, his teacher called a meeting with his parents and the school psychologist.

But even after they developed a plan for managing Mark's behavior in class, Mark showed little improvement. Finally, after an extensive assessment, they found that Mark had an attention deficit that included hyperactivity. He was put on a medication called Ritalin to control the hyperactivity during school hours. Although Ritalin failed to help, another drug called Dexedrine did. With a psychologist's help, his parents learned to reward desirable behaviors, and to have Mark take "time out" when he became too disruptive. Soon Mark was able to sit still and focus on learning.

Lisa

Because Lisa wasn't disruptive in class, it took a long time for teachers to notice her problem. Lisa was first referred to the school evaluation team when her teacher realized that she was a bright girl with failing grades. The team ruled out a learning disability but determined that she had an attention deficit, ADHD without hyperactivity. The school psychologist recognized that Lisa was also dealing with depression.

Lisa's teachers and the school psychologist developed a treatment plan that included participation in a program to increase her attention span and develop her social skills. They also recommended that Lisa receive counseling to help her recognize her strengths and overcome her depression.

Henry

When Henry's son entered kindergarten, it was clear that he was going to have problems sitting quietly and concentrating. After several disruptive incidents, the school called and suggested that his son be evaluated for ADHD. As the boy was assessed, Henry realized that he had grown up with the same symptoms that specialists were now finding in his son. Fortunately, the psychologist knew that ADHD can persist in adults. She suggested that Henry be evaluated by a professional who worked with adults. For the first time, Henry was correctly diagnosed and given Ritalin to aid his concentration. What a relief! All the years that he had been unable to concentrate were due to a disorder that could be identified, and above all, treated.

How is ADHD identified and diagnosed?

Many parents see signs of an attention deficit in toddlers long before the child enters school. For example, as a 3-year-old, Henry's son already displayed some signs of hyperactivity. He seemed to lose interest and dart off even during his favorite TV shows or while playing games. Once, during a game of "catch," he left the game before the ball even reached him!

Like Henry's son, a child may be unable to focus long enough to play a simple game. Or, like Mark, the child may be tearing around out of control. But because children mature at different rates, and are very different in personality, temperament, and energy level, it's useful to get an expert's opinion of whether the behaviors are appropriate for the child's age. Parents can ask their pediatrician, or a child psychologist or psychiatrist to assess whether their toddler has an attention disorder or is just immature, has hyperactivity or is just exuberant.

Seeing a child as "a chip off the old block" or "just like his dad" can blind parents to the need for help. Parents may find it hard to see their child's behavior as a problem when it so closely resembles their own. In fact, like Henry, many parents first recognize their own disorder only when their children are diagnosed.

In many cases, the teacher is the first to recognize that a child is hyperactive or inattentive and may consult with the school psychologist. Because teachers work with many children, they come to know how "average" children behave in learning situations that require attention and self control. However, teachers sometimes fail to notice the needs of children like Lisa who are quiet and cooperative.

Types of professionals who make the diagnosis

School-age and preschool children are often evaluated by a school psychologist or a team made up of the school psychologist and other specialists. But if the school doesn't believe the student has a problem, or if the family wants another opinion, a family may need to see a specialist in private practice. In such cases, who can the family turn to? What kinds of specialists do they need?

Specialty	Can diagnose ADHD	Can prescribe medications, if needed	Provides counseling / training
Psychiatrists	yes	yes	yes
Psychologists	yes	no	yes
Pediatricians or family physicians	yes	yes	no
Neurologists	yes	yes	no

The family can start by talking with the child's pediatrician or their family doctor. Some pediatricians may do the assessment themselves, but more often they refer the family to an appropriate specialist they know and trust. In addition, state and local agencies that serve families and children, as well as some of the volunteer organizations listed in the back of this booklet, can help identify an appropriate specialist.

Knowing the differences in qualifications and services can help the family choose someone who can best meet their needs. Besides school psychologists, there are several types of specialists qualified to diagnose and treat ADHD.

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Child psychiatrists are doctors who specialize in diagnosing and treating childhood mental and behavioral disorders. A psychiatrist can provide therapy and prescribe any needed medications. Child psychologists are also qualified to diagnose and treat ADHD. They can provide therapy for the child and help the family develop ways to deal with the disorder. But psychologists are not medical doctors and must rely on the child's physician to do medical exams and prescribe medication. Neurologists, doctors who work with disorders of the brain and nervous system, can also diagnose ADHD and prescribe medicines. But unlike psychiatrists and psychologists, neurologists usually do not provide therapy for the emotional aspects of the disorder. Adults who think they may have ADHD can also seek a psychologist, psychiatrist, or neurologist. But at present, not all specialists are skilled in identifying or treating ADHD in adults.

The specialist's first task is to gather information that will rule out other possible reasons for the child's behavior.

Within each specialty, individual doctors and mental health professionals differ in their experience with ADHD. So in selecting a specialist, it's important to find someone with specific training and experience in diagnosing and treating the disorder.

Steps in making a diagnosis

Whatever the specialist's expertise, his or her first task is to gather information that will rule out other possible reasons for the child's behavior. In ruling out other causes, the specialist checks the child's school and medical records. The specialist tries to sense whether the home and classroom environments are stressful or chaotic, and how the child's parents and teachers deal with the child. They may have a doctor look for such problems as emotional disorders, undetectable (petit mal) seizures, and poor vision or hearing. Most schools automatically screen for vision and hearing, so this information is often already on record. A doctor may also look for allergies or nutrition problems like chronic "caffeine highs" that might make the child seem overly active.

Next the specialist gathers information on the child's ongoing behavior in order to compare these behaviors to the symptoms and diagnostic criteria listed in the DSM (*Diagnostic and Statistical Manual of Mental Disorders*).

This involves talking with the child and if possible, observing the child in class and in other settings.

The child's teachers, past and present, are asked to rate their observations of the child's behavior on standardized evaluation forms to compare the child's behaviors to those of other children the same age. Of course, rating scales are subjective—they only capture the teacher's personal perception of the child. Even so, because teachers get to know so many children, their judgment of how a child compares to others is usually accurate.

The specialist interviews the child's teachers, parents, and other people who know the child well, such as school staff and baby-sitters. Parents are asked to describe their child's behavior in a variety of situations. They may also fill out a rating scale to indicate how severe and frequent the behaviors seem to be.

In some cases, the child may be checked for social adjustment and mental health. Tests of intelligence and learning achievement may be given to see if the child has a learning disability and whether the disabilities are in all or only certain parts of the school curriculum.

In looking at the data, the specialist pays special attention to the child's behavior during noisy or unstructured situations, like parties, or during tasks that require sustained attention, like reading, working math problems, or playing a board game. Behavior during free play or while getting individual attention is given less importance in the evaluation. In such situations, most children with ADHD are able to control their behavior and perform well.

The specialist then pieces together a profile of the child's behavior. Which ADHD-like behaviors listed in the DSM does the child show? How often? In what situations? How long has the child been doing them? How old was the child when the problem started? Are the behaviors seriously interfering with the child's friendships, school activities, or home life? Does the child have any other related problems? The answers to these questions help identify whether the child's hyperactivity, impulsivity, and inattention are significant and long-standing. If so, the child may be diagnosed with ADHD.

Adults are diagnosed for ADHD based on their performance at home and at work. When possible, their parents are asked to rate the person's behavior as a child. A spouse or roommate can help rate and evaluate current behaviors. But for the most part, adults are asked to describe their own experiences. One symptom is a sense of frustration. Since people with ADHD are often bright and creative, they often report feeling frustrated that they're not living up to their potential. Many also feel restless and are easily bored. Some say they need to seek novelty and excitement to help channel the whirlwind in their minds. Although it may be impossible to document when these behaviors first started, most adults with ADHD can give examples of being inattentive, impulsive, overly active, impatient, and disorganized most of their lives.

Half the children with ADHD continue to have symptoms through adulthood.

Until recent years, adults were not thought to have ADHD, so many adults with ongoing symptoms have never been diagnosed. People like Henry go for decades knowing that something is wrong, but not knowing what it is. Psychotherapy and medication for anxiety, depression, or manic-depression fail to help much, simply because the ADHD itself is not being addressed. Yet half the children with ADHD continue to have symptoms through adulthood. The recent awareness of adult ADHD means that many people can finally be correctly diagnosed and treated.

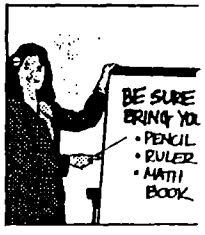
A correct diagnosis lets people move forward in their lives. Once the disorder is known, they can begin to receive whatever combination of educational, medical, and emotional help they need.

An effective treatment plan helps people with ADHD and their families at many levels. For adults with ADHD, the treatment plan may include medication, along with practical and emotional support. For children and adolescents, it may include providing an appropriate classroom setting, the right medication, and helping parents to manage their child's behavior.

What are the educationa options?

Children with ADHD have a variety of needs. Some children are too hyperactive or inattentive to function in a regular classroom, even with medication and a behavior management plan. Such children may be placed in a special education class for all or part of the day. In some schools, the special education teacher teams with the classroom teacher to meet each child's unique needs. However, most children are able to stay in the regular classroom. Whenever possible, educators prefer to not to segregate children, but to let them learn along with their peers.

Children with ADHD often need some special accommodations to help them learn. For example, the teacher may seat the child in an area with few distractions, provide an area where the child can move around and release excess energy, or establish a clearly posted system of rules and reward appropriate behavior. Sometimes just keeping a card or a picture on the desk can serve as a visual reminder to use the right school behavior, like raising a hand instead of shouting out, or staying in a seat instead of wandering around the room. Giving a child like Lisa extra time on tests can make the difference between passing and failing, and gives her a fairer chance to show what she's learned. Reviewing instructions or writing assignments on the board, and even listing the books and materials they will need for the task, may make it possible for disorganized, inattentive children to complete the work.



