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Assessment of Reading and Learning Disabilities A Research-Based Intervention-Oriented Approach

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Assessment practices for children with learning disabilities (LD) in reading are driven by the three primary components of the federal definition of LD: discrepancy, heterogeneity, and exclusion. This article reviews the implications of these three components for the assessment of children with reading disabilities and other forms of LD. We propose a rationale and procedures for more efficient approaches to the identification of children as learning disabled in reading or at-risk for these disabilities that are aligned with research on reading disabilities and other forms of LD. This approach emphasizes the assessment of academic skills and their components in an effort to develop intervention plans. Intelligence tests are not necessary for the identification of children as learning disabled and do not contribute to intervention planning. © 2002 Society for the Study of School Psychology. Published by Elsevier Science Ltd

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Over the past 30 years, considerable evidence has accumulated concerning how children learn to read and why some experience difficulties. This research has produced new insights into the nature of learning disabilities (LD) in reading and how such disabilities should be assessed, and has led to new assessment procedures. However, procedures used to assess children in schools, especially as part of the determination of eligibility for special education services, continue to be dominated by conventional and, we

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will argue, now obsolete interpretations of the federal definition of LD. The purpose of this article is to present a rationale and procedures for evidence-based approaches to the assessment and identification of children as learning disabled in reading or at-risk for these disabilities that are more efficient than current approaches. We suggest that assessments should be completed with a primary goal of enhancing intervention.

The article has three sections. The first section reviews the three major components of the federal definition of LD—discrepancy, heterogeneity, and exclusion—with an eye toward their implications for assessment. The second section discusses alternative approaches to assessment that are based on the emerging research base on reading development and reading disabilities, including a conceptual framework for assessment and applications to reading disabilities. The third section expands the discussion of assessment into the area of early identification and screening.

FEDERAL DEFINITION OF LD AND ASSESSMENT

The assessment of reading disabilities and other forms of LD has been heavily influenced by the federal definition of LD adopted by the U.S. Office of Education in 1969. This definition was continued when Public Law 94-142 was adopted in 1975 and is presently in its reauthorization as the Individuals with Disabilities Education Act (IDEA) of 1992 and 1997. Perhaps more important than the federal definition is the operationalization suggested by the U.S. Office of Education in 1977 and maintained in IDEA when states indicated that the federal definition of LD did not provide clear guidelines for identification:

A severe discrepancy between achievement and intellectual ability in one or more of the following areas: (1) oral expression; (2) listening comprehension; (3) written expression; (4) basic reading skill; (5) reading comprehension; (6) mathematics calculation; or (7) mathematic reasoning. The child may not be identified as having a specific learning disability if the discrepancy between ability and achievement is primarily the result of: (1) a visual, hearing, or motor handicap; (2) mental retardation; (3) emotional disturbance, or (4) environmental, cultural, or economic disadvantage. (United States Office of Education, 1977)

These criteria suggest that there are three essential components in the federal definition of LD: discrepancy, heterogeneity, and exclusion. Each of these components can be represented as hypotheses about how academic deficiencies should be classified, with different implications for assessment.

Discrepancy Hypothesis

According to the 1977 operationalization of federal definition, LD is indicated when a child exhibits a severe discrepancy between achievement and

intellectual ability. When originally proposed, this stipulation was not inconsistent with studies suggesting that IQ discrepancy demarcated a specific type of reading disability (Rutter & Yule, 1975). Thus, in practice, the definition suggests that intelligence (IQ) and achievement tests are necessary to identify LD. Children are eligible for special education as learning disabled if their achievement test score is some degree below their IQ score. The amount of discrepancy and how it is calculated varies from state to state, but some form of discrepancy is used by most states (Mercer, Jordan, Allsop, & Mercer, 1996). Although test scores are not the sole basis for eligibility as LD in IDEA, a typical assessment in the schools almost always includes IQ tests and achievement tests (MacMillan & Siperstein, in press). Recent conceptual models that attempt to operationalize determination of LD begin with the presence of a discrepancy (Kavale & Forness, 2000). Regardless of the regulations, IQ scores have a firm foothold on eligibility. Higher scores on an IQ test, as opposed to lower scores on an achievement test, are often the critical factor that results in a determination that a child is eligible for special education under the LD category. In practice, IQ test scores are often sorting low-achieving children.

This sorting reflects an implicit classification hypothesis that low achievement in the face of discrepancy is different from low achievement in its absence. Unfortunately, as Sternberg and Grigorenko (this issue) suggested, the conceptual and empirical bases of the IQ-discrepancy classification hypothesis are weak, and the studies that originally supported the IQ-discrepancy model have not been replicated (Fletcher et al., 1998).

To illustrate, a forthcoming empirical synthesis of research on this classification hypothesis by Stuebing et al. (2001) as well as another recent meta-analysis (Hoskyn & Swanson, 2000) support this conclusion. Stuebing et al. (2001) synthesized 46 studies that compared groups composed of poor readers who met explicit criteria for IQ discrepancy or low achievement. These studies were derived from a review of several hundred articles completed from 1973–1998 that potentially addressed the validity of the discrepancy hypothesis. The 46 studies met multiple criteria for inclusion and exclusion, the most important of which required explicit discrepancy criteria to form the IQ-discrepant group, and an indication that the low-achieving nondiscrepant group did not include individuals who might be IQ-discrepant or typically achieving readers.

Stuebing et al. (2001) coded these 46 studies and computed overall differences between IQ-discrepant and low-achieving groups (effect sizes) in behavior, achievement, and cognitive ability domains. An effect size difference of 0 indicates complete overlap of the two groups, whereas effect sizes $>.2$ are considered small; $>.5$ are considered medium; and $>.8$ are considered large. They found negligible aggregated effects for the behavior domain ($-.05$, 95% confidence interval = $-.14$, $.05$) and achievement domain ($-.12$, 95% confidence interval = $-.16$, $-.07$). A small effect size was

found for the cognitive ability domain (.30, 95% confidence interval = .27, .34). The effect sizes for the behavioral domain were consistent across types of behaviors, but there was evidence that the effect sizes may vary depending on which tasks in the achievement and cognitive ability domains were examined.

When the specific tasks within the achievement domain were evaluated, those that involved word recognition, oral reading, and spelling showed small effect sizes, indicating poorer performance by the IQ-discrepant groups. However, tasks involving reading comprehension, math, and writing yielded negligible effect sizes. The small effect sizes for the former measures may reflect their similarity to the types of tasks used to define poor readers in many of the studies. Similarly, those cognitive abilities closely related to reading yielded negligible effect sizes: phonological awareness (-.13, 95% confidence interval = -.23, -.02), rapid naming (-.12, 95% confidence interval = -.30, .07), memory (.10, 95% confidence interval = -.01, .19), and vocabulary (.10, 95% confidence interval = -.02, .22). Thus, even the core cognitive skills that research (see Torgesen, this issue) has shown to underlie reading disability do not discriminate between IQ-discrepant and low-achievement groups. Not surprisingly, measures of IQ yielded large effect size differences, whereas measures of cognitive skills similar to those measured by IQ tests (spatial cognition, concept formation) yielded small-to-medium effect sizes, the direction of both showing better performance by the IQ-discrepant group. However, even with the inclusion of these measures of cognitive ability, the overall difference across the 46 studies was only about three tenths of a standard deviation, demonstrating substantial overlap between the group. Other analyses indicated that the size of the effects in different studies could be predicted simply by knowing the scores on the IQ and reading tasks used to define the groups (i.e., sampling variation across studies) and the correlation of these definitional variables with the tasks used to compare the two groups. Like Sternberg and Grigorenko (this issue) and Hoskyn and Swanson (2000), Stuebing et al. (2001) concluded that classifications of LD based on IQ discrepancy had, at best, weak validity.

Such findings strongly question the need for IQ tests in *identifying* children with LD in reading and, most likely, in other academic areas (Fletcher et al., 1998, in press; Siegel, 1992). As Sternberg and Grigorenko (this issue) point out, there are also no treatment implications stemming from the use of IQ tests. Such measures certainly do not indicate a child's aptitude for mastering academic skills. There are major psychometric issues involved in the interpretation of difference scores. Irrespective of the research, the application of IQ tests to identify children as learning disabled is essentially an example of "milk and jug" thinking epitomized by the following statement by Sir Cyril Burt: "Capacity must obviously limit content. It is impossible for a pint jug to hold more than a pint of milk and

it is equally impossible for a child's educational attainment to rise higher than his educable capacity" (1937, p. 477).

