Toward Distinguishing Between Cognitive and Experiential Deficits as Primary Sources of Difficulty in Learning to Read: The Importance of Early Intervention in Diagnosing Specific Reading Disability

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BACKGROUND

Specific reading disability, as an etiological concept, carries with it the implicit assumption that reading problems in beginning readers are caused primarily by constitutional factors such as organic disorder or genetic limitations that adversely affect cognitive abilities that underlie reading ability. Yet, notwithstanding commonly used exclusionary criteria designed to distinguish between factors that lead to relatively circumscribed learning difficulties and factors that lead to general learning difficulties (e.g., low general intelligence, sensory deficits, emotional disorder, environmental impoverishment), there are no definitive criteria that would allow us to distinguish between constitutional causes of reading disability and experiential causes such as inadequate instruction and/or inadequate preliteracy experience. And, whereas psychological studies conducted in recent years have provided highly convergent evidence that reading disability may be caused by language deficits of one description or another rather than visual–spatial or occulomotor deficits, as was once believed to

1The longitudinal study briefly discussed in this chapter is described in greater detail elsewhere (Vellutino et al., 1996).
be the case, there is not uniform agreement as to which of the language systems is a preeminent cause of the disorder. Results from genetic, neurological, and electrophysiological studies are also consistent with a language deficit explanation of reading disability, but results from these studies are yet inconclusive.

Regarding psychological research, the most compelling and convergent evidence suggests that reading disability is caused by phonological coding deficits that impair the acquisition of facility in word identification, letter-sound mapping, and spelling, as basic reading subskills. The evidence for this suggestion comes from a large number of cross-sectional studies that have found robust and reliable differences between both age-matched and reading-level-matched poor and normal readers, not only on tests evaluating these reading subskills, but also on tests evaluating phonological skills, such as phoneme segmentation, name encoding, name retrieval, and verbal (working) memory, all of which are presumed to underlie reading ability (e.g., Brady & Shankweiler, 1991; Bruck, 1990, 1992; Liberman & Shankweiler, 1979; Mann, Liberman, & Shankweiler, 1980; Stanovich, 1988; Tunmer, 1989; Vellutino & Scanlon, 1987a, 1987b; Vellutino, Scanlon, Small, & Tanzman, 1991; Vellutino, Scanlon, & Sizing, 1995; Vellutino, Scanlon, & Tanzman, 1994). Also supportive are results from longitudinal studies demonstrating that these and other phonological skills, such as letter naming and rapid automatized naming, are reasonably good predictors of achievement in reading (Blachman, 1984; Bradley & Bryant, 1983; Liberman, Shankweiler, Fischer, & Carter, 1974; Lundberg, Olofsson, & Wall, 1980; Vellutino & Scanlon, 1987a; Wolf, 1984); and regression studies documenting that tests evaluating phonological skills, such as alphabetic mapping and phoneme segmentation, account for much more variance on measures of word identification than do tests evaluating other language-based skills or tests evaluating visual processing abilities (Vellutino et al., 1991, 1994). But especially impressive are results from training studies demonstrating that instruction in phoneme segmentation and alphabetic mapping has a positive effect on reading and spelling ability (Blachman, 1994; Blachman, Ball, Black, & Tang, 1994; Bradley & Bryant, 1983; Byrne & Fielding-Barnes, 1991, 1993; Foorman, Francis, Novy, & Liberman, 1991; Lundberg, Frost, & Petersen, 1988; Torgesen, Wagner, & Rashotte, this volume; Vellutino & Scanlon, 1987a; Williams, 1980).