Many of the strategies of special education are simply good teaching methods. Telling students in advance what they will learn, providing visual aids, and giving written as well as oral instructions are all ways to help students focus and remember the key parts of the lesson.

Students with ADHD often need to learn techniques for monitoring and controlling their own attention and behavior. For example, Mark's teacher taught him several alternatives for when he loses track of what he's supposed to do. He can look for instructions on the blackboard, raise his hand, wait to see if he remembers, or quietly ask another child. The process of finding alternatives to interrupting the teacher has made him more self-sufficient and cooperative. And because he now interrupts less, he is beginning to get more praise than reprimands.

In Lisa's class, the teacher frequently stops to ask students to notice whether they are paying attention to the lesson or if they are thinking about something else. The students record their answer on a chart. As students become more consciously aware of their attention, they begin to see progress and feel good about staying better focused. The process helped make Lisa aware of when she was drifting off, so she could return her attention to the lesson faster. As a result, she became more productive and the quality of her work improved.

Because schools demand that children sit still, wait for a turn, pay attention, and stick with a task, it's no surprise that many children with ADHD have problems in class. Their minds are fully capable of learning, but their hyperactivity and inattention make learning difficult. As a result, many students with ADHD repeat a grade or drop out of school early. Fortunately, with the right combination of appropriate educational practices, medication, and counseling, these outcomes can be avoided.

Right to a free public education

Although parents have the option of taking their child to a private practitioner for evaluation and educational services, most children with ADHD qualify for free services within the public schools. Steps are taken to ensure that each child with ADHD receives an education that meets his or her unique needs. For example, the special education teacher, working with parents, the school psychologist, school administrators, and the classroom teacher, must assess the child's strengths and weaknesses and design an Individualized Educational Program (IEP). The IEP outlines the specific skills the child needs to develop as well as appropriate learning activities that build on the child's strengths. Parents play an important role in the process. They must be included in meetings and given an opportunity to review and approve their child's IEP.

Many children with ADHD or other disabilities are able to receive such special education services under the Individuals with Disabilities Education Act (IDEA). The Act guarantees appropriate services and a public education to children with disabilities from ages 3 to 21. Children who do not qualify for services under IDEA can receive help under an earlier law, the National Rehabilitation Act,

Some coping strategies for teens and adults with ADHD

When necessary, ask the teacher or boss to repeat instructions, rather than guess.

Break large assignments or job tasks into small, simple tasks. Set a deadline for each task and reward yourself as you complete each one.

Each day, make a list of what you need to do. Plan the best order for doing each task. Then make a schedule for doing them. Use a calendar or daily planner to keep yourself on track.

Work in a quiet area. Do one thing at a time. Give yourself short breaks.

Write things you need to remember in a notebook with dividers. Write different kinds of information—like assignments, appointments, and phone numbers—in different sections. Keep the book with you all of the time.

Post notes to yourself to help remind yourself of things you need to do. Tape notes on the bathroom mirror, on the refrigerator, in your school locker, or dashboard of your car—wherever you're likely to need the reminder.

Store similar things together. For example, keep all your Nintendo disks in one place, and tape cassettes in another. Keep canceled checks in one place, and bills in another.

Create a routine. Get yourself ready for school or work at the same time, in the same way, every day.

Exercise, eat a balanced diet, and get enough sleep.

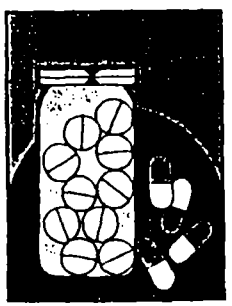
Adapted from: Weinstein, C. "Cognitive Remediation Strategies." *Journal of Psychotherapy Practice and Research*. 3(1):44-57, 1994.

Section 504, which defines disabilities more broadly. Qualifying for services under the National Rehabilitation Act is often called "504 eligibility."

Because ADHD is a disability that affects children's ability to learn and interact with others, it can certainly be a disabling condition. Under one law or another, most children can receive the services they need.

What treatments are available?

For decades, medications have been used to treat the symptoms of ADHD. Three medications in the class of drugs known as stimulants seem to be the most effective in both children and adults. These are methylphenidate (Ritalin), dextroamphetamine (Dexedrine or Dextrostat), and pemoline (Cylert). For many people, these medicines dramatically reduce their hyperactivity and improve their ability to focus, work, and learn. The medications may also improve physical coordination, such as handwriting and ability in sports. Recent research by NIMH suggests that these medicines may also help children with an accompanying conduct disorder to control their impulsive, destructive behaviors.



Ritalin helped Henry focus on and complete tasks for the first time. Dexedrine helped Mark to sit quietly, focus his attention, and participate in class so he could learn. He also became less impulsive and aggressive. Along with these changes in his behavior, Mark began to make and keep friends.

Unfortunately, when people see such immediate improvement, they often think medication is all that's needed. But these medicines don't cure the disorder, they only temporarily control the symptoms. Although the drugs help people pay better attention and complete their work, they can't increase knowledge or improve academic skills. The drugs alone can't help people feel better about themselves or cope with problems. These require other kinds of treatment and support.

For lasting improvement, numerous clinicians recommend that medications should be used along with treatments that aid in these other areas. There are no quick cures. Many experts believe that the most significant, long-lasting gains appear when medication is combined with behavioral therapy, emotional counseling, and practical support. Some studies suggest that the combination of medicine and therapy may be more effective than drugs alone. NIMH is conducting a large study to check this.

Use of stimulant drugs

Stimulant drugs, such as Ritalin, Cylert, and Dexedrine, when used with medical supervision, are usually considered quite safe. Although they can be addictive to teenagers and adults if misused, these medications are not addictive in children. They seldom make children "high" or jittery. Nor do they sedate the child. Rather, the stimulants help children control their hyperactivity, inattention, and other behaviors.

Many experts believe that the most significant, long-lasting gains appear when medication is combined with behavioral therapy, emotional counseling, and practical support.

Different doctors use the medications in slightly different ways. Cylert is available in one form, which naturally lasts 5 to 10 hours. Ritalin and Dexedrine come in short-term tablets that last about 3 hours, as well as longer-term preparations that last through the school day. The short-term dose is often more practical for children who need medication only during the school day or for special situations, like attending church or a prom, or studying for an important exam. The sustained-release dosage frees the child from the inconvenience or embarrassment of going to the office or school nurse every day for a pill. The doctor can help decide which preparation to use, and whether a child needs to take the medicine during school hours only or in the evenings and on weekends, too.

Nine out of 10 children improve on one of the three stimulant drugs. So if one doesn't help, the others should be tried. Usually a medication should be tried for a week to see if it helps. If necessary, however, the doctor will also try adjusting the dosage before switching to a different drug.

Other types of medication may be used if stimulants don't work or if the ADHD occurs with another disorder. Antidepressants and other medications may be used to help control accompanying depression or anxiety. In some cases, antihistamines may be tried. Clonidine, a drug

normally used to treat hypertension, may be helpful in people with both ADHD and Tourette's syndrome. Although stimulants tend to be more effective, clonidine may be tried when stimulants don't work or can't be used. Clonidine can be administered either by pill or by skin patch and has different side effects than stimulants. The doctor works closely with each patient to find the most appropriate medication.

Sometimes, a child's ADHD symptoms seem to worsen, leading parents to wonder why. They can be assured that a drug that helps rarely stops working. However, they should work with the doctor to check that the child is getting the right dosage. Parents should also make sure that the child is actually getting the prescribed daily dosage at home or at school—it's easy to forget. They also need to know that new or exaggerated behaviors may also crop up when a child is under stress. The challenges that all children face, like changing schools or entering puberty, may be even more stressful for a child with ADHD.

Some doctors recommend that children be taken off a medication now and then to see if the child still needs it. They recommend temporarily stopping the drug during school breaks and summer vacations, when focused attention and calm behavior are usually not as crucial. These "drug holidays" work well if the child can still participate at camp or other activities without medication.

Children on medications should have regular checkups. Parents should also talk regularly with the child's teachers and doctor about how the child is doing. This is especially important when a medication is first started, re-started, or when the dosage is changed.

The medication debate

As useful as these drugs are, Ritalin and the other stimulants have sparked a great deal of controversy. Most doctors feel the potential side effects should be carefully weighed against the benefits before prescribing the drugs. While on these medications, some children may lose weight, have less appetite, and temporarily grow more slowly. Others may have problems falling asleep. Some doctors believe that stimulants may also make the symptoms of Tourette's syndrome worse, although recent

Myths about stimulant medication

- **Myth:** Stimulants can lead to drug addiction later in life.

  Fact: Stimulants help many children focus and be more successful at school, home, and play. Avoiding negative experiences now may actually help prevent addictions and other emotional problems later.

- **Myth:** Responding well to a stimulant drug proves a person has ADHD.

  Fact: Stimulants allow many people to focus and pay better attention, whether or not they have ADHD. The improvement is just more noticeable in people with ADHD.

- **Myth:** Medication should be stopped when the child reaches adolescence.

  Fact: Not so! About 80 percent of those who needed medication as children still need it as teenagers. Fifty percent need medication as adults.

research suggests this may not be true. Other doctors say if they carefully watch the child's height, weight, and overall development, the benefits of medication far outweigh the potential side effects. Side effects that do occur can often be handled by reducing the dosage.

It's natural for parents to be concerned about whether taking a medicine is in their child's best interests. Parents need to be clear about the benefits and potential risks of using these drugs. The child's pediatrician or psychiatrist can provide advice and answer questions.

Another debate is whether Ritalin and other stimulant drugs are prescribed unnecessarily for too many children. Remember that many things, including anxiety, depression, allergies, seizures, or problems with the home or school environment can make children seem overactive,

impulsive, or inattentive. Critics argue that many children who do not have a true attention disorder are medicated as a way to control their disruptive behaviors.