In response, Share, McGee, and Silva (1991) suggested:

It is very likely that broad-based tests such as the WISC and Stanford-Binet, which include a diversity of educationally relevant tasks, are indeed the best predictors of *general* educational achievement. But professional preoccupation with IQ, stemming in part from "milk and jug" conceptions, is liable to obscure those significant advances achieved over the last 15 years in the field of reading research that have enabled us to identify domain-specific factors (such as phonological processing) that are more potent than all-purpose measures, such as IQ... More importantly, these domain specific factors go much farther than IQ in helping us understand and deal with reading failure... the dearth of studies directly investigating the diagnostic validity of IQ-based classification highlights the stranglehold that traditional "milk and jug" notions about IQ and reading have exercised over thinking about reading failure. (p. 697)

Current research indicates that every healthy child can learn to read provided the child does not have generalized mental deficiency. As such, every child who is behind in reading is working below their potential. The challenge is to discover and remediate the child's underlying difficulties, whether they be cognitive, instructional, and so forth. Performance on IQ tests does not facilitate this process. Rather, the assessment of "domain specific factors" is very important (Share et al., 1991; Torgesen & Wagner, 1998).

Heterogeneity Hypothesis

The heterogeneity hypothesis suggests that LD may manifest itself as a disorder involving speaking, listening, basic reading (word recognition), reading comprehension, math calculations, math reasoning, and written expression. Moreover, a child may have a disorder in more than one of these domains. Thus, in addition to an IQ test as the primary inclusionary criterion, federal guidelines suggest that it may be necessary to assess multiple achievement domains in order to qualify a child. However, a single definition for LD can be applied to each of these potential forms of LD based on the presence of IQ discrepancy and different exclusionary criteria.

There is evidence for the heterogeneity hypothesis. However, the notion that a single definition can be used does not do justice to the variations in the neurobiological and cognitive correlates and required interventions associated with these academic domains (Lyon et al., 2001). Moreover, there is insufficient evidence that all the domains represented in the federal definition are distinct types of LD or that all possible types of LD are included in the federal definition of LD. Finally, specifying these domains indicates only the manifestations of LD. Remediation must focus on the basis for the academic difficulties. There are empirical and conceptual considerations of heterogeneity, especially the question of which domains should be rep-

resented as LD—and which ones are missing—that we will briefly outline here and return to below in a discussion of the assessment of reading disabilities.

Consider first that disorders of speaking and listening are essentially oral language disorders. As these disabilities are incorporated in IDEA under the speech and language category, the need for their inclusion in the LD category is not well established. Moreover, difficulties in listening comprehension typically parallel problems with reading comprehension (Shankweiler et al., 1999; Stothard & Hulme, 1996). It is likely that children cannot understand written language any better than they can understand oral language. Most studies comparing reading and listening comprehension show high levels of overlap between the two in normative samples. It is possible that there are some cases in which a dissociation of listening and reading comprehension occurs, such that reading comprehension is better than listening comprehension. Regardless, any phonological, syntactic, or semantic problems that hinder oral language comprehension will also affect the ability to read written text or even to comprehend when someone reads them the text. The conceptual basis for including disorders of listening and speaking is not well established.

In turning to reading, there is strong evidence for disabilities in reading at the level of words (basic reading) and texts (reading comprehension). However, what about reading speed? There is evidence that disabilities in reading speed can occur in children who are accurate word readers and that this problem affects reading comprehension even in children who have adequate listening comprehension (Wolf & Bowers, 1999). There is also some evidence that not all slow readers are poor comprehenders, although these studies examine text reading speed and do not specifically select children with word-level reading disorders (Oakhill, 1993; Rankin, 1993). The issue of reading speed needs more study and should be assessed in any child suspected of LD.

Problems with math calculations have been studied and there is evidence that difficulties completing math computations may demarcate a specific type of math disability (Rourke, 1993). There is little research on a disorder of math reasoning, nor has much attention been paid to possible difficulties with other branches of mathematics that have less to do with numbers and arithmetic. In any event, a disability of math reasoning has not been well defined and is difficult to conceptualize. Many domains of mathematics, including math computations, likely require some type of reasoning such as logical reasoning abilities and abstraction skills (Devlin, 2000).

Finally, there is evidence for difficulties involving written expression (Berninger & Graham, 1998; Graham & Harris, 2000; Graham, Harris, & Fink, 2000). The research base is not large, and it is not clear whether such difficulties involve problems with spelling, handwriting, or writing at the

level of text. These problems have different correlates: spelling in conjunction with problems involving phonological analysis, knowledge of orthographic conventions specific to the child's language of instruction, and word recognition; handwriting in children with fine motor, motor planning, and working memory difficulties (with respect to the need for rapid retrieval of orthographic representations); and disorders of written expression in children with more pervasive oral language and reading difficulties (Berninger & Graham, 1998).

The example of written expression also makes clear that one of the assessment issues involving the heterogeneity hypothesis is that of overlap. Some children with word recognition problems have problems with math calculations and/or written expression. In some instances, the underlying cognitive difficulties express themselves in more than one domain, often reflecting the pervasiveness of difficulties with language development. For example, poorly developed phonological memory skills may be related to reading disability and math disability in some children (Geary, 1993; Swanson & Siegel, in press). In other instances, there is a true "comorbid" association, meaning that the child has more than one disorder, with more than one underlying set of core cognitive difficulties.

Exclusion Hypothesis

Exclusion indicates that LD is not identified when the "primary" cause is mental deficiency, sensory disorder, emotional disturbance, cultural, social, or economic disadvantage, or inadequate instruction. Stipulating that LD is not due to mental deficiency or sensory disorders is reasonable, as these children have different intervention needs. Admittedly, there are issues with distinctions between mental deficiency and LD that make the precise demarcation unclear, but information beyond IQ tests is essential for identifying mental deficiency (MacMillan & Siperstein, in press). It is not necessary to give an IQ test to every child referred for LD to make the determination that the child is not mentally deficient. Ultimately, it is the child's intervention needs and not test scores that should guide decisions by the interdisciplinary team.

It is important to recognize that these exclusions stem from policy decisions that involved the need to avoid the comingling of special education and compensatory education funds as well as the existence of other eligibility categories in IDEA (e.g., mental retardation, emotional disturbance). Although exclusion does not necessarily directly impact psychometric assessment, IDEA requires that these potential "causes" be considered as part of the LD eligibility process. Keep in mind that the original exclusionary definitions were meant not to exclude children from placement, which has been the practical outcome, but to better classify the child's difficulties so that treatment could be specific to the disability.

From an intervention perspective, whether such distinctions are productive is not well established. The problem is that the cognitive correlates of academic difficulties in children with achievement deficiencies attributed to emotional disturbance, inadequate instruction, and cultural, social, and economic disadvantage do not appear to be different according to these putative causes relative to children identified as learning disabled. Moreover, the intervention needs, response to intervention, or mechanisms whereby interventions work do not appear to vary according to these factors (Fletcher et al., in press; Lyon et al., 2001). As such, these distinctions are not strongly related to the types of intervention programs that are likely to be effective, especially in reading. Of particular concern is the idea that inadequate instruction precludes LD when, in fact, it may cause LD.

What is important for assessment is to be aware of the contextual variables that impact the child's test performance. Some of these exclusionary variables may reflect factors considered intrinsic to the child, such as a family history of reading problems. Others may reflect environmental factors such as the language spoken in the home or adverse economic circumstances. Many behavioral difficulties are not causal, but actually reflect comorbid associations in which the child has more than one difficulty. For example, 30–70% of children with a reading disability also have evidence for attention deficit/hyperactivity disorder (ADHD; Shaywitz, Fletcher, & Shaywitz, 1997). For ADHD, a recent consensus report from the American Academy of Pediatrics (2000) estimated that 25% have reading disabilities and that 33% have a disruptive behavior disorder. The reading disability and ADHD do not interact, but are additive, in that children who have both disorders tend to have poorer cognitive skills (Fletcher, Shaywitz, & Shaywitz, 1999). However, the child appears reading disabled when examined through the cognitive lens and appears ADHD when examined through the behavioral lens. Both components of the child's difficulties may require intervention. So, the exclusions are often other factors that must be considered when developing an intervention plan for the child.

Summary

This review of the discrepancy, heterogeneity, and exclusion hypotheses suggests the need for alternative definitions of LD that, in turn, would lead to alternative approaches to assessment and identification. There is little evidence that IQ tests are either necessary or sufficient for the identification of LD. Heterogeneity mandates that multiple academic domains be examined, particularly because the cognitive correlates and intervention needs vary. A single definition may not be adequate, and inclusionary definitions that specify what LD is—not what LD is not—may lead to more efficient and targeted assessments of children potentially identified as learning disabled. Finally, factors that are typically seen as exclusionary may

actually function as important inclusionary factors that will promote understanding of the context in which the LD has developed. In the next section, a comprehensive model of assessment will be provided that suggests an alternative approach to assessment. This approach takes advantage of what we know from research, does not require IQ tests, and focuses instead on component-based assessments of academic skills and cognitive domains. The goal is to use assessment information derived from research to inform evidence-based instruction.

