

Reading and spelling difficulties in high school students: Causes and consequences

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ABSTRACT: Basic skills in reading and spelling and supporting metalinguistic abilities were assessed in ninth and tenth grade students in two school settings. Students attending a private high school for the learning disabled comprised one group and the other comprised low to middle range students from a public high school. Both the LD students and the regular high school students displayed deficiencies in spelling and in decoding, a factor in reading difficulty that is commonly supposed to dwindle in importance after the elementary school years. Treating the overlapping groups as a single sample, multiple regression analysis was used to investigate the contribution of nonword decoding skill and phonological and morphological awareness to spelling ability. The analysis revealed that decoding was the major component, predicting about half of the variance in spelling. The effect of phonological awareness was largely hidden by its high correlation with decoding, but was a significant predictor of spelling in its own right. Morphological awareness predicted spelling skill when the words to be spelled were morphologically complex. An additional study showed that differences in decoding and spelling ability were associated with differences in comprehension after controlling for reading experience and vocabulary. Even among experienced readers individual differences in comprehension of text reflect efficiency of phonological processing at the word level.

KEY WORDS: Decoding, High school poor readers, Metalinguistic abilities, Spelling

INTRODUCTION

Of the skills needed for reading mastery, most are shared with spoken language. Facility in recognition of words in printed form is the one new skill a person must acquire to be a reader, and this is the skill that most clearly separates readers from non-readers (Gough & Hillinger 1980; Gough & Tunmer 1986; Shankweiler & Liberman 1972). We assume, therefore, that the heart of reading in an alphabetic system is a set of strategies for decoding the phonological and morphological structure of the printed word. Only a reader who can decode has the ability to use the alphabetic principle productively, as manifested by the ability to read new words.

In spite of evidence that years of instruction and much practice are required to attain fluency in word recognition, it is widely assumed that most children with ordinary educational opportunities will become fluent readers of age-appropriate material before the end of elementary school. This expectation undoubtedly colors the interpretation of reading and writing difficulties that

are encountered later. Given the presumption that by secondary school all but a few students will have mastered word recognition, it is natural to suppose that the reading skills older students may still lack are strategies for text comprehension. This would explain why studies of reading problems in teenagers and adults have so often focused on comprehension, not word recognition. Relatively few studies have examined word reading and spelling skills in post-elementary school students, even among those who are known to be experiencing reading difficulties. Yet the little information available suggests that it may be an error to take the basic code-related abilities of older students for granted (see Fowler & Scarborough 1993). Certainly this is true for those with a childhood history of reading problems, as findings of Bruck (1990), Finucci, Gottfredson & Childs (1985), and Scarborough (1984) attest.

If the level of proficiency in word recognition in some significant proportion of high schoolers is in fact inadequate to support a level of reading comprehension required in the work place, or for more advanced studies, then it would seem prudent to assess decoding skills routinely in these older students to evaluate the possibility that insufficient mastery of lower-level reading skills may be an important contributor to comprehension difficulties. Clearly, more information is needed, especially about students who will likely terminate their formal education at or before completing high school. As a first step, we examined decoding and spelling skills in high school students of average reading achievement and below, and we have obtained additional measures of underlying metalinguistic abilities in phonological and morphological segmentation. In a companion study, we investigated the relationships between basic orthographic skills and reading comprehension.

Knowledge of how the orthography represents the phonology of words is taxed both in reading at the decoding stage and in writing at the spelling stage. Decoding from orthography to phonology can best be assessed by asking the reader to sound out nonwords that follow the spelling conventions of English. Nonwords, being unfamiliar, force the reader to rely on phonologically analytic strategies. To assess spelling, we selected words that incorporate a variety of spelling patterns, including some that are complex morphologically. Reading and spelling abilities tend to be highly correlated, as would be expected (Juel, Griffith & Gough 1986), but of course these abilities can diverge, especially in later life. Spelling constitutes a more stringent test of orthographic knowledge than reading. This is expected because to accurately encode a word, a writer must produce not merely a plausible spelling, but one that corresponds to the conventional form.

The first requirement for grasping the alphabetic principle, and thereby gaining the means to mastery of reading and spelling, is the ability to analyze the words of our vocabularies into their consonant and vowel phonemes. Phoneme segmentation abilities do not develop as a normal consequence of experience with the spoken language alone. We learn this from the fact that these skills are weak or absent in illiterate and semiliterate adults (Lukatela, Carello, Shankweiler & Liberman, in press; Morais, Cary, Alegria

& Bertelson 1979; Morais 1991). If phonological awareness is a precondition for mastery of reading in an alphabetic system, we should suppose that spelling, too, would require that the writer know how words are segmented phonologically. In fact, children's phonemic segmentation ability is highly correlated with their ability to represent all the phonemes in spelling words (Lieberman, Rubin, Duques & Carlisle 1985). Poor spellers perform significantly worse than spelling-level matched (and hence younger) normal spellers on tests of segmentation ability (Rohl & Tunmer 1988). Ability to represent the internal consonant of an initial consonant cluster is a good predictor of overall spelling and reading ability in the early grades (Shankweiler 1992).

The importance for reading and spelling of attaining awareness of the internal structure of words is also evident at the morphological level. Since English spelling is a hybrid system, partly phonemic and partly morphemic (Chomsky & Halle 1968; DeFrancis 1989; Venezky 1970), one could expect that awareness of morphological relationships would aid the learner in surmounting some of the seeming irregularities in the English spelling system. For example, the spelling of HEALTH (not as HELTH) underscores its derivation from HEAL. Carlisle's (1987, 1988) investigations have supported the relevance of morphological awareness for spelling. Seeking evidence of children's use of morphological relationships in spelling, Carlisle showed that in fourth, sixth, and eighth graders the ability to produce derived forms from base forms tends to run ahead of the ability to spell those same derived forms. She identified four increasingly complex transformations from base to derivation, in which the base form undergoes no change (ENJOYMENT), orthographic change only (GLORIOUS), phonological change only (MAGICIAN), or both orthographic and phonological change (DEPTH). Success in spoken production and spelling of derived forms was predictable from the complexity of the transformation from the base form to the derived form. A further study (1987) showed that ninth grade learning-disabled students typically fell between normal sixth and eighth graders in spoken morphological production, but their *spelling* of derived forms was greatly retarded, being only at the fourth grade level. These students apparently knew morphological facts that they were unable to use in their spellings, and they were more likely than even the fourth graders to ignore morphological structure in their spellings of derived forms. But unlike the fourth graders, the ninth graders' spellings usually did represent all the phonemes in the target words. Thus good and poor readers may be distinguished in orthographic knowledge beyond the level of grapheme-phoneme mappings. These findings confirm that an ability to divide words into segments at phonological and morphological levels is an important component of skill in both reading and spelling.

Since decoding is strongly correlated with spelling in beginning readers (Shankweiler 1992; Stage & Wagner 1992), it is important to ask if these code-related skills retain their close associations with one another in experienced readers, and if they retain their power to account for individual differences. Some researchers seem to assume that they do not (Miller 1988). With expe-

rience, say these researchers, readers may develop an autonomous sight lexicon that obviates the need to convert printed words into phonological strings (Stanovich 1986). Consequently, decoding is seen as a skill that is mainly relevant at the initial stages of learning to read, and is, accordingly, thought to contribute to individual differences chiefly among children in the early primary grades. A review of findings on reading instruction (Anderson, Hiebert, Scott & Wilkinson 1985) recommends that 'except in cases of diagnosed individual need, phonics instruction should have been completed by the end of the second grade' (1985: 43).

Such remarks would seem to convey a belief that decoding skill does not ordinarily represent a limiting factor in reading at the high school level. Spelling difficulties, though widely acknowledged in older students and adults, tend to be regarded as unrelated to difficulties in reading. If, alternatively, it can be shown that at the high school level there remain significant difficulties in word or nonword decoding, and if these difficulties are strongly correlated with spelling problems at that age, a common cause for both kinds of difficulty could be inferred. It would then be reasonable to suppose that phonological and morphological deficiencies play a continuing role in explaining older students' shortcomings in both reading and writing.

Accordingly, we asked the following questions. First, do inaccuracies of decoding and spelling still occur with significant frequency among normally-achieving high school students, or are they confined to those with a history of reading problems? Secondly, is there a close association between levels of skill in decoding and spelling in these students? If word recognition is not phonologically analytic in experienced readers there would be no reason to expect a close association between decoding and spelling. Finally, is there a continuing relationship between spelling and alphabet-relevant metalinguistic skills (i.e., phonological awareness and morphological awareness) at the secondary school level? We approached these questions by administering diagnostic test materials to groups of readers of middle to low ability, to determine whether a significant proportion are deficient in word recognition and spelling and to ask whether these also show deficiencies in phonological and morphological abilities parallel to those displayed by poor beginning readers.