Medication and self-esteem

When a child's schoolwork and behavior improve soon after starting medication, the child, parents, and teachers tend to applaud the drug for causing the sudden change. But these changes are actually the child's own strengths and natural abilities coming out from behind a cloud. Giving credit to the medication can make the child feel incompetent. The medication only makes these changes possible. The child must supply the effort and ability. To help children feel good about themselves, parents and teachers need to praise the child, not the drug.

It's also important to help children and teenagers feel comfortable about a medication they must take every day. They may feel that because they take medicine they are different from their classmates or that there's something seriously wrong with them. CH.A.D.D. (which stands for Children and Adults with Attention Deficit Disorders), a leading organization for people with attention disorders, suggests several ways that parents and teachers can help children view the medication in a positive way.

- Compare the pills to eyeglasses, braces, and allergy medications used by other children in their class. Explain that their medicine is simply a tool to help them focus and pay attention.
- Point out that they're lucky their problem can be helped. Encourage them to identify ways the medicine makes it easier to do things that are important to them, like make friends, succeed at school, and play.

Treatments to help people with ADHD and their families learn to cope

Life can be hard for children with ADHD. They're the ones who are so often in trouble at school, can't finish a game, and lose friends. They may spend agonizing hours each night struggling to keep their mind on their homework, then forget to bring it to school.

It's not easy coping with these frustrations day after day. Some children release their frustration by acting contrary, starting fights, or destroying property. Some turn the frustration into body ailments, like the child who gets a stomachache each day before school. Others hold their needs and fears inside, so that no one sees how badly they feel.

It's also difficult having a sister, brother, or classmate who gets angry, grabs your toys, and loses your things. Children who live with or share a classroom with a child who has ADHD get frustrated, too. They may feel neglected as their parents or teachers try to cope with the hyperactive child. They may resent their brother or sister never finishing chores, or being pushed around by a classmate. They want to love their sibling and get along with their classmate, but sometimes it's so hard!

It's especially hard being the parent of a child who is full of uncontrolled activity, leaves messes, throws tantrums, and doesn't listen or follow instructions. Parents often feel powerless and at a loss. The usual methods of discipline, like reasoning and scolding, don't work with this child, because the child doesn't really *choose* to act in these ways. It's just that their self-control comes and goes. Out of sheer frustration, parents sometimes find themselves spanking, ridiculing, or screaming at the child, even though they know it's not appropriate. Their response leaves everyone more upset than before. Then they blame themselves for not being better parents. Once children are diagnosed and receiving treatment, some of the emotional upset within the family may fade.

Medication can help to control some of the behavior problems that may have lead to family turmoil. But more often, there are other aspects of the problem that medication can't touch. Even though ADHD primarily affects a person's behavior, having the disorder has broad emotional repercussions. For some children, being scolded is the only attention they ever get. They have few experiences that build their sense of worth and competence. If they're hyperactive, they're often told they're bad and punished for being disruptive. If they are too disorganized and unfocused to complete tasks, others may call them lazy. If they impulsively grab toys, butt in,

or shove classmates, they may lose friends. And if they have a related conduct disorder, they may get in trouble at school or with the law. Facing the daily frustrations that can come with having ADHD can make people fear that they are strange, abnormal, or stupid.

Often, the cycle of frustration, blame, and anger has gone on so long that it will take some time to undo. Both parents and their children may need special help to develop techniques for managing the patterns of behavior. In such cases, mental health professionals can counsel the child and the family, helping them to develop new skills, attitudes, and ways of relating to each other. In individual counseling, the therapist helps children or adults with ADHD learn to feel better about themselves. They learn to recognize that having a disability does not reflect who they are as a person. The therapist can also help people with ADHD identify and build on their strengths, cope with daily problems, and control their attention and aggression. In group counseling, people learn that they are not alone in their frustration and that others want to help. Sometimes only the individual with ADHD needs counseling support. But in many cases, because the problem affects the family as well as the person with ADHD, the entire family may need help. The therapist assists the family in finding better ways to handle the disruptive behaviors and promote change. If the child is young, most of the therapist's work is with the parents, teaching them techniques for coping with and improving their child's behavior.

Children with ADHD and their parents may need special help to develop techniques for managing behavior.

Several intervention approaches are available and different therapists tend to prefer one approach or another. Knowing something about the various types of interventions makes it easier for families to choose a therapist that is right for their needs.

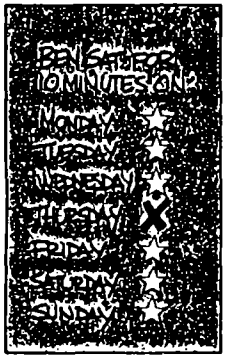
Psychotherapy works to help people with ADHD to like and accept themselves despite their disorder. In psychotherapy, patients talk with the therapist about upsetting thoughts and feelings, explore self-defeating patterns of behavior, and learn alternative ways to handle their emotions. As they talk, the therapist tries to help them understand how they can change. However, people dealing with ADHD usually want to gain control of their symptomatic behaviors more directly. If so, more direct kinds of intervention are needed.

Cognitive-behavioral therapy helps people work on immediate issues. Rather than helping people understand their feelings and actions, it supports them directly in changing their behavior. The support might be practical assistance, like helping Henry learn to think through tasks and organize his work. Or the support might be to encourage new behaviors by giving praise or rewards each time the person acts in the desired way. A cognitive-behavioral therapist might use such techniques to help a belligerent child like Mark learn to control his fighting, or an impulsive teenager like Lisa to think before she speaks.

Social skills training can also help children learn new behaviors. In social skills training, the therapist discusses and models appropriate behaviors like waiting for a turn, sharing toys, asking for help, or responding to teasing, then gives children a chance to practice. For example, a child might learn to "read" other people's facial expression and tone of voice, in order to respond more appropriately. Social skills training helped Lisa learn to join in group activities, make appropriate comments, and ask for help. A child like Mark might learn to see how his behavior affects others and develop new ways to respond when angry or pushed.

Support groups connect people who have common concerns. Many adults with ADHD and parents of children with ADHD find it useful to join a local or national support group. Many groups deal with issues of children's disorders, and even ADHD specifically. The national associations listed at the back of this booklet can explain how to contact a local chapter. Members of support groups share frustrations and successes, referrals to qualified specialists, and information about what works, as well as their hopes for themselves and their children. There is strength in numbers—and sharing experiences with others who have similar problems helps people know that they aren't alone.

Parenting skills training, offered by therapists or in special classes, gives parents tools and techniques for managing their child's behavior. One such technique is the use of "time out" when the child becomes too unruly or out of control. During time outs, the child is removed from the agitating situation and sits alone quietly for a short time to calm down. Parents may also be taught to give the child "quality time" each day, in which they share a pleasurable or relaxed activity. During this time together, the parent looks for opportunities to notice and point out what the child does well, and praise his or her strengths and abilities.



An effective way to modify a child's behavior is through a system of rewards and penalties. The parents (or teacher) identify a few desirable behaviors that they want to encourage in the child—such as asking for a toy instead of grabbing it, or completing a simple task. The child is told exactly what is expected in order to earn the reward. The child receives the reward when he performs the desired behavior and a mild penalty when he doesn't. A reward can be small, perhaps a token that can be exchanged for special privileges, but it should be something the child wants and is eager to earn. The penalty might be removal of a token or a brief "time out." The goal, over time, is to help children learn to control their own behavior and to choose the more desired behavior. The technique works well with all children, although children with ADHD may need more frequent rewards.

In addition, parents may learn to structure situations in ways that will allow their child to succeed. This may include allowing only one or two playmates at a time, so that their child doesn't get overstimulated. Or if their child has trouble completing tasks, they may learn to help the child divide a large task into small steps, then praise the child as each step is completed.

Parents may also learn to use stress management methods, such as meditation, relaxation techniques, and exercise to increase their own tolerance for frustration, so that they can respond more calmly to their child's behavior.

Controversial treatments

Understandably, parents who are eager to help their children want to explore every possible option. Many newly touted treatments sound reasonable. Many even come with glowing reports. A few are pure quackery. Some are even developed by reputable doctors or specialists—but when tested scientifically, cannot be proven to help.

Here are a few types of treatment that have *not* been scientifically shown to be effective in treating the majority of children or adults with ADHD:

- biofeedback
- restricted diets
- allergy treatments
- medicines to correct problems in the inner ear
- megavitamins
- chiropractic adjustment and bone re-alignment
- treatment for yeast infection
- eye training
- special colored glasses

A few success stories can't substitute for scientific evidence. Until sound, scientific testing shows a treatment to be effective, families risk spending time, money, and hope on fads and false promises.

Mark

Today, at age 14, Mark is doing much better in school. He channels his energy into sports and is a star player on the intramural football team. Although he still gets into fights now and then, a child psychologist is helping him learn to control his tantrums and frustration, and he is able to make and keep friends. His grandparents point to him with pride and say, "We knew he'd turn out just fine!"

Lisa

Lisa is about to graduate from high school. She's better able to focus her attention and concentrate on her work, so that now her grades are quite good. Overcoming her depression and learning to like herself have also given her more confidence to develop friendships and try new things.

Lately, she has been working with the school guidance counselor to identify the right kind of job to look for after graduation. She hopes to find a career that will bypass her attention problems and make the best use of her assets and skills. She is more alert and focused and is considering trying college in a year or two. Her counselor reminds her that she's certainly smart enough.

Henry

These days, Henry is successful and happy in his job as a shoe salesman. The work allows him to move around throughout the day, and the appearance of new customers provides the variety he needs to help him stay focused. He recently completed a course in time management, and now keeps lists, organizes his work, and schedules his day. Now that he has harnessed his energy, his ability to think about several things at once allows him to be creative and productive.