ASSESSMENT OF LD AND READING DISABILITIES

In approaching assessment of LD, it is important to recognize that the strict use of test scores to set cut-points for eligibility purposes is a complex and difficult proposition. Achievement test scores—like IQ test scores—are continuous and largely normally distributed, especially within two standard deviations of the mean. The tests used to measure these domains have measurement error. Any attempt to set a cut-point will lead to instability around the cut-point, as scores fluctuate back and forth across the cut-point upon repeat testing, even for something as transparently straightforward as demarcating low achievement. This problem of scores fluctuating back and forth across the cut-point is not a problem of repeat testing, nor is it a problem of picking the “right” cut-score. The problem stems from measurement error and the fact that no single score perfectly measures a student’s ability in a single domain. The extent of fluctuation will also vary from test to test, depending, in part, on the location of the cut-score, as tests are more or less precise in various ranges of the ability scale.

A second problem with the typical use of cut-scores concerns the arbitrary nature of cut-points. The use of norm-referenced as opposed to criterion-referenced tests in setting cut-scores exacerbates the problem, but not because norm-referenced tests experience more fluctuation around the cut-point. Rather, a cut-point on a norm-referenced test represents an arbitrary and relative standard of performance for identifying that a problem exists, rather than setting an absolute standard. The arbitrariness does not reflect lack of association of a cut-point with detection of a problem. The cut-point is arbitrary in the sense that distinctions between, for example, the 15th and 20th percentile (or the 20th and 21st percentile) are not meaningful. In comparing two students, one scoring at the 18th percentile and one scoring at the 22nd percentile on any particular standard norm-referenced achievement test, the skill sets of the two students are virtually indistinguishable from one another, even when we are willing to except that the scores contain no measurement error. This problem of arbitrariness is not a strict indictment of the use of norm-referenced tests in establishing cut-points for designating problems, but an indictment of any sys-

tem that would make critical decisions to provide or withhold services to an individual child based on a single such indicator.

These problems can be illustrated using real data in which an epidemiological sample received IQ and reading tests in Grades 3 and 5 (Fletcher et al., in press; Shaywitz, Escobar, Shaywitz, Fletcher, & Makuch, 1992). For this study, groups were formed in Grade 3 based on IQ discrepancy (reading scores 1.5 standard errors below IQ test scores), low achievement (reading scores below 25th percentile), and typically achieving students not meeting either definition. In comparing the stability of group membership from Grade 3 to Grade 5, 18% of a group that was IQ discrepant in Grade 3 was low achieving in Grade 5, and 22% were typically achieving. In a group of low-achieving third graders, 5% were IQ discrepant and 32% were typically achieving in Grade 5. In the Grade 3 typically achieving group, 1% was IQ discrepant and 8% were typically achieving in Grade 5. Even in simulated data where the tests are modeled to have high stability and small measurement errors, this type of fluctuation is apparent and is predictable based on the standard error of measurement of the tests and the properties of the normal distribution.

The implications of these findings are that *strict* reliance on test scores for eligibility purpose is fallible and should be avoided. Although test scores can help establish impairment in a domain and identify factors associated with the impairment, the interdisciplinary team must go beyond test scores in making decisions about eligibility. Moreover, these decisions should be monitored. Response to intervention over time may be a far better indication of a true disability than a single assessment, where the type of instability described above is an inherent part of the process (MacMillan & Siperstein, in press).

In the next section, the tone of this article will shift toward a softer, more clinical use of test scores. IDEA does not require that interdisciplinary teams base placement on test scores, and mandates consideration of other factors. A model and some ideas for effectively using tests will be provided.

Overall Approach

We use a heuristic model of assessment for all children with LD that we have termed the biobehavioral systems approach (Fletcher, Taylor, Levin, & Satz, 1995). The model, summarized in Figure 1, divides the assessment process into four components:

1. Description of the problem characterizing the child's apparent inability to meet age-appropriate expectations for performance (*manifest disability*).
2. Assessment of the *child's traits* that influence the manifest disability. Those traits may be cognitive or psychosocial in nature and are often closely related.

3. Evaluation of *environmental variables*— social, cultural, familial, and contextual—that are directly related to the psychosocial traits.
4. Evaluation of *biological variables*, related to brain integrity, genetics, and medical history that influence the cognitive traits of the child.

The four components represent three levels of analysis. At the first level, an attempt is made to define the presenting problems (manifest disabilities) and core cognitive and psychosocial traits that underlie the difficulties leading to referral. At the second level of analysis, the influence of cognitive and psychosocial factors on each other and on the manifest disabilities is considered. Children do not develop cognitive skills in isolation from environmental and internal psychological variables such as attitude and motivation. At the third level, attempts are made to understand how various environmental and neurobiological variables influence the child's cognitive and psychological traits.

For children with reading disabilities and any form of LD, a key issue is the relationship between specific academic deficits (manifest disability) and the child traits. This relationship is assessed in a hierarchical fashion whereby patterns of achievement test results are used to predict cognitive deficits (i.e., child traits). This assessment occurs in the context of the child's psychosocial traits, which moderate the relationship of manifest dis-

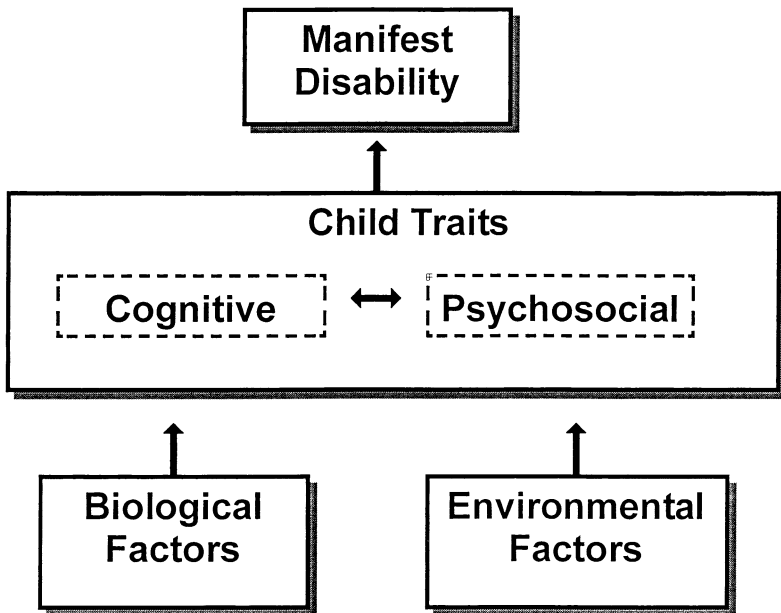


Figure 1. Assessment framework for the biobehavioral systems approach.

abilities and cognitive traits. The knowledge base for LD is not adequately developed to permit specific causal statements concerning the relationship of the first two levels of analysis with the third level (biological and environmental factors), but it is emerging.

Manifest Disabilities

When assessing the manifest disability in children for whom LD is a consideration, a core battery of achievement tests is utilized. The battery from which these tests are chosen is less important than the constructs that are measured. As the discussion of heterogeneity shows, the important constructs are word recognition, reading comprehension, reading speed, math computations, spelling, and written expression. Torgesen (this issue) outlined some of the assessment issues involved in assessing reading disabilities (see also Torgesen & Wagner, 1998). It is important to recognize that whereas most children with LD have problems with reading, they may also have difficulties with math and written expression. A smaller number of children will not display word-level reading problems, but may experience difficulties with reading comprehension or speed. Still others have good development of reading ability, but struggle with math and/or written expression. Thus, a thorough (but not time-consuming) assessment of academic skills is essential. Identifying the *pattern* of academic strengths and weaknesses is the key to understanding the manifest disability.

There is empirical support for the assessment of these academic domains. Fletcher et al. (1996) completed a latent variable study of the underlying constructs measured by a large battery of achievement tests. They found evidence for five constructs assessed by different achievement subtests: recognition of real words, recognition of pseudowords, reading/listening comprehension, spelling, and math skill. This study did not have extensive measures of written expression or reading, writing, or math speed. The heterogeneity hypothesis suggests that a broader range of achievement constructs needs to be assessed. Assessments of speed may be especially important.

Table 1 outlines these constructs and how they can be assessed with the newly revised Woodcock-Johnson Achievement Battery-III (WJ; Woodcock, McGrew, & Mather, 2001). In providing this table, we do not imply that there are nine different types of LD or that children would have problems in only one domain. In reality, many children will have problems in multiple domains. It is the *pattern* that is critical.