EXPERIMENT I

Method

Subjects. Two groups of students from Connecticut high schools served as subjects. The first group comprised 30 ninth graders from the public high school of a small Connecticut city. The make-up of the school from which we drew these subjects approximates a demographic cross-section of the southern New England region. Students in this school are grouped according

to reading and writing ability. We drew our sample from middle level classrooms. By excluding students who were markedly above or below average for their school in reading and writing achievement, we sampled largely from the segment of the student population who will end their formal education with high school. This group represents a large portion of the work force in industrial and service occupations. All the students who returned a parental consent form participated in the study (mean age 14 years, 11 months). They were paid for their participation.

The second group comprised 35 ninth and tenth grade students (mean age 16 years, 10 months) from a private residential high school for the learning disabled. All were of at least average intelligence (IQ 90 and above), and they represented a range of reading abilities and academic achievement. Many, but not all, of these students would meet established criteria for reading disability. The information available to us did not permit us to categorize them further. This group was included in the study because it was anticipated that they would extend the range of the sample at the lower end and increase the likelihood of detecting qualitatively different patterns of deficit, while keeping within a broadly average range of intelligence.

Materials. Measures of reading and spelling and component language skills were administered to the subjects.

Experimental spelling test (SPEL). A list of words was selected to represent some typical spelling patterns of English orthography. Twelve categories of spelling patterns were incorporated: silent 'e' (e.g., *explode*), dropping a letter in a derivation (*argument*), doubled consonants (*omitting*), changing 'y' to 'i' (*happiness*), choice of '-ible' vs '-able' (*sensible*), choice of '-ery' vs '-ary' (*cemetery*), formation of plurals after vowels (*valleys*), 'ie' vs 'ei' (*fiend*), doubled consonants at prefixes (*dissolve*), choice of '-ence' vs '-ance' (*occurrence*), agentive suffixes (*contractor*), and words whose spellings, though regular, fail to reflect common pronunciations (e.g., *hundred* as 'hunnerd', *prescription* as 'perscription'). Each spelling pattern was represented by six words, two each of low, medium, and high frequency (occurrences per million below 15, from 15 to 65, and greater than 65, respectively, based on frequencies in Carroll, Davies & Richman 1971).

For the most part, these words could not be spelled by simple one-to-one translation rules for converting phonemes into letter strings, nor did they depend wholly on word-specific knowledge (as might be the case with highly irregular words); spelling them required some facility with a variety of orthographic conventions in order to produce the correct spelling. (Word specific knowledge did play a role in spelling some of the words, however - especially those chosen as examples of violations of simple conventions. For example, *valleys* fails to change its 'y' to 'ie' in forming the plural.) Scores on this test correlated 0.93 with the spelling subtest of the WRAT-R2 (Jastak & Wilkinson 1984) in our LD sample, and 0.90 in an earlier sample from the same average reader population.

Morphology Spelling Test (MST). A list of twenty derived words provided a measure of spelling that draws on morphological knowledge. Ten of the words changed both phonologically and orthographically relative to their base forms (*description* from 'describe'), and ten changed only phonologically (*musician* from 'music'). These words were taken from Carlisle's Test of Morphological Awareness (Carlisle 1988). Six of the words were common to both the MST and the morphology test.

Test of Morphological Awareness (Fowler & Liberman 1994). This was adapted from Carlisle's (1988) test of morphological awareness. Ability to retrieve derivationally related words was tested orally by presenting a base form and cueing a corresponding derived form, and vice versa. Subjects heard a test word followed by a cueing sentence minus the final word. The task was to supply the appropriate word to complete the sentence; for example: 'Deep - The diver swam to a great ____'; 'Easy - She climbed up the ladder with ____'. Forty-two words were tested as base targets and derived targets, for a total of eighty-four items. The test consisted of two counterbalanced subtests. In one subtest, half of the test words were base form items and the other half were derived form items; these were reversed for the second subtest.

Phoneme Deletion (Rosner & Simon 1971). A measure of phonological awareness required subjects to repeat a word after the experimenter and then to say the word with a specified segment or segments deleted. For example:

(E) "say 'block'."

(S) "'block'."

(E) "say 'block' without /b/."

(S) "'lock'."

Segments to be omitted included syllables, phonemes from initial, medial, and final positions, consonant clusters, and individual phonemes from clusters. Of the forty items, all but four resulted in a real word when the segment was deleted.

Decoding Skills Test (DST) (Richardson & DiBenedetto 1986). Decoding ability was measured by presenting a list of 60 nonwords followed by 60 real words to be read aloud. The words were orthographically regular, progressing from short single syllables to words of up to three syllables containing consonant clusters and vowel digraphs. Nonwords were produced by changing one or two segments in each of the real words, yielding items which retained the spelling patterns of the corresponding real words.

Controlled Words Decoding Test. As a second reading measure, a list of 39 regular and 39 irregular words was taken from Coltheart, Besner, Jonasson & Davelaar (1979). The spellings of words classified as irregular yielded incorrect pronunciations according to rules proposed by Wijk (1966) and Venezky (1970). Regular and irregular words were matched on frequency (Kucera & Francis 1967), numbers of letters, syllables, morphemes, concreteness/imageability and part of speech (including inflections).

The inclusion of this task enabled us to test skill in reading irregular words.

It also provided an independent measure of skill in word reading, in addition to the DST. If the nonword section of the DST were used to predict performance on real words, similarity of the spelling patterns would result in an inflated correlation. This potential confound is avoided by using DST nonword reading performance to predict success in reading words from the Coltheart et al. list.

Procedure. The spelling tests were group administered during the school day. Students who returned a parental consent form participated in the second part of the study. The second stage tests, which were conducted on an individual basis, comprised the Morphology test, the Phoneme Deletion test, and the decoding tests. The order of the tests in the individual sessions was: Morphology subtest A (or B); DST; Rosner; Controlled Words Decoding Test; and Morphology subtest B (or A). The order of the Morphology subtests was balanced, and the two subtests were separated in time by approximately fifteen minutes of intervening testing. In each test subjects were encouraged to offer a response even if they thought they didn't know the correct answer. An item was repeated for a subject if requested. For the experimental spelling test, the test words were dictated, followed by a sentence using the word in context, followed by repetition of the word. On the morphology spelling test, each test word was repeated twice.

The words of the DST were presented in large type, printed ten to a page. For the Controlled Words Decoding Test, the order of the 117 words was randomized (mixing regular, irregular, and nonwords) and the resulting list was similarly presented in large type. Subjects read the words aloud and their responses were recorded on audio tape, which was later transcribed and the errors classified by category (60 each of real and nonwords for the DST; 39 each of regular, irregular, and nonwords for the Controlled Words Decoding Test).

In classifying the spelling errors on the Experimental Spelling test, we attempted to match the students' choice of graphemes to the phonemes they were meant to represent. The catalog of errors we adopted (one consistent with our aim of investigating the role of phonological knowledge in spelling) treated graphemes of any length, not individual letters, as units.¹ Adhering to this principle, we divided the errors into five general types:

1. *Misrepresentations.* A phoneme was represented by a letter or letters that represent that phoneme in some words of English, but not in this instance as conventional spelling would dictate. For example, using *s* for /sh/ in 'ship' could count as misrepresentation of that phoneme.
2. *Unrelated substitutions.* A phoneme was represented by an inappropriate letter or letter combination having a range of phonological values not including the intended phoneme. Thus this category would refer to a case in which the attempted representation shared no salient distinctive features with the target. Substitution of *a* for /ε/ thus would not be an extreme enough error to count as 'unrelated', but substituting *i* for /o/ would be.

3. *Sequence errors* were scored when the correct letters of a grapheme (or graphemes) were present and in close proximity (within three letters) to their correct positions. Although this category mainly describes the level of letters and not graphemes, it was necessary because an analysis of such a misordering in terms of the resulting strange substitutions would yield a misleadingly large number of more serious errors.
4. *Insertions* were scored when the number of graphemes present was greater than the number of phonemes in the word. Sometimes this was simply a matter of an added syllable (*desiriring*), but in some cases we had to exercise judgment – to decide, for example, that *visiable* (for *visible*) has an extra grapheme in it instead of a misrepresented fourth phoneme (*ia* for */I/*).
5. *Omissions* refer to the absence of a grapheme to represent one or more phonemes, not to all cases in which there is a missing letter. Thus, *secetary* for *secretary* counts as an omission, but not *piches* for *pitches*. Omissions, along with unrelated substitutions, were considered the most serious types of errors from a phonological perspective.