He is proud that he and his wife have developed important parenting skills for working with their son, so that he, too, is doing better at home and at school. Henry is also pleased with his new ability to follow through on projects. In fact, he just finished making his son a beautiful wooden toy chest for his birthday.

Can ADHD be outgrown or cured?

Even though most people don't outgrow ADHD, people do learn to adapt and live fulfilling lives. Mark, Lisa, and Henry are making good lives for themselves—not by being cured, but by developing their personal strengths. With effective combinations of medicine, new skills, and emotional support, people with ADHD can develop ways to control their attention and minimize their disruptive behaviors. Like Henry, they may find that by structuring tasks and controlling their environment, they can achieve personal goals. Like Mark, they may learn to channel their excess energy into sports and other high energy activities. And like Lisa, they can identify career options that build on their strengths and abilities.

As they grow up, with appropriate help from parents and clinicians, children with ADHD become better able to suppress their hyperactivity and to channel it into more socially acceptable behaviors, like physical exercise or fidgeting. And although we know that half of all children with ADHD will still show signs of the problem into adulthood, we also know that the medications and therapy that help children also work for adults.

All people with ADHD have natural talents and abilities that they can draw on to create fine lives and careers for themselves. In fact, many people with ADHD even feel that their patterns of behavior give them unique, often unrecognized, advantages. People with ADHD tend to be outgoing and ready for action. Because of their drive for excitement and stimulation, many become successful in business, sports, construction, and public speaking. Because of their ability to think about many things at once, many have won acclaim as artists and inventors. Many choose work that gives them freedom to move around and release excess energy. But some find ways to be effective in quieter, more sedentary careers. Sally, a computer programmer, found that she thinks best when she wears headphones to reduce distracting noises. Like Henry, some people strive to increase their organizational skills. Others who own their own business find it useful to hire support staff to provide day-to-day management.

What hope does research offer?

Although no immediate cure is in sight, a new understanding of ADHD may be just over the horizon. Using a variety of research tools and methods, scientists are beginning to uncover new information on the role of the brain in ADHD and effective treatments for the disorder. Such research will ultimately result in improving the personal fulfillment and productivity of people with ADHD.

For example, the use of new techniques like brain imaging to observe how the brain actually works is already providing new insights into the causes of ADHD. Other research is seeking to identify conditions of pregnancy and early childhood that may cause or contribute to these differences in the brain. As the body of knowledge grows, scientists may someday learn how to prevent these differences or at least how to treat them.

Using a variety of research tools and methods, scientists are beginning to uncover new information on the role of the brain in ADHD and effective treatments for the disorder.

NIMH and the U.S. Department of Education are cosponsoring a large national study—the first of its kind—to see which combinations of ADHD treatment work best for different types of children. During this 5-year study, scientists at research clinics across the country will work together in gathering data to answer such questions as: Is combining stimulant medication with behavior modification more effective than either alone? Do boys and girls respond differently to treatment? How do family stresses, income, and environment affect the severity of ADHD and long-term outcomes? How does needing medicine affect children's sense of competence, self-control, and self-esteem? As a result of such research, doctors and mental health specialists may someday know who benefits most from different types of treatment and be able to intervene more effectively.

NIMH grantees are also trying to determine if there are different varieties of attention deficit. With further study, researchers may find that ADHD actually covers a number of different disorders, each with its own cluster of symptoms and treatment requirements. For example, scientists are exploring whether there are any critical differences between children with ADHD who also have anxiety, depression, or conduct disorders and those who do not. Other researchers are studying slight physical differences that might distinguish one type of ADHD from another. If clusters of differences can be found, scientists can begin to distinguish the treatment each type needs.

Other NIMH-sponsored research is examining the long-term outcome of ADHD. How do children with ADHD turn out, compared to brothers and sisters without the disorder? As adults, how do they handle their own children? Still other studies seek to better understand ADHD in adults. Such studies give insights into what types of treatment or services make a difference in helping an ADHD child grow into a caring parent and a well-functioning adult.

Animal studies are also adding to our knowledge of ADHD in humans. Animal subjects make it possible to study some of the possible causes of ADHD in ways that can't be studied in people. In addition, animal research allows the safety and effectiveness of experimental new drugs to be tested long before they can be given to humans. One NIH-sponsored team of scientists is studying dogs to learn how new stimulant drugs that are similar to Ritalin act on the brain.

Piece by piece, through studies of humans and animals, scientists are beginning to understand the biological nature of attention disorders. New research is allowing us to better understand the inner workings of the brain as we continue to develop new medications and assess new forms of treatment.

As we learn more about what actually happens inside the brain, we approach a future where we can prevent certain brain and mental disorders, make valid diagnoses, and treat each effectively. This is the hope, mission, and vision of the National Institute of Mental Health.

What are sources of informatio and support?

Several publications, organizations, and support groups exist to help individuals, teachers, and families to understand and cope with attention disorders. The following resources provide a good starting point for gaining insight, practical solutions, and support. Other resources are outpatient clinics of children's hospitals, university medical centers, and community mental health centers. Additional printed information can be found at libraries and book stores.

Books for children and teens

Galvin, M. *Otto Learns about his Medication.* New York: Magination Press, 1988. (for young children)

Gehret, J. *Learning Disabilities and the Don't Give Up Kid.* Fairport, New York: Verbal Images Press, 1990. (for classmates and children with learning disabilities and attention difficulties, ages 7-12)

Gordon, M. *Jumpin' Johnny, Get Back to Work! A Child's Guide to ADHD/Hyperactivity.* DeWitt, New York: GSI Publications, 1991. (for ages 7-12)

Meyer, D.; Vadasy, P.; and Fewell, R. *Living with a Brother or Sister with Special Needs: A Book for Sibs.* Seattle: University of Washington Press, 1985.

Moss, D. *Shelly the Hyperactive Turtle.* Rockville, MD: Woodbine House, 1989. (for young children)

Nadeau, K., and Dixon, E. *Learning to Slow Down and Pay Attention.* Annandale, VA: Chesapeake Psychological Publications, 1993.

Parker, R. *Making the Grade: An Adolescent's Struggle with ADD.* Plantation, FL: Impact Publications, 1992.

Quinn, P., and Stern, J. *Putting on the Brakes: Young People's Guide to Understanding Attention Deficit Hyperactivity Disorder.* New York: Magination Press, 1991. (for ages 8-12)

Thompson, M. *My Brother Matthew.* Rockville, MD: Woodbine House, 1992.

Books for adults with attention disorders

Adelman, P., and Wren, C. *Learning Disabilities, Graduate School, and Careers: The Student's Perspective.* Lake Forest, IL: Learning Opportunities Program, Barat College, 1990.

Hallowell, E., and Ratey, J. *Driven to Distraction.* New York: Pantheon Books, 1994.

Hartmann, T. *Attention Deficit Disorder: A New Perception.* Lancaster, PA: Underwood-Miller, 1993.

Kelly, K., and Ramundo, P. *You Mean I'm Not Lazy, Stupid, or Crazy?!* Cincinnati, OH: Tyrell and Jeremy Press, 1993.

Weiss, G., and Hechtman, L. (eds). *Hyperactive Children Grown Up.* 2d ed. New York: Guilford Press, 1992.

Weiss, L. *Attention Deficit Disorder in Adults.* Dallas, TX: Taylor Pub. Co., 1992.

Wender, P. *The Hyperactive Child, Adolescence, and Adult: Attention Deficit Disorder Through the Lifespan.* New York: Oxford University Press, 1987.

Books for parents

Anderson, W.; Chitwood, S.; and Hayden, D. *Negotiating the Special Education Maze: A Guide for Parents and Teachers.* 2d ed. Rockville, MD: Woodbine House, 1990.

Bain, L. *A Parent's Guide to Attention Deficit Disorders.* New York: Dell Publishing, 1991.

Barkley, R. *Defiant Children.* New York: Guilford Press, 1987.

Child Psychopharmacy Center, University of Wisconsin. *Stimulants and Hyperactive Children.* Madison: 1990. Order by calling (608) 263-6171.

Copeland, E., and Love, V. *Attention, Please!: A Comprehensive Guide for Successfully Parenting Children with Attention Disorders and Hyperactivity.* Atlanta, GA: SPI Press, 1991.

Fowler, M. *Maybe You Know My Kid: A Parent's Guide to Identifying, Understanding, and Helping your Child with ADHD.* New York: Birch Lane Press, 1990.

Goldstein, S., and Goldstein, M. *Hyperactivity: Why Won't My Child Pay Attention?* New York: J. Wiley, 1992.

Greenberg, G.; Horn, S.; and Wade F. *Attention Deficit Hyperactivity Disorder: Questions & Answers for Parents.* Champaign, IL: Research Press, 1991.

Ingersoll, B., and Goldstein, S. *Attention Deficit Disorder and Learning Disabilities: Realities, Myths, and Controversial Treatments.* New York: Doubleday, 1993.

Moss, R., and Dunlap, H. *Why Johnny Can't Concentrate: Coping with Attention Deficit Problems.* New York: Bantam Books, 1990.

Kennedy, P.; Terdal, L.; and Fusetti, L. *The Hyperactive Child Book.* New York: St. Martrin's Press, 1993.

Silver, L. *Dr. Silver's Advice to Parents on Attention-Deficit Hyperactivity Disorder.* Washington, DC: American Psychiatric Press, 1993.

Vail, P. *Smart Kids with School Problems.* New York: EP Dutton, 1987.

Wilson, N. *Optimizing Special Education: How Parents Can Make a Difference.* New York: Insight Books, 1992.

Windell, J. *Discipline: A Sourcebook of 50 Failsafe Techniques for Parents.* New York: Collier Books, 1991.

Other resources

For individuals with a computer and modem, there are on-line bulletin boards where parents, adults with ADHD, and medical professionals share experiences, offer emotional support, and ask and respond to questions. Two such on-line services include CompuServe [(800) 848-8990] and America Online [(800) 827-6364]. You may also wish to check with other national and local on-line communications companies to see if they offer similar services.