Consistent with the important role of phonologically based word recognition deficits in reading disability (see Torgesen, this issue), Table 1 proposes assessment of recognition of real words and pseudowords, keys to the identification of word-level reading disabilities. Reading comprehension can be screened with the WJ Passage Comprehension subtest, which is a

Table 1
Achievement Constructs in Relation to Subtests

Word Recognition
Real words—Word Identification
Pseudowords—Word Attack
Fluency
Reading Fluency
Reading Comprehension
Passage Comprehension
Math
Computations—Calculations
Concepts—Quantitative Concepts
Written Expression
Spelling
Handwriting
Writing Fluency

Note. The assessment of reading comprehension and writing may not be adequate unless they involve text-level processes.

cloze-based assessment. The WJ also has a reading speed subtest. An alternative is the Test of Word Reading Efficiency (Torgesen, Wagner, & Rashotte 1999). Both measures are quick and efficient. In general, the approach is to identify an area of deficiency and then target it for more specific assessments.

Reading comprehension is a difficult construct to assess (Pearson, 1998). Assessments of reading comprehension vary considerably in what the child is asked to read (sentences, paragraphs, pages), in the response format (cloze, open-ended questions, multiple choice, think aloud), in memory demands (answering questions with and without the text available), and in the aspects of comprehension being measured (gist understanding, literal understanding, inferential comprehension). A single assessment is rarely adequate, and it is difficult to determine the source of the child's difficulties based on a single measure. Thus, when comprehension, but not word recognition or fluency, appears to be an issue, multiple assessments using measures that tap different aspects of comprehension may be necessary.

For math, the Calculations subtest of the WJ is identified in Table 1. It is a paper-and-pencil test of math computations. Identifying children weak on this type of task leads to predictable variation in cognitive skills depending on other academic strengths and weaknesses (Rourke, 1993). For more targeted assessments, Math Fluency on the WJ is a timed test of single-digit arithmetic facts that is quick to administer and may be helpful for identifying children who lack speed in basic arithmetic skills, which may place constraints on learning more advanced aspects of math computations. If it is desirable to assess math concepts or "reasoning," the Quantitative Con-

cepts subtest of the WJ may be more useful than the Applied Problems subtest. Although both subtests assess counting concepts in younger children, the latter introduces word problems that may be difficult for children with reading and/or working memory problems. The former tests knowledge of arithmetic notations, understanding of quantitative vocabulary, and an understanding of how numbers are sequenced.

Spelling is not part of the federal definition of LD but should be assessed, as it may represent the source of difficulty for children who have problems involving written expression. Spelling also provides important informal assessments of handwriting and error patterns. The error patterns can be interpreted in terms of whether or not the errors are phonetically constrained (Rourke, Fisk, & Strang, 1986). Phonetically inaccurate errors occur in children with phonological processing difficulties, whereas phonetically accurate errors reflect problems that occur at an orthographic level. Phonetically accurate misspellings may also occur in children with difficulties in spatial cognition or motor planning. Providing explicit instruction in spelling and writing helps many children improve in the accuracy and, possibly, the speed of word recognition (Bradley & Bryant, 1983; Ehri & Wilce, 1987; Uhry & Shepherd, 1993). This is because writing words so they are spelled accurately requires retrieval and encoding of specific orthographic conventions that must be represented in writing. Knowledge of orthographic conventions enhances sight-word recognition, which in turn helps automate word recognition, making it more efficient.

Although Table 1 identifies WJ measures of written expression, it is important to recognize that these are not text-level assessments; that is, they do not require the child to construct and write passages or stories. In the classroom, written expression may be the level at which some children experience difficulties. Thus, as with reading comprehension, it may be important to assess written expression at a text level. Formal assessments through the Thematic Maturity subtest of the Test of Written Language (Hammill & Larsen, 1998) may also be useful. Measuring speed with a measure such as the WJ Writing Fluency subtest could reflect a source of classroom difficulties because how quickly a child can write predicts not only quantity but also quality of composition.

Altogether, the goal for the assessment of manifest disabilities in identifying LD is to measure the pattern of academic weaknesses that represent the disability. In many children, simply assessing word recognition, reading fluency, reading comprehension, spelling, and math computations is sufficient and takes 30–45 min, depending on the age and proficiency of the child. There are characteristic patterns that emerge. If there are concerns about text-level processes, especially reading comprehension and written expression, more detailed assessments will be necessary. Similarly, a math disability may require more detailed assessments and qualitative scoring to identify error and strategy patterns.

Child Traits

The child traits represent cognitive and psychosocial functions intrinsic to the child that are related to the manifest disability. In terms of cognitive factors, Fletcher et al. (1996) identified eight constructs in a latent variable analysis of a battery of over 30 tasks in a large sample of children with LD: phonological awareness, rapid naming, verbal short-term memory, nonverbal short-term memory, lexical/vocabulary, speech production, perceptual-motor functions, and visual attention. From other work we have done, we have been able to further differentiate various measures of attention and executive functions, and perceptual, motor, and tactile functions (Francis, Fletcher, & Rourke, 1988, 1992). However, the cognitive tests that will be used depend on what emerges as the manifest disability.

LD is easily identified when the expected pattern of covariation occurs between a manifest disability and their cognitive correlates. Thus, a child with word recognition difficulties should show difficulties with different aspects of phonological processing. If the pattern is not present, the task for the assessment professional is to determine why the pattern is not present. For example, some children with ADHD may have poor word recognition skills, but good phonological processing. In these children, it may be that their attention and behavior problems preclude transfer of these skills to reading. Alternatively, children with reading problems who have been in remediation may show better word reading than phonological processing, representing the focus of the intervention on print-related skills.

The lack of covariation may also reflect the operation of psychosocial or behavioral factors that influence the child's performance in school and behavioral adjustment at home (see Figure 1). These factors include motivation to learn, previous intervention experiences, affective disorder, and other factors that influence the child's adjustment (e.g., marital and family dysfunction, quality of school). These issues will be addressed in the assessment of child traits to help develop an intervention plan. Rating scales by parents and teachers and interviews are essential and lead to an efficient evaluation. Often these factors are those considered "exclusionary" in the federal definition of LD.

To illustrate, most important for reading disability and any form of LD is the assessment of ADHD and disruptive behavior (e.g., oppositional defiant disorder). Disorders of attention and behavior should be assessed primarily on the basis of history and the pervasiveness of the child's pattern of behaviors. Parent and teacher rating scales are very important. Performance on cognitive tests is neither a necessary nor a sufficient assessment for the identification of ADHD (Barkley, 1997). In evaluating the child for ADHD, issues such as the age of onset, pervasiveness and situational specificity of the behaviors, and potential sources of comorbidity (obsessive compulsive disorder, aggression) are critical considerations in order to de-

velop an adequate intervention program. It is very important to take into consideration all of the *Diagnostic and Statistical Manual of Mental Disorders* (fourth edition; American Psychiatric Association, 1994) criteria for ADHD, including age of onset, situational specificity and pervasiveness, and impairment of adaptation (American Academy of Pediatrics, 2000). Many children will display behaviors consistent with ADHD, but the severity may not be sufficient to warrant intervention because the pervasiveness criterion is not met or there is little impact on the child's adaptation. If ADHD or another comorbid condition emerges, this must be accounted for in developing an intervention plan for addressing the LD.

Biological Factors

In evaluating any child with LD, it is important to carefully review the history to ensure that there are not aspects of the developmental history that might potentially explain the learning problem, such as brain injury. In addition, it is important to review issues involving family history of learning problems. There is no evidence that children with learning problems should be referred for elaborate laboratory studies including blood tests and various brain-imaging scans or electrophysiological measures (Shaywitz et al., 1997), so long as routine physical examinations or history do not suggest a need for these procedures. Because of the importance of biological (and environmental) influences, parents are often asked to complete questions about the medical, educational, and developmental history of themselves and the child. A family history of reading difficulties is important, especially when the family may not be oriented to reading or the parents may have reading difficulties themselves.

Environmental Factors

There are many environmental factors that are relevant to understanding the relationship between the manifest disability and the child traits. These factors include the child's family situation, quality of the marriage, resources of the family, past learning history, school placement, resources in the community and the school, and a host of variables that moderate the relationship between neurocognitive correlates and psychosocial variables. It is particularly important to carefully review the child's instructional history and to ensure that the types of instructional programs in which the child has been placed are adequate. For example, some older children with severe reading problems may never have experienced intensive attempts to remediate their word recognition deficits. Parents may have invested significantly in interventions that would not be expected to benefit the child's reading problems. All of this information is critical for developing the intervention plan.

Applying the Biobehavioral Systems Model

In this section, applications of this model to reading disabilities involving word recognition, speed, and comprehension are described. We will also briefly discuss other forms of LD in the context of reading disability, but because reading assessments are the best developed example of an evidence-based alternative approach, the focus will be on reading. Examples of definitions based on inclusionary criteria and the relationship between academic skills and cognitive correlates will be included.