Plainly the authors' orthographic intuitions played some part in these decisions. But in questionable cases, we sought concurrence from colleagues. It was clear to us that a subject's actual spelling errors are unlikely to conform perfectly to any classification. This was apparent in those (relatively infrequent) cases when overlapping errors within a word lent themselves to more than one interpretation. In these cases we opted for the alternative that would minimize both the number and severity of the errors.

Results

Comparison of LD and average students. Summary data for each group are presented in Table 1. The mean number of words spelled correctly on the SPEL test was 51 percent for the LD group and 66 percent for the Average group. An independent measure of spelling, the Morphology Spelling Test, yielded similar levels of performance (55 and 74% correct, respectively). Appreciable errors also occurred on measures of reading. On the test of decoding nonwords (DSTN), LD students scored 76% correct and Average students scored 86%. On reading real words, the LD students performed at 86% correct and the Average students at 92%. It is notable that most of the between group difference on the latter test is due to irregular words of which the LD group read 78% correctly and the Average group read 87%.

In addition to the discrepancies in performance on the reading and spelling measures just noted, each group displayed significant difficulty in apprehending the internal structure of spoken words. Thus, on the Phoneme Deletion Test (PD), the LD group scored 68% correct and the Average group scored 78%. On the Morphological Awareness Test (MA), the corresponding scores were higher: 92 and 95%, respectively, still significantly different. Table 1

Table 1. Summary scores for Average and LD groups

Task	Max	Average	Learning disabled	<i>t</i>	Combined
		Mean (sd)	Mean (sd)		Mean (sd)
Spelling					
Experimental spelling test (SPEL)	72	47.70 (9.4)	36.51 (13.19)	3.88**	41.68 (12.81)
Morphology spelling test (MST)	20	14.73 (3.79)	11.09 (5.48)	3.15**	12.77 (5.08)
Reading					
<i>Decoding Skills Test</i>					
Real words (DSTR)	60	59.17 (1.29)	57.40 (3.94)	2.50*	58.22 (3.13)
Nonwords (DSTN)	60	51.40 (6.20)	45.69 (11.37)	2.56*	48.32 (9.71)
<i>Controlled Words Decoding Test</i>					
Regular (CWR)	39	37.77 (1.45)	36.80 (2.60)	1.88	37.25 (2.19)
Irregular (CWI)	39	33.77 (2.70)	30.60 (4.24)	3.64**	32.06 (3.92)
Total (CWT)	78	71.53 (3.79)	67.40 (5.85)	3.42**	69.31 (5.38)
Metalinguistic					
Phoneme deletion (PD)	40	31.37 (4.69)	27.29 (5.22)	3.29**	29.17 (5.35)
Morphological awareness (MORPH)	84	79.63 (2.67)	77.00 (5.27)	2.59*	78.22 (4.45)

* $p < 0.05$; ** $p < 0.01$.

includes the significance tests (t-tests) for the differences between the groups on each of the measures. All were significant at $p < 0.05$, with the exception of the Regular Words subtest of the Controlled Words Reading Test. Thus, as expected, there were consistent differences between the group means on the tests of spelling and reading and also on tests of supporting abilities.

It is apparent that although the group means differ significantly, the scores from the two groups overlap considerably. Figure 1 displays the distributions of scores on spelling (SPEL) and nonword reading (DSTN) for the combined group. For each measure the resulting distribution is unimodal. It therefore seemed appropriate to pool the scores from each group and use the pooled scores as the basis for examining relationships among the various dependent measures.

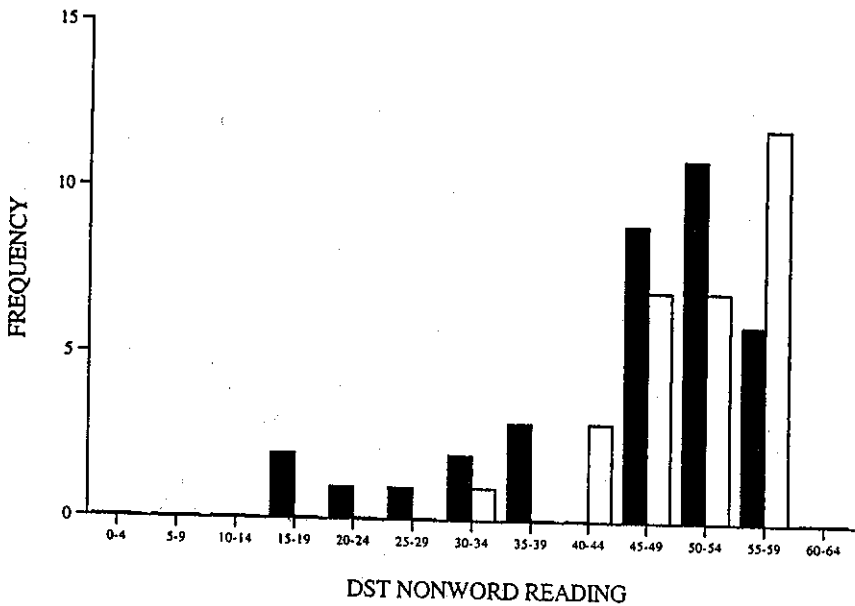
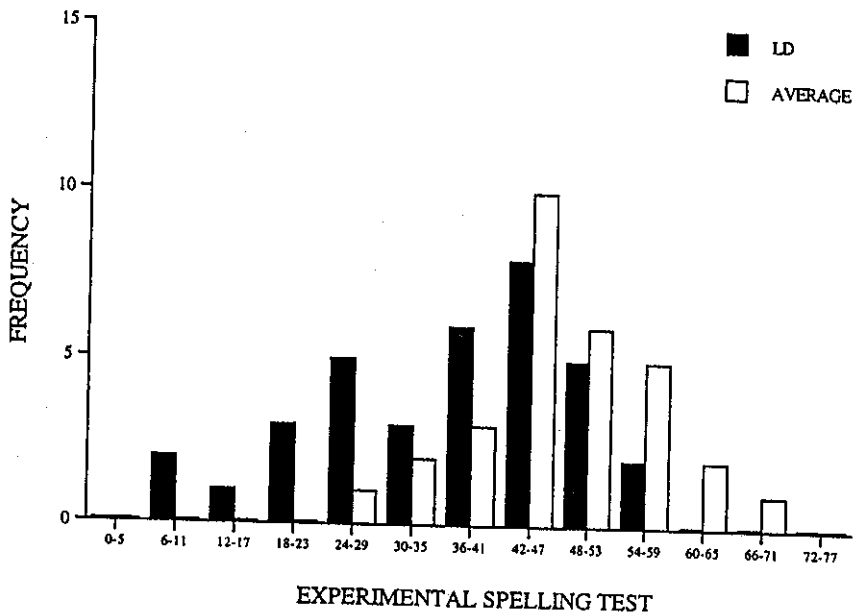


Figure 1. Frequency distribution of scores on spelling (SPEL) and nonword reading (DSTN) for LD and average groups.

Relations among reading and spelling measures for the combined group. The matrix of correlations among the dependent measures for the combined group is shown in Table 2. The incorporation into the test protocol of independent measures of word reading and spelling makes it possible to gauge the consistency of these measures. It can be seen that there was a high degree of consistency among the individual measures of spelling and reading. For example, the correlation between the two independent measures of spelling was 0.85. Moreover, with the exception of the Irregular Words subtest from the Controlled Words Test, all the correlations among the reading measures were above 0.70.

Table 2. Correlations among test scores for the combined group

	SPEL	MST	DSTR	DSTN	CWR	CWI	CWT	PD	MORPH
Experimental spelling test	-								
Morphology spelling test	0.85	-							
Decoding skills test (Real words)	0.68	0.68	-						
Decoding skills test (Nonwords)	0.70	0.75	0.85	-					
Controlled words test (Regular)	0.62	0.50	0.72	0.72	-				
Controlled words test (Irregular)	0.80	0.75	0.67	0.61	0.52	-			
Controlled words test (Total)	0.83	0.75	0.78	0.73	0.78	0.94	-		
Phoneme deletion	0.59	0.55	0.56	0.64	0.39	0.53	0.55	-	
Morphological awareness	0.52	0.57	0.47	0.55	0.34	0.47	0.48	0.45	-

From Table 1 we see that difficulties in basic decoding skills, as measured by the DST Nonword score, are widespread within the combined group (errors averaged 19% overall). In contrast, the matching real words (in the DST Real word subtest) yielded a much lower error rate (3%). Arguably, it is the nonword reading score, however, that yields the more realistic estimate of a student's ability to read new words. The level of skill in reading a set of nonwords is strongly associated with the ability to read *unrelated* real words. Thus the correlation between reading the DST nonwords and reading the unrelated real words of the Controlled Words Test is 0.73 (see Table 2). The close association between spelling and reading measures is to be expected of tasks that draw on highly overlapping abilities. It may be seen from Table 2 that performance in decoding words and nonwords in reading is strongly correlated with performance in spelling (e.g., for DST nonwords and spelling (SPEL), $r = 0.70$).