Resources for teachers and specialists

Barkley, R. *Attention Deficit Hyperactivity Disorder* (four 40-minute videocassettes in VHS format). New York: Guilford Publications, 1990.

Copeland, E., and Love, V. *Attention Without Tension: A Teacher's Handbook on Attention Disorders.* Atlanta, GA: 3 C's of Childhood, 1992.

Harris, K., and Graham, S. *Helping Young Writers Master the Craft.* Cambridge, MA: Brookline Books, 1992.

Johnson, D. *I Can't Sit Still—Educating and Affirming Inattentive and Hyperactive Children: Suggestions for Parents, Teachers, and Other Care Providers of Children to Age 10.* Santa Cruz, CA: ETR Associates, 1992.

Parker, H. *The ADD Hyperactivity Handbook for Schools.* Plantation, FL: Impact Publications, 1992.

Related materials available from NIH

Attention Deficit Disorder Information Packet and *Know Your Brain Fact Sheet.* Both are available from NIH Neurological Institute, P.O. Box 5801; Bethesda, MD 20824 (800) 352-9424

Learning Disabilities (NIH Pub. No. 93-3611) and *Plain Talk about Depression* (NIH Pub. No. 93-3561). These are available by contacting: NIMH, Room 7C-02, 5600 Fishers Lane, Rockville, MD 20857.

Support groups and organizations

Attention Deficit Information Network (Ad-IN)
475 Hillside Avenue
Needham, MA 02194
(617) 455-9895
Provides up-to-date information on current research, regional meetings. Offers aid in finding solutions to practical problems faced by adults and children with an attention disorder.

ADD Warehouse
300 NW 70th Avenue
Plantation, FL 33317
(800) 233-9273
Distributes books, tapes, videos, assessment on attention deficit hyperactivity disorders. A central location for ordering many of the books listed above. Call for catalog.

Center for Mental Health Services
Office of Consumer, Family, and Public Information
5600 Fishers Lane, Room 15-105
Rockville, MD 20857
(301) 443-2792
This national center, a component of the U.S. Public Health Service, provides a range of information on mental health, treatment, and support services.

Children and Adults with Attention Deficit Disorders (CH.A.D.D.)
499 NW 70th Avenue, Suite 109
Plantation, FL 33317
(305) 587-3700
A major advocate and key information source for people dealing with attention disorders. Sponsors support groups and publishes two newsletters concerning attention disorders for parents and professionals.

Council for Exceptional Children
11920 Association Drive
Reston, VA 22091
(703) 620-3660
Provides publications for educators. Can also provide referral to ERIC (Educational Resource Information Center) Clearinghouse for Handicapped and Gifted Children.

Federation of Families for Children's Mental Health
1021 Prince Street
Alexandria, VA 22314
(703) 684-7710
Provides information, support, and referrals through federation chapters throughout the country. This national parent-run organization focuses on the needs of children with broad mental health problems.

HEATH Resource Center
American Council on Education
1 Dupont Circle, Suite 800
Washington, DC 20036
(800) 544-3284
A national clearinghouse on post-high school education for people with disabilities.

Learning Disabilities Association of America
4156 Library Road
Pittsburgh, PA 15234
(412) 341-8077
Provides information and referral to state chapters, parent resources, and local support groups. Publishes news briefs and a professional journal.

National Association of Private Schools
for Exceptional Children
1522 K Street, NW, Suite 1032
Washington, DC 20005
(202) 408-3338
Provides referrals to private special education programs.

National Center for Learning Disabilities
99 Park Avenue, 6th Floor
New York, NY 10016
(212) 687-7211
Provides referrals and resources. Publishes "Their World" magazine describing true stories on ways children and adults cope with LD.

National Clearinghouse for Alcohol and Drug Information
P.O. Box 2345
Rockville, MD 20847
(800) 729-6686
Provides information on the risks of alcohol during pregnancy, and fetal alcohol syndrome.

National Information Center for Children
and Youth with Disabilities (NICHCY)
P.O. Box 1492
Washington, DC 20013
(800) 695-0285
Publishes free, fact-filled newsletters. Arranges workshops. Advises parents on the laws entitling children with disabilities to special education and other services.

Sibling Information Network
A.J. Pappanikou Center
1776 Ellington Road
South Windsor, CT 06074
(203) 648-1205
Publishes a newsletter for and about siblings of children with special needs.

Tourette Syndrome Association
42-40 Bell Boulevard
Bayside, NY 11361
(718) 224-2999
State and local chapters provide national information, advocacy, research, and support.

Credits

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MENTAL RETARDATION AND DEVELOPMENTAL DISABILITIES
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THE CURRENT STATE OF SCIENCE AND THE FUTURE OF SPECIFIC READING DISABILITY

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and The University of Virginia (VC)

We review critical scientific advances in specific reading disability. We summarize research findings relevant to genetic neurobiological, and cognitive etiologies, as well as data related to early identification, developmental course, and response to treatment intervention. Converging scientific findings are applied to the development of a proposed new definition of dyslexia and future research directions are outlined. © 1996 Wiley-Liss, Inc.*
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Key Words: dyslexia, learning disability, definition, developmental course, neuroimaging, treatment

Of all the learning disabilities, reading disabilities have the richest clinical and experimental history. Many sources provide fine-grained analyses of historical and current studies of reading disabilities, including their clinical presentation [Wiederholt, 1974; Liberman, 1989; Shankweiler and Liberman, 1989; Adams, 1990; Doris, 1993], definition and classification [Fletcher and Morris, 1986; Hooper and Willis, 1989; Morris, 1993; Lyon, 1995a, 1995b], neurobiological foundations [Duane, 1991; Duane and Gray, 1991; Hynd et al., 1991; Rumsey, in press], genetic etiology [DeFries and Gillis, 1991; DeFries et al., 1991], and response to treatment [Lyon, 1985a, b; Berninger, 1994; Berninger and Abbot, 1994; Torgesen et al., 1992]. These sources should be consulted for a more comprehensive review of the issues we will discuss here. Readers will note that the terms reading disability and dyslexia are both used in this paper. For the purposes of the discussion, both terms refer to significant deficits in the decoding and recognition of single words [see Lyon, 1995a for a rationale for this criterion].

AMBIGUOUS DEFINITIONS AND THE STATE OF THE SCIENCE IN READING DISABILITY

Despite longstanding recognition of reading disorder as a clinical entity that has significant deleterious effects on children and adults, converging empirical support for reading disability as a valid diagnostic concept has been slow to emerge. The difficulty in establishing a strong empirical scientific base for reading disability can be primarily attributed to the field's recalcitrance in establishing an objective, inclusionary definition and classification system for the disorder [Fletcher and Morris, 1986; Lyon, 1995a, 1995b]. Why is an objective, inclusionary definition so important, and how has the scientific status of the field been hindered in its absence?

As we have pointed out elsewhere [Lyon, 1995a], a precise and inclusionary definition is critical for at least three reasons. First, accurate identification of reading disability requires that the key symptoms and characteristics be specified. Second, treatment of reading disability, including early intervention and general teaching methods, must be based on an informed understanding of the difficulties that impede reading development and mastery for children and adults with the disorder. Third, an operational definition is essential for research purposes. More specifically, without the well-defined subject selection criteria that an operational definition provides, research examining the causes and consequences of reading disability, the existence of different types of the disorder, and the responses of affected individuals to different forms of treatment typically can not be interpreted, replicated, and generalized. From an applied perspective, vague definitions result in capricious clinical decision-making. For example, when definitional criteria are ambiguous and unsupported by research findings, the basis for assigning support services are unclear and numerous inequities exist with respect to who does and does not receive special education. Traditional definitions of reading disability have contributed to the loose conceptual and theoretical thinking about dyslexia.

Historically, early definitions of reading disability or dyslexia have been exclusionary [see Fletcher and Morris, 1986]. Within this context, reading disability is identified if the difficulty in reading exists in the absence of other problems (e.g., mental retardation or sociocultural deprivation) that could lead to it. As Rutter [1978] pointed out, an exclusionary definition "... not only fails to add conceptual clarity, but also implies that dyslexia (or reading disability) cannot be diagnosed in a child from a poor or unconventional background. In short, it suggests that if all the known causes of reading disability can be ruled out, the unknown (in the form of dyslexia) should be invoked" (p. 42).

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In addition, many early definitions such as those advocated by the United States Office of Education [USOE, 1977], cast the identification of reading disability into the broader category of learning disabilities. As Stanovich [1993] has argued, attempting to define reading disability via the general characteristics set out for the extremely heterogeneous category of learning disabilities will result in vague and ambiguous criteria for subject selection—a process guaranteed to obscure any legitimate scientific discovery about the reading process. It should also be stressed that a number of classification scientists [Fletcher et al., 1993; Lyon, 1995a, 1995b] have pointed out that even domain-specific definitions of reading disability such as those developed for the DSM-IV [APA, 1994] and the ICD-10 Classification of Mental and Behavioural Disorders [World Health Organization, 1993] continue to embody vague criteria that are difficult to operationalize. In addition, these definitions continue to recommend the use of IQ-reading achievement discrepancy data in the diagnostic process—a recommendation that recent research suggests is invalid.

Another issue that has confounded scientific progress in reading disability relates to measurement practices designed to operationalize the construct of unexpected underachievement that is inherent in most definitions of reading disability. Unexpected underachievement in reading simply refers to the notion that deficits in reading are hypothesized to be unexpected, and thus can not be predicted by a child's age, intelligence, other academic abilities, exposure to instruction, or sociocultural opportunities. Typically, IQ-reading achievement discrepancy formulas have been employed to provide an objective analysis of the degree of relationship between individuals' general cognitive ability (i.e., IQ) and their reading performance. The more disparate the two scores, the greater the degree of unexpected underachievement.