Word-Level Disabilities (Dyslexia)

In the past 15 years, major advances have been made in our understanding of word-level reading disability including the most common form, dyslexia. Whereas dyslexia has traditionally been defined largely by what it isn't, research has advanced to the point where it is possible to define dyslexia using well-established research-based criteria that indicate what it represents. Dyslexia provides an excellent example of the inclusionary definitions that we feel are both possible and useful for redefining different types of LD. Compare the 1968 World Federation of Neurology exclusionary definition of dyslexia with the research-based inclusionary definition from the Research Committee of the International Dyslexia Society developed in 1994 (see Lyon, 1995; Shaywitz, 1996) that we modified to account for more recent research developments:

1968—A disorder manifested by difficulties in learning to read despite conventional instruction, adequate intelligence, and socio-economic opportunity. It is dependent upon fundamental cognitive disabilities, which are frequently of constitutional origin (Critchley, 1970, p. 11).

1994–2001—Dyslexia is one of several distinct learning disabilities. It is a specific language-based disorder characterized by difficulties in the development of accurate and fluent single-word decoding skills, usually associated with insufficient phonological processing and rapid naming abilities. 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. Reading comprehension problems are common, reflecting word decoding and fluency problems.

This definition indicates that dyslexia is a word-level reading disorder associated with problems with phonological processing. It is the most common form of LD, with Lerner (1989) reporting that 80% of children served in special education have reading problems. Kavale and Reese (1992) reported that over 90% of children in special education in Iowa had reading difficul-

ties. Most of these disabilities are at the word level. Children are identified with dyslexia as a manifest disability when their word recognition skills are impaired. The cognitive correlates involve phonological processing, rapid naming, and phonological memory. However, this should not be taken to imply that children with dyslexia are a homogenous group. Although the reading problems characteristic of children with dyslexia have some features that are relatively invariant (e.g., poor phonological awareness skills), dyslexia is more than a reading disability (Fletcher, Foorman, Shaywitz, & Shaywitz, 1999). Many children with dyslexia have problems in other areas such as motor skills, attention, and other aspects of language that make them heterogeneous. The value of assessing these areas, however, does not reflect concerns about the reading problem and often reflects comorbid associations with other forms of LD and ADHD that would be identified through the assessment of the manifest disability.

There is evidence for subtypes of reading disability. Morris et al. (1998) searched for subtypes based on the eight constructs identified in Fletcher et al. (1996). They found seven subtypes, with six sharing impairment in phonological awareness skills, but varying in performance on other cognitive skills. Figure 2 summarizes one way of conceptualizing the subtypes. As Figure 2 shows, there are subtypes that are pervasively impaired in multiple domains of language function and others with impairments that are restricted to the cognitive domain. These patterns are consistent with the phonological core-variable differences model of reading disability developed by Stanovich (1988). The model is based on a relatively invariant view of the relationship of phonological processing and word recognition, so that whenever this pattern is present, reading problems would be expected (i.e., phonological core). However, children with the phonological core may have other problems in academic and cognitive domains (i.e., variable differences). If the pattern is restricted to phonological processing, the child can be viewed as having a "specific" reading disability. If other domains of cognitive functions are impaired, the child might be considered a "nonspecific" or "garden-variety" poor reader.

Two subtypes were pervasively impaired on all linguistic measures and were most clearly differentiated from the other five subtypes by their lower vocabulary levels. These subtypes conformed to children who have been described by many as garden-variety poor readers (e.g., Stanovich, 1988). It is important to recognize that these children are not reliably indexed by IQ scores or by IQ discrepancy, although their *average* scores on tests of verbal intelligence were in the low-average range. The causal directionality, however, is from language to IQ, not from IQ to language (Francis, Fletcher, Shaywitz, Shaywitz, & Rourke, 1996). As Torgesen (this issue) noted, these children will require remedial programs that address vocabulary and other aspects of language development as well as attempts to remediate their reading development.

Subtypes of Reading Disabilities

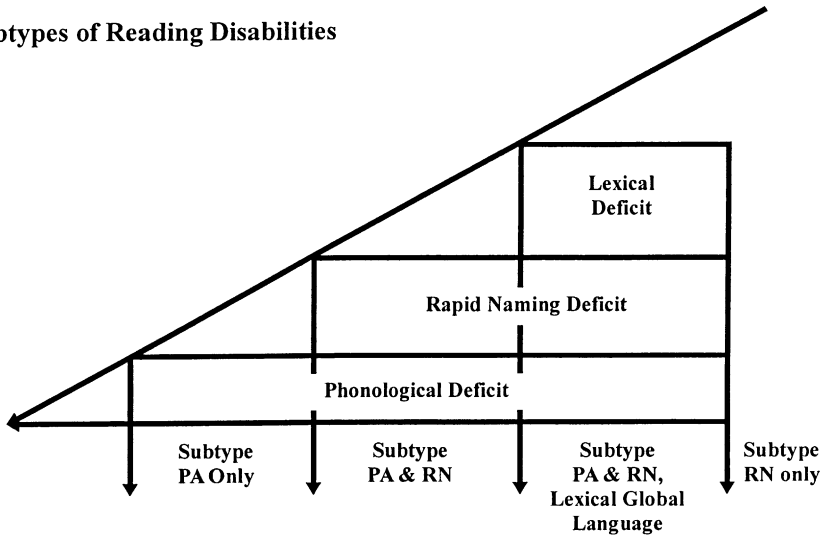


Figure 2. Subtypes of reading disability based on phonological awareness (PA), rapid naming (RN), and vocabulary skills. Working memory is not depicted, but would also represent a subtyping dimension.

Morris et al. (1998) also identified five specific subtypes of reading disability in children. The higher vocabulary levels of the specific subtypes reliably indexed the difference between these five “specific” subtypes and the two garden-variety subtypes. One subtype (rate-disabled) was not impaired in phonological processing or word recognition (see Figure 2). This subtype experienced difficulties on any timed measure, including rapid naming, and also had difficulties on measures of reading speed and text comprehension. Another subtype, which was the largest, had difficulties with phonological awareness, working memory, and rapid naming. This subtype was as severely impaired in reading as the two garden-variety subtypes. It also was the only subtype where a higher proportion of both parents reported reading difficulties. For remedial purposes, this is likely the subtype most difficult to remediate. These children will require interventions that are very intensive, have considerable scaffolding and repetition, and that also recognize their need to build fluency. In contrast, another subtype only had problems with phonological awareness. Children in this subtype may do well in a variety of interventions that teach phonological analysis and word recognition skills. The other two subtypes varied in rapid naming and working memory, so these deficiencies should be considered in developing interventions that address fluency and repetition.

As Figure 2 shows, the most important cognitive traits to assess when a child has a word-level reading disability are phonological awareness, phonological (working) memory, rapid naming (for letters), and oral vocabulary. The former three constructs can be assessed with the recently published Comprehension Test of Phonological Processes (Wagner, Torgesen, & Rashotte, 1999) or other subtests from the WJ Cognitive Battery (Woodcock et al., 2001). There are many adequate measures of oral language vocabulary.

Reading Comprehension

Children with dyslexia commonly experience difficulties with reading comprehension because of problems with the accuracy and fluency (automaticity) of word-level skills (Shankweiler et al., 1999). Some likely would have reading comprehension problems even if their word-level skills were better developed because of weaknesses in vocabulary and other language abilities. However, in some children, reading comprehension problems exist in the face of proficient decoding skills. This problem rarely occurs in isolation of another disorder, particularly in association with oral language disorders that reflect problems either with receptive language skills (i.e., oral language disorders; Stothard & Hulme, 1996) or discourse-level processing, and has been found in both neurologically normal children (see review in Oakhill, 1993) as well as in children with early hydrocephalus and other forms of brain injury (Barnes & Dennis, 1998). Similarly, children with ADHD may experience problems with reading comprehension because of weaknesses in specific cognitive skills (working memory) or because they don't pay attention to what they read.

Assessments of vocabulary, syntax, and listening comprehension are key constructs for the assessment of cognitive traits if the child shows adequate word recognition skills and poor reading comprehension. If the child's word recognition skills are adequate, extensive assessment of phonological processing is probably not necessary.

Reading Speed

Children with dyslexia commonly have problems with reading speed because word recognition is slow and labored. The question of whether there exists a subgroup of children with disabilities in reading characterized specifically by difficulties in reading speed alone is controversial. Wolf and Bowers (1999) argued for a "rate-deficit" group that does not have problems with phonological processing. This group has text-level difficulties that reflect a more general problem in rapidly processing information. Morris et al. (1998) found evidence for a rate-deficit subtype that was not phonologically impaired, but that showed difficulty on any task that re-

quired speeded processing, including rapid naming. This subtype did not have problems with word recognition, but experienced difficulties with reading fluency and comprehension.

