EMPIRICAL AND THEORETICAL SUPPORT FOR DIRECT DIAGNOSIS OF LEARNING DISABILITIES BY ASSESSMENT OF INTRINSIC PROCESSING WEAKNESSES

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Traditionally, the term *learning disabilities* has been used to refer to problems acquiring academic knowledge and skills that are caused by disorders in basic psychological processes. These processing weaknesses, in turn, are caused by dysfunction of the central nervous system (U.S. Department of Education, 1977). Further, these processing weaknesses are thought to have a strictly limited impact on cognitive development; they impede the acquisition of certain academic skills while leaving many other cognitive abilities to develop normally. This conceptualization is meant to differentiate children with specific learning disabilities from those who have learning problems in school for other reasons. The idea that the processing disabilities have a relatively narrow impact on cognitive development differentiates children with *specific* learning disabilities from those who have the kind of *general* learning weaknesses associated with mental retardation. The idea that the processing limitations are intrinsic, or constitutionally based, differentiates children with learning disabilities from children whose problems learning in school are the result of lack of opportunity or motivation to learn.

The issue of concern in this paper is whether we currently have sufficient scientific knowledge to recommend that schools adopt a method of identifying children with learning disabilities that involves direct measurement of the intrinsic processing disabilities that are the presumed heart of the disorder. At present, these children are identified for special education services primarily through methods that attempt to exclude other possible explanations for the academic problem in question. By requiring children to show a discrepancy between "general learning potential" as assessed by IQ tests and performance on measures of specific academic skills, current approaches attempt to rule out explanations for learning problems associated with low general learning aptitude. Current approaches are also supposed to rule out other potential causes of the learning problem such as lack of instructional opportunities (both home- and school-based), emotional disturbance, or sensory impairment. Our current consideration of alternative approaches to classification of children with learning disabilities is motivated by widespread dissatisfaction with the IQ discrepancy approach that derives from both theoretical and empirical issues (Fletcher et al., 1998; Siegel, 1989; Stanovich, 1991).

The alternative approach to be evaluated in this paper involves direct diagnosis of learning disabilities by measurement of the *intrinsic* processing or capacity weaknesses that are presumed to underlie the academic performance problems shown by these children. Although the concept of intrinsic processing weaknesses is central to current definitions of learning disabilities, federal regulations specifying operational criteria for classification of children with learning disabilities do not require a demonstration of specific processing weaknesses for the diagnosis to be made (U.S. Department of Education, 1992). Assessment of intrinsic processing weaknesses was not included as part of the operational criteria for diagnosis of learning disabilities in current regulations because there has been little consensus about what these deficient processes are or how to measure them (Hammill, 1990). In the absence of agreement about the nature of the intrinsic processing weaknesses responsible for specific learning disabilities, it has become a category defined by exclusion.

During the two decades since the original regulations that outlined the operational criteria to "objectively and accurately" identify children with learning disabilities were formulated (U.S. Department of Education, 1977, p. 250), there have been enormous advances in our scientific understanding of learning disabilities. Thus, it is important to consider whether we currently have sufficient knowledge to shift away from discrepancy-based approaches that emphasize diagnosis by exclusion to direct diagnosis of learning disabilities based upon assessment of intrinsic processing weaknesses. Information relevant to this question will be organized into six sections:

1....a definition of intrinsic processes with distinctions between them and other kinds of mental processes;
2....evidence for intrinsic processing weaknesses as the cause of specific learning disabilities;
3....advantages of a processing approach to diagnosis over current discrepancy-based approaches;
4....difficulties in the implementation of diagnosis based on direct assessment of intrinsic processes;
5....alternatives to classification based on assessment of intrinsic processes; and
6....threats to the concept of specific learning disabilities at the levels of science and educational practice of a decision to eschew assessment of intrinsic processes as part of classification procedures.

What Is Meant By the Term "Intrinsic Processing" Weaknesses?

When I first began my study of children with learning disabilities in the spring of 1974, the field was in a state of considerable intellectual disarray. I remember coming home from the library one evening so confused about the meaning of the word *process* from my reading about children with learning disabilities, that I sat down and looked it up in the dictionary. The dictionary gave two definitions and an example that helped to fix the meaning of the word in my mind. The first definition was "a natural phenomenon marked by gradual changes that lead toward a particular result," and the second was "a series of actions or operations conducing to an end" (*Webster's Seventh New Collegiate Dictionary*, 1965). The example provided was of the Bessemer Steel Process—a set of well specified manufacturing operations that led to the production of steel. This definition makes it clear that a process is a set of steps, operations, or developing conditions that follow one another in a certain way and that lead to, or produce, a given outcome. Of course, it is not clear that the writers of the federal definition of learning disabilities had this definition in mind when they described learning disabilities as resulting from a disorder in one or more of the basic psychological processes. However, what was very clear in 1974, and what continues to be a problem in the current literature on learning disabilities, is that the term *process* is used in many different ways to describe a broad variety of problems shown by children with learning disabilities. It was this confusion about the term *process* that led those who formulated the popular definition proposed by the National Joint Committee on Learning Disabilities (NJCLD, 1988) to delete the phrase "basic psychological processes" from their definition. This omission did not change the essential meaning of the definition, however, as the NJCLD definition still contained language about learning disorders that were intrinsic to the individual and presumed to be caused by dysfunction of the central nervous system.

The Use of Processing Language in Different Levels of Explanation

One of the difficulties with the word *process* is that it is not tied to any particular level of explanation of human behavior. For example, a neurophysiologist might describe a problem arising from weaknesses in the processes involved in transmission of electrical impulses within neurons or across synapses, or with the transmission of information between the hemispheres of the brain. A neuropsychologist might describe primary deficits in visual-spatial-organizational processes or complex psychomotor processes. A cognitive psychologist trained within the information processing paradigm might explain a learning difficulty in terms of deficient processes operating within working memory or problems with rate of acquisition for certain types of information in long-term memory. Finally, an educator might describe a reading difficulty in terms of deficient alphabetic decoding processes or weak reading comprehension processes.

At what level of explanation are processing difficulties best described and studied in children with learning disabilities? There are three issues to be considered here. First, as one moves from descriptions at the neurophysiological level through the neuropsychological level and the cognitive level to descriptions at the educational level, the processing operations involved in the description become progressively easier to link to the actual academic performance problem that is being explained. Since, as we will see later, one of the most difficult challenges in describing academic performance problems in terms of intrinsic processing weaknesses is to be sure of the causal connection between processes and outcomes, processing descriptions that are as close as possible to the academic problem being explained have some inherent advantages. On the other hand, the higher one goes in the explanatory hierarchy (from neurophysiological to educational), the more difficult it is to be sure the processing differences used in the explanation are intrinsic, or constitutionally based, rather than learned through varying experiences. Finally, the measurement technology and expertise required to identify processing weaknesses also varies with the level of explanation. Assessment of processes occurring at the neuronal level requires highly specialized equipment and considerable technical training, while assessment of processing differences at the educational level require less technology.

Since one purpose of this paper is to consider whether it is practical, at this point in time, to recommend that the public school system in the United States classify children as learning disabled by identifying those with intrinsic processing weaknesses, measurement considerations are of obvious importance. It is also clear that the level of explanation we choose should be below the educational level, as that is simply a description of the learning outcome. For example, when genetic influences on variability in reading skill are discussed, no one seriously entertains the idea that there is a specific gene, or combination of genes, for reading *per se*. Similarly, few would agree that it is adequate to explain the problem by indicating the child has a disability in "the reading process." Rather, the most common current explanations of genetic influences on reading growth are that they directly affect the phonological component of natural language ability (Olson, 1999). That is, specific weaknesses in the ability to process phonological information are offered as an explanation for the reading difficulty, and phonological processing disabilities are conceptualized as intrinsic or constitutionally based limitations that are significantly heritable.

To provide additional context for considering which level of explanation is most viable for diagnostic and classification purposes, consider the levels of explanation required for complete understanding of any particular of learning disability (Torgesen, 1999). This discussion starts with the recognition that children can have learning problems in school for many reasons, and that the definition of learning disabilities is meant to focus our attention on one particular type of learning problem. Thus, a theory of learning disability must be consistent with the major elements of current definitions. The first step in the development of a coherent theory of learning disabilities is to specify the learning or performance problem that is to be explained by the theory. There cannot be a single coherent theory of learning disabilities because the term *learning disabilities* refers to a heterogeneous set of learning problems. It is not reasonable, for example, to expect the same theory to explain both difficulties acquiring word reading skills and difficulties with listening comprehension. Thus, the starting point for any coherent theory of learning disabilities must be a precise and focused description of the specific academic problem to be explained.

The first level of *explanation* in a coherent theory of any type of learning disability should be a description of the basic psychological processes that are the proximal cause of the academic learning problem. This is the first level at which we might reasonably begin to attach the word *intrinsic*. It is meant to identify the fundamental information processing limitations that cause the child to have difficulty acquiring specific academic skills. It is at this level of explanation that we have made enormous advances in the last 20 years. These advances have occurred not only in understanding the basic processes that underlie development, but also in identifying those processing limitations that produce individual differences in learning outcomes for children exposed to the same learning opportunities. The reason for these advances is that the information processing paradigm, as a way of studying and explaining human behavior, has matured during this time, and it has contributed important methodologies and theoretical constructs to the understanding of human learning and behavior.

The information processing approach is of fairly recent origin (Massaro, 1975), and was developed in the aftermath of successful simulation of human cognitive achievements (i.e., chess playing, numerical calculations) by computers. The availability of clear descriptions of the different processes by which computers solve human-like intellectual problems led researchers to the hope that similar descriptions of internal psychological events intervening between receipt of a stimulus and emission of a response might also be developed for humans. Thus, information processing accounts treat mental processes in terms of different operations that are performed on information. John Flavell, an eminent cognitive developmental psychologist, explained the paradigm this way:

> Like a computer, the (human) system manipulates or processes information coming in from the

> environment or already stored within the system. It processes the information in a variety of ways: encoding, recoding, or decoding it; comparing or combining it with other information; storing it in memory or retrieving it from memory; bringing it into or out of focal attention or conscious awareness, and so on…the ideal goal of the information-processing approach is to achieve a model of cognitive processing in real time that is so precisely specified, explicit, and detailed that it can actually be run successfully as a working program on a computer. (Flavell, Miller, & Miller, 1993, pp. 8–9).