Metalinguistic abilities involving spoken words were associated with measures of reading and spelling. The Rosner Phoneme Deletion Test (PD), a measure of ability to segment and manipulate spoken words as sequences of phonemes, yielded a success rate of only 73% in the combined group (Table 1). There was a significant association ($r = 0.64$) between the phoneme deletion measure of phonological awareness (PD) and skill in decoding non-

words. The correlation between PD and real word reading on the Controlled Words Test was also substantial ($r = 0.55$), as was the correlation between PD and SPEL ($r = 0.59$). With regard to the awareness of morphological aspects of word structure, as these were assessed by the morphology production test, the success rate was considerably higher (93%). Nonetheless, correlations of this measure with the literacy measures paralleled those obtained with PD. Thus, morphological awareness correlated 0.55 with DST nonwords, 0.48 with real words, and 0.52 with SPEL. The correlation with real words may be depressed by a ceiling effect. It was expected that measures of phonological awareness, morphological awareness, and orthographic decoding together would account for most of the variance in spelling scores. Since these measures are highly interrelated, we varied the order in which they were entered into a regression equation to permit us to identify the unique contribution of each variable. The results of these analyses are displayed in Table 3.

It may be seen that accuracy in decoding nonwords was the single best predictor of spelling among the three variables, accounting for about half of the total variance. Beyond that, PD and MORPH, together, explain an additional 5% of the variance. They account for little additional variance because

Table 3. Ordered regression analyses with spelling measures as the dependent variable

Dependent measure: spelling			
Independent measure	R ²	R ² change	F
A. Experimental Spelling Test (SPEL)			
DSTN	0.50	—	—
PD	0.53	0.03	4.01*
MORPH	0.55	0.02	2.53
PD	0.34	—	—
DSTN	0.53	0.18	23.98**
MORPH	0.55	0.02	2.53
MORPH	0.27	—	—
PD	0.43	0.15	16.57**
DSTN	0.55	0.12	16.02**
DSTN	0.50	—	—
PD	0.53	0.03	4.01*
MORPH	0.55	0.02	2.53
CWI	0.72	0.18	38.71**
B. Morphology Spelling Test (MST)			
PD	0.31	—	—
MORPH	0.43	0.13	13.8**

* $p < 0.05$; ** $p < 0.01$.

each is substantially correlated with the first measure, nonword reading. Notably, when PD is entered first into the regression equation, it accounted for 34% of the variance in spelling scores. When nonword reading was added second, it contributed an additional 18%. Thus the sum equals about half of the total variance, the same proportion accounted for by nonword reading alone.

With regard to the role of morphological ability in spelling, we noted that MORPH made little contribution to SPEL beyond the contribution attributable to nonword reading. When entered alone, however, it accounted for 27% of the variance in SPEL (see Table 3a, third regression) and 32% of the variance in the Morphology Spelling Test ($r = 0.57$). Since the latter test is entirely composed of morphologically complex words we would expect that awareness of derivational relationships would have special relevance for the spelling of these words. In Table 3b, accordingly, we find that when it is added second after PD, MORPH predicts an additional 13% of variance in the MST. In predicting SPEL scores the increment contributed by the MST is less (8%), which is to be expected since few words on the SPEL list were morphologically complex. Thus, fluency in morphological production, though it accounted for a smaller portion of the variance in spelling than phoneme segmentation, proved to be a relevant factor in contributing to accuracy in spelling morphologically complex words.

It is worth noting that ability to read *irregular* words accounted for additional variance in SPEL when entered last after the DSTN, MORPH, and PD measures (Table 3a). Thus, the Irregular words subscore from the Controlled Words Reading Test (CWI) adds an increment of 18% to the variance accounted for by the foregoing measures.

Word reading ability, considered as the sum of the regular and irregular word subscores of the CWT (abbreviated as REAL), was expected to be strongly associated with decoding ability and phonological awareness. The regression analyses in Table 4 support this expectation. Together, nonword reading and PD accounted for 55% of the variance in reading real words. However, nonword reading alone as a predictor accounted for 54%, while PD alone accounted for only 30%. This suggests that phonological aware-

Table 4. Ordered regression analyses with real word reading as the dependent variable

Dependent measure: real word reading (REAL = CWR+CWI)			
Independent measure	R ²	R ² change	F
DSTN	0.54	—	—
PD	0.55	0.01	1.42
PD	0.30	—	—
DSTN	0.55	0.25	33.94**

** $p < 0.01$.

ness is largely contained within the decoding measure and that the effect of PD is simply absorbed by nonword reading (as was the case in predicting spelling from these measures). Overall, the pattern of regressions, like the first-order correlations, reveals a high degree of consistency in the relations between measures of basic skills in spelling, reading, and supporting meta-linguistic abilities.

Qualitative aspects of the errors on the SPEL test were examined according to the schema presented in the methods section.² Most errors were of the misrepresentation type (mean errors per person = 38.14, *sd* = 18.54): the grapheme selected could represent the phoneme intended in some contexts, but it violates the conventional spelling of the word. (For instance, OCCURANCE was a very popular misspelling of 'occurrence', containing two misrepresentations: /r/ as R instead of RR, and /e/ as A instead of E.) Omissions were next in frequency (mean = 4.18, *sd* = 9.02), followed by insertions (mean = 2.71, *sd* = 3.19). (Errors of these types included DRILLIG for 'drilling', and ADMINTANCE for 'admittance', respectively.) Although there were more unrelated substitutions (e.g., DESORING for 'desiring') and sequence errors (SERCETARY for 'secretary') in the LD group than in the Average group (as is true for the other errors as well), there were, in fact, very few of these in either group (mean occurrences 0.52, *sd* = 1.73, and 0.62, *sd* = 0.93, for unrelated and sequence errors respectively). Such errors were confined to a few students. Omissions and insertions were also relatively infrequent, but occurred throughout the sample.

Correlations among the five error types and total errors in SPEL, PD, and nonword reading are shown in Table 5. The highest correlation between any two error types is that between omissions and misrepresentations, $r = 0.67$. Such a strong relationship is what we would expect if errors that are often attributed to failure of recall (i.e., misrepresentations) are in fact continuous with those indicating inadequate knowledge of the orthographic code (i.e., omissions). Note that the rate of misrepresentations – a phoneme-level error count – is nearly perfectly correlated (0.95) with word level errors (SPEL) for those words. This tells us that skill in representing the individual phonemes

Table 5. Correlations of spelling error types with total spelling score, phoneme deletion, and nonword reading

	MISREP	UNREL	INSERT	SEQ	OMIS	SPEL	PD	DSTN
Misrepresentations	-							
Unrelated substitutions	0.40	-						
Insertions	0.60	0.36	-					
Sequence errors	0.32	0.18	0.54	-				
Omissions	0.67	0.62	0.57	0.42	-			
Experimental spelling test	0.95	0.47	0.69	0.41	0.71	-		
Phoneme deletion	0.58	0.21	0.48	0.38	0.37	0.59	-	
Decoding skills test (Nonwords)	0.70	0.45	0.70	0.45	0.70	0.70	0.64	-

of a word coincides almost perfectly with skill in spelling whole words correctly.

Discussion

It was expected that spelling performance would be the most sensitive indicator of continuing difficulties in using the orthographic code, and that these difficulties would also be manifested on tests of reading nonwords. These expectations were met. Given their educational histories we would expect the LD group to include individuals with a constitutionally weak phonological component. The findings are also consistent with this expectation. Correlated difficulties on metalinguistic tests of phonological awareness and morphological awareness suggest that deficits are not fully compensated in spite of a history of intensive remedial treatment.

The public school 'average' students included many who tested only borderline in basic skills, an outcome we found unsettling. Although we expected that these students would perform better than the LD group, it is clear that their performances were continuous with those of the LD students. The mean differences, though statistically significant, were not large, and there was much overlap between the two groups. Pooling the scores from both groups resulted in distributions that were unimodal and fairly symmetrical.