Yet, despite the wealth of evidence supporting the view that phonological skills deficiencies are preeminent causes of reading disability, some have suggested that the disorder may, in some cases, be caused by deficiencies in semantic and/or syntactic development (Byrne, 1981; Donahue, 1986; Flood & Menyuk, 1983; Fry, Johnson, & Muehl, 1970; Loban, 1963; Scarborough, 1990; Vellutino, 1979, 1987). These suggestions are largely based on studies finding differences between poor and normal readers on tests of semantic and syntactic competence, but the conclusions drawn from such studies are compromised by the fact that most of them employed intermediate- or adolescent-age subjects, thus presenting the possibility that reader group differences on tests of semantic and syntactic abilities are a consequence of longstanding reading difficulties, rather than a primary cause of such difficulties (Stanovich, 1986). In the semantic domain, this possibility is supported by the finding of strong and reliable reader group differences on tests of vocabulary knowledge and other semantic abilities, but only in adolescent-age children, and not in elementary-age children (Vellutino et al., 1991, 1994; Vellutino & Scanlon, 1987b; Vellutino, Scanlon, & Tanzman, 1988). Vellutino et al. (1991, 1994) replicated this pattern in the syntactic domain. Moreover, several studies have provided documentation that syntactic deficits of the types observed in poor readers (e.g., comprehending syntactically complex sentences, judging grammaticality, using sentence contexts for word identification) may be caused by more basic deficits in phonological coding (Mann, Shankweiler, & Smith, 1984; Shankweiler & Crain, 1986; Shankweiler, Crain, Brady, & Macaruso, 1992; Shankweiler, Smith, & Mann, 1984). These issues, nevertheless, remain open.

Finally, there is now abundant evidence that poor readers tend to perform as proficiently as do normal readers on tests evaluating visual-spatial and occulo-motor abilities (Olson, Kliegl, & Davidson, 1983; Stanley, Smith, & Howell, 1983; Vellutino, 1979, 1987), thus undermining visual defect theories of reading disability. However, most of these studies evaluated children who were not beginning readers, and at least one

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2 A number of investigators have, more recently, theorized that reading disability may be caused by a deficit in the "transient visual system" (Badcock & Lovegrove, 1981; Breitmeyer, 1988; Lovegrove, Martin, & Slaghuis, 1986). The transient system is a functional component of the visual system that is operative during sacadic movements and is believed to be responsible for inhibiting the visual trace that normally persists for a short duration (approximately 250 milliseconds) after a visual stimulus has been terminated. Poor readers are presumed to suffer from a deficit in the inhibitory function of the transient system, producing a visual trace of abnormal longevity that creates masking effects and, thus, visual acuity problems when the children are reading connected text. Some experimental evidence to support this theory is provided by studies showing that poor and normal readers process high and low spatial frequency grids differently and that they have different contrast sensitivity functions, such that the poor readers require greater luminosity than the normal readers for distinguishing low frequency grids (Badcock & Lovegrove, 1981; Martin & Lovegrove, 1984). However, as pointed out by Hulme (1988), the trace persistence theory of reading disability predicts that poor readers should be impaired only when they are reading connected text and not when they encounter printed words one at a time under foveal vision conditions. Yet, we know that poor readers have as much or more difficulty identifying printed words encountered one at a time, under foveal vision conditions, as they have identifying words encountered in connected text. Moreover, there is no evidence that poor readers are impaired by visual masking and visual acuity problems under normal reading conditions. We, therefore, doubt that visual trace persistence is a significant cause of reading disability.
prominent theory of reading disability suggests that visual deficits, which might be causally related to the disorder, would be observed very early in the child's development, but perhaps not later (Satz, Taylor, Friel, & Fletcher, 1978).

Regarding the possibility that reading disability may be caused by constitutional deficits of one description or another, suggestive evidence is provided by neuroanatomical (Galaburda & Kemper, 1979; Galaburda, 1983), electrophysiological (Shucard, Cummins, Gay, Lairsmith, & Welanko, 1985), and neuroradiological (Filipek, 1995; Hynd & Semrud-Clikeman, 1989) studies demonstrating structural and functional anomalies in the brains of impaired readers, although results to date are conflicting. More impressive are results from genetic studies documenting that reading difficulties occur more often among family members of reading-impaired individuals than in the population at large. Furthermore, reading difficulties have a higher concordance rate in twins than in other siblings, especially monozygotic twins (Olson, Wise, Conners, & Rack, 1990). Moreover, a recent study has tentatively located a gene for reading disability on chromosome 6 (Cardon et al., 1994), although this finding has not yet been replicated. Additionally, twin studies have shown that measures of reading ability as well as measures of phonologically based skills—such as phoneme segmentation, letter-sound mapping, and rapid naming—have high degrees of heritability, thereby providing the most compelling evidence to date for a direct link between genetic endowment and cognitive abilities underlying reading ability.