From the point of view of information processing theory, processes are defined as sequences of mental actions or operations that transform and manipulate information between the time it enters as a stimulus and the time a response to it is selected and executed. Although, as we shall see, some information processing skills or capacities are clearly acquired through learning and experience, others may represent basic features of the biological "hardware" that would qualify as intrinsic or constitutionally-based features of an individual child's cognitive capabilities.

Once a theory of learning disabilities has identified the deficient psychological processing operations that are the proximal cause of the poor learning outcome, the next level of explanation must involve identification of the locus of neurological impairment that is a likely cause of the limitation in processing capacity. Again, this is a requirement of any theory that is consistent with current definitions. The locus of neurological impairment might be either structural (e.g., a difference in distribution, organization, or density of neurons, or presence of anomalous formations) or functional. If a functional limitation is identified, it might use concepts from neurophysiology, and when fully understood, would probably be described as a deficient neurophysiological process. One advantage of having a precise description of processing deficiencies at the psychological level is that it can provide guidance about where to look for impairments in the central nervous system. For example, the strong evidence that one common form of reading disabilities is caused by weaknesses in phonological processing ability has directed attention to the left temporal region of the brain, which is identified with speech processing, as a possible locus of central nervous system dysfunction in children with reading disabilities. Conversely, if no structural or functional anomalies are found in these areas, this should lead to additional theory development at the psychological level.

The last level of explanation required by a complete theory of learning disabilities involves specification of the etiology of the structural or functional impairment in the central nervous system causing the disability. Like the word *process*, the meaning of the word *constitutional* is not well specified in current definitions of learning disabilities. Use of the term in the context of other elements of the definition (e.g., they are not the result of extrinsic conditions such as cultural differences or lack of opportunities to learn) would suggest that it means something similar to *inherent*; it is a biologically based disability that is present when the child is born. The prototypical cause for this kind of disability would be genetic. That is, a child's genes would either lead to the development of information processing weaknesses present at birth or would influence the emergence of processing weaknesses arising during development. However, there are clearly other causal possibilities for intrinsic, constitutionally based processing weaknesses arising from dysfunction or damage to the central nervous system (Rourke, 1989). It is also possible for children to bring "intrinsic" processing disabilities with them to school that arise as a result of environmental conditions following birth (Hallahan, Kauffman, & Lloyd, 1996).

This extended excursion into learning disabilities theory is offered in support of the idea that processing disabilities conceptualized at the psychological level are potentially most useful for widespread identification and classification purposes. As we will see shortly, there is clear evidence for intrinsic psychological processing capabilities that are given as part of our genetic or biological make-up and that are also accessible to assessment outside the medical or biological laboratory. Thus, for the remainder of this paper, the focus will be to determine whether we currently have enough scientific knowledge to begin classifying children as learning disabled by direct assessment of the psychological processing weaknesses responsible for their observed learning difficulties. I will begin by making some important distinctions among different types of psychological processes.

DISTINCTIONS AMONG TYPES OF PSYCHOLOGICAL PROCESSES

One important distinction among psychological processing operations is that between processing sequences or capabilities that appear to function automatically as part of the biological "hardware" of the brain and those that are assembled as an adaptive response to the requirements of specific tasks. When humans enter the world, they are immediately capable of complex information processing activities in a number of domains. For example, newborn infants can perform the complex mental calculations required to localize sounds without seeing the sound source (Morrongiello, Fenwick, Hillier, & Chance, 1994; Wertheimer, 1961). The brain also seems "wired" to perceive phonemic contrasts categorically, which is of enormous assistance in acquiring receptive speech capabilities (Aslin, Jusczyk, & Pisoni, 1998; Eimas, Siqueland, Jusczyk, & Vigorito, 1971). Human beings also appear to process information about the frequency of events automatically, without really thinking about it or even intending to do it, and children as young as 5 years old are as effective as college students in retaining this kind of information (Hasher & Zacks, 1984).

One of the central themes of developmental psychology over the past 20 years is the increasing recognition that human beings are capable of much more behavioral complexity and complex information processing at very young ages than was previously thought. As Fischer and Bidell (1991) suggest:

> The behavioral abilities with which human beings are genetically endowed are far richer and more complex than traditional accounts of cognitive development imply. New research seems to have revealed rich sets of perceptual and cognitive abilities in infants and young children. … these early abilities show the starting points from which cognitive development must emerge. As starting points, they set limits or constraints on what is possible and thereby help to channel the direction of development. (p. 200)

Flavell and his colleagues (Flavell et al., 1993) go on to point out that:

> We seem to be biologically prepared to do very specific kinds of information processing and very specific kinds of learning, with no apparent links between one set of processing mechanisms (e.g., those for discriminating speech sounds) and another (e.g., those for extracting numerical information). Different theorists talk about these highly specialized capacities in different ways… Common to the various conceptions, however, is an emphasis on domain specificity—these are processes that perform very specific tasks, not all-purpose learning mechanisms. (p. 336–353)

As suggested in the comments by Flavell and his colleagues, processes can be domain-specific or they can be domain-general. A good example of a domain-general learning process that is present from birth is the ability to form representations of objects or events so they can be recognized as familiar (Werner & Siqueland, 1978). The rate at which children can learn to recognize objects as familiar predicts their later general intelligence quite accurately (Rose, Feldman, & Wallace, 1992). This recognition capability is a domain-general process and thus exerts a relatively broad influence on cognitive development: Infants who are slow to habituate to an item on repeated presentation show slower rates of general cognitive development, resulting in lower measured intelligence at later points in development. Domain-general processes or capacities are not a good place to look for explanations of specific learning disabilities, because their effect on learning and performance is so pervasive. If a child is deficient in an important domain-general information processing skill, the likely result will be mild to serious mental retardation rather than development of a specific learning disability.

A third important distinction among different kinds of information processing activities is between automatic and controlled processes. Processes that require significant amounts of attention and conscious direction are labeled controlled, while those that require little, if any attention, are labeled automatic. Activities that are initially accomplished through controlled processing activities can eventually be accomplished via automatic processes as the brain establishes highly practiced information processing routines. A clear example of this change from controlled to automatic information processing occurs during the acquisition of reading skills. Whereas the first time a word is encountered in print it must be identified using a combination of controlled processes involving phonemic analysis and contextual constraints (Share & Stanovich, 1995), after the word has been read accurately several times, the brain forms a representation of its spelling that allows it to be recognized instantly and automatically, with almost no attention or effort involved (Ehri, 1998). This transition from controlled to automatic processes is important in development, because when automatic processes are employed, mental resources are freed to accomplish other tasks. In the case of reading, when word recognition occurs automatically, processing resources are freed to construct the meaning of the passage.

The distinction between automatic and controlled processes is important for the present discussion because it has important implications for assessment of processes and capacities in children with learning disabilities. For example, one of the strongest themes in developmental psychology over the past 20 years is that older children are more adaptive and efficient in the use of controlled information processing strategies to accomplish both novel and routine tasks (Siegler, 1998). Frequently, when older children perform better than younger children on a learning or memory task, it is not because the older child has greater learning or memory capacity *per se*, but because older children more successfully use the processing resources they have to adapt to the requirements of the task.

Another factor that affects measurement of basic psychological processes is that automatic processes can become more efficient with experience. For example, as children acquire more familiarity, or exposure, to different types of information, their processing of it becomes more and more efficient. Thus, one important explanation for the significant difference between younger and older children in their ability to remember sequences of numbers involves older children's greater familiarity with numbers: They process the numbers more automatically, and thus their apparent capacity for remembering them increases (Case, Kurland, and Goldberg, 1982). In this case, what might initially be interpreted as a difference in memory capacity between older and young children can be directly explained in terms of the older child's more automatic processing of the stimuli to be remembered. Siegler's (1998) discussion of differences between older and young children's processing experience, and its relationship to their apparent processing capacities, provides a cautionary note about the potential difficulties involved in directly assessing intrinsic processing or capacity limitations in children with learning disabilities:

> Developmental improvements in performance can be produced either by an increase in the child's resources or by a decrease in the resources the child expends in doing the task. How might the resources required to do a task decrease with development? The older children know more about numbers. This greater familiarity could help them remember the numbers more efficiently. They also know more strategies, such as rehearsal, for enhancing their recall. They also are more skillful in choosing when to use the strategies they know. Thus it is clear that older children can store more material in working memory, but it remains unknown (and perhaps unknowable) whether this is because of a change in the actual capacity of working memory or because of changes in knowledge and strategies that allow more material to be stored within the same capacity. (p. 189).

Ways in Which Psychological Processes Can Cause Individual Differences in Performance

Processing differences among children can affect learning and performance in a number of ways. For example, children can be different from one another in accuracy of processing for specific types of information. A good example of this type of processing difficulty is provided in the work of Paula Tallal and her colleagues (Tallal, 1980; Tallal, Stark, & Mellits, 1985). They have developed a theory to explain language disabilities by suggesting that some children have special difficulties processing rapidly changing or rapidly sequential auditory stimuli. This difficulty arises because these children's brains do not sample acoustic signals sufficiently rapidly to note changes of short temporal duration. Thus, the children perceive some speech contrasts, or other rapid temporal events, inaccurately.

Children's performance on a variety of tasks can also be affected by differences in processing speed. Wolf and Bowers (1999) have developed a hypothesis to explain certain kinds of reading difficulties in terms of limitations in visual processing speed for letters. They hypothesize that "slow letter (or digit) naming speed may signal disruption of the automatic processes which support induction of orthographic patterns, which, in turn, result in quick word recognition" (Bowers & Wolf, 1993), p. 70). According to this explanation, if children are sufficiently slow at visual recognition of letters, it interferes with their ability to construct a mental representation of a word's spelling that will allow the word to be recognized automatically.