In most measures the two score distributions (including reading and spelling) resembled samples drawn from neighboring regions of a single ordered population.³ This fact is in keeping with recent findings obtained from large scale studies of reading in schoolchildren. Learning disabilities, in common practice, have been defined by a discrepancy between actual performance in the domain of the disability and performance that would be expected on the basis of general ability measures (usually IQ).⁴ Increasingly, this practice is being challenged by findings reported in the research literature (Shaywitz, Fletcher, Holahan & Shaywitz 1992; Stanovich & Siegel 1994). In fact, a strong case can now be made that individual differences in reading proficiency are on a continuum (Fletcher et al. 1994; Share & Silva 1986; Shaywitz, Escobar, Shaywitz, Fletcher & Makuch 1992). Dyslexia, or reading disability, is the lower end of the continuum. Well-attested poor readers who are broadly within the range of normal intelligence, no matter what the criteria for identifying them, largely share a common cognitive profile prominently involving a deficit in phonological awareness and related skills (Shankweiler et al. 1995; Stanovich & Siegel 1994). Seeing, as we did, a single pattern of difficulties common to both groups of students, our observations are wholly compatible with the continuity view.

Let us then consider the pattern of difficulties without regard to group. First, there was a high error rate overall in spelling – an average of 53% of words of only moderate difficulty were misspelled. In addition, word reading difficulties, notably for nonwords and irregular words, were highly correlated with the spelling difficulties, pointing to the unity of knowledge under-

lying both aspects of literacy. Secondly, in keeping with much earlier research, it was found that phonological awareness, as measured by the phoneme deletion task, was significantly correlated with both reading and spelling.

The variance attributable to phonological awareness was almost entirely contained within the decoding measure: phonological awareness added only 3% to the variance in spelling scores accounted for by nonword reading. This finding, of course, does not challenge the importance for spelling of phonological awareness. Since decoding ability requires phonological awareness, abilities assessed by the PD task are already implicitly included in nonword reading. When word reading (the REAL subscore from the Controlled Words list) was used as the dependent variable, a parallel pattern emerged. Phonological awareness and decoding skill seem to contribute similarly to reading (at the level of word identification) and spelling. Thirdly, morphological awareness is related significantly to reading and spelling, although the correlations were not as large as those involving phoneme awareness. It was found that the morphological measure played a greater or lesser role in spelling depending on the characteristics of the words included in the spelling test. Thus, the morphological test made a slightly greater contribution (13% vs 8%) to the spelling of morphologically complex words than to monomorphemic words (from the Experimental Spelling Test), when entered after phoneme deletion in a regression equation.

To gain further information about the orthographic abilities of these students, we sought a way of classifying errors on the Experimental Spelling Test. Unlike many error taxonomies in which the letter is the unit of analysis, we took the phoneme as the unit, basing our error count on the number of phonemes comprising each test word that were plausibly represented in the subject's spelling. Thus, the error categories adopted for the analysis were: misrepresentations, unrelated substitutions, insertions, sequence errors, and omissions. There were notably few phonetically illegal spellings among the errors. Counting misrepresentation errors as phonetically legal, the combined group had a mean of only eight phonemes (out of a total 468) that were transcribed by graphemes deemed illegal for representing those segments. It has been shown previously that elementary school children of different ability levels may be differentiated by the degree to which their spellings deviate from a legal transcription of the word (Lieberman et al. 1985; Shankweiler 1992); not surprisingly, this criterion is no longer applicable in describing individual differences in spelling among high school students. Our subjects' erroneous spellings were in nearly all cases plausible representations of the phonological structure of the target word, but representations that could be regarded as simplifications of the standard system (for example, in spelling 'likelihood' as LIKELYHOOD). Difficulties occurred most often when the context of the surrounding letters determines a grapheme's phonemic value (i.e., a vowel in CVC context takes its 'long' sound when a word ends in 'e', as in MAT/MATE; IE is pronounced /ai/ in 'lie' and /i/ in 'believe'). Correct spelling consists of detecting and encoding these morpho-phonological regu-

larities. The average students' misspellings demonstrated lack of awareness of many morpho-phonological spelling patterns that good spellers have internalized. Thus, their spellings tend to look immature.

Errors on reading irregular words may also derive from the same deficiencies in apprehension of complex spelling patterns. In contrast to the low error rate on regular words, irregular words proved difficult for the students. But it should be emphasized that the difficulties are not confined to irregular spellings, as might be supposed. Nonwords which contained the same regular spelling patterns as corresponding words also elicited many errors. Together these results affirm the continuity of processes underlying nonword decoding and irregular word reading, and support the contention of Gough & Walsh (1991) that decoding skill is necessary although not sufficient for reading irregular words.

The pattern of interrelationships among phonological awareness, word decoding, and spelling that are so consistently present in these data have been noted repeatedly in studies of younger subjects (Dreyer, Luke & Melican 1995; Juel, Griffith & Gough 1986; Stanovich, Cunningham & Cramer 1984). Stage & Wagner (1992) showed that in beginning readers (through second grade) the variance common to spelling and decoding could be explained by phonological awareness and short-term verbal memory. By third grade, however, they found that these two predictors were no longer sufficient to account for all the variance common to spelling and decoding. Stage and Wagner proposed that some additional factor takes on importance as children's literacy skills advance. Given the strong association among the three skills (phonological and morphological awareness, decoding, and spelling) in the present study, we suggest that advancing linguistic sophistication is the ability that Stage and Wagner sought. By linguistic sophistication we mean finely-tuned knowledge of word families, derivational morphology, and orthographic conventions, gained through experience in both written and spoken language (see Liberman, Liberman, Mattingly & Shankweiler 1980).

Among those who have emphasized the complexity of the orthographic 'cipher' and the linguistic sophistication that underlies it are Gough, Juel & Griffith (1992). In their words, '... even when the attempt is made to teach the cipher directly, as in synthetic phonics, the rules that children are taught are not the rules that they must internalize' (1992: 39). In keeping with this emphasis on the complexity of the orthographic code, we have suggested how decoding and spelling are related in a code-based, as opposed to a rote-memory-based, system, and we have indicated why we should expect to find continuing evidence of these dependencies in subjects well beyond the beginning stage. Specifically, the regularities of the code may often apply at more than one level, embracing both phonological and morphological structures. Some spelling patterns will be of very narrow scope, applying to no more than a few words in the language. In the extreme case word-specific knowledge may be the only source of information about a spelling (in the last segment of 'shoe', for instance). If Gough and his colleagues are right, all aspects of

orthographic skill, including word-specific knowledge, should be viewed as parts of a single code-based system (Gough & Walsh 1991; Gough, Juel & Griffith 1992). In support of this claim, Gough & Walsh have demonstrated that first and second graders with proficiency in nonword reading can learn to read and spell exception words, whereas children lacking decoding skill usually fail on exception words. Knowledge of the code (or 'cipher', in their words) is the foundation for mastery of the complexities of the orthography.

In summary, we have presented evidence that large individual differences in proficiency with the orthographic code persist among many high school age readers. In order to assess the full impact of these differences on literacy, it remains to be discovered whether they are reflected in correlated differences in reading comprehension. We therefore undertook to measuring decoding, spelling, and comprehension skills in a similar group of high school students.

EXPERIMENT 2

To inquire whether phonologically-based differences in decoding skill have a practical impact on reading comprehension, a follow-up study was undertaken with ninth graders chosen on the same basis as the public school sample in Experiment 1. Experiment 2 asks whether spelling ability and the ability to decode isolated words are in fact related to measures of text comprehension when differences in experience with print are controlled.

Method

Subjects. A group of 86 students from the same public high school was selected from seven ninth grade classrooms to provide a larger sample and to represent a wider range of abilities. Of the four streams of reading and writing ability identified by the school, we chose one class from the top group (16 students) three from the second (40 students), and three from the third (30 students). (The fourth group contained low ability students who were deemed not capable of doing academic work at the high school level.) This mix seemed likely to give us adequate variance for correlational and multiple regression analysis, while allowing us to sample most heavily from the middle and lower-middle level students which we had identified as our target population. The average was 15 years, 2 months.

Materials and procedure. As in the first study, several group-administered tests of reading and language abilities were administered.

Comprehension. The comprehension measure was the Fast Reading Subtest of the Stanford Diagnostic Reading Test (Karlsen & Gardner 1985). This subtest consists of a continuous prose passage interrupted by thirty choice points. At each choice point three words are presented, and the subject is asked

to mark the appropriate alternative. Students were allowed five minutes to complete the task. They were asked to mark the last item they had completed after three minutes in order to provide a ceiling-free estimate of their performance.