However, as clearly articulated in a very penetrating paper by Clay (1987), virtually all studies concerned with the etiology of reading disability are equivocated by the fact that none have controlled for or evaluated the early literacy experiences or the school histories of the impaired readers who were the objects of inquiry. At the same time, early intervention studies suggest that most reading-impaired children, who might be diagnosed as "reading disabled," are not truly "disabled" in the sense in which this term is typically used (i.e., implying organically based cognitive deficits), but may simply have gotten off to a poor start because of experience and/or instruction that did not adequately prepare them for success in beginning reading (Clay, 1985; Iversen & Tunner, 1993; Pinnell, 1989; Wasik & Slavin, 1993). Yet, results from these studies are, themselves, inconclusive, because none compared the cognitive abilities of children who were difficult to remediate with the cognitive abilities of children who were readily remediated, in order to ascertain whether cognitive deficits presumed to be causally related to reading disability are found more often in the former than in the latter group. Moreover, none attempted to evaluate rudimentary literacy and other precursor skills acquired by the children in these two groups before they had any formal instruction in reading.

16. COGNITIVE AND EXPERIENTIAL DEFICITS

To accomplish these objectives, we conducted a longitudinal study that incorporated an early intervention component designed as a "first cut" diagnostic to aid in distinguishing between children whose reading difficulties are caused by basic cognitive deficits and children whose reading difficulties are caused by inadequate experience and/or instruction (Vellutino et al., 1996). Of special interest was the question of whether or not these two groups would differ on the types of tasks that have consistently distinguished between poor and normally developing readers in previous research; in particular, tasks that depend heavily on phonological coding ability. Accordingly, kindergartners from several participating school districts (n = 1,407) in middle- to upper-middle-class neighborhoods in the Albany, New York, area were administered a large battery of psychological tests evaluating relevant cognitive abilities and rudimentary literacy skills. In mid-first grade, subsamples of poor readers (n = 118) and normal readers (n = 65) were selected from the population that remained following attrition (n = 1,284). Selection was based upon teacher recommendations, achievement testing, and the application of exclusionary criteria typically employed in reading disability research. The number of poor readers identified by these exclusionary criteria represents 9% of the total population of available children.\(^3\) The poor and normal reader groups were studied in depth from kindergarten through fourth grade. In winter of first grade, the poor readers were randomly assigned to either a "tutored" or "nontutored" group. The children in the tutored group (n = 76) were given daily (one-to-one) tutoring (½ hour per day) for a minimum of one and a maximum of two school semesters, depending on progress. Children in the nontutored group were given school-based remediation, which typically entailed small-group instruction (n = 26). However, in given

\(^3\)To qualify for the poor reader sample, children had to be identified by their classroom teacher as experiencing substantial difficulties with reading and had to have a score at or below the 15th percentile on either the Word Identification or Word Attack subtests of the Woodcock Reading Mastery Test—Revised (Woodcock, 1987). To qualify as a normal reader, children had to be identified by their classroom teacher as progressing at an average or above-average level in reading and had to score at or above the 40th percentile on both subtests. All (prospective) subjects also had to have an IQ of at least 90 or above on either the Verbal or the Performance Scales of the Wechsler Intelligence Scale for Children—Revised. These criteria were employed only after initial screening using the exclusionary criteria previously referred to.
instances, it entailed some amount of one-to-one instruction (n = 16). All target children (both poor and normal readers) were given annual achievement tests through fourth grade. They were also evaluated in first and third grades on a large battery of tests assessing cognitive abilities believed to underlie reading. A few additional measures were administered in second grade. The various tests discussed in this chapter are briefly described in Fig. 16.1.

The tutoring program was tailored to individual needs and the degree of emphasis placed on given remedial activities varied in accord with the child’s strengths and weaknesses. However, in each session, some time was spent: helping the child acquire facility in whole word identification, helping him or her acquire phoneme awareness, attuning him or her to the alphabetic principle, and facilitating phonetic decoding and writing skills. In addition, each session typically included approximately 15 minutes devoted to reading connected text, both to facilitate reading for meaning and fun, and to foster deliberate and interactive use of a variety of strategies for word identification, in particular sentence and/or thematic contexts for prediction and monitoring, external aids (e.g., picture clues), and phonetic (letter-sound) decoding. Instruction was provided by teachers (n = 14) who were certified in either elementary education or in reading. All but one had at least 2 years of teaching experience.