Children can also be different from one another in processing capacity, and this would certainly produce individual differences in performance on tasks that place demands on this capacity. Lee Swanson and his colleagues have conducted an extensive series of studies from which they propose that children with both reading and math disabilities suffer from a domain-general capacity limitation in working memory (Swanson & Ashbaker, 2000). This hypothesis will be discussed more completely in the next section.

Finally, differences in learning or performance can also result from children's use of inefficient processing sequences, or weaknesses in the coordination of processing components.

It is by now widely acknowledged that a reliable characteristic of many learning disabled children is that they frequently appear disorganized on tasks and often do not use efficient strategies to solve problems or acquire new information (Denckla, 1994; Meltzer, 1993). However, whether these problems in organization and strategy execution qualify as intrinsic processing limitations and primary causes of learning disabilities or whether they are a secondary characteristic arising as a reaction to early and chronic academic failure is a question that is not completely resolved (Kistner & Torgesen, 1987; Meltzer, 1993). One problem with strategy-based explanations of processing weaknesses in children with learning disabilities is that strategic, or controlled, processes are highly susceptible to modification through experience, motivation, and opportunities to learn (Siegler, 1998). In studying these kinds of processes, the researcher has an especially heavy burden to show that weaknesses in their execution and organization have a biological rather than an experiential basis.

Summary

A major conclusion of this section is that the most productive level to search for intrinsic processing weaknesses in children with learning disabilities is the psychological or neuropsychological level. At this level of explanation, it is possible to identify processing capacities and skills that can be conceptually linked to the biological substrate (and would thus qualify as intrinsic to the child), but which are also potentially measurable outside a medical or biological laboratory. At this level, processes are defined as sequences of specific mental actions that transform and manipulate information between the time it enters as a stimulus and the time a response to it is selected and executed. It is important to note that these processes, or processing descriptions of behavior, are theoretical constructs. There is no claim that they are a veridical representation of specific neurological events. Rather, these processing descriptions are offered to help understand reliable patterns of human cognitive functioning, and they are an intermediate level of explanation between overt behavioral outcomes (e.g., extreme difficulties acquiring automatic recall of math facts or difficulties acquiring use of phonemic decoding skills in reading) and their biological underpinnings.

There is good evidence that humans are born with biological hardware capable of supporting complex information processing routines. Since they are present from birth, these biologically based processing capabilities are part of the child's constitutionally based information processing capability and are thus subject to the same kind of variability in speed, accuracy, or capacity as other biological endowments. It is processing capabilities that arise relatively early in development, that are domain-specific, and that are relatively automatic in execution and operation that are the most likely candidates for the kind of intrinsic processing weaknesses that are referred to in definitions of learning disabilities.

Evidence for Intrinsic Processing Weaknesses as the Cause of Specific Learning Disabilities

In order to justify a recommendation that children be identified as learning disabled by showing they have the kind of intrinsic processing weaknesses that are a central part of the definition, we must have reasonable evidence that the type of learning disability specified in the definition does, in fact, exist. In order to validate the theoretical elements in the definition of learning disabilities from a scientific perspective, all that is required is to show that children with neurologically based, intrinsic learning disabilities are a reality. Even one case of a child with this type of disorder can serve as an “existence proof” for the definition and concept.

However, validation of the definition from the perspective of learning disabilities as a field in special education (which can be considered a social-political-educational movement) is much more difficult. This type of validation requires nothing less than evidence that a *significant portion* of children currently being served in learning disabilities programs fit the essential elements of the definition. It is on this point that the theoretical assumptions of the definition are most frequently attacked. For example, Jim Ysseldyke and his colleagues have reported on a program of research showing that school-identified learning disabled children cannot be differentiated from other kinds of poor learners on the basis of their patterns of intellectual abilities (Ysseldyke, 2001). In his book *The Learning Mystique*, Gerald Coles (1987) also mounted an extensive attack on the idea that most school-identified learning disabled children have neurological problems as the basis of their learning difficulties. In fact, he is right in showing that the evidence for this idea is exceedingly weak.

In contrast, the evidence in support of the idea that constitutionally based, intrinsic processing weaknesses can produce important patterns of learning disability in specific children is very strong. I will now briefly review two coherent lines of research that provide support for the concept of learning disabilities as it is presently defined.

The Theory of Phonologically Based Reading Disabilities

This theory, which is perhaps the most completely developed and widely supported current conceptualization of a specific learning disability type (Torgesen, 1999), starts with the observation that children identified as severely reading disabled most frequently experience extreme difficulties in acquiring word level reading skills. Even more specifically, the outcome to be explained by this theory is these children’s inordinate difficulties mastering the alphabetic principle in learning to read (Rack, Snowling, & Olson, 1992; Stanovich & Siegel, 1994). These children have extreme difficulties learning to use grapheme-phoneme correspondences to decipher words they have not seen before in print.

The psychological explanation for this overt learning difficulty is that these children have difficulties processing the phonological features of words (Liberman, Shankweiler, & Liberman, 1989). These phonological processing difficulties manifest themselves on a variety of non-reading measures including tests of phonological awareness, rapid automatic naming, verbal short-term memory, and speech perception (Manis, McBride, Seidenberg, Doi, & Custodio, 1993; Stanovich & Siegel, 1994; Torgesen, 1999). Investigation of the relationships between these variables and reading growth has been the focus of intense study over the past two decades, and there is now a substantial body of both longitudinal-correlational (Wagner, Torgesen, & Rashotte, 1994; Wagner et. al, 1997) and experimental (Bradley & Bryant, 1985; Hatcher, Hulme, & Ellis, 1994; Lundberg, Frost, & Peterson, 1988) evidence indicating that differences among children on these language skills are *causally* related to variability in the rate at which children acquire early word reading abilities.

At the next level of explanation, the neurobiological locus of the specific processing weakness, there is consistent evidence indicating that poor readers exhibit disruption primarily but not exclusively in the left hemisphere serving language. Thus, neurobiologic investigations using postmortem brain specimens (Galaburda, Menard, & Rosen, 1994), brain morphometry (Filipek, 1996), and diffusion tensor magnetic resonance imaging (Klingberg et al., 2000) suggest that there are subtle structural differences in several regions of the brain between children who are learning to read normally and children with reading disabilities. There is also emerging evidence from a number of laboratories using functional brain imaging that indicates an atypical pattern of brain organization in children with reading disabilities. These studies show reductions in brain activity while performing reading tasks usually, but not always, in the left hemisphere (Shaywitz et al., 2000). In a recent summary of the evidence concerning the neurobiological substrate for specific reading disabilities, Zeffiro and Eden (2000) conclude that, "the combined evidence demonstrating macroscopic, morphologic, microscopic neuronal, and microstructural white matter abnormalities in dyslexia is consistent with a localization of the principal pathophysiological process to perisylvian structures predominantly in the left hemisphere" (p. 23). However these authors also hint at the possible need to enlarge our conceptualization of the biological differences between dyslexic and typical children by pointing out that there is emerging evidence for brain abnormalities in these children extending beyond the classically defined language areas.

At the level of etiology of the neurobiological and processing differences that cause difficulties acquiring accurate and fluent word reading skills, there is strong and consistent evidence that these kinds of information processing weaknesses are significantly heritable (Olson, 1999). That is, reading disabilities run in families, and a child with a parent who has a reading disability is approximately 8 times more likely to have a reading difficulty than a child of unaffected parents.

Although the theory of phonologically based reading disabilities is widely accepted at present, there are several interesting problems remaining that are relevant to the issues considered in this paper. The most fundamental question involves the nature of the specific processing limitation that interferes with performance on both reading and non-reading measures of phonological skill. For example, oral language measures of phonological awareness are strongly predictive of difficulties acquiring alphabetic reading skills, but phonological awareness is defined as a kind of knowledge and understanding about words and phonemes, not as a basic psychological processing capability (Wagner & Torgesen, 1987). In other words, deficits in phonological awareness are an outcome of processing weakness and are not a direct measure of an intrinsic processing disability. It is true that children must engage in phonological processing (the processing of phonological information) in order to succeed on measures of phonological awareness, but the processing required on phonological awareness tasks is also supported by knowledge about words and phonemes that is acquired through experience and instruction. The causal relationship between phonological awareness and reading is actually reciprocal (Ehri, 1989; Morais, Alegria, & Content, 1987; Perfetti, Beck, Bell, & Hughes, 1987); differences in initial levels of phonological awareness cause different success in learning to read, and different responses to early reading instruction cause further differences in growth of phonological awareness.

Currently the two leading hypotheses concerning the information processing weaknesses that causes performance difficulties on both measures of phonological awareness and alphabetic reading skill are a speech-specific perceptual processing problem (Studdert-Kennedy & Mody, 1995) and a more general problem processing rapidly changing or rapidly successive acoustic stimuli (Tallal, 1980). It is interesting that measures of neither of these information processing skills are used as widely as measures of phonological awareness to predict the emergence of reading difficulties in young children or to verify the diagnosis of specific reading disability in older children.

Another point of controversy within the theory of phonologically based reading disabilities at present concerns the question of whether rapid automatic naming tasks are primarily measures of phonological processing skill or whether they measure a different kind of processing capability that influences aspects of reading growth other than the initial attainment of accuracy in using alphabetic reading strategies. For example, Wolf and Bowers (Bowers, Golden, Kennedy, & Young, 1994; Wolf & Bowers, 1999; Wolf, 1991) and their colleagues have argued against viewing rapid automatic naming tasks as primarily phonological in nature, and instead they emphasize the visual and speed components of these tasks. They propose that rapid naming tasks assess the operation of a "precise timing mechanism" that is important in the formation of the visually based representations of words that allow them to be recognized as whole units in text. If Wolf and Bowers are correct, this would mean that that an additional (other than phonological), as yet unspecified processing weakness causes reading failure in some children.