Decoding. A group-administered test of decoding ability was a paper and pencil version of Olson, Fosberg, Wise & Rack's (1994) individually-administered test. Each of the sixty items consisted of three nonwords, one of which was homophonic with a real word. The task was to identify the homophone. For example, a subject might see SHARF, SLOUT, SKORE and would have to circle SKORE because it is homophonic with 'score'. To succeed at this the student would have to be able to decode the nonwords and to compare phonological values of each with entries in the internal lexicon. Before beginning the Decoding test, feedback was provided for five practice items to be sure the subjects understood the task.

Spelling. The students were given a fifty item spelling test. Fifteen regular words and their matched irregular words were selected from the controlled word list compiled by Coltheart et al. (1979), that was used as a reading measure in the first part of the study. In addition to these thirty real words, twenty nonwords were constructed in which the number of syllables, number of consonant clusters, size of the cluster, and position of the cluster within the syllable were systematically varied, factors that would be sensitive to decoding difficulties. Words and nonwords for spelling were presented as dictated lists. Items were repeated upon request.

Vocabulary. Vocabulary knowledge was assessed by a synonym-detection test, which comprised twenty-five items chosen from the vocabulary subtest of the Gates-MacGinitie Reading Tests, 3rd ed., Level 7/9 (MacGinitie & MacGinitie 1989). On each trial a subject must choose the best word or phrase among five alternatives that matched the meaning of a target word. The target was presented in a carrier phrase sufficient to disambiguate the word but containing no clues as to its meaning. Although the test form presented all necessary information for the students to proceed independently, the experimenter read each item and the five foils aloud to ensure in as far as possible that vocabulary knowledge was not confounded with reading ability assessment. Students were asked to follow along rather than work ahead through this test.

Print exposure. Stanovich & West's (1989) Magazine Recognition Test (MRT) required students to check off as many magazine titles as they were able to recognize from an alphabetical list of fifty actual magazine titles and fifty false ones. Students were told that some magazine titles were not genuine and that they should check off only the actual ones. By including this measure we hoped to gain an estimate of differences in students' reading behavior outside of school and the availability of reading material in the home.

All of the students were tested on the same day during their English class period and were offered a small snack as a reward for their participation. A test packet containing all materials was given to them at the beginning of the

class. The experimenter proceeded through the materials in a fixed order: Comprehension Test, Silent Decoding Test, Spelling Test, Vocabulary Test, and Magazine Recognition Test.

Results

Correlations among the measures are presented in Table 6. All are significant at the 0.01 level. As expected, measures of spelling and decoding were moderately well correlated with reading comprehension. Not surprisingly, the vocabulary measure showed the highest correlation with reading comprehension, according for 40% of the comprehension variance on its own.

Table 6. Correlations among test scores for second high school sample

	COMP	VOC	DEC	SPREG	SPIR	SPN	MRT
Comprehension	-						
Vocabulary	0.64	-					
Decoding	0.45	0.50	-				
Spelling: Regular	0.58	0.65	0.60	-			
Spelling: Irregular	0.49	0.62	0.51	0.70	-		
Spelling: Nonwords	0.57	0.60	0.65	0.74	0.66	-	
Magazine recognition test	0.41	0.60	0.37	0.58	0.57	0.52	-

In order to tease apart the unique contribution of each of the measures to reading comprehension, regression analyses were performed with comprehension as the dependent variable. The Magazine Recognition Test (MRT), a measure of print exposure, was used in the analysis as a control for individual differences in reading comprehension that are consequences of experience with printed matter. The contribution of the other measures over and above that of the MRT was then assessed in a regression analysis. Decoding added a significant increment of 10.7% ($p < 0.01$) to the variance in comprehension accounted for by print exposure alone. The three spelling subscores also accounted for significant independent variance beyond the MRT: regular words added 16.7% ($p < 0.001$), nonwords 13.3% ($p < 0.001$), and irregular words 5.5% ($p < 0.05$). After both MRT and decoding were entered into the regression equation, two spelling subscores still accounted for significant (though small) amounts of independent variance: regular word spelling added 6.9% to the variance accounted for ($p < 0.05$), and nonword spelling added 4.2% ($p < 0.05$).

These spelling measures also contributed significant amounts of variance to comprehension when each was entered after vocabulary in a regression equation (regular word spelling, 6.1%, $p < 0.05$; nonword spelling, 3.7%, $p < 0.05$). Irregular word spelling did not make a significant independent contribution after vocabulary was partialled out. The small size of these

increments reflects the large proportion of variance shared in common between the spelling and vocabulary measures: correlations with vocabulary were 0.65, 0.62, and 0.60 for regular, irregular, and nonword spelling, respectively. Removing vocabulary thus removes a great deal of the variance common to reading comprehension and spelling. For the same reason, decoding also failed to contribute significant unique variance to comprehension, beyond the contribution made by vocabulary.

Discussion

The five literacy measures – decoding, spelling, vocabulary, comprehension, and print exposure – were significantly intercorrelated in a second, larger group of ninth grade high school students. Regression analyses were performed to determine whether the basic skills tapped by the decoding and spelling tests could predict differences in comprehension within this group. To control for differences in other factors that may be related to performance on literacy tasks, we first partialled out scores on the print exposure test (MRT). The MRT was used as a control measure because print exposure has been found to make an independent contribution to specific literacy skills over and above general cognitive ability and specific metalinguistic abilities (Stanovich & Cunningham 1992).⁵

Word decoding made a significant, if small, contribution to comprehension after print exposure was partialled out. The findings of Bell & Perfetti (1994) would lead us to expect that the measured correlation between the decoding measures and comprehension would have been greater if latency measures of comprehension and decoding had been obtained. All three spelling subscores – regular, irregular, and nonwords – also predicted independent variance in comprehension beyond what print exposure accounted for. Thus, there is clear evidence that the differences in orthographic skills which we have uncovered in these experienced readers are indeed reflected in their comprehension abilities.

Regular and nonword spelling accounted for variance in comprehension after both the print exposure measure and decoding were partialled out. It is likely that spelling is tapping the same analytic abilities as decoding, but presumably because the spelling task makes greater demands on these abilities, it was the better measure. Moreover, the orthographic skills tapped by regular and nonword spelling accounted for significant comprehension variance even beyond vocabulary, which was highly correlated with each of the reading measures.

Thus, although spelling is, of course, not a component of reading, it provides a valuable indicator of the level of orthographic skill on which all literacy activities ultimately depend. Word recognition and all subsequent higher level processes that take place in reading are constrained by the ability to fluently transcode print into language. Perfetti's verbal efficiency theory explains cogently how a lack of fluency in decoding will reduce the efficiency

of all higher level processes that depend on decoding (Perfetti 1985; see also Shankweiler & Crain 1986).⁶

GENERAL DISCUSSION

The evidence of widespread deficiencies in basic literacy skills within two groups of high school students gains importance in light of commonly held views about the sources of reading difficulties in older students and adults. The reading difficulty that is probably most often attributed to schooled teenagers and adults is poor text interpretive skills. Comprehension difficulty is usually presented as a problem in its own right, not one that may be linked to underlying deficiencies in word decoding skills. Our data suggest, contrary to the supposition of some authorities, that even students who are not considered backward or learning-disabled may lack skill in word-level reading. Indeed, Fowler & Scarborough (1993), writing about the needs of adult poor readers, stress the importance of remediating their persisting difficulties with word recognition skills.

To be sure, we found that the students we tested generally had sufficient reading abilities to recognize most common words in print. Most, however, were less than adequate in their abilities to read irregularly spelled or unfamiliar words, and even regular nonwords. (In these respects our ninth graders resembled adults with childhood diagnoses of dyslexia who were studied by Bruck (1990).) From the latter result we can infer that the students' ability to read new words would be correspondingly poor. The lack of fluency in decoding that characterizes even the better readers in our sample could surely be expected to place limits on their comprehension of many kinds of text (see Bell & Perfetti (1994) on individual differences among college students). Significant deficiencies in spelling were even more widespread throughout the group. The mean proportion correct for words of only moderate difficulty (the test represented common spelling patterns but excluded rare words and 'spelling demons') was little more than half. As we had anticipated, reading comprehension was significantly correlated with word-level skills in both reading and spelling.

Tests of metalinguistic abilities also proved relevant for literacy differences among these students. Performance on the phoneme deletion task showed levels of achievement not grossly deficient, yet characteristic of somewhat younger readers (Rosner & Simon 1971). Variations in performance on this measure were significantly associated with performance in reading and spelling. Similarly, correlations with reading and spelling were found for a measure of morphological awareness. As shown by their performance on these tasks, and the high error rate in non-word reading and spelling, these students (with some exceptions) have achieved a basic level of linguistic awareness. However, they lack the linguistic sophistication that would permit them to attain higher levels of orthographic knowledge and skill in its application.