Tutor training consisted initially of a 30-hour seminar supplemented by reading of theoretically and practically relevant materials. To ensure fidelity of treatment, all tutoring sessions were recorded on audiotape, and 1 out of every 10 tapes was randomly selected for review and feedback by one of the authors, each of whom met weekly with one or another tutor on a rotating basis. There were also biweekly meetings with all of the tutors as a group, during which relevant issues and problems were discussed.

SUMMARY OF SALIENT FINDINGS

Our primary interest in the current study was in comparing children who were initially identified as poor readers but were readily remediated, with similarly identified children who were difficult to remediate, relative to normally developing readers. Thus, the results summarized in the ensuing sections focus on the target poor readers who received daily (one-to-one) tutoring and the normal reading control subjects. We discuss only the data collected during the period from kindergarten through second grade because data collection beyond this grade has only recently been completed. Growth rate in reading ability was estimated by calculating the slope for the line of best fit for the reading outcome measures using Rasch-based ability (“W”) scores on the Basic Skills Cluster (BSC) of the

FIG. 16.1. (Continued)
5. **Verbal Memory and Visual-Verbal Learning**
   a. Sentence Memory - child hears sentences and must repeat each verbatim.
   b. Word Memory - child hears strings of randomly ordered words and must repeat each verbatim.
   c. Visual-Auditory Learning subtest from the Woodcock Reading Mastery Test-Revised - child learns to associate novel symbols with words and learns to "read" sentences made up of these symbols.

6. **Visual Skills**
   1. **Visual-Spatial Reasoning**
      a. The Block Design subtest from the WPPSI-R - evaluates analysis and synthesis of spatial relations, visual-spatial reasoning, visual-motor coordination, etc. Child assembles blocks to reproduce geometric designs.
   2. **Visual Memory**
      a. Child is asked to reproduce dot patterns from memory on a magnetic drawing board. Patterns are either labelable (e.g., dots form a "T") or non-labelable (randomly arranged).
   3. **Executive Functions** (Attention, Concentration, Planning and Vigilance)
      1. Visual matching (Matching Familiar Figures Test-Modified) - the child is asked to find the identical match for a line drawing in a group of four similar drawings.
      2. Visual Search (Target Search Test) - the child is asked to look at a large group of geometric designs and put a line through all those that are identical to a target design.

**FIRST GRADE BATTERY**

A. **Intelligence Ability**
   1. The full Wechsler Intelligence Scale for Children-Revised (WISC-R) was administered to all target subjects.

B. **Achievement Measures**
   1. **First Grade Selection Measures**
      a. **Woodcock Reading Mastery Test-Revised**
         1. Word Identification - evaluates whole word naming.
         2. Word Attack - evaluates ability to decode nonsense syllables.
   2. **First Grade Outcome Measures**
      a. WMT-R Word Identification - see above
      b. WMT-R Word Attack - see above
      c. Test reading - evaluates oral reading accuracy using narrative text presented in short paragraphs.
   3. **Math Achievement (Woodcock-Johnson Tests of Achievement)**
      a. Calculation - assesses ability to perform written math calculations such as addition and subtraction.
      b. Applied Problems - assesses the ability to solve math "story problems."
   4. **Language Measures**
      a. **Phonological Processing**
         1. Phonic Awareness - initial phoneme deletion, final phoneme deletion, phoneme articulation (see kindergarten measures for descriptions).
         2. Phonological Memory - memory for six nonsense syllables assessed over eight presentation/recall trials.

**SECOND GRADE BATTERY**

A. **Achievement Outcome Measures**
   1. WMT-R Word Identification
   2. WMT-R Word Attack
   3. Silent Reading Comprehension subtest of the Spache Diagnostic Reading Scales - evaluates ability to answer factual and inferential questions about narrative text presented in print.
   4. **Executive Functions** (Attention, Concentration, Planning and Vigilance)
      1. Target Search Test (Symbols) - see kindergarten battery
      2. Target Search Test (Letters) - child searches a 14 x 10 array of CVC syllables through which he/she is to draw a line.
      3. Targets Search Test (Numbers) - child searches an array of 3 digit numbers for all occurrences of a target number.