A final issue that is important in the present context is that individual differences in phonological awareness, which is the primary measure of phonological processing capability used in research and diagnosis of reading disabilities, are only roughly 50% heritable. The other half of the variability in phonological awareness is produced by environmental factors, such as the language environment in the home and factors related to socioeconomic status (Hecht, Burgess, Torgesen, Wagner, & Rashotte, 2000). Further, we know that phonological awareness and reading have a reciprocal causal relationship (Wagner et al., 1997). Thus, in current practice, we have strong evidence that one of the most commonly used measures of children's intrinsic processing weaknesses in the phonological area is influenced both by constitutionally based differences in processing capability and by environmental/instructional factors at home and school.

The Nonverbal Learning Disabilities Syndrome

Children with nonverbal learning disabilities (NLD) were originally identified by their particularly poor performance on mechanical arithmetic tasks (Rourke & Finlayson, 1978; Rourke, Young, & Flewelling, 1971). Over the past 30 years, Rourke and his colleagues have expanded their description of these children's academic difficulties to include problems with graphomotor skills (early problems with printing and cursive writing), difficulties in reading comprehension, mathematical reasoning, and tasks in science that involve complex concept formation. In Rourke's work, it is the *pattern* of strengths and weaknesses in academic skills, rather than their absolute levels, that is the most defining feature of the syndrome. Thus, children with NLD show striking weaknesses in math computation skills *relative* to their word recognition and spelling skills. Their deficits in reading comprehension are also relative to their much stronger word-level reading skills. These children show persistent difficulties in academic subjects that require problem solving and complex concept formation relative to their strengths on tasks that require simple rote learning. Children with NLD have also been shown to have quite severe social/behavioral problems.

Rourke's theory does not identify intrinsic cognitive deficits within an information processing model of mechanical arithmetic or other academic outcomes. Rather, he describes these children's intrinsic processing weaknesses in terms of a pattern of neuropsychological assets and deficits. The theory indicates how a core of primary neuropsychological difficulties involving tactile perception, visual-spatial-organizational skills, and complex psychomotor functions lead to a variety of difficulties with academic and social/behavioral outcomes.

Rourke's theoretical description of children with NLD also includes explicit discussion of areas of normal cognitive development. Early in development, these areas of strength include auditory perception, simple motor behaviors, and rote memory ability. Later, these intact areas of functioning produce normal levels of skill in phonological processing, receptive language, verbal knowledge and associations, and verbal output. As with outcomes at the academic and social skill level, it is the pattern of performance (strength versus weaknesses) that is most important in identifying children for the diagnosis of NLD. Thus, it is performance deficits on visual-spatial-organizational skills relative to performance on measures of vocabulary, or relative deficits on measures of complex motor versus simple motor skills, that are considered the most reliable indicators of the diagnosis.

The major locus of neurological impairment in children with NLD, according to Rourke's theory, is in the right cerebral hemisphere. Specifically, he states that

> "the necessary condition for the production of the NLD syndrome is the destruction or dysfunction of white matter that is required for intermodal integration. (For example, a significant reduction of callosal fibers or any other neuropathological state that interferes substantially with 'access' to right hemispheral systems [and thus, to those systems that are necessary for intermodal integration] would be expected to eventuate in the NLD syndrome)"(Rourke, 1988, p. 312).

According to the theory, each individual will manifest specific aspects of the NLD syndrome depending upon both the total amount of white matter that is affected and upon the location and stage of development at which the white matter was damaged.

In terms of etiology, Rourke views the NLD syndrome to be the “final common pathway” for a number of different conditions that produce white matter disease or dysfunction (Rourke, 1995). Examples of such conditions include head injury involving shearing of white matter, hydrocephaly, treatment of acute lymphocytic leukemia with large doses of X-irradiation for a long period of time, congenital absence of the corpus callosum, or significant tissue removal from the right cerebral hemisphere. Other etiologies that might produce the kind of white matter destruction or dysfunction associated with the NLD syndrome include teratogenic effects between conception and birth and extremely low birth weight itself. At present, there is no evidence that NLD is transmitted genetically, except as specific diseases that produce white matter damage may be transmitted genetically (Rourke, 1995).

If it is true that Rourke’s neuropsychological assessments are valid measures of intrinsic cognitive processing weaknesses in children with NLD, then his approach to assessment could serve as a prototype for the type of process-oriented direct diagnosis of learning disabilities that is being discussed in this paper. The diagnosis does not depend on the presence of a discrepancy between general IQ and academic achievement, but rather on the identification of a pattern of strengths and weaknesses in neuropsychological functioning that are the core of the learning disability being identified. For Rourke, the diagnosis is made at the neuropsychological level, and the academic and social outcomes are simply the common expression or phenotype of the disorder (Rourke, 1995).

One continuing weakness of the theory of nonverbal learning disabilities, from the present point of view, is that it does not clearly specify how the cognitive, or neuropsychological, limitations of NLD children actually produce the primary academic symptoms such as difficulties with mechanical arithmetic. A useful addition to the theory would be the development of a more complete information processing model of their problems acquiring arithmetic skills. This model would add to the theory in two ways. First, it would help to refine our understanding of NLD children’s specific difficulties in acquiring arithmetic skills in a way that might suggest remedial interventions. Second, it might also help to clarify or validate theoretical statements about the underlying cognitive limitations of NLD children. Such a model is important if tight theoretical links are to be established between the academic performance problem and the intrinsic cognitive disabilities of NLD children. A problem that is associated with this latter issue is that the theory has been developed primarily from clinical observation and interpretation of empirical data that is exclusively correlational. Although statements about causality in the theory are embedded within a comprehensive model of neuropsychological development, they have not been subject to rigorous analysis of causal relationships in longitudinal-correlational studies or treatment-intervention studies.

SUMMARY

There is very strong evidence that current definitions of learning disabilities are, in fact, a valid description of the learning difficulties of many children. For the theory of phonologically based reading disabilities, the strongest evidence for intrinsic cognitive weaknesses as the cause of the reading disability comes from the consistent evidence that the phonological component of reading skills is strongly heritable (Olson, 1999). For the NLD theory, this evidence comes from neuropsychological studies of brain-behavior relationships in which specific anomalies within the central nervous system have been reliably associated with patterns of performance on neuropsychological measures (Rourke, 1995).

In spite of this evidence for the validity of the intrinsic processing component of the definition, however, serious problems remain in terms of reliable assessment of the critical processing weaknesses that are causally related to the academic outcomes. In the case of phonologically based reading disabilities, the tasks that are most commonly used to predict reading disabilities or to establish the diagnosis in older children are not direct measures of the processing weaknesses that are fundamental to the disorder. In the case of NLD, evidence for causal relationships between the specific neuropsychological problems identified in the syndrome and the academic outcomes associated with the syndrome is still relatively weak.

ADVANTAGES OF A PROCESSING APPROACH TO DIAGNOSIS OVER CURRENT DISCREPANCY-BASED APPROACHES

If it were possible to reliably identify children with learning disabilities by directly assessing their intrinsic processing weaknesses, advantages over current aptitude-achievement discrepancy approaches would be apparent in three areas. First, it would allow identification of the learning disability very early in the instructional process so that preventive, rather than remedial, instruction could become the norm. We now know a great deal about the negative consequences to children of serious academic failure during the early years of schooling (Cunningham & Stanovich, 1998; Kistner & Torgesen, 1987; Stanovich, 1986), and discrepancy approaches to diagnosis require the child to show significant failure in basic academic subjects before the diagnosis can be made. Recent evidence (Torgesen, Rashotte, & Alexander, 2001) suggests that the costs of waiting to intervene for children who have serious reading disabilities may be enduring difficulties in reading fluency that are extremely difficult to overcome.

A second advantage of process assessment, or primary diagnostic, approaches over discrepancy-based approaches is that they will not arbitrarily exclude children from receiving instruction that is appropriate to their educational needs. For example, discovery of the core phonological problems associated with specific reading disability has had at least one unanticipated consequence. The ability to assess these core language problems directly has led to the discovery that the early word reading difficulties of children with relatively low general intelligence are associated with the same weaknesses in phonological processing that interfere with early reading growth in children who have large discrepancies between general intelligence and reading ability (Fletcher et al., 1994; Share & Stanovich, 1995; Stanovich & Siegel, 1994). This discovery is consistent with recent reports from intervention studies that general verbal ability does not predict growth in early word reading ability when differences in phonological ability are controlled (Torgesen et al., 1999; Vellutino et al., 1996). It is also consistent with findings that discrepant (IQ higher than reading ability) and non-discrepant (IQ similar to reading ability) groups show a similar rate of growth in word-level reading skill, both during early elementary school (Foorman, Francis, Shaywitz, Shaywitz, & Fletcher, 1997) and into early adolescence (Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996).

Thus, to exclude children from special instruction designed to help them acquire good word-level reading skills because their reading ability is not significantly discrepant from their general intelligence level fails to recognize that they have the *same learning handicap* as children who score higher on tests of general intelligence. The learning handicap in both cases involves weaknesses in phonological processing ability. Children with this particular handicap respond equally well to explicit and intensive instruction in phonological awareness and phonemic decoding skills, regardless of their level of general intelligence (within the broadly “normal” range) (Torgesen et al., 1999).

The final potential advantage of an approach to diagnosis involving identification of basic processing weaknesses involves benefits for instruction. If we had full understanding of the component processes and knowledge required to perform specific academic tasks, and we could measure these component processes and knowledge accurately in children, this would be of enormous potential benefit for instruction. An example from the research on reading disabilities can serve to illustrate this potential in two ways.

Although we have already acknowledged that measures of phonological awareness do not directly assess an intrinsic processing disability, they do assess a kind of knowledge about phonemes and an ability to process them in specific ways that is causally related to ability to acquire alphabetic reading skills. Children who cannot successfully perform simple measures of phonological awareness in kindergarten are highly likely to experience difficulties learning to read (Wagner et al., 1997). There is also a powerful convergence of evidence (National Reading Panel, 2000) that special attention to stimulating phonemic awareness in young children (particularly those who have weaknesses in this area) helps them to learn to read more easily. Although instruction to build phonemic awareness does not necessarily remediate children’s intrinsic weaknesses in phonological processing, it does help them to acquire a specific kind of knowledge and skill required in learning to read. So, even if a fundamental processing weakness is not directly remediable, knowing about its presence in specific children may direct our attention to the need for special and/or sustained instruction to build the specific reading or pre-reading skills that the processing weakness makes it difficult for the child to acquire.