For at least two major reasons, an IQ-reading achievement discrepancy is an inappropriate and invalid marker for reading disability. First, it is not clear how IQ-achievement discrepancies are to be operationalized and defined [Lyon, 1987, 1988; Aaron, 1989; Share et al., 1989; Zigmond, 1993]. For example, which IQ score and which IQ measure should be employed? Is the Full Scale IQ the most appropriate metric, or should the Verbal or Performance IQ be used as the measure of aptitude or potential ability to read? In addition, which statistical calculation should be used to derive the degree of unexpected underachievement? Should a difference between IQ and achievement standard (Z) scores be employed or should one apply a formula that derives the difference between expected and actual achievement levels based on the regression of IQ and achievement?

Although these psychometric issues are debated, the second and more important question is whether IQ-achievement discrepancies, no matter how they are measured, tell us anything about reading disability. Apparently they do not. If one defines reading disability as deficits in decoding and recognizing single words, a discrepancy between IQ and reading achievement appears to be an invalid marker. Specifically, children with reading disability who have high IQ scores (discrepant poor readers) do not differ from children with reading disability who have lower intellectual aptitudes (nondiscrepant poor readers) on measures assessing decoding and word recognition skills [Olson et al., 1989; Siegel, 1989; Fletcher, 1992; Fletcher et al., 1994; Francis et al., 1994], phonological skills [Fletcher et al., 1994; Stanovich & Siegel, 1994, Shankweiler et al., 1995], genetic characteristics [Pennington et al., 1992; Pennington, 1995], or neurological characteristics [Stanovich and Siegel, 1994]. Simply put, reading disability involving deficits in reading single words is not correlated in any way with IQ discrepancy. This lack of validity demonstrated for IQ-reading achievement discrepancies does not, at least at this point, obviate the conceptual notion that the reading deficits observed in children with reading disability can be characterized as unexpected. As Stanovich [1991] has pointed out, the critical task will be to identify the most valid predictor of an individual's potential to read at the single-word level. Thus, it is quite possible that reading disability may be characterized by poor decoding and word recognition against a background of other cognitive and academic strengths (e.g., listening comprehension), but not expressed as an IQ-reading achievement discrepancy. Clearly, the state of science in reading disability will be advanced as the issue of unexpected underachievement is clarified.

Traditional definitions of reading disability have contributed to the loose conceptual and theoretical thinking about dyslexia.

SCIENTIFIC PROGRESS AND MOMENTUM IN READING DISABILITY

With the increasing recognition that studies on children identified as having reading disability via exclusionary definitions typically lead to difficulties in replicating results, more recent research efforts have begun to investigate reading difficulties in well-defined samples within the context of prospective, longitudinal designs. In contrast to studies of children in schools and clinics who previously were defined as having reading disability on the basis of inconsistent definitional and diagnostic criteria (i.e., using IQ-reading achievement discrepancies), investigations based on prospective, longitudinal designs can provide an opportunity for the same children to be initially studied as they enter the first grade and then repeatedly observed over time. Thus, there is no need for a priori assumptions about what reading disability is, particularly if children are initially identified during preschool or the first grade, then studied for several years within a wide range of cognitive, linguistic, neurobiological, and genetic contexts. In essence, this type of design allows the researcher to test hypotheses about which classification and definitional criteria are the most valid. Prospective, longitudinal studies of reading disability can therefore serve as a research platform to attain a number of goals, including identification of critical cognitive, academic, and behavioral diagnostic characteristics that may be manifested in different ways at different developmental periods; identification of neurobiological and genetic features that predict reading disability; development of valid early predictors of achievement and underachievement in such components of reading as decoding, word recognition, and comprehension; mapping of the developmental course of reading disability; identification of comorbidities and secondary behavioral consequences that develop in response to reading disability; and assessment of the efficacy of different treatment and intervention methods.

During the past decade, the National Institute of Child Health and Human Development (NICHD) within the National Institutes of Health (NIH) has undertaken a substantial effort to

conduct longitudinal research to achieve these goals. Specifically, in addition to a comprehensive 30-year NICHD study of language and reading ability/disability underway since 1966 at the Haskins Laboratory, the NICHD supports Learning Disability Research Centers at Yale University, the University of Colorado, and Johns Hopkins University; Dyslexia Research Projects at the Bowman Gray School of Medicine, Yale University, the University of Colorado, and Beth Israel Hospital/Harvard University; and Reading Disability Treatment/Intervention Research Projects at Florida State University and the University of Houston. Additional Learning Disability Research Centers at the University of Washington, Seattle, and Children's Hospital in Boston (Harvard) came on line in December 1995.

The comprehensive multidisciplinary longitudinal investigations undertaken at these sites (with the exception of those at Beth Israel, which are animal studies) have obtained converging data indicating that deficits in phonological processing reflect a core cognitive deficit in reading disability; that illuminate the neurobiological and genetic underpinnings of phonological deficits; that provide a map of the developmental trajectory of reading disability; and that show, for the first time, how different treatments can alter the course of the disorder [see Lyon, 1995b].

Thus, a science of reading disability is emerging that has its roots in both biology and behavior and that uses the expertise of cognitive neuroscientists, linguists, neurologists, pediatricians, neuropsychologists, radiologists, and educators.

Reading Disability Is a Language-Based Disorder

Data derived from a substantial number of well-designed studies indicates that reading disability typically reflects insufficient phonological processing abilities [Liberman and Shankweiler, 1985; Adams, 1990; Brady & Shankweiler, 1991; Liberman, 1992; Stanovich, 1993; Fletcher et al., 1994; Share and Stanovich, 1995].

A phoneme is the smallest unit of functional sound. Our apprehension of these segments within running speech is made possible by our ability to process phonological information within our brains. Phonological processing has been conceptualized as encompassing at least three different components or skills: phonological awareness, typically assessed by phoneme deletion and rhyming tasks; phonological recoding in lexical access, which can be assessed by rapid naming tasks; and phonetic recoding in working memory, which can be measured by digit- and word-span tasks [for reviews, see Wagner & Torgesen, 1987; Adams, 1990].

Of these three major phonological processing skills, phonological awareness appears to be the most deficient language skill in disabled readers. In a practical sense, phonological awareness is essential in enabling children to map, or translate, printed symbols (letters and letter patterns) to sound. If children cannot perceive the sounds in spoken words—for example, if they cannot "hear" the "at" sound in "fat" and "cat" and perceive that the difference between these sound segments lies in the first sound, they will have difficulty decoding words accurately and fluently [Beck and Juel, 1995].

Thus, a science of reading disability is emerging that has its roots in both biology and behavior and that uses the expertise of cognitive neuroscientists, linguists, neurologists, pediatricians, neuropsychologists, radiologists, and educators.

From an empirical standpoint, there is a wealth of evidence that deficits in phonological awareness not only co-occur with deficits in basic reading skills [Vellutino and Scanlon, 1987; Pratt and Brady, 1988], but that the relationship is, in fact, a causal one, with deficits in phonological awareness impeding the acquisition of reading skills [Wagner and Torgeson, 1987; Catts, 1989; Brady and Shankweiler, 1991; Stanovich, 1993; Olson et al., 1994; Torgesen, 1996]. Indeed, the nature of the English orthography and its alphabetic characteristics rely on this linguistic ability, which allows the reader to segment words into their constituent phonemes. The beginning reader must be conscious of the sound segments in syllables and words and must be able to manipulate them on demand. Such awareness is critical if one wishes to rhyme words, speak in "pig-latin," segment words into syllables and syllables into sounds, and, most importantly, to decode and recognize words accurately, automatically, and fluently. Simply put, limitations in phonological awareness lead to slow, labored, and inaccurate decoding of words, which, in turn, leads to poor reading comprehension [Lyon, 1995a].

Additional candidate linguistic and visual processes have been implicated in reading disability. For example, Wolf and her associates [Wolf et al., 1986; Wolf, 1986, 1991] have argued that reading deficits can also be caused by visual naming-speed deficits, or impairments in precise timing processes underlying rapid retrieval of names for visual symbols. According to Bowers and Wolf [1993], children with both visual naming-speed deficits and phonological deficits are the poorest readers, but children with either deficit alone are significantly less capable in reading than are youngsters who are phonologically adept and rapid namers.

In another line of research, Tallal and her associates [Tallal and Piercy, 1973; Tallal, 1980, 1988] have suggested that the same verbal and nonverbal temporal processing deficits that appear to impede linguistic development in children with language impairment may also be responsible for the reading deficits of children with reading disability. However, we refer readers to Studdert-Kennedy and Mody [in press] for an explanation of some of the difficulties with this research. In short, Studdert-Kennedy and Mody argue that Tallal's interpretation of the data indicating temporal processing deficits in children with reading disability may be confounded by the fact that the children are having difficulty discriminating highly similar tonal and syllabic stimuli rather than difficulties judging their temporal order.

Another potential challenge to a strictly phonological account of reading disability derives from Scarborough's [1990] longitudinal research, which showed that children who would manifest reading deficits by the second grade could be distinguished from their normal-reading age-mates at 30 months of age on a variety of language tasks that assessed, among other abilities, sentence length, semantic knowledge, and syntactical and grammatical complexity. Scarborough's findings suggest that reading disability may be related to a broader language-based deficit that exceeds the boundaries

of a specific phonological core deficit. In addition, Lovegrove and his associates [Lovegrove et al., 1987; Martin and Lovegrove, 1988] have adduced data suggesting that a subgroup of children with reading disability read poorly because of deficiencies in rapid visual orthographic processing. These data remain controversial [Vellutino et al., 1994]. Also, the causal linkages between the visual processing deficits and reading disability that Lovegrove described have not yet been firmly established [Hulme, 1988].