Reading speed problems are common in children with ADHD and brain injury, as are difficulties with rapid automatized naming (Tannock, Martynussen, & Frijters, 2000). For example, Barnes, Dennis, and Wilkinson (1999) matched children with traumatic brain injury and typically achieving children on their word decoding accuracy. Reading rate and naming speed were poorer in children with traumatic brain injury. These findings have also been observed in non-brain-injured children with learning difficulties outside the word recognition domain (Waber, Wolff, Forbes, & Weiler, in press; Wolf & Bowers, 1999). Reading speed was related to reading comprehension scores in all these populations. Thus, although there is presently insufficient evidence to establish a form of reading disability that involves only speed deficits, the assessment of speed is critical. Many children who become accurate with word recognition skills remain poor readers because of slow reading rates, though slow word reading may not always necessarily result in poor comprehension. This problem often needs to be addressed as part of an educational plan. Thus, in addition to assessing reading speed, assessment of rapid naming is especially important at the level of cognitive traits.

Written Expression and Spelling

Spelling and writing problems are pervasive in children with dyslexia. In children with word recognition difficulties, spelling problems are almost always present. This makes any written language task difficult. Isolated problems with spelling in the absence of word recognition deficits do occur, but occur most often in children with a history of phonological processing difficulties who might have had some remediation of word recognition problems. Younger children may have problems on spelling tests because of more general graphomotor difficulties. Thus, when only writing is involved, assessments of visual-motor skills may be important.

In children with more pervasive oral language difficulties, written language tasks are difficult because of problems formulating thought into language. Some children, particularly with isolated impairments in math or with ADHD, will show dysgraphia, reflecting often-profound motor planning and execution difficulties. This should not be confused with a phonologically based spelling problem. Qualitative analysis of spelling errors can be helpful.

There is some research that focuses specifically on handwriting and written expression (Berninger & Graham, 1998; Graham & Harris, 2000). These studies investigated processes related to handwriting and more general aspects of written expression. However, when difficulties with spelling

and motor skills are taken into account, children with isolated problems in written expression may be rare. More research is clearly needed, but for the present, the evidence for isolated problems in written expression is limited.

Math

Children with dyslexia often have problems with math, particularly if language is more pervasively impaired. Those children whose reading problems may be related to language-processing difficulties have special difficulty with word problems. They also forget number facts and procedures necessary for the successful execution of mechanical or computational arithmetic—errors that may reflect problems with phonological or working memory and the child's more general language-based difficulties (Ackerman & Dykman, 1995; Geary, Hoard, & Hamson, 1999). Jordan and Hanich (2000) found that children with both reading and mathematics difficulties showed problems in multiple domains of mathematical thinking. Thus, whenever a child shows word recognition and math difficulties, the possibility of more severe language and working memory difficulties must be considered when assessing cognitive traits.

Some children will display isolated math problems and good word recognition skills. This may be in association with ADHD, but also may occur in children without ADHD who have been described as having nonverbal LD (Rourke, 1993) and in children with brain injury (Barnes et al., in press). Those children are characterized, in part, by severe impairment of basic computational arithmetic skills. However, in contrast with children with word recognition problems who also show arithmetic deficits, these children tend to make errors that reflect difficulties in using algorithms and procedures, poor spatial organization, inattention to detail, and graphomotor problems.

Math disabilities in isolation of word recognition difficulties occur infrequently, but there is support for this type of LD (Rourke, 1993; Rourke & Finlayson, 1978; Torgesen, 1993). As with reading, math disabilities co-occur with ADHD, but some children with ADHD do poorly on math tests because they do not pay attention to their work. These children may have math test scores that are low because they make many errors, but these errors do not accurately reflect their knowledge. Math problems in the absence of word recognition difficulties are more common in children with brain injury. In a study of children with spina bifida and hydrocephalus, Barnes et al. (in press) showed that good readers with spina bifida made more procedural errors than typically achieving children, but made similar numbers of math fact retrieval and visual-spatial errors. Furthermore, their procedural errors were similar to those of younger children who were matched in math ability with these older brain-injured children. In other

words, the good readers with hydrocephalus made errors in written computation that were developmentally immature for their age, but not different in kind from younger children with no math disability. These data are consistent with the hypothesis that children who are good readers, but who are poor at math, can have a procedural deficit that involves the application of developmentally immature algorithms for solving written computations. Assessments of cognitive traits involving psychomotor functions, procedural learning, and working memory may be essential.

Summary: Assessment and Intervention

The goal of this approach to assessment of LD is to examine *patterns* of academic strengths and weaknesses and how such patterns relate to cognitive and psychosocial traits. The Appendix provides seven examples of the relationship of achievement patterns (manifest disability) and child traits (cognitive correlates) in reading and math LD. The relationships have been established through research (e.g., Rourke & Finlayson, 1978), but the guidelines for cut-points and decision rules should be used with caution. Although most problems with achievement can be addressed by comparing a child's scores with age/grade expectations, there is insufficient data to say where on the normal distribution the cut-point should be placed. Thus, by specifying the 25th percentile, we are not saying that 25% of all children are LD. Rather, we would emphasize the need for less concern about the *level* of a child's performance and more concern about the *pattern* of performance and the consequences for adaptive functions (Rourke et al., 1986). The decision process should focus on what is needed for intervention as opposed to arbitrary decisions about cut-points. Test scores should be used to guide intervention and not used as a gate-keeping mechanism. Low achievement is relative to a host of contextual variables, and there are good reasons for the flexibility provided by the guidelines in IDEA that allow interdisciplinary committees to move beyond test scores. The ultimate goal of any assessment should be to enhance student performance regardless of the placement decision. The Appendix is designed to illustrate how assessments for LD can be more streamlined, research based, and intervention oriented.

The purpose of assessment is ultimately to plan instruction and develop an intervention plan. Identification may be necessary for compliance purposes, but is an intermediate step in the path to remediation. The types of assessments we have identified in this article lead to specific recommendations. In addition to defining programs, we try to provide specific ideas of what sorts of interventions will be effective and name programs where possible.

In the area of reading, several consensus documents have called for "balanced" approaches to reading instruction (National Reading Panel, 2000; Snow, Burns, & Griffin, 1998). Balanced approaches to reading instruction

are essential regardless of the type or severity of the reading problem. Programming in the reading area must begin in kindergarten with an emphasis on reading instruction all through elementary school and, if necessary, secondary school. In their report, Snow et al. (1998) discussed different elements necessary to facilitate learning to read and prevent reading disabilities. The report specifically emphasized the need to integrate (a) knowledge of the alphabetic principle, (b) teaching for meaning, and (c) opportunities for practice in a balanced comprehensive approach to reading instruction. Even children with dyslexia need approaches to reading instruction in which the three elements are integrated. The key is what an individual teacher does with an individual child and the teacher's ability to respond to the needs of different children. Assessments of the type we and others (Share et al., 1991; Torgesen & Wagner, 1998) have proposed that examine the relation of key academic skills and their cognitive correlates may help identify these needs. Providing feedback on the efficacy of interventions through curriculum-based assessment (Fuchs & Fuchs, 1998) may also be useful for modifying the intervention and identifying children who may have more significant disabilities.

In a child with a reading disability, assessment results can help guide instruction and indicate how to balance different components of the reading program and support the child. There are no "magic bullets," and children will vary in their needs depending on their stage of reading development. Certainly, beginning reading processes are characterized by a need to focus on mastery of the alphabetic principle. As the child develops word-level skills and becomes more fluent, comprehension processes become more prominent. There is rarely any point in the development of reading skills where alphabetic skills should be taught in isolation of reading for meaning or opportunities to learn through reading and writing.

There is little evidence that interventions addressing visual processes have any efficacy with children who have word-level reading disorders (Fletcher, Foorman et al., 1999). Indeed, the eyes, eyeballs, and visual processes do not appear to have much to do with word-level disorders. Controlled research evidence shows that interventions involving visual processes, including optometric exercises, colored overlays, or special lenses, have no specific efficacy for children with reading disability (Iovino, Fletcher, Breitmeyer, & Foorman, 1999). Similarly, interventions with no appreciable print content do not generalize to the reading area. An excellent example is training in phonological awareness where the link to the alphabetic code is not made explicit or practiced by building and recognizing words. The child may develop an enhanced capacity in phonological processing, but there will not be any significant generalization to the actual process of identifying words. Instructional programs that are effective with children who have dyslexia provide structured opportunities to learn phonological processing skills with a significant print component. The pro-

grams must include explicit attempts to build fluency and automaticity, comprehension, and writing skills.

SCREENING AND PREDICTION

The assessment model presented thus far largely involves children in the latter part of Grade 1 and beyond who are candidates for special education or other remedial services. However, the skills related to different forms of reading disability develop and begin to emerge well before Grade 1. Given the evidence that early intervention programs are often effective in preventing reading disability (Torgesen, this issue), how might we go about implementing early identification programs necessary for prevention? Here, the assessment procedures outlined above focuses on cognitive traits as *precursors* to manifest disabilities.