An even more dramatic, albeit still speculative, approach to direct intervention for children's processing weaknesses is illustrated in the work of Tallal and her colleagues (Tallal et al., 1996; Merzenich et al., 1996). These investigators have reported success in directly modifying children's ability to process the rapidly changing or rapidly successive features of auditory signals. In effect, they claim to have a technique that can change the way the brain processes speech, and other auditory signals, so that perception and understanding of speech and language is improved. These effects have been documented primarily for language comprehension in children with severe language disabilities, but some evidence has also been reported that the method can lead directly to improvements in phonemic awareness (DeMartino, Espresser, Rey, & Habib, in press; Habib et al., 1999). This latter finding is consistent with the idea that the method may have some use in treating the core information processing deficits of children with developmental dyslexia. Because negative results for this method and its theory are also being reported (cf. McAnally, Hansen, Cornelissen, & Stein, 1997; Mody, Studdert-Kennedy, & Brady, 1997; Nittrouer, 1999), its applicability as a widely useful intervention technique for children with reading disabilities is still uncertain. Although the field of learning disabilities is rightfully wary of instructional methods that claim to affect basic processing capabilities and thus to improve academic learning outcomes (Hallahan & Cruickshank, 1973; Hammill & Larson, 1974; Torgesen, 1979), we must remain open to genuine scientific achievements that may be powerfully beneficial to many children.

Summary

Direct diagnosis of the processing weaknesses of children with learning disabilities has three important advantages over IQ-discrepancy approaches. First, a processing approach to diagnosis would not require that the child endure a period of failure in school before the diagnosis was made. This would encourage early intervention and prevention of learning difficulties so that many of the effects on learning attitudes and lost opportunities for academic growth that are the result of failure could be avoided. Second, direct assessment of processing weaknesses would allow instruction to be targeted to all children who have common learning handicaps, and not just to those who satisfy an arbitrary discrepancy criterion. Finally, identification of children's intrinsic processing weaknesses has the potential, at least, to help focus instruction in areas of greatest need.

Difficulties in Implementation of Diagnosis Based on Direct Assessment of Intrinsic Processing Weaknesses

From the material discussed thus far, it is clear that direct diagnosis of learning disabilities by assessment of the intrinsic processing limitations that cause them has a number of important advantages over current discrepancy-based approaches. Conceptually, the process assessment approach is more consistent with definitions that specify deficits in psychological processing capabilities as the proximal cause of poor academic outcomes in children with learning disabilities. As we have just seen, the process approach to diagnosis would also support early identification and intervention as well as targeting of instruction to both the children and in the specific cognitive/neuropsychological areas of greatest need. However, the utility of approaches that emphasize assessment of psychological processing strengths and weaknesses is also critically dependent upon a knowledge base about human learning and cognitive functioning that is not available now, nor is it likely to be available in the immediately foreseeable future. In this section I will briefly describe a range of difficulties that preclude the widespread use of process-oriented approaches to the diagnosis of learning disabilities in present practice.

THE KNOWLEDGE BASE REQUIRED TO SUPPORT PROCESS ASSESSMENT AS A DIAGNOSTIC APPROACH

Current federal regulations specify that children may be identified with learning disabilities that affect learning outcomes in any one of seven areas: 1) oral expression, 2) listening comprehension, 3) written expression, 4) basic reading skill, 5) reading comprehension, 6) mathematics calculation, or 7) mathematics reasoning. A well validated theory of each of these types of learning disorder is required to support the kind of diagnostic approach being evaluated in this paper. To justify diagnosing learning disabilities by assessing the intrinsic psychological processing weaknesses that supposedly underlie them, we must have a well-established understanding of the nature of those processes. Our theoretical understanding of each of these areas of learning disability must start with agreement about how the learning problem, at the outcome level, is to be specified. For example, what exactly is meant by a problem in "written expression"? Can children have more than one kind of problem in this area? If so, what are the several types (and how should each be measured)?

Next, we must be able to identify the specific psychological processing weaknesses that cause the problem with learning outcome. This is extremely difficult to do: It requires several lines of converging evidence to be at least reasonably confident about causality in psychological theory. For example, in the well developed theory of phonologically based reading disabilities, we have evidence from three lines of research that phonological weaknesses are causally related to problems acquiring basic reading skill. In the most convincing research, phonological processing weaknesses have been indexed by performance on measures of phonological awareness. Evidence that individual differences in phonological awareness are causally related to the early growth of alphabetic reading skills comes from: 1) both standard and causal modeling studies of longitudinal-correlational data (Mann, 1993; Stanovich, Cunningham, & Cramer, 1984; Wagner et al., 1994; Wagner et al., 1997); 2) studies showing that older reading disabled children are more impaired in phonological awareness than younger, normal readers matched to them on reading level (Bowey, Cain, & Ryan, 1992); and 3) true experiments that show improved growth in word-level reading skills as a result of prior training in phonological awareness (Cunningham, 1990; Hatcher, Hulme, & Ellis, 1994; Lundberg et al., 1988; Torgesen, Morgan, & Davis, 1992).

When performance on rapid automatic naming tasks is used as a marker for phonological processing difficulties (or some other processing disability), there are two sources of evidence for their causal role in the development of early word reading ability: 1) standard and causal modeling analyses of longitudinal-correlational data (Felton & Brown, 1990; Wagner et al., 1994, Wagner et al., 1997; Wolf & Goodglass, 1986); and 2) differences between younger normal and older reading disabled children matched for reading level (Bowers et al., 1994).

There are beginning attempts to specify the psychological processing problems associated with other forms of academic failure (Berninger, 1994; Berninger & Graham, 1998; Geary, 1993; Geary, Hamson, & Hoard, 2000; Rourke, 1995), but none of these theories is as well developed as the theory of basic reading difficulties caused by phonological processing weaknesses. As an illustration of the difficulties involved in establishing causal relationships between intrinsic processing limitations and learning outcomes, consider the work of Lee Swanson and his colleagues in studying the role of domain-general capacity limitations in working memory as a cause of problems in word reading ability, reading comprehension, and math calculation skills. In a careful and extensive series of studies (Swanson, 1994; Swanson, 1999; Swanson & Alexander, 1997; Swanson & Sachse-Lee, in press), Swanson and his colleagues have shown that children with learning disabilities in either reading or math perform more poorly than typical learners on measures of working memory that require children to both store and process information at the same time. Because of specific correlational patterns in the data, Swanson argues that at least part of the math and reading difficulties of these children is caused by a domain-general limitation in working memory capacity. Apart from the difficulties inherent in arguing the presence of a constitutionally based *domain-general* processing weakness as the cause of *specific* learning disabilities, Swanson also must establish that this domain-general capacity limitation is the cause of the learning problems and has not, in fact, been caused by them. Thus far, none of the three categories of causal evidence described earlier consistently supports the hypothesis that constitutionally based, or inherent, domain-general limitations in working memory capacity actually cause specific learning disabilities in reading or math.

It is, in fact, very likely that almost all children with learning disabilities will show performance problems on complex measures of working memory, because these tasks draw so heavily on a variety of knowledge and skills that are acquired during successful learning experiences. Siegler (1998) makes explicit the difficulties involved in interpreting performance problems on these tasks when he describes the various factors that can contribute to differences between older and younger children on many memory tasks:

> One explanation is that older children have superior basic processes and capacities. In terms of the computer metaphor, this means that development occurs in the hardware of the system—its absolute information processing capacity or its speed of operation. A second explanation emphasizes strategies. Older children know a greater variety of strategies than young children and use them more often, more efficiently, and more flexibly. A third explanation highlights metacognition—knowledge about one's own cognitive activities. Older children better understand how memory works; they use this knowledge to choose strategies and allocate memory resources more effectively. Finally, older children have greater prior knowledge of the types of content they need to remember or process; this greater content knowledge may be a major source of their superior memory. (p. 178)

It is easy to imagine how the functional capacity of working memory will be affected by the chronic learning failures experienced by children with learning disabilities. Since early failure affects motivation to learn or succeed in school, children become less engaged in putting consistent effort into school learning tasks (Kistner & Torgesen, 1987). Not only does this affect acquisition of new knowledge across many domains, but it also undermines growth in the control processes and strategies that help children adapt successfully when asked to perform complex tasks such as those used to measure working memory. In this way, it is plausible that domain-general limits in the *functional capacity* of working memory would be characteristic of many children with learning disabilities. While it is important to know about these domain-general limitations (because they will affect these children's adaptation to new learning challenges and limit their success on complex tasks), if they arise as a result of chronic failure caused by other domain-specific processing limitations, then they are secondary characteristics (Torgesen, 1993) and not the kind of intrinsic processing limitations specified in the definition.

In sum, to support the widespread application of a diagnostic process that involves the identification of intrinsic processing disabilities, we will need substantial concurrence about what the critical intrinsic processes are that affect every type of learning disability specified by the definition. For almost all of the learning and skill outcomes specified in the definition, it is possible to find an isolated study (or a single investigator) that purports to have discovered a unique processing disability to explain the learning difficulty. However, emerging speculative scientific understanding is not sufficient justification for advocating widespread, everyday measurement of these processes by school psychologists or diagnosticians. For this level of application, we require converging evidence from many different investigators, as well as compelling theoretical descriptions of the mechanisms by which the processing disability acts as a proximal cause of the learning difficulty.