By 'linguistic sophistication' we mean to include first, knowledge of derived forms and other morphological relations that are important for using English orthography (readers as well as writers are aided by grasping that English spelling is morphemic as well as phonemic). Second, awareness of English spelling conventions is necessary because many regular spelling patterns cannot be understood as letter by letter transcriptions of the phonetic surface (for example, the spelling IGHT as in 'LIGHT'). Third, knowledge of word families would also be important, since spellings reflect the language of origin of the extensive and diverse foreign borrowings in the lexicon of English.

Linguistic sophistication can be fostered by teachers who structure their literacy classes to emphasize the kinds of word-related information described above in the course of vocabulary building and spelling. If evidence from beginning readers is any guide, experience with print alone is not sufficient to instill recognition of many useful regularities (Byrne 1992). Moreover, since the orthography encodes morphologic information beyond the strictly phonological, readers beyond the earliest stages should be armed with morphological awareness in addition to acquiring basic skills in phonological segmentation.

The finding (of Experiment 2) that individual differences in comprehension reflect differences in word-level skills is telling. It points to one more good reason why we should not neglect to assess decoding (and spelling) in diagnostic studies at the high school and adult level. At present we have far too little information about basic literacy skills in those young people who end their formal education at or before high school graduation. Yet it is precisely from this population that the legions of the 'functionally illiterate' are recruited. Unfortunately, with the exception of studies of college students, there has been relatively little analytic research on reading beyond the elementary grades (but see Scarborough 1984). It is true, of course, that assessments of reading comprehension among samples of American adults have been reported recently. Typically, the tests pose functionally-defined tasks, such as interpreting directions or obtaining information from various forms of printed material. Tests of this kind may be of some value to gauge practical reading levels (Kirsch, Jungeblut, Jenkins & Kolstad 1993). Our objection is that they provide no *diagnostic* information: they cannot identify the source of the reader's difficulties in interpreting printed material. Such criterion-based tests need to be supplemented with code-based approaches, as illustrated in studies by Liberman et al. (1985) on adults enrolled in literacy classes, and by Read & Ruyter (1985) on a prison population.

Reading materials designed for school use, from the fourth or fifth grade on, 'contain an ever greater number of words that are unfamiliar, rare, specialized, abstract, literary, and bookish' (Chall 1987: 8). High school students who have difficulty reading nonwords and irregular words cannot be expected to cope adequately with new vocabulary. Contrary to Miller's (1988) assertion, there seem to be grounds to question whether word decoding skills are

adequately mastered by most students by the time they reach high school. Certainly if these results are at all typical of the target population it would be risky to presume that this is true. Further investigation of this population is needed to clarify the links between limitations in reading at the level of word recognition skills and the various problems that text comprehension poses (see Shankweiler 1989). In this connection, we find clarifying the 'simple view' of Gough & Tunmer (1986), who emphasize that *listening* comprehension sets an upper bound on comprehension in reading, and that the only other relevant factor is decoding.

ACKNOWLEDGMENTS

We are grateful to the students and staff of the Forman School, Litchfield, Connecticut, and Windham High School, Willimantic, Connecticut, for their generous co-operation in making this study possible. Support was provided by a Program Project Grant to Haskins Laboratories from the National Institute of Child Health and Human Development (HD-01994). This project was originally conceived and planned with the collaboration of our late colleague Isabelle Y. Liberman, who made important contributions to the success of the project but did not live to see its completion. We thank Alvin M. Liberman, Hollis Scarborough, and Sally Shaywitz for their comments on earlier drafts.

NOTES

1. Conventional analyses of spelling errors proceed from the assumption that difficulties in spelling are difficulties in remembering letter sequences, rather than inability to make productive use of a complex code. But the omission of letter H from the grapheme SH is surely a different kind of error than leaving out the (whole grapheme) T from the grapheme sequence ST. The first error misrepresents a phoneme; the second omits one altogether.
2. The total number of errors in this classification does not correspond to the total discussed in the previous section, because in that analysis we tallied errors using the whole word as the unit of analysis, whereas in this analysis the individual phoneme segments are the units.
3. A possible explanation for this circumstance may lie in the selection of subjects. The average students were judged by their teachers to represent the average skill level of students in the ninth grade; the fact that this was a public high school drawing from a largely middle-class population would tend to support the generality of this evaluation. The LD students, on the other hand, are not distinguished from the average students by performance-independent criteria (see Note 4). They come from a school that accepts a wide range of learning disabilities. They are given individually-tailored code-based instruction to combat problems in reading and spelling - an added benefit that must be less available to students at the public school. In addition, it is likely that the cost of tuition would restrict attendance to students from families with higher than average incomes. Our LD students were also two years older on average than the public school group. All of these factors might contribute to

- reducing the differences between the groups. However, it seems to us that the most parsimonious explanation of the groups' similarities is that offered by the continuity of performance view we discuss.
4. Psychometric criteria for inclusion in any diagnostic category are partly arbitrary, often resulting in too wide or too narrow a scope for a given diagnosis. Accordingly, learning disability has been defined in other ways too, such as refractoriness to treatment.
 5. Since our study is concerned specifically with factors that are known to be highly correlated with vocabulary, it would have been inappropriate to use vocabulary as a control measure. Much of the variance in comprehension that would be accounted for by basic skills measures is also accounted for by vocabulary alone because of the high intercorrelations of the literacy measures with vocabulary. Thus little variance remains for succeeding terms in the regression to predict. In addition to the reasons that reading and vocabulary may be correlated in the real world (e.g., vocabulary growth is in some measure attributable to reading experience; see Nagy, Herman & Anderson 1985), our tests may not have succeeded fully in isolating each ability. Given that the vocabulary task presented the words and foils in print as well as in spoken form, good readers who could use both modes would possibly have an advantage.
 6. The specific words from the Coltheart list that the ninth graders most often failed to spell correctly are of some interest. As expected, the irregular words were spelled correctly less often than their frequency-matched regular word counterparts. (The two exceptions were the regular words SHERRY and STREWN, which were misspelled more frequently than their matched irregular counterparts CASTLE and SCARCE.) It is instructive to note that, nonetheless, regular words were among those very often misspelled. Among the items missed by more than one third of the subjects were the regular words SHERRY, STREWN, SPLENDID, and THRONG. For the last two of these it is difficult to imagine a plausible alternative spelling. Nine of the fifteen irregular words were misspelled by at least one third of the subjects, notwithstanding that a number of them are mid-frequency words: DEBT, MORTGAGE, LOSE, THOROUGH, SCARCE, YACHT, TROUGH, BISCUIT, and SUBTLE.

REFERENCES

- Anderson, R. C., Hiebert, E. H., Scott, J. A. & Wilkinson, I. A. G. (1985). *Becoming a nation of readers: The report of the commission on reading*. Champaign, IL: Center for the Study of Reading.
- Bell, L. C. & Perfetti, C. A. (1994). Reading skill: Some adult comparisons, *Journal of Educational Psychology* 86: 244-255.
- Bruck, M. (1990). Word-recognition skills of adults with childhood diagnoses of dyslexia, *Developmental Psychology* 26: 439-454.
- Byrne, B. (1992). Studies in the acquisition procedure for reading: Rationale, hypotheses, and data. In: P. B. Gough, L. C. Ehri & R. Treiman (eds.), *Reading acquisition* (pp. 35-48). Hillsdale, NJ: Erlbaum.
- Carlisle, J. F. (1987). The use of morphological knowledge in spelling derived forms by learning disabled and normal students, *Annals of Dyslexia* 37: 90-108.
- Carlisle, J. F. (1988). Knowledge of derivational morphology and spelling ability in fourth, sixth, and eighth graders, *Applied Psycholinguistics* 9: 247-266.
- Carroll, J., Davies, P. & Richman, B. (1971). *The American heritage word frequency book*. Boston: Houghton-Mifflin.
- Chall, J. S. (1987). Two vocabularies for reading: Recognition and meaning. In: M. G. McKeown & M. E. Curtis (eds.), *The nature of vocabulary acquisition* (pp. 7-17). Hillsdale, NJ: Erlbaum.