Although deficits in visual naming speed, temporal processing, semantic development, syntactic processing, and visual orthographic skills may ultimately be found to exert some independent influences on the developmental reading process, the current evidence remains no more than suggestive. Specifically, the precise role of these deficits, outside of their association with phonology, is not clearly understood [Lyon, 1995a]. At this time, taken together, the data derived from the longitudinal investigations of reading disability strongly indicate that deficits in phonological awareness constitute the major impediment to learning to read. But how do deficits in phonological awareness interfere with the reading process?

THE SINGLE WORD AS THE CRITICAL UNIT OF ANALYSIS

In essence, reading disability can best be observed as a child or adult attempts to read single words, either in list form or in text. As individuals with reading disability read aloud, one typically observes a labored approach to decoding and recognizing single words that is characterized by hesitations, mispronunciations, and multiple attempts to "sound out" the word. If asked about the meaning of what they have read, the individuals frequently do not know: most of their cognitive resources have been deployed toward deciphering the words. There is no way to bypass this word-recognition stage of reading, and context is of little help [Adams and Bruck, 1995; Beck and Juel, 1995]. In fact, attempting to use context as a strategy to aid the recognition of unknown words actually hampers rather than helps individuals with reading disability because they allocate even more effort to decoding at the expense of comprehension [Stanovich, 1994]. Memorizing each word in the English language as a whole is impossible, given the sheer number of words. Unless would-be-readers learn to decode and recognize single words rapidly, accurately, and fluently, information will not be easily available to them through print.

This description of reading disabled individuals attempting to read reflects three well-replicated scientific findings. First, although reading is a meaning-driven activity, the key to meaning for proficient readers starts with the immediate and accurate recognition of a single written word [Adams, 1990; Adams and Bruck, 1995; Beck and Juel, 1995]. This finding is one of the most robust in the reading, cognitive, and developmental literatures; it has been obtained by research teams in the United States [Felton and Brown, 1989; Olson, et al., 1989; Fletcher et al., 1994; Olson et al., 1994; Vellutino et al., 1994], Canada [Lovett, 1987; Lovett et al., 1988; Bruck, 1988, 1990, 1992; Siegel, 1989; Stanovich, 1991, 1992, 1993, 1994], Great Britain [Goswami and Bryant, 1990; Snowling, 1990], and New Zealand [Tunmer & Nesdale, 1985; Tunmer and Hoover, 1993]. Although this discovery may appear to be at odds with the argument that reading comprehension is the most salient ability in reading development [Goodman, 1986; Smith, 1971], comprehension depends on the ability to decode and recognize single words rapidly and accurately [see Stanovich, 1994 for an excellent discussion of this point].

Unless would-be-readers learn to decode and recognize single words rapidly, accurately, and fluently, information will not be easily available to them through print.

Children and adults with reading disability are not impaired in their ability to use contextual clues to aid in word recognition. In fact, children with reading disability consistently have been found to rely more than do skilled readers on the semantic clues available in print to assist them in decoding unknown words [Perfetti, 1985; Bruck, 1990]. Unfortunately, as noted previously, this compensatory device actually impedes the efforts of individuals with reading disability and further reduces speed and automaticity in reading. In short, the locus of difficulty for children with reading disability involves acquisition of the skills necessary to read single words.

Deficits in single word decoding and word recognition reflect the specific impact of the deficits in phonological awareness discussed earlier. Difficulties in understanding that phonological segments can be mapped onto letters and letter patterns are a function of the child not understanding that syllables and words are composed of constituent sounds (phonemes) and that these segments can be parsed according to their acoustic boundaries. For individuals with reading disability, this metalinguistic awareness that words have parts is difficult to understand because the phonemes within syllables and words cannot be heard by the ear [Liberman et al., 1967; Liberman, 1992]. Rather, phonological awareness is made possible by the intact functioning of the brain. In many individuals with reading disability, the brain is not processing specific types of linguistic information in an efficient manner.

THE GENETICS AND NEUROBIOLOGY OF READING DISABILITY

Several papers in this issue address the genetic and neurophysiological substrates of reading disability, but we include a brief overview to emphasize the substantial contributions that behavioral and molecular genetics, neuropsychology, and neuroimaging have made to establishing a science of reading disability. During the past twenty years, a wealth of evidence has been obtained suggesting that reading disability aggregates in families, is heritable, and probably reflects autosomal dominant transmission [see Pennington, 1995, for a comprehensive review]. In addition, recent studies using genetic linkage analyses suggest that there are effects of major genetic loci on the transmission of phonological deficits and subsequent reading problems [Cardon et al., 1994; Pennington, 1995].

The specific mechanisms by which genetic factors operate to predispose someone to reading disability are not yet clear. As Pennington [1995] suggests, it is possible that genetic alterations in dyslexia alter or constrict the range of neural development and, perhaps, produce "hardwired" aberrations in the neural tissue substrate [for examples of the neuroanatomical correlates of reading disability, see Galaburda and Kemper,

1979; Rumsey et al., 1986; Galaburda, 1988, 1991; Hynd et al., 1991; Rumsey et al., in press]. It has been hypothesized that such changes in dynamic neural development can compromise emerging neural systems, typically within the left cerebral hemisphere, which are involved in accessing and interpreting linguistic information. For example, previous and ongoing research suggests that poor phonological processing is associated with atypical cortical activation in the left temporal region, as indicated in studies of regional cerebral blood flow [Wood, 1990; Wood et al., 1991]. A number of recent studies employing positron emission tomography (PET) [Rumsey et al., 1995; Rumsey, in press] suggest that the phonological deficits in reading disability are strongly related to decreased activation of the left temporoparietal and superior temporal cortex. Additional functional neuroimaging work [Shaywitz et al., 1995; Shaywitz et al., in press] has shown that anterior regions of the brain are also activated during the performance of a rhyming or phonological task. These findings are important because they demonstrate the utility and precision of noninvasive functional neuroimaging methods that can be used safely with children.

Given the experimental nature of the current neuroimaging research involving children and adults with reading disability, caution should be exercised in interpreting the results at this time. Nevertheless, the technological explosion in the development of neuroimaging methods and instruments, coupled with improvements in task-activation paradigms, bodes favorably for scientific understanding of the neurobiological foundations of reading development and disability. For comprehensive reviews of these advances, see Lyon and Rumsey [in press], Thatcher et al. [in press], and Krasnegor et al. [in press] for comprehensive recent reviews of these advances.

THE ISSUE OF CORMORBIDITY

As we have pointed out, converging data have clearly shown that the linguistic abilities causally related to learning to read involve phonology, with deficits in phonological awareness best predicting poor reading behavior at the single-word level [Wagner and Torgesen, 1987; Ball and Blachman, 1991; Torgesen, 1988; Catts, 1989; Juel, 1988; Cunningham, 1990; Kahnu et al., 1990]. It is important to note that phonologically based reading disability can co-occur with other linguistic/cognitive deficits as well as with attention-deficiet disorder (ADD). Within the linguistic domain, it is highly possible that the phonological deficit is also the etiological culprit in the development of abilities in spelling and written expression [Ehri, 1989; Moats, 1994; Fowler and Liberman, 1995]. Specifically, deficits in spelling and writing typically share some of the same core deficiencies in phonology [Lindamood, 1994], as do more general deficits in many levels of oral language [Scarborough, 1990; Johnson, 1994].

In contrast, even though reading disability and ADD frequently co-occur in both referred samples (40% co-morbidity) and nonreferred epidemiological samples (15% co-morbidity) [Shaywitz et al., 1994] the two disorders are distinct and separable. Reading disability is most highly associated with deficits in phonological awareness; the effects of ADD on cognitive functioning are variable, with primary deficits in rote verbal learning and memory and limited association with retrieval and phonological deficits [Wood et al., 1991; Ackerman et al., 1994]. Although reading disability and ADD reflect different etiologies, it is clear that ADD exacerbates the severity and cognitive morbidity of reading disability [Wood et al., 1991].

During the past twenty years, a wealth of evidence has been obtained suggesting that reading disability aggregates in families, is heritable, and probably reflects autosomal dominant transmission.

The development of any biological and cognitive science of reading disability requires that distinctions and interrelationships between different types of disorders be identified and clarified. The failure to develop classifications that account for co-morbidity has been an important factor in our persistent difficulties in establishing a reliable and valid definition of reading disability or dyslexia [Fletcher and Morris, 1986; Fletcher et al., 1993]. The state of the science in this regard is rapidly improving.

ADVANCES IN TREATMENT INTERVENTION RESEARCH

The finding that reading disability frequently is related to and, probably, caused by deficits in phonological awareness has provided a strong empirical foundation for the conduct of treatment intervention studies. Because phonological deficits can be identified in kindergarten and first grade [Blachman, 1991], systematic studies of the effects of early interventions can be conducted. Within this context, a number of well-designed longitudinal treatment or intervention studies have been conducted during the past five years by Blachman and her associates [Ball and Blachman, 1991; Blachman, 1991; Blachman et al., 1994], Torgesen and his group [Torgesen et al., 1992, 1994, in press], and Foorman [1995]. The data from these studies indicates that children with phonologically based reading disability require treatment programs composed of direct and explicit instruction in phonemic awareness combined with instruction to develop sound-symbol relationships via synthetic phonics instructional methods. It should be noted however, that all the research groups cited here have found that even with highly intensive and informed instruction, a number of children are resistent to the treatments given. This consistent finding points out the stability of severe deficits in phonological processing skills, as well as the need to examine the ways in which additional child characteristics (such as home and family background, demographic variables, and linguistic and dialectical characteristics) interact with specific treatment methods and approaches. What is clear from both the epidemiological and treatment studies is that early identification and early intervention are critical to helping children with reading disability gain facility in reading. As Shaywitz et al. [1994] have reported, if youngsters with reading disability are not identified and provided with intervention before reaching nine years of age, at least 74% of them will remain disabled throughout their high school years.