Difficulties in the Assessment of Psychological Processes Themselves

In his discussion of the difficulties involved in diagnosing the presence or absence of specific processing capabilities in children, Flavell (Flavell et al., 1993) described them as "many, varied, and very, very troublesome"(p. 320). In their most general form, these problems arise because of the complex organization and interactions among processes and knowledge in all academic learning and performance outcomes. As Flavell and his colleagues point out,

> the mind is a very highly organized device, one whose numerous 'parts' are richly interconnected to one another. It is not a collection or aggregate of unrelated cognitive components, but rather a

> complexly organized system of interacting components…each process plays a vital role in the operation and development of each other process, affecting it and being affected by it. This idea of mutual, two-way interactions among cognitive processes is an exceedingly important one. (p.3)

Any deficit in academic outcome or performance that fits the definition of a learning disability always involves a complex admixture of a processing weakness (or weaknesses) present at some point in development (perhaps not even concurrently present), an instructional context in which that processing weakness operates, the child's motivational and emotional reaction to the learning difficulties caused by the processing weakness, and the domain-specific knowledge acquired to support performance on the task. As children become older and acquire longer learning histories, measurement ambiguity increases until, when measuring a "psychological processing disability" in a 9-year-old child with suspected learning disabilities, it is extremely difficult to be certain that what we have identified is a constitutionally based, or intrinsic, processing disability.

With this general description of the complexities of cognitive diagnosis as a background, let us now consider three specific problems that make diagnosis of learning disabilities by identifying intrinsic processing weaknesses a daunting prospect. First, psychological processing weaknesses in school-aged children can be identified accurately only by multiple measurements that vary from one another in theoretically meaningful ways. For example, in order to establish that a child has specific difficulties processing rapidly changing or rapidly sequential aspects of the auditory signal (Tallal's temporal processing hypothesis), one would have to present a series of stimuli that required processing across varying temporal durations. Only if the child showed an aberrant effect of rapid, as opposed to slower changes, could one infer that the child was particularly affected at rapid rates of change. Since measurement of many of the basic processing skills underlying poor performance on academic tasks is likely to require very precise delivery of stimuli and/or precise measurement of response times under conditions that eliminate potentially distracting or confounding stimuli, there are likely to be enormous practical difficulties involved in assessing the basic processes and capacities that are alluded to in definitions of learning disabilities.

Another problem with assessing basic processes and capacities is that, as we attempt to assess them outside the context of the task for which they are purportedly required, we run a serious risk of distorting them. As Ericsson (in press) has pointed out, "when investigators design tasks that minimize the relevance of prior knowledge and eliminate redundant stimuli, all these factors combined are likely to induce processes mediating performance that have limited relevance to behavior in everyday life" (p. 12). In other words, humans adapt to the requirements of single, or simple tasks by trying to use the most efficient strategy possible. Strategies that enhance performance on a simple task might actually interfere when the processing skill supposedly measured by that task is embedded in a more complex task environment.

A final difficulty in diagnosing the basic psychological processing weaknesses responsible for difficulties in a particular academic domain is that performance on academic tasks, for which skill is acquired over time, is likely to depend on control processes or knowledge structures that are not required on simpler tasks. These more complex integrative or management processes and knowledge structures will not be assessed when single or elemental processes are measured. The example of long-term working memory is relevant here. When people are first exposed to tasks that are unfamiliar, their performance is tightly constrained by the limited capacity of their working memory. However, these rigid constraints of working memory tend to disappear once individuals have had sufficient skill-building experience with the tasks (Ericsson & Kintsch, 1995). Acquiring almost any academic skill involves acquisition of problem solving routines and knowledge structures that help one to appear more efficient in processing information on that task or in related domains. If relatively small differences in processing capacity or skill give rise to very different learning histories, or if different motivational patterns or learning opportunities produce similar differences in skill acquisition, children will manifest very different information processing skill profiles after several years. The essential point here is that acquisition of academic skills themselves has such an important effect on a child's processing capabilities that it becomes very difficult, indeed, to determine which processing weaknesses are intrinsic and which are acquired.

Summary

There are two very difficult problems that severely limit the viability of approaches to the diagnosis of learning disabilities that depend upon identification of intrinsic or constitutionally based psychological processing weaknesses. The first problem is that we do not have a complete understanding of the psychological processing capabilities that are required to attain good learning outcomes in all the areas specified in the definition and regulations. Although individual psychologists, in school or private practice, often speculate about the specific processing weaknesses that underlie a child's academic performance problems, these speculations are most often not supported by reliable scientific evidence. They are a kind of "psychometric phrenology" that has limited diagnostic reliability or instructional usefulness.

The second problem involves technical issues that interfere with the valid assessment of basic psychological processing weaknesses within the complexly organized cognitive systems of children who have substantial learning histories. It is most difficult to know for certain whether performance problems on psychological tests reflect intrinsic processing limitations or whether performance is limited by deficits in acquired knowledge structures and acquired automatic processing routines.

Overall, the foundation for reliable and valid assessment of the intrinsic psychological processing weaknesses of children with learning disabilities is not strong enough to recommend it for widespread application in schools. The premature use of process-oriented approaches to diagnosis and treatment has lead the learning disabilities field down many blind alleys (Hallahan & Cruickshank, 1973; Torgesen, 1979) in the course of its history. Although there is now good evidence that current definitions of learning disabilities are valid for many children, we are still not ready to directly apply the concept of intrinsic processing weaknesses in the routine diagnosis of learning disabilities in school. We will now consider an alternative that, although it does not involve assessment of intrinsic processing weaknesses, is still consistent with the definition and may enable critical early interventions to be more widely applied for children with learning disabilities.

Alternatives to Classification Based on Assessment of Intrinsic Processes

To be considered as an improvement over current diagnostic procedures for children with learning disabilities, any alternative must meet several important criteria. First, it must support identification of children with learning disabilities before their academic failure has progressed to the point that it begins to have motivational/emotional consequences and produce secondary knowledge and skill deficits (Cunningham & Stanovich, 1998). We know enough about the advantages of early intervention to assert that whatever diagnostic criteria are selected, they should facilitate intervention to prevent children with learning disabilities from falling seriously behind their age peers in critical academic skills.

Second, new diagnostic criteria should support the delivery of appropriate instruction to all children, not just those who show an arbitrary level of discrepancy between one set of learning abilities and another. For example, current evidence suggests that *all* children who have weaknesses in phonological abilities require more explicit instruction in this area in order to learn to read (Foorman & Torgesen, in press). Further, level of discrepancy between general intelligence and phonological ability is not a powerful or unique predictor of how well children will profit from this type of instruction (Torgesen et al., 1999; Vellutino et al., 1996). In other words, one cannot argue that children who do not show a discrepancy between their phonological processing abilities and other cognitive abilities (i.e., general intelligence) do not have a very important learning disability that affects their ability to acquire accurate and fluent word-level reading skills. They clearly have such a disability, but they are excluded from services under procedures that require an aptitude-achievement discrepancy for identification.

Finally, new diagnostic procedures must meet broadly acceptable standards for psychometric reliability and validity. That is, the criteria established should be those that can be measured with reasonable reliability, and they should also be conceptually and empirically consistent with current definitions. If indicators of potential failure are used to identify children at risk for the development of learning disabilities once formal school instruction has begun, these indicators must have sufficient predictive validity to warrant their widespread use in early identification.

The Use of Process-Marker Variables for Early Identification and of Outcome/ Response to Treatment Variables for Later Diagnosis

I made the point earlier that measures of phonological awareness are not direct measures of intrinsic or constitutionally based psychological processing weaknesses. Rather, individual differences in phonological awareness reflect both the operation of biologically based processing abilities and the learning opportunities to which a child has been exposed. On the one hand, if a child has a weakness in intrinsic phonological processing capability, phonological awareness will be weak in spite of ample preliteracy learning opportunities. On the other hand, if a child's preschool environment does not provide the kind of experiences that stimulate growth of beginning levels of phonological sensitivity and awareness, the emergence of phonological awareness will be delayed even if phonological processing abilities are relatively intact.

Even though measures of phonological awareness do not directly assess an intrinsic processing weakness, they are *markers* for the presence of a pre-literacy skill that is critical in learning to read. The same could be said for rapid automatic naming tasks; they are markers for a functional capability (arising from an interaction between intrinsic processing capabilities and experience) that is causally related to early reading growth. There is also substantial evidence that simple knowledge of letter-sound relationships in kindergarten, or the ability to "invent" phonetic spellings for words, has the same or even greater predictive power (Mann & Ditunno, 1990; Scarborough, 1998) for later reading growth. Thus, outcomes on these pre-reading skills are markers for early failure to acquire skills that are critical to the process of deciphering print. In essence, variability on these markers reflects the operation of both basic (intrinsic) processing capabilities and learning opportunities in the child's environment. Both the ability to acquire these skills and the actual presence of the skill itself in sufficient strength are predictive of response to future instruction in reading.

The alternative diagnostic scheme proposed here would facilitate early intervention through assessment of reliable and valid predictors of future difficulties acquiring essential academic skills. Measurement of these marker variables would allow us to identify children in need of more powerful instruction in a particular domain. Children would be initially identified for this special preventive instruction because they met some criteria of low performance on these marker (predictor) variables and were not classifiable as mentally retarded. The label *learning disabled* would not be assigned until some later point in development (perhaps 2nd or 3rd grade, or even later), but in the meantime, *every* child who was determined to require special instruction in reading, math, or writing on the basis of low performance on these marker variables, and who was not mentally retarded, would be eligible for special instructional services designed to maintain the child's academic growth (e.g., reading or pre-reading skills) within normal limits. During the period of early intervention (and before labels were assigned), response to instruction would be periodically assessed to examine the continuing need for the assignment of at-risk status and the associated special interventions to which the child had been assigned. Thus, every child who was failing to acquire critical pre-academic or academic skills at acceptable levels, and who was not classified as mentally retarded or some other primary classification, would be eligible for special education services under learning disabilities regulations. These children would not be officially labeled as learning disabled until later in development, but would have at-risk status and be eligible for services until their achievement fell within normal limits or they were officially labeled as learning disabled.