- Chomsky, N. & Halle, M. (1968). *The sound pattern of English*. New York: Harper & Row.
- Coltheart, M., Besner, D., Jonasson, J. T. & Davelaar, E. (1979). Phonological encoding in the lexical decision task, *Quarterly Journal of Experimental Psychology* 31: 489-507.
- DeFrancis, J. (1989). *Visible speech: The diverse oneness of writing systems*. Honolulu: University of Hawaii Press.
- Dreyer, L. G., Luke, S. D. & Melican, E. (1995). Children's acquisition and retention of word spellings. In: V. W. Berninger (ed.), *The varieties of orthographic knowledge. II: Relationships to phonology, reading, and writing* (pp. 291-320). Dordrecht/Boston/London: Kluwer Academic Publishers.
- Finucci, J. M., Gottfredson, L. S. & Childs, B. (1985). A follow-up study of dyslexic boys. *Annals of Dyslexia* 35: 117-136.
- Fletcher, J. M., Shaywitz, S. E., Shankweiler, D. P., Katz, L., Liberman, I. Y., Stuebing, K. K., Francis, D. J., Fowler, A. E. & Shaywitz, B. A. (1994). Cognitive profiles of reading disability: Comparisons of discrepancy and low achievement definitions, *Journal of Educational Psychology* 86: 6-23.
- Fowler, A. E. & Liberman I. Y. (1994). Morphological awareness as related to early reading and spelling ability. In: L. Feldman (ed.), *Morphological aspects of language processing* (pp. 157-188). Hillsdale, NJ: Erlbaum.
- Fowler, A. E. & Scarborough, H. S. (1993). Should reading disabled adults be distinguished from other low literacy adults?, National Center for Adult Literacy, TR 93-7.
- Gough, P. B. & Hillinger, M. L. (1980). Learning to read: An unnatural act, *Bulletin of the Orton Dyslexia Society* 30: 179-196.
- Gough, P. B., Juel, C. & Griffith, P. L. (1992). Reading, spelling, and the orthographic cipher. In: P. B. Gough, L. C. Ehri & R. Treiman (eds.), *Reading acquisition* (pp. 35-48). Hillsdale, NJ: Erlbaum.
- Gough, P. B. & Tunmer, W. E. (1986). Decoding, reading, and reading disability, *Remedial and Special Education* 7: 6-10.
- Gough, P. B. & Walsh, M. (1991). Chinese, Phoenicians, and the orthographic cipher of English. In: S. Brady & D. Shankweiler (eds.), *Phonological processes in literacy* (pp. 199-209). Hillsdale, NJ: Erlbaum.
- Jastak, S. & Wilkinson, G. S. (1984). *Wide range achievement test - revised*. Wilmington, DE: Jastak Associates.
- Juel, C., Griffith, P. L. & Gough, P. B. (1986). Acquisition of literacy: A longitudinal study of children in first and second grade, *Journal of Educational Psychology* 78: 243-255.
- Karlsen, B. & Gardner, E. F. (1985). *Stanford Diagnostic Reading Test*, 3rd ed. New York: The Psychological Corporation.
- Kirsch, I. S., Jungeblut, A., Jenkins, L. & Kolstad, A. (1993). *Adult literacy in America: National adult literacy survey*. Princeton, NJ: Educational Testing Service.
- Kucera, H. & Francis, W. N. (1967). *Computational analysis of present-day American English*. Providence, RI: Brown University Press.
- Liberman, I. Y., Liberman, A. M., Mattingly, I. G. & Shankweiler, D. (1980). Orthography and the beginning reader. In: J. F. Kavanagh and R. Venezky (eds.), *Orthography, reading, and dyslexia* (pp. 137-153). Baltimore: University Park Press.
- Liberman, I. Y., Rubin, H., Duques, S. & Carlisle, J. (1985). Linguistic abilities and spelling proficiency in kindergartners and adult poor spellers. In: D. B. Gray & J. F. Kavanagh (eds.), *Biobehavioral measures of dyslexia* (pp. 163-176). Parkton, MD: York Press.
- Lukatela, K., Carello, C., Shankweiler, D. & Liberman, I. Y. (in press). Phonological awareness in illiterates: Observations from a Slavic language, *Applied Psycholinguistics*.
- MacGinitie, W. H. & MacGinitie, R. K. (1989). *Gates-MacGinitie reading tests*, 3rd ed. Chicago, IL: Riverside Publishing Company.
- Miller, G.A. (1988). The challenge of universal literacy, *Science* 241: 1293-1299.
- Morais, J. (1991). Constraints on the development of phonemic awareness. In: S. A. Brady &

- D. P. Shankweiler (eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 5-27). Hillsdale, NJ: Erlbaum.
- Morais, J., Cary, L., Alegria, J. & Bertelson, P. (1979). Does awareness of speech as a sequence of phonemes arise spontaneously?, *Cognition* 7: 323-331.
- Nagy, W. E., Herman, P. A. & Anderson, R. A. (1985). Learning words from context. *Reading Research Quarterly* 20: 233-253.
- Olson, R., Fosberg, H., Wise, B. & Rack, J. (1994). Measurement of word recognition, orthographic, and phonological skills. In: G. R. Lyon (ed.), *Frames of reference for the assessment of learning disabilities: New views on measurement issues*. (pp. 243-277). Baltimore, MD: Paul H. Brookes.
- Perfetti, C. A. (1985). *Reading ability*. New York: Oxford University Press.
- Read, C. & Ruyter, L. (1985). Reading and spelling skills in adults of low literacy, *Remedial and Special Education* 6: 43-52.
- Richardson, E. & DiBenedetto, B. (1986). *Decoding skills test*. Parkton, MD: York Press.
- Rohl, M. & Tunmer, W. E. (1988). Phonemic segmentation skill and spelling acquisition, *Applied Psycholinguistic* 9: 335-350.
- Rosner, J. & Simon, D. P. (1971). The auditory analysis test: An initial report, *Journal of Learning Disabilities* 4: 384-392.
- Scarborough, H. S. (1984). Continuity between childhood dyslexia and adult reading, *British Journal of Psychology* 75: 329-348.
- Shankweiler, D. (1989). How problems of comprehension are related to difficulties in decoding. In: D. Shankweiler & I. Y. Liberman (eds.), *Phonology and reading disability* (pp. 35-68). Ann Arbor, MI: University of Michigan Press.
- Shankweiler, D. (1992). Surmounting the consonant cluster in beginning reading and writing. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.
- Shankweiler, D. & Crain, S. (1986). Language mechanisms and reading disorders: A modular approach, *Cognition* 24: 136-168.
- Shankweiler, D., Crain, S., Katz, L., Fowler, A. E., Liberman, A. M., Brady, S. A., Thornton, R., Lundquist, E., Dreyer, L., Fletcher, J. M., Stuebing, K. K., Shaywitz, S. E. & Shaywitz, B. A. (1995). Cognitive profiles of reading-disabled children: Comparison of language skills in phonology, morphology, and syntax, *Psychological Science* 6: 149-156.
- Shankweiler, D. & Liberman, I. Y. (1972). Misreading: A search for causes. In: J. F. Kavanagh & I. G. Mattingly (eds.), *Language by ear and by eye: The relationships between speech and reading* (pp. 293-317). Cambridge, MA: MIT Press.
- Share, D. L. & Silva, P. A. (1986). The stability and classification of specific reading retardation: A longitudinal study from age 7 to 11, *British Journal of Educational Psychology* 56: 32-39.
- Shaywitz, S. E., Escobar, M. D., Shaywitz, B. A., Fletcher, J. M. & Makuch, R. (1992). Evidence that dyslexia may represent the lower tail of a normal distribution of reading ability. *New England Journal of Medicine* 326: 145-150.
- Shaywitz, B. A., Fletcher, J. M., Holahan, J. & Shaywitz S. E. (1992). Discrepancy compared to low achievement definitions of reading disability: Results from the Connecticut longitudinal study, *Journal of Learning Disabilities* 25: 639-648.
- Stage, S. A. & Wagner, R. K. (1992). Development of young children's phonological and orthographic knowledge as revealed by their spellings, *Developmental Psychology* 28: 287-296.
- Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy, *Reading Research Quarterly* 21: 360-407.
- Stanovich, K. E. & Cunningham, A. E. (1992). Studying the consequences of literacy within a literate society: The cognitive correlates of print exposure, *Memory & Cognition* 20: 51-68.
- Stanovich, K. E., Cunningham, A. E. & Cramer, B. B. (1984). Assessing phonological aware-

- ness in kindergarten children: Issues of task comparability, *Journal of Experimental Child Psychology* 38: 175-190.
- Stanovich, K. E. & Siegel, L. S. (1994). Phenotypic performance profile of children with reading disabilities: A regression-based test of the phonological-core variable-difference model, *Journal of Educational Psychology* 86: 24-53.
- Stanovich, K. E. & West, R. F. (1989). Exposure to print and orthographic processing, *Reading Research Quarterly* 24: 402-433.
- Venezky, R. L. (1970). *The structure of English orthography*. The Hague/Paris: Mouton.
- Wijk, O. (1966). *Rules of pronunciation for the English language*. London: Oxford University Press.

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