FUTURE RESEARCH DIRECTIONS

We have addressed the role of definition in the conduct of science in the area of reading disability and, in particular, the role that poorly constructed definitions have played in our persistent inability to unravel the mysteries of reading disability. Perhaps the best example of the current state of science relating to reading

disability can be found in the new definition of dyslexia proposed by the Orton Dyslexia Society discussed in detail by Lyon [1995a]. The new definition is as follows:

> Dyslexia is one of several distinct learning disabilities.
>
> It is a specific language-based disorder of constitutional origin characterized by difficulties in single word decoding, usually reflecting insufficient phonological processing. These difficulties in single word decoding are often unexpected in relation to age and other cognitive and academic abilities; they are not the result of generalized developmental disability or sensory impairment. Dyslexia is manifest by variable difficulty with different forms of language, often including, in addition to problems reading, a conspicuous problem with acquiring proficiency in writing and spelling.

We cite this definition to underscore the scientific progress that has been made in our understanding of reading disability (dyslexia) during the past decade. In contrast to previous definitions, this one is inclusionary rather than exclusionary. It makes explicit, operational data-based statements about the phenotypic expression of reading disability (deficits in single word decoding); the proximal cause of such deficits (insufficient phonological processing); the genetic and biological underpinnings of the disorder (language-based disorder of constitutional origin); and its clinical presentation (unexpected in relation to age and other cognitive and academic abilities). In its last sentence, this definition also addresses the issue of co-morbidity, and is careful to limit exclusionary statements to only those conditions that have a distinctly different etiology (generalized developmental disability or sensory impairment). It is most important to note that the definition has evolved directly from replicated research efforts. Certainly, the criteria specified in this definition are dynamic and subject to modification as new data become available. However, if science continues to prevail, any additions or modifications will be data-driven rather than policy-driven.

Future research efforts at the NICHD will continue to concentrate on the development of a valid and operational classification system for reading disability. In addition, emphasis is being placed on the development of instruments and intervention programs that will have the highest probability of success in identifying at-risk children and applying efficacious treatment intervention programs. Substantial energy will be devoted to the application and interpretation of noninvasive structural and functional neuroimaging modalities to achieve better understanding of the linkages that exist among genotype, brain, and phenotype. The information derived from these research initiatives will be used to close the gap between observing and appropriately addressing the learning needs of children and adults with reading disability. ■

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NICHD RESEARCH PROGRAM IN LEARNING DISABILITIES

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RESEARCH ARTICLES

In 1985, the Health Research Extension Act was passed by Congress and signed into law by the President (Public Law 99-158). This Act mandated the establishment of a Federal Interagency Committee on Learning Disabilities which was charged with the task of making specific recommendations to increase the effectiveness of research in learning disabilities. The National Institute of Child Health and Human Development (NICHD) was selected to lead this effort. The Interagency Committee thus recommended that new research be conducted that was long-term, prospective, longitudinal, and multidisciplinary in nature.

In response to this challenge, the NICHD initiated the development of a collaborative research network that now is composed of five learning disability research centers (LDRCs), four multidisciplinary research programs for the study of dyslexia, and three large research programs devoted to the study of treatment and intervention approaches for language-based reading disabilities. The LDRCs are located at the University of Colorado, Yale University, Johns Hopkins University, Harvard University, and the University of Washington-Seattle. The Dyslexia Research Programs are located at Beth Israel Hospital in Boston, Bowman- Gray School of Medicine in Winston-Salem, Yale University, and the University of Colorado. The three dyslexia treatment research programs are located at Florida State University, the University of Houston, and Georgia State University.

HOW THE PRESENT RESEARCH DIFFERS FROM RESEARCH IN THE PAST

Until 1985, the study of learning disabilities (LD) had not been effectively coordinated. Studies were typically conducted on biased samples, obviously leading to biased results. Specifically, the majority of studies conducted during the 1960s, 1970s, and 1980s were carried out with children (and adults) who had been identified as LD according to widely varying definitions and criteria. For example, studies involving individuals with LD in Iowa would obtain different findings from studies undertaken in Florida, primarily because the samples selected for study were different. The state or local criteria for the identification of LD differed and thus the samples differed. No doubt this haphazard research strategy led to predictable difficulties in replicating and generalizing research findings.

In addition, the majority of studies of LD over the past 20 years have attempted to understand the disorder by studying individuals who were grouped according to the vague and ambiguous label "Learning Disabled." This was unfortunate. The LD category is actually composed of seven different types of disabilities, each of which is significantly different from the others. As a number of scientists have recently pointed out, it simply makes little sense to conduct investigations of some broadly defined entity called "learning disability" given what we already know about the differences between the various types of learning disabilities. Thus, the NICHD LD Research Program defines groups specifically in terms of their specific deficit (i.e., reading disability, mathematics disability, etc.) prior to study. By insuring that the research is focused on specific types of LD, rather than the general category, and by conducting investigations in a prospective longitudinal fashion, the NICHD has begun to obtain highly replicable results that have clinical significance.

The longitudinal nature of the NICHD research is of critical importance. In the main, studies are initiated with children before they enter school and the children are then followed and studied as they proceed through school. This research strategy serves as a platform to (1) identify critical learning and behavioral characteristics that may be manifested different ways at different developmental periods, (2) develop early predictors of academic difficulties, (3) map the developmental course of specific types of LD, (4) identify commonly co-occurring disorders and secondary behavioral consequences that develop in response to failure in school, and (5) assess the efficacy of different treatments and teaching methods for the different types of LD.

WHAT HAS BEEN LEARNED?

During the past 10 years, NICHD research has concentrated on reading disabilities as a specific type of LD. This is because reading disabilities are the most common type of LD and clearly the most damaging in terms of an individual's school learning, school adjustment, and occupational and vocational success. By focusing on reading disabilities, NICHD researchers have now been able to replicate several findings related to the etiology (causes), developmental course, cognitive features, and biological characteristics of reading disabilities, as well as to the effectiveness of different treatment/intervention approaches. These findings are summarized below:

- Definitional issues continue to be the single greatest impediment to understanding learning disabilities and to helping children and adults with LD.
- The use of the general term "learning disabilities" in research practice may hinder our ultimate understanding of the causes, developmental courses, and outcomes of the specific types of disabilities subsumed within the LD category. The research community must grapple with the need to address each type of LD in its own right in order to arrive at clear definitional statements and a coherent understanding of etiology, diagnosis, prevention, and treatment. This particular finding does not, in any way, detract from the clear need to continue to use the term learning disabilities in forging public policy and advocating for the millions of individuals whose lives are affected by LD.
- Language-based reading disabilities are the most prevalent type of LD and affect approximately 17% of school-age children to some degree. This type of reading difficulty is typically reflected in inaccurate and slow decoding and word recognition. This laborious reading of single words frequently impedes the individual's ability to comprehend what has been read, even though listening comprehension is adequate.
- While other factors will no doubt be identified as contributing to reading disability, deficits in phonological processing appear to reflect the major impediment to learning to read. Deficits in phonological processing are characterized by difficulties in segmenting syllables and words into constituent sound units called phonemes—in short, there is a difficulty in turning spelling into sounds.
- Deficits in phonological processing can be identified in late kindergarten and first grade, and the presence of these deficits is a strong indicator that difficulties in learning to read will follow.
- Deficits in phonological processing appear to be heritable, as shown in both behavioral and molecular genetic studies. Likewise, language-based reading disabilities are highly related to significant dif-

ferences in neural processing.

■ Although we now have the ability to identify children who are at-risk for reading failure, and we now understand some of the instructional conditions that must be considered for teaching, the majority of LD readers are not identified until the third grade. This is apparently too late. Seventy-five percent of children identified after nine years-of-age continue to demonstrate reading difficulties throughout high school.

■ Despite the widely-held belief that boys are more likely to have reading disabilities than girls, research has shown that as many girls as boys have difficulties learning to read. More boys are identified by teachers in school because of their tendency to be more rowdy and active than girls.

■ The most powerful interventions that have been identified for reading disabilities to date consist of a combination of explicit instruction in phonemic awareness, explicit instruction in sound-symbol relationships (phonics), and direct and integrated instruction in text reading and comprehension. This balanced approach appears to be necessary for adults as well as children with reading disabilities.

Deficits in phonological processing appear to reflect the major impediments to learning to read

■ Unfortunately, teachers remain seriously unprepared to address individual differences in many academic skills, but particularly reading. However, teachers cannot be expected to know what they have not been taught. More specifically, current university-based teacher preparation programs have been found to be inadequate for the preparation of teachers to address reading disabilities and other types of LD.

WHAT THE FUTURE HOLDS

During the next five years, the NICHD will continue to conduct prospective longitudinal studies of language and reading disabilities and will expand these programs to include investigations of disabilities in written language, mathematics, and social behavior. In addition, the NICHD research will focus on the study of disorders of attention and the relationship of such disorders to difficulties learning to read, write, and to develop competencies in arithmetic calculation and mathematics reasoning.

The NICHD will also continue to design, conduct, and support neuroimaging and other neurophysiological studies that provide a window on the relationship between the developing brain and the ability to learn. We need to better understand how the brain is organized for complex behaviors, and to know more specifically how the child with learning disabilities and the child without such disabilities differ with respect to central nervous system functioning. Within this context, it is important for us to know how neurophysiological and neuroanatomical differences are related to genetic factors and to environmental influences.

Very importantly, we will be expanding our basic and applied research programs to understand how different treatment and teaching interventions affect well-defined learning deficits in children with learning disabilities. It is critical that we identify the teaching conditions that must be in place in order to help youngsters develop competencies in academic and social skills. We must develop a better understanding about which preventative strategies and/or treatment interventions are most effective for particular types of learners at different stages of development, in different content areas, and in different settings. It is our view that our future ability to prepare professionals to teach children with learning disabilities would necessarily depend on a clear understanding of these conditions. ■

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