At whatever point in development it is judged proper to assign the official label of learning disabled, this designation would be applied to any child who fell below designated levels on measures of the learning outcomes specified in the definition and regulations and who also had general intelligence above some agreed-upon level. This level should probably be the same as the criteria for the diagnosis of mental retardation (i.e., IQ above 70), so that there would be continuity with earlier procedures for determining at-risk status and so that we would not automatically create a category of children critically behind in academic skills but who "fall through the cracks" between diagnostic categories. Additional processing or non-academic cognitive assessments would be part of the diagnostic criteria for learning disabilities only if it is clearly established that they provide information critical to further instruction, or if they predict future academic growth beyond the predictive power of the child's current academic levels.

The diagnostic and classification model I am proposing here is a combination of early assessment of marker variables for academic failure combined with ongoing assessment to determine response to treatment. At this point, I want to be very clear about one thing. This model will not guarantee that *only* children with intrinsic psychological processing disabilities will be identified as learning disabled. In fact, *there is no practical way to do that on a large-scale basis at present.* Stanovich and Siegel (1994) make this point in a powerful way when they sum up evidence against using IQ-discrepancy procedures to classify children as learning disabled:

> …neither the phenotypic nor the genotypic indicators of poor reading are correlated in a reliable way with IQ discrepancy. If there is a special group of children with reading disabilities who are behaviorally, cognitively, 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. Thus, the basic assumption that underlies decades of classification in research and educational practice regarding reading disabilities is becoming increasingly untenable. (p. 48)

Some would argue (Vellutino et al., 1996) that only children who do not respond adequately to well designed instruction can be considered classically learning disabled (in the sense that they have fundamental processing limitations). This is simply not true. For example, failure to respond to interventions could be the result of factors other than intrinsic processing deficits that are either not understood or not measured for each child. The only way to rule this out is to be completely sure one has accurately measured the entire knowledge and skill domains, as well as the motivational and emotional domains, as well as the environmental domains (support for learning outside the immediate instructional situation) that are relevant to achievement in the area being instructed. In a recent study of intensive preventive instruction in early reading skills, we (Torgesen et al., 1999) found that the three best independent predictors of response to the intervention were beginning levels of phonological processing ability, socioeconomic status of the child's parents, and classroom teacher ratings of attention and behavior. Further, the intrinsic processing disabilities that cause academic failure are almost certainly normally distributed in terms of their severity (Shaywitz, Escobar, Shaywitz, Fletcher, & Makuch, 1992). Children with mild intrinsic processing disabilities will respond to more intensive and explicit instruction, and those with more severe problems will respond less well. A good response to excellent instruction does not mean that the child does not have a constitutionally based processing disorder; it just means the particular instruction the child received was powerful enough to compensate for it.

In principle, any methodology that uses response to treatment as a way of classifying children as learning disabled has no greater chance of correctly identifying children with intrinsic learning disorders than do traditional assessment procedures. The children identified by the response-to-treatment method will be those who are most difficult to teach, no matter what the reason. For example, some estimates suggest that the variability in pre-school exposure to literacy learning opportunities can vary by as much as 1,000 hours in children from different home environments (Adams, 1990). If these estimates are close to being correct, and unless we can measure all the effects of the environmental difference before instruction begins, we cannot tell whether problems in responding to an intervention in kindergarten are the result of constitutionally based processing weaknesses or to unspecified weaknesses in the knowledge domains most relevant to the task being learned.

No method of educational or psychological assessment currently available can identify with certainty children who have intrinsically based psychological processing disorders. However, children who continue with severe learning difficulties after several years of appropriate early intervention are the ones most likely to have this kind of enduring learning disability. Thus, within present assessment capabilities, the method most likely to reliably identify the kind of children who are described in widely accepted definitions of learning disabilities involves early identification with process/outcome markers followed by careful monitoring of growth on critical skills in response to appropriate and consistent early interventions. This model clearly implies that our *methods of early identification and monitoring will develop and change as we learn more about the developmental course of each of the kinds of learning disability outcomes described in current definitions*. If the federal government were to specify which early markers of pre-academic development can be used to identify children for at-risk status to be served under learning disabilities regulations, this set of process/outcome markers would need to be periodically updated as new knowledge about emergent indicators of learning disabilities is developed.

Points of Vulnerability in the Proposed Classification Model

Two immediate points of vulnerability and difficulty with the classification model just presented are current levels of accuracy in identifying children at risk for learning disabilities and problems ensuring that children who are identified as at risk receive appropriate, research-based instruction delivered with sufficient intensity and skill. The model can easily break down, and create many difficulties for schools, children, and families, if identification for preventive instruction is not reasonably accurate and if preventive interventions are not optimal. There are a few facts relevant to these two issues to guide formation of policy in this area. First, if we want to ensure that a very high proportion of children at risk for the most serious reading difficulties (e.g., the bottom 10%) are identified in kindergarten for preventive instruction, we must be prepared to provide preventive instruction to more than 10% of children.

Two kinds of errors can be made when identifying children at risk for future reading failure. False positive errors are made when children who will eventually become good readers score below the cut-off score on the predictive instrument and are falsely identified as at risk. In general, the proportion of this type of error has ranged between 20% and 60%, with an average of around 45% (Catts, 1996; Scarborough, 1998). That is, almost half of the children identified during kindergarten as at risk turn out not to have serious reading problems by the end of first grade. False negative errors occur when children who later exhibit reading problems are identified as not being at risk. Typical percentages of false negative errors range from 10% to 50%, with an average of around 22%. That is, on average, current procedures fail to identify about 22% of children who eventually end up with serious reading difficulties (Catts, 1996; Scarborough, 1998).

In any given study, the relative proportion of false positive and false negative errors is somewhat arbitrary, since it depends on the level of the cut-off score. For example, we (Torgesen & Burgess, 1998) reported a significant reduction in the percentage of false negative errors within the same sample of children by doubling the number of children we identified as at risk. Our goal was to identify, during the first semester of kindergarten, the children most at risk to be in the bottom 10% in word reading ability by the beginning of second grade. When we selected the 10% of children who scored lowest on our predictive tests, our false negative rate was 42% (we missed almost half the children who became extremely poor readers). However, when we identified the 20% of children who scored lowest on our measures, the false negative rate was reduced to 8%. As a practical matter, if schools desire to maximize their chances for early intervention with the most impaired children, they should provide this intervention to as many children as possible. This is less of a waste of resources than it might seem at first glance, because, although many of the falsely identified children receiving intervention may not be among the most seriously disabled readers, almost all of them are likely to be below-average readers (Torgesen & Burgess, 1998).

It is also important to note that prediction accuracy increases significantly the longer a child has been in school. Prediction of reading disabilities from tests given at the beginning of first grade is significantly more accurate than from tests administered during the first semester of kindergarten (Scarborough, 1998; Torgesen, Burgess, & Rashotte, 1996). Given the widely varying range of children's pre-school learning opportunities, many children may score low on early identification instruments in the first semester of kindergarten simply because they have not had the opportunity to learn the skills. However, if pre-reading skills are actively taught in kindergarten, some of these differences may be reduced by the beginning of the second semester of school. Accuracy of identification of at-risk students can potentially be increased to

100% by frequent assessments of critical pre-reading and reading skills during the early elementary years. A model such as that established in Texas using the *Texas Primary Reading Inventory* (Texas Education Agency, 2000), in which a combination screening/assessment instrument is administered three times a year during kindergarten through 2nd grade will guarantee that any child who falls critically behind in important early literacy skills will be identified for extra supportive instruction.

The examples of assessment issues provided here have focused on reading, because that is the area we know the most about. However, Berninger and her colleagues (Berninger, in press; Berninger, Stage, Smith, & Hildebrand, 2001) have demonstrated the effectiveness of a "3-Tier Model for Prevention and Remediation" that involves early assessment to identify children at risk for difficulties in writing and math. The 3-Tier model is actually quite similar to the model being proposed here, except that it has an additional layer of intervention at the classroom level. In the simpler model I am proposing, I am assuming that classroom teachers are doing all they can to deliver high-quality, research-based instruction to all children, and that they are actively trying to accommodate individual differences in response to their instruction. If this is not the case, there will be far too many children requiring services under the learning disabilities regulations for the system to work effectively (Foorman & Torgesen, in press).

What do we know about the effectiveness of early interventions in preventing serious reading disabilities? We know, for example, that the best preventive interventions tested in research thus far typically reduce the percentage of children who are continuing be at risk for reading failure (defined as falling below the 30th percentile on critical word reading skills) at the end of first or second grade to about 2% to 6% of the population (Torgesen, 1999). We also know a great deal about the characteristics of effective instruction for children with learning disabilities (Foorman & Torgesen, in press; Swanson, Hoskyn, & Lee, 1999; Vaughn, Gersten, & Chard, 2000), and we know that they will frequently require instruction that is much more intensive and systematic than typical children if they are to attain reading levels within the normal range (Torgesen et al., 2001). One of the major challenges for politicians, school administrators, teachers, and parents in the model I have presented would be to ensure that all children who are at risk for learning disabilities receive appropriate and skillful instruction delivered with the right intensity for sufficient periods of time. A further challenge would be to ensure even greater levels of intensity and skill in instruction for children who do not respond successfully to the first layers of intervention.

As an example of what can be accomplished if excellent classroom instruction in reading is supplemented with more intensive instruction for children identified as at risk for reading failure, consider what happened at Hartsfield Elementary School over a period of 5 years (King & Torgesen, 2000). Hartsfield Elementary School serves a mixed population of school children of whom about 65% qualify for free and reduced lunch services and of whom about 65% are minority (primarily African-American). In the first year of the multiyear change project when only partially improved classroom instruction in reading was accomplished, 32% of the children obtained scores below the 25th percentile on a nationally standardized measure of word-level reading skills at the end of first grade. Once classroom instruction was more consistently high-quality and early identification procedures were in place, only 3.7% of the children fell below the 25th percentile at the end of first grade, and only 2.4% fell below this mark in second grade. In the present model, it would be those 2.4% of children who were still struggling to acquire basic reading skills who might be eligible for further assessment and diagnosis as learning disabled.