FIG. 16.1. (Continued)
Woodcock Reading Mastery Test—Revised (WRMT—R), which combines the Word Identification and Word Attack subtests. The BSC served as the dependent variable, and time of test (in months from entry into kindergarten through fall of second grade) served as the independent variable (Bryk & Raudenbush, 1987; Rogosa & Willet, 1985). Growth rates were computed for each child separately based on four data points: fall of kindergarten, winter of first grade, late spring of first grade, and fall of second grade. The slopes for the entire poor reader group were then rank ordered, and four (roughly) equal groups were formed based on relative status on the slopes continuum. The four groups were designated as follows: very limited growth (VLG), limited growth (LG), good growth (GG), and very good growth (VGG). To more fully evaluate the possible effects of IQ on the various dependent measures, the normal reader group was partitioned into two groups by dividing it at the normal reader mean IQ (WISC—R Full Scale IQ: Wechsler, 1974), yielding an average IQ normal reader group (AVIQNorm) and an above-average IQ group (ABAVIQNorm).

In the ensuing sections, we organize the exposition as follows. We first present results on the sample selection measures in order to provide baseline data on reading subskills prior to remediation, and to document that results on our reading achievement and intelligence measures conformed with acceptable psychometric criteria for defining specific reading disability. We next present results on the reading achievement outcome measures used to evaluate growth in reading over time to provide documentation for the utility of early intervention as a “first cut” diagnostic in distinguishing between problem readers impaired primarily by basic cognitive deficits and problem readers impaired primarily by experiential deficits. We thereupon summarize the most important findings on the preintervention kindergarten and first-grade assessment batteries, and present evidence that the cognitive profiles of readily remediated poor readers are more like those of normal readers than are the cognitive profiles of difficult to remediate problem readers.

Selection Measures

Table 16.1 presents results on the measures used for sample selection. It can be seen that the children in the various tutored groups performed well below the children in both normal reader groups on the word identification and phonetic (pseudoword) decoding tests (respectively, WRMT—R Word Identification and WRMT—R Word Attack). In contrast, the two normal reader groups performed at comparable levels on these tests. Note, however, that among the tutored groups, those who manifested the most limited growth in reading had the lowest scores on the word identification subtest at the outset, whereas those who manifested
the greatest amount of growth in reading had the highest scores at the outset. In contrast, virtually all tutored children had inadequate facility in phonetic decoding at the outset. It is also worth noting that the poor readers in respective tutored groups and the average IQ normal readers performed at comparable levels on the intelligence measures.

Reading Achievement Outcome Measures

In accord with results obtained in previous intervention studies (Clay, 1985; Iversen & Tunmer, 1993; Pinnell, 1989; Wasik & Slavin, 1993), most of the children given daily tutoring (67.1%) scored solidly in the average range (>30th percentile) on the Basic Skills Cluster (BSC) after only one semester of remediation. In fact, 44.7% of these children scored above the 45th percentile on the BSC, whereas only 19.2% of the children given small-group instruction scored in this range. At the same time, 26.9% of the children given small-group instruction scored at or below the 15th percentile on the BSC, whereas only 15.8% of the children given daily tutoring scored in this range. This pattern of results indicates that, in most cases, daily tutoring was a more effective intervention procedure than was small-group instruction. (Note that two of the children initially given daily tutoring were subsequently lost through attrition. Thus, analyses reported in the ensuing sections are based on a total of 74 tutored children.)