Predictors of Reading Ability

There is a long history of research on the predictors of reading ability. Smith (1928) found that a child's capacity for letter matching early in the first grade correlated .87 with the subsequent development of word recognition skills later in first grade. Monroe (1935) published a battery of pre-reading skills. This battery included measures of oculomotor control and attention, auditory discrimination, vocabulary, motor skills, sound blending, and other tasks. Bond and Dykstra (1967) suggested that familiarity with print, auditory and visual discrimination skills, and intelligence were characteristics of kindergarten students that were related to success in learning to read.

In the 1970s, Satz, Taylor, Friel, and Fletcher (1978), Silver and Hagin (1975), and Jansky and de Hirsch (1972) developed research programs in which attempts were made to evaluate instruments that could be used to identify individual children at risk for reading difficulties. The batteries were based on longitudinal studies that assessed children in kindergarten, and then followed them for several years to measure reading outcomes. The variables that predicted reading skills, however, varied depending on the theory that led to the development of the screening battery and the measures that were evaluated. A variety of spoken language and perceptual skills were found to be predictive of subsequent reading ability. However, this research predated the research on skills such as phonological awareness and rapid naming.

With the development of reading research, new data have emerged on prereading variables that predict reading skills. In a comprehensive review of prediction studies since 1976, Scarborough (1998) found that the best kindergarten predictors of reading skills—usually assessed by measures of word recognition skills—involved measures of print-specific knowledge

and skills, particularly letter identification and concepts of print. Other language skills such as picture naming, sentence recall, phonological awareness skills, and rapid naming were also moderately related to reading outcomes. Intelligence measures, receptive and expressive language measures, and verbal memory tasks were more weakly related to outcomes, whereas measures of perceptual skills, motor ability, and speech perception were largely unrelated to reading skill development. Sociodemographic variables, including socioeconomic status, home literacy environment, familial incidence of reading problems, gender, and the age of the child at school entry were not strongly related to reading outcomes.

As Scarborough (1998) noted, it is not surprising that measures more directly related to the print component of reading, such as letter identification, are better predictors of reading skills than measures that do not involve knowledge of print (e.g., phonological awareness). This finding has been apparent in many studies beginning with Smith (1928). Assessment of phonological awareness skills that involve the child's ability to relate concepts of sound to print are better predictors of reading skills than measures of phonological awareness that only involve concepts of sound (Blachman, 1997). Nonetheless, given the theoretical importance of phonological awareness skills, it is surprising that these abilities in kindergarten are not more strongly related to reading skills development. Scarborough (1998) attributed this finding to the possibility that phonological awareness skills are usually assessed at the very beginning of the child's introduction to school at a time when variability in this skill may not be meaningful in terms of later success in reading. This hypothesis is not consistent with other research, which shows substantial variability in the development of phonological awareness skills in young children depending on how and when phonological awareness is assessed (Schatschneider, Francis, Foorman, & Fletcher, 1999).

In their examination of the construct validity of a battery of different measures of phonological awareness skills using item response theory, Schatschneider et al. (1999) found that phonological awareness was a unitary construct that varied on a continuum of complexity. The simplest assessments involve initial sound comparison and rhyming, while the most complex assessments involve segmenting and blending of multiple phonemes. Moreover, assessments at the beginning of kindergarten may be less reliable than assessments in the middle or end of kindergarten, reflecting the child's need to acclimate to the learning environment. Hence, whether phonological awareness skills are predictive may involve how and when such skills are assessed—relationships that are obscured when correlations are averaged across studies, as in Scarborough (1998).

To address these issues, Schatschneider, Fletcher, Foorman, & Francis (2001) utilized data from a longitudinal study of 945 children in kindergarten, Grade 1, and Grade 2 that began in 1992. Many of these children

were initially evaluated at the beginning of kindergarten and followed through Grade 2. In kindergarten, the children received a battery of tests that included measures of phonological awareness, phonological (working) memory, rapid naming of letters and objects, expressive and receptive syntax, vocabulary, knowledge of letter names and sounds, and perceptual skills. The battery was based on the more recent studies reviewed by Scarborough (1998) as well as the older studies reviewed above (e.g., Satz et al., 1978). This battery was administered four times (October, December, February, and April) in kindergarten and in Grade 1 to address the issues of the time-point at which the best predictors could be made. At the end of Grades 1 and 2 (May), norm-referenced achievement tests were administered to assess outcomes.

The question of particular interest to Schatschneider et al. (2001) concerned what tasks accounted for the unique variance in the test battery when predicting from each of the four kindergarten assessments to outcomes at the end of Grades 1 and 2. Thus, a statistical method that permitted such interpretations was applied to each possible prediction: October, December, February, and April in the kindergarten year to reading outcomes (word recognition, word attack, reading comprehension) at the end of both Grades 1 and 2. The results revealed that although the strength of the overall relationship was, as might be expected, stronger at the end of Grade 1 than Grade 2, the unique kindergarten predictors were generally the same. Similarly, the predictive relationship was weaker from the beginning of kindergarten than from the end of kindergarten, but the differences were not significantly different. Moreover, the same set of variables accounted for most of the unique variance.

The unique variance in the predictive relationship of the kindergarten assessment battery to reading outcomes at the end of Grades 1 and 2 was accounted for by measures of (a) alphabetic knowledge, assessed by a child's knowledge of letter names and letter sounds; (b) phonological awareness, assessed by a prepublication version of the Comprehensive Test of Phonological Processing (Wagner et al., 1999); and (c) rapid naming of letters. Letter names were predictive only at the beginning of kindergarten, and the relationship of rapid letter naming and reading at this time-point was accounted for largely by whether the child knew the names of the letters. By the end of kindergarten, letter-name knowledge was much less predictive and was dissociated from knowledge of letter sounds. From the end of kindergarten to Grade 1 or Grade 2 outcomes, rapid naming of letters, phonological awareness, and knowledge of letter sounds tended to be comparably predictive, with some slight variation depending on which reading outcome was utilized.

The results of Schatschneider et al. (2001) were largely consistent with Scarborough's (1998) suggestion that print-related skills are more predictive of reading ability than those that do not require print. Indeed, in the

data used by Schatschneider et al. (2001), adding a word recognition task at the beginning of Grade 1 that was independent of the words assessed in the outcome battery accounted for most of the unique variance in reading outcomes, with phonological awareness contributing slightly only at the beginning of Grade 1. At the beginning of Grade 2, word reading accounted for all the unique variance.

These results are not inconsistent with Torgesen's (this issue) discussion of marker variables or our recommendation that the assessment of cognitive traits associated with reading disability focus on four core measures: phonological awareness, rapid naming of letters, phonological (working) memory, and vocabulary (see also Torgesen & Wagner, 1998). Schatschneider et al. (2001) utilized a normative sample where children were not selected for reading disabilities. When large samples of children with reading disabilities are utilized, there is clear evidence for individual differences, epitomized by the subtyping study of Morris et al. (1998). In the same sample of Grade 2–3 children and using the same eight measures employed by Morris et al. (1998), Fletcher, Foorman, et al. (1999) found that the four core constructs accounted for the unique variance in multiple reading and spelling outcomes, with some variations in ranking depending on the reading outcome (see Table 2).

Texas Primary Reading Inventory

The predictor data from Schatschneider et al. (2001) were used in the development of an empirical screen that is part of the Texas Primary Reading Inventory (TPRI; Foorman, Fletcher, & Francis, in press), a teacher-administered early reading assessment. A screening component was developed for the TPRI to identify those students who had high probabilities of success at the end of Grades 1 and 2. The screen consists of those measures most predictive of reading success from Schatschneider et al. (2001), except for rapid naming of letters, which would be difficult to format and ad-

Table 2
Stepwise Multiple Regression Predicting Achievement Domains With Cognitive Constructs

	R^2			
	Real Word Decoding	Pseudoword Decoding	Reading Comprehension	Spelling
Phonological awareness	.54	.60	.46	.49
Rapid naming	.59	.64	.59	.53
Vocabulary	.62	.63	.54	
Phonological (working) memory				.56

Note. The order of entry varied across constructs, but is indicated by the size of R^2 .

minister. The screens vary depending on when they are administered: measures of letter-sound knowledge and phonological awareness in kindergarten and the beginning of Grade 1; word reading and phonological awareness at the beginning and end of Grade 1; and word reading at beginning of Grade 2. The goal of screening is to identify children who *do not need* the inventory in order to save time for the teacher. As such, the screens were specifically designed to be more accurate in not missing children who may be “at-risk,” deliberately allowing for over-identification of children. Over-identification is acceptable because the consequences of failing to identify a child who is truly at risk are more significant than missing a child as the teacher follows-up with the screen. Thus, the consequence of identifying a child is that the teacher administers the inventory, which protects against over-identification. For children still developing the screening concepts, the inventory is administered to set learning objectives.