SUMMARY

The classification model being recommended in this paper is a two-stage or two-tier model that combines assessment of marker (predictor) variables with careful and continuous monitoring of children's response to early and subsequent interventions. Initially, children in first grade, kindergarten, or even preschool (depending on accuracy of predictive measures) would be identified for special preventive instruction under learning disabilities regulations if they performed below criterion on predictors of specific academic achievement and were not mentally retarded. These children would be assigned some kind of at-risk status to justify or certify their eligibility for these special services. The pre-academic or academic skills of these children would be assessed periodically (at least three times a year, perhaps more) to determine their continuing need for special services, and any child not being served could be identified for special services by referral and administration of similar tests. Any child not classified with some other primary disability (e.g., mental retardation, visual handicap) who was achieving below criterion on markers for at-risk status would be eligible for services.

Children would not be assigned the formal label of learning disabled until later in elementary school (perhaps 3rd grade or later). After receiving several years of special preventive instruction, a child could be certified as learning disabled if they continued to experience severe difficulties with any of the academic skills specified in the definition and regulations and if they attained a score on a measure of general learning ability above a given level. Any child with continuing severe academic difficulties who was not classified with some other primary disability (e.g., mental retardation, visual disabilities) would be considered learning disabled for purposes of instruction and accommodation. Additional processing or non-academic cognitive assessments would be part of the diagnostic criteria only if it is clearly established that they provide information critical to further instruction, or if they predict future academic growth beyond the predictive power of the child's current academic levels.

Potential Threats to Concepts and Practices from the Proposed Diagnostic Approach

The term learning disabilities is associated both with a social-political-educational movement and with a field of scientific research and study. Changes to common diagnostic practices as guided by federal regulations will have foreseeable and unforeseeable effects in both areas. As a social-political-educational movement, the field is associated with teacher training programs, parent and professional organizations, legal requirements for educational and workplace accommodations, status as a "handicapping condition," public and private school programs, etc. As a field of scientific inquiry, it is associated with research funding programs, professional identities of scientists, scientific journals and publications, research conventions and questions, etc. Changing the diagnostic criteria for learning disabilities in the manner suggested in this paper will have major impact in some of these areas and little impact in others. It is beyond the scope of this paper (to say nothing of the ability and knowledge of its writer) to give full consideration to all potential effects of a change such as the one proposed here. Nevertheless, a few of the more obvious consequences will be briefly discussed.

Consequences for the Field as a Social-Political-Educational Movement

One of the most obvious consequences of a change in classification procedures such as the one being recommended here is a change in the characteristics of children being identified for special educational services under learning disabilities regulations. The group identified by these new procedures will be much more heterogeneous with regard to general intelligence. Further, many children currently served as learning disabled might not be served because the absolute level of their academic performance problem may not be sufficiently severe. In current practice, it is the size of the discrepancy between general intelligence and academic skill, rather than the absolute level of academic skill, that leads to a diagnosis of learning disability. Many children with average to above-average general intelligence are served as learning disabled because of the discrepancy between their level of reading skill and their level of general ability, even though the absolute level of their reading abilities is substantially higher than other children who show less of a discrepancy between IQ and reading level. If a criterion involving actual reading level were substituted for the currently used discrepancy criteria, it is obvious that many children with mild reading problems (but large discrepancies) would no longer be served as reading disabled (unless service delivery capacity was considerably expanded over present limits). It is also likely that the ethnic composition and socioeconomic status of children identified as having learning disabilities would shift more strongly toward minorities and lower socioeconomic status groups, because these groups tend to have fewer of the specific types of pre-school language experiences that support the growth of phonological awareness and other pre-academic skills (Whitehurst & Lonigan, 1998).

One of the most widely accepted conventions about learning disabilities is that they involve "unexpected" academic underachievement. The poor academic performance of these children is not expected given their general level of learning ability (as measured by IQ tests), adequate learning opportunities, and reasonable motivation for learning. The trouble with this concept in practice, at least for the development of reading skills, is that standard IQ measures are not equally predictive of all aspects of reading growth. Standard IQ measures are not good independent predictors of early word reading growth (Stanovich, Cunningham & Feeman, 1984; Torgesen et al., 1999), but they are good predictors of individual differences in reading comprehension (Stanovich et al., 1984) once word reading ability has been acquired. IQ measures are good predictors of reading comprehension scores in older children because IQ scores are heavily influenced by level of vocabulary and verbal skills, and this kind of knowledge is also required in reading comprehension. If IQ measures contained a more thorough assessment of phonological abilities and knowledge, they would also be very predictive of growth in early word reading skill. Thus, while general IQ (and particularly verbal IQ) does not lead to clear expectations for growth in early word reading ability, it does justify clear expectations for the ultimate level of reading comprehension that we may expect from individual children. Children with broad verbal and language comprehension abilities far below average cannot be expected to comprehend written material at average levels even if they can decipher all the words in print accurately.

Ultimately, our educational response to children, as well as our system of accommodation to their learning disability, will need to recognize a far greater range of individual differences than it currently does. For example, it is clear that a child with high levels of domain-related knowledge and verbal ability who cannot decipher words fluently should have this reading disability accommodated on tests in which the object is to demonstrate mastery and understanding of a given subject area. However, is there an appropriate accommodation for a child who can decipher the words accurately, but who does not have the domain-related knowledge and broad verbal ability that is required for good performance on the test? The problem, in terms of thinking through the implications of the presently proposed classification scheme, is that both of these students would probably be classified as learning disabled. The example suggests that the concept of accommodations for learning disabilities would need to be more finely developed and clearly articulated than it often is at present.

Another potential consequence of changing the classification criteria for learning disabilities to a system that does not explicitly contain discrepancy criteria is that it might lose its identity as a focus for political action and educational funding. As scientifically flawed and unfair as current discrepancy criteria are, they at least *attempt* to make a distinction between learning difficulties resulting from specific, constitutionally based processing weaknesses and learning difficulties that are the result of many other causes such as lack of motivation, lack of home support, or low general learning ability. Any classification procedure that does away with the discrepancy idea runs the risk of destroying the concept of learning disabilities in the minds of politicians and educators. The point being made in this paper is that it is not currently feasible to accurately identify children whose learning difficulty is the sole result of an intrinsically based processing disability, and we should not try to do so using invalid discrepancy-based procedures. By publicly acknowledging the problem in moving to a classification criteria that involves neither direct assessment of intrinsic processing weaknesses nor use of discrepancy criteria, we do run the risk of weakening the base for political and social action on behalf of children with developmental learning disabilities.

Consequences for the Field as an Area of Scientific Inquiry

In contrast to the potential consequences for learning disabilities as a political-social-educational movement, which do involve some serious risks, the change to more encompassing and inclusive criteria for classification of learning disabilities should have mostly positive consequences for the field as an area of scientific inquiry. Perhaps the most positive consequence is that it will underline the heterogeneity of children with learning disabilities in a way that will promote more careful specification of sample characteristics in research as they relate to the questions being asked.

It has long been recognized that researchers should not use school-defined samples of children with learning disabilities as the focus of research, for such samples are simply too heterogeneous to be the basis for coherent theory development (Senf, 1986; Stanovich, 1993; Torgesen, 1993). Since the study of learning disabilities is essentially the study of individual differences in learning and performance, samples should always be carefully selected in relationship to the particular question being addressed in the research. For example, if one wants to determine if weaknesses in a given ability or processing skill can cause a learning difficulty independently from levels of other important abilities (such as verbal or nonverbal intelligence, vocabulary, syntactic skill, general knowledge, etc.) then samples of learning disabled and nondisabled children should be carefully equated on the abilities being controlled. Without such methods, it is arguable that we may never have discovered the unique contributions of word-level reading problems or phonological processes to developmental dyslexia (reading disability), because lower IQ children so frequently also have problems in broad verbal ability and language comprehension (Torgesen, 1989). If the goal is to develop a theory of math disabilities, then only children with a specified type of math disability should be used in the research—and it would also be important to ask how levels of other abilities (such as general intelligence) affect the expression of the disability.

The major threat to the field of learning disabilities as an area of scientific inquiry would involve a potential loss of focused identity if research articles never contained the term learning disabilities but only mentioned topics like “problems with math fact retrieval in children of average intelligence,” “difficulties in expressive language in young children with adequate receptive skills,” or “factors involved in handwriting difficulties in young children.” If a more inclusive definition of learning disabilities applied in the public schools created a loss of cohesion among researchers studying these children, this might make it more difficult to focus public attention on learning disabilities as an area for research funding. It might also create such diversity of focus in professional societies that the synergistic effects found in groups that gather to discuss common interests would be diluted.

Summary

Changing procedures for the classification of children with learning disabilities in the manner suggested in this paper would have several clear consequences for the field of learning disabilities as an educational-social-political movement. First, the children identified for learning disabilities services in the school would become more heterogeneous with regard to level of general intelligence. This would require a more differentiated approach to the provision of accommodations than is presently the case, in which children often can receive accommodations simply because of their status as learning disabled. Second, children identified as at risk for learning disabilities on the basis of their performance on process/outcome measures would also be more likely to come from minority ethnic groups and homes of lower socioeconomic status. This would occur simply because children from these kinds of pre-school environments often enter school less well prepared on the critical markers, or predictors for various learning outcomes. Finally, unless service delivery capacity were substantially increased, many children now receiving learning disabilities services would no longer receive them. For example, a child with mild reading difficulties that are significantly discrepant from IQ can qualify for learning disabilities services under current IQ-discrepancy procedures. However, if absolute level of process/outcome scores or reading scores were used to identify children as reading disabled, the same child might not qualify because his or her scores would not be low enough. In order to serve all children who do not have another primary disability but whose learning difficulties in specific academic areas were severe enough to interfere with their ability to accomplish grade level work, there is no question that special instructional capacity for children with learning disabilities would need to be expanded.

The changes to classification procedures recommended in this paper might also impact the scientific study of learning disabilities, but these effects would probably be less severe or threatening than those to the education and politics of learning disabilities. Potentially, the changes could positively affect the scientific study of learning disabilities by forcing investigators to more carefully define their samples, and to select them in more principled ways. The major negative impact might arise from a loss of identity for the field as it divided into separate groups, each focusing on different kinds of learning difficulties.

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