More important, for present purposes, are results from the growth curve analyses comparing the progress of children who were found to be difficult to remediate with that of children who were more readily remediated, relative to the progress made by the normal readers. Figures 16.2 and 16.3 present growth curves for raw score averages on the WRMT—R Word Identification and Word Attack subtests (respectively) for children in the two normal reader groups and children in each of the tutored groups. (Although the tutored groups were partitioned on the basis of slopes for BSC W scores obtained from kindergarten through fall of second grade, we also present data for winter and spring of second grade to demonstrate stability in the rank ordering of these respective groups following remediation.) It can be seen that the slopes representing growth in word identification in the AvIQNorm and AbAvIQNorm groups (Fig. 16.2) are virtually identical throughout the period evaluated. And, as would be expected, the growth rates for these two groups, prior to initiation of the intervention program (fall of kindergarten to winter of first grade), are much greater than the growth rates for the tutored groups during the same period. However, after only one semester of remediation (winter to spring of first grade), the performance levels for respective tutored groups rose dramatically, indicating that the intervention program had a positive effect on children in each of these groups. Yet, it is apparent, from both group differences in the performance levels representing initial response to the intervention program and the consistency of the rank ordering of these performance levels over the period following intervention, that children in the VGG group were best able to profit from remediation, whereas children in the VLG group were least able to do so. Children in the GG group did not profit as much from remediation as did children in the VGG group, but
profited more than children in the LG group, who, in turn, profited more than children in the VLG group. Essentially, the same pattern of results emerged in assessment of growth in phonetic decoding ability.

It can be seen (Fig. 16.3) that the growth curves depicting change in phonetic (pseudoword) decoding ability are similar to the growth curves depicting change in word identification, insofar as the tutored children made little or no progress in acquiring this skill prior to initiation of the intervention program. However, their growth rates increased sharply from winter of first grade to spring of first grade, after one semester of remediation. In contrast, growth rates for the AvIQNorm and AbAvIQNorm groups increased sharply from kindergarten to winter of first grade, and continued to increase steadily thereafter. And, as was true of word identification, the growth rate in these two groups were virtually identical. In addition, the rank ordering of respective groups was maintained throughout the period following intervention. Note also that, following intervention, the performance level of the VGG group was more like that of the two normal reader groups than like those of the other tutored groups. Indeed, the disparity between the VGG group and the other tutored groups, vis-à-vis growth in phonetic decoding ability, was greater than the disparity between these groups, vis-à-vis growth in word identification. Given the heavy reliance of alphabetic mapping on phonological coding ability, these results lead one to expect that the VGG group would also be closer to normal readers than to the other tutored groups on nonreading cognitive tasks that also depend on phonological coding ability. As is seen further in this discussion, this expectation was essentially realized.

Finally, because respective tutored groups were partitioned on the basis of Basic Skills Cluster (BSC) W scores, Table 16.2 presents the BSC percentile ranks corresponding with these scores to allow norm-based comparison of the general reading abilities of respective groups, beginning with the BSC percentile ranks achieved just prior to initiation of the intervention program (winter of first grade). Table 16.2 also presents: raw score means and standard deviations for the oral (text) reading test administered to the children in each of the groups at the end of first grade, and grade equivalent on the test of reading comprehension administered at the end of second grade. It can be seen that the rank orderings (of respective) group means on the BSC obtained in first and second grade are cross-validated by the rank orderings of group means on both the text reading and reading comprehension tests, each of which provides an independent measure of reading ability.

It should be clear, from the stability of the results yielded by the reading achievement measures that, following intervention, the reading subskills of children in the VGG group were much closer to those of the normal readers than were the reading subskills of children in the other three
Kindergarten Battery

Table 16.3 presents results on kindergarten measures of foundational literacy skills and cognitive abilities that distinguished between the tutored children and the normal readers, and in some instances, between the VGG and the VLG groups. Raw score means and standard deviations are presented for the average IQ normal readers. For all other groups, the data are presented as effect sizes computed relative to the performance of the average IQ normal reader group. Because of space constraints, the tables present data only for measures that produced statistically significant differences between given groups.

No less surprisingly, the normal readers performed significantly better ($p < .05$) than did children in both the VLG and VGG groups on the measures of letter and word naming administered in kindergarten. The normal readers also performed better on the tests (respectively) evaluating counting by 1s and number naming, although their performance was significantly better than that of the VGG group only on the number naming test. These latter results are significant because each of these tests involves many of the same cognitive processes as letter and word naming, in particular, name encoding, name retrieval, phonological coding, and visual-verbal association learning. Thus, it is not surprising that the normal readers also performed significantly better than did children in the VLG group on WPPSI—R Arithmetic, (which also evaluates counting, as well as the ability to solve simple math “story” problems, among other rudimentary number skills) and on tests evaluating rapid naming of objects, fluency in articulation, sentence memory, word memory, and visual-verbal learning.

In contrast, the normal readers performed significantly better than did children in the VGG group only on WPPSI—R Arithmetic and on the