The items on the screen were further refined through the application of Item Response Theory to a larger set of items from each of the tests that discriminated reading outcomes at the end of Grades 1 and 2. For predictions involving Grades 1 and 2, the WJ Broad Reading cluster, which consists of a word identification task and a cloze-based passage comprehension measure, was used. The criteria for risk were set at grade equivalents that would identify a child who was 6 months behind in reading: 1.4 or lower on the WJ at the end of Grade 1; 2.4 or lower at the end of Grade 2. In Grade 1, this grade equivalent represents the 18th percentile; in Grade 2, the 35th percentile. The cut-point was deliberately set higher in Grade 2 because of the greater stability in the prediction equations and the reduction in time available for a student to reach the Texas goal of being at grade level by the end of Grade 3.

Separate analyses were conducted on the five assessment time-points. A series of prediction equations were established that minimized missing at-risk children (false negative errors), allowing for over-identification of not-at-risk children (false positives). This decision about effective predictors was based both on the accuracy of individual child predictions and on the relation of false positive and false negative errors. False positives and false negatives are inherent to any assessment device and are inevitably linked. To use screening as an example, false negatives occur when a child meets criteria on the screening but fails to learn to read; a false positive occurs when a child does not meet criteria on the screening but, nevertheless, becomes a successful reader. A false negative error is more serious because these children do not receive the additional assistance they require at the earliest possible time, which makes their problems more difficult to remediate at a later time. False positive errors are a concern because they place an increased demand on scarce resources. False positives in kindergarten and the beginning of first grade may reflect the assessment of children from poor neighborhoods or who have limited English proficiency whose

opportunity to become literate comes from instruction at school. The cut-points were adjusted for each screen to keep false negative rates below 10%. As a consequence, false positive rates in kindergarten and first grade ranged from about 35% in kindergarten and beginning of first grade to about 25% at the end of first grade, and to less than 15% at the beginning of second grade. False positive rates could be reduced, but false negative rates would increase. Thus, decisions about screening must be based on the results of decisions about individual cases and the relationship of false positive and false negative errors. Overall accuracy is important, but less so than decisions about the consequences of different errors of prediction (Meehl & Rosen, 1955).

The TPRI provides an example of how early screening can be accomplished. There are other longitudinal studies that can be used to develop screening devices; this has been done by Wood, Hill, and Meyer (2001) and could easily be done with other longitudinal studies such as those completed by Wagner, Torgesen, and Rashotte (1994) and Vellutino, Scanlon, and Lyon (2000). Screening is only predictive when done from a longitudinal study that follows children over the time period of interest. It is necessary to have longitudinal data in order to set cut-points and to evaluate cut-points against error rates for individual children. Although a norm-referenced test could be used as a different approach to the assessment of risk, the absence of longitudinal data makes it difficult to assess the errors associated with these decisions.

Unfortunately, the longitudinal screening devices developed in Texas and elsewhere will be difficult to implement outside the states where they were developed without revalidation of the cut-points. A large-scale national sample is necessary. Alternatively, a large-scale national sample such as that provided by the ongoing National Kindergarten study currently underway and directed by the National Center for Educational Statistics in the U.S. Department of Education might be used to develop a screening device with national applicability.

CONCLUSIONS

In this article, we focused on the consequences of the federal definition of LD for the identification and assessment of children. The federal definition leads to assessment practices that are oriented toward eligibility and less toward intervention. The primary focus is on whether the child's IQ score is high enough relative to their academic levels, such that in practice, IQ tests are used to sort children. This approach makes it more likely that children will be identified as LD at older ages, effectively "preventing prevention" despite the burgeoning evidence that the most common form of LD, dyslexia, can be prevented in many children through early identification and intervention (Torgesen, this issue).

These findings indicate that the assessment role of school psychologists needs to be expanded. In part, as a consequence of the implementation of the federal definition of LD, school psychologists have been saddled with much of the data collection necessary to support the eligibility process for children who may be LD. Thus, school psychologists spend considerable time administering IQ and achievement tests. Although the latter is appropriate, there is little evidence that the former contributes significantly to an eligibility decision supported by a valid classification of LD.

An alternative approach would be based on inclusionary definitions that specify the attributes of the disabilities of interest. Instead of spending time administering IQ tests, school psychologists could focus more specifically on the assessment of the attributes associated with individual differences in children who have reading disabilities and other forms of LD. Such assessments may well have important implications for intervention, and fit in well with an attempt to introduce early identification procedures as well as innovations such as curriculum-based assessment and the assessment of response to intervention (Fuchs & Fuchs, 1998).

A hierarchical approach to assessment in which the relationship of academic deficits, cognitive skills, and psychosocial factors is carefully evaluated for each child would facilitate the ability of an interdisciplinary team to develop an intervention plan. The primary goal of placement in special education should be to close the achievement gap and return the child to the educational mainstream. In the area of reading, interventions based on inclusion or the types of interventions commonly employed in large groups with little differentiated instruction are ineffective (Klingner, Vaughn, Schumm, Hughes, & Elbaum, 1997; Moody, Vaughn, Hughes, & Fischer, 2000; Vaughn, Moody, & Shuman, 1998). Collection of the types of data proposed in this article may help provide a better basis for more differentiated and scaffolded instruction. Particular consideration should be given to providing curriculum-based assessment at the prereferral and intervention stages to assess the child's response to intervention as a key factor in placement decisions (Fuchs & Fuchs, 1998).

Early intervention programs can be effective in preventing serious disabilities in reading (Torgesen, this issue). School psychologists should be active participants in screening and early identification procedures. Although it is not realistic to expect that school psychologists can screen every child, they can play a vital role in helping teachers learn to administer screening tools and interpret results. IDEA permits qualification of 6-through 9-year-old children in the "developmental delay" category. The component-based assessments described in this article could play a major role in establishing eligibility for this category, though streamlining of the eligibility process would make it more useful. Regardless, aggressive attempts to identify children at risk for reading disabilities and other LD prior to the age at which identification is typically made may potentially

help reduce the number of children who need special education and provide opportunities for more intense interventions for those who do not respond to general education practices or to early intervention.

There is flexibility in federal regulations under IDEA in placement and eligibility decisions. However, this flexibility is obscured by the focus on test scores. The types of test scores that are presently collected in accordance with the federal definition of LD do not have a strong conceptual or empirical basis. It is time to revise the federal definition of LD and encourage assessment practices that are more closely aligned with evidence from the scientific study of LD. This means a focus on component-based assessments and a greater emphasis on early identification and prevention. Although prevention should be a major issue for general education, it should also come under the purview of special education, with greater collaboration among professionals in all areas of education, psychology, and allied disciplines sharing interest in children with LD.

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APPENDIX

Seven Achievement Patterns Usually Representative of LD

The patterns are based on relationships between reading decoding (D), reading comprehension (C), spelling (S), and arithmetic computations (A). It is assumed that any score below the 25th percentile (standard score = 90) is impaired and that a difference of 0.5 standard deviations is significant (± 7 standard score points). None of these patterns are related to IQ scores. The patterns are prototypes and the rules should not be strictly applied.

1. DS: decoding and spelling <90; arithmetic 7 points higher than decoding and spelling and at least 90. This is a prototypic dyslexic pattern

characterized by problems with single-word decoding skills and better arithmetic ability. Reading comprehension varies depending on how it is assessed, but is usually impaired. Children with this pattern have significant phonological language problems and preservation of spatial and motor skills.

2. A: arithmetic <90 , decoding and spelling >90 and at least 7 points higher. Children with nonverbal LD show this pattern, along with children with ADHD. Nonverbal LD are characterized by problems with motor and spatial skills, problem-solving deficiencies, and disorganization. Arithmetic scores are reduced in children with ADHD because of problems with procedural detail, math facts, and carelessness. Comprehension varies.
3. DCSA: decoding, comprehension, spelling, and arithmetic <90 . This is the most common achievement pattern and is a more severe form of reading disability characterized by pervasive language and working-memory problems. Other skills vary across children.
4. SA: spelling and arithmetic <90 , decoding >90 and 7 points higher. Essentially, the same pattern as A, except the motor (and writing) component is more severe in SA than A.
5. C < D or C: reading comprehension <90 and 7 points below decoding. This pattern often reflects long-term oral language disorder or an association with ADHD. In children with reading disability, problems with receptive language, attention, and short-term memory are apparent, with preservation of phonological language skills.
6. DS < C: When decoding skills are 7 points lower than comprehension skills and <90 , this pattern reflects a persistent phonological language disorder with usually better than average semantic language and spatial skills. The pattern is not apparent for reading comprehension measures that are timed or require significant amounts of text reading.
7. S: Isolated problems where only spelling <90 reflect (a) motor deficits in a young child or (b) residuals of earlier phonological language problems that have been remediated or compensated in older children and adults. The pattern is common in adults with a history of dyslexia. Rate and automaticity of reading skills are often impaired.