READING SKILL AND LANGUAGE SKILL

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Abstract. To learn to read is to acquire a visual language skill that systematically maps onto extant spoken language skills. Some children perform this task quite adeptly, while others encounter much difficulty, and it has become a question of both scientific and practical merit to ask why there exists such a range of success in learning to read. Obviously, learning to read places a complex burden on many emerging capacities, and in principle, at least, reading disability could arise at any level from general cognition to visual perception. Yet since reading is parasitic on spoken language, the possibility also exists that reading disability is derived from some subtle difficulty in the language domain. In this article, my intent is to review some of the many studies that have explored the association between reading skill and spoken language skill. These reveal that when certain spoken-language skills of good and poor beginning readers are critically examined, considerably many, though perhaps not all, poor readers prove to possess subtle deficiencies that correlate with their problems in learning to read.

LINGUISTIC SHORT-TERM MEMORY DIFFERENTIATES GOOD AND POOR BEGINNING READERS

One of the more compelling reasons to view reading deficiency as the derivative of a language deficiency is that success at learning to read is associated with the adequacy of certain linguistic short-term memory skills. In our work at Haskins Laboratories, my colleagues and I have found clear indications of this association in a variety of different studies of good and poor beginning readers. For the moment, however, let me put aside a discussion of those studies in order to consider first the short-term storage requirements of normal language processing, and to summarize some recent findings as to how these requirements are met by the mature language user. These considerations pertain to both written and spoken language and provide a

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necessary introduction to any discussion of linguistic short-term memory among beginning readers.

An adequate short-term memory is essential to language comprehension simply because the component words of a phrase or sentence must often be held temporarily, pending extraction of the meaning of the whole phrase or sentence (Baddeley, 1978). It is for precisely this reason that many current models of sentence processing explicitly include some form of short-term memory buffer as a part of their parsing device (cf. Frazier & Fodor, 1978; Kimball, 1975; Marcus, 1980). Some consideration has been given to the form of memory representation that mediates human parsing. Current psychological theory has it that some level of phonetic representation is likely to be involved, this being an abstract representation of the articulatory gestures that constitute the material being parsed (Liberman, Mattingly, & Turvey, 1972). There are many experimental findings to corroborate this view. On the one hand, adult subjects have given evidence of relying on phonetic representation while performing such ecologically invalid tasks as recalling a string of letters or a string of words (Conrad, 1964; Drewnowski, 1980). More importantly, there is evidence that phonetic representation is also involved during comprehension of both written and spoken sentences (cf. Baddeley, 1978; Daneman & Carpenter, 1980; Kleiman, 1975; Levy, 1977; Slowiaczek & Clifton, 1980; Tzeng, Hung, & Wang, 1977).

It is, of course, not inconceivable that, in reading, some nonlinguistic representation of written words might be employed in lieu of a phonetic one (cf. Kleiman, 1975; Meyer, Schvaneveldt, & Ruddy, 1974). There is, after all, much evidence to suggest that access to the mental lexicon for printed words may not necessarily require reliance on phonetic representation (cf. Baron, 1973; Kleiman, 1975; Meyer et al., 1974). Nonetheless, it is important to emphasize that reading typically involves more than mere lexical access alone. A successful reader must often go beyond the lexicon and place reliance on the grammatical structure of the material being read. In contrast to experiments involving lexical access, those experiments concerned with reading situations where sentence structure is at stake have consistently given evidence of the involvement of phonetic representation (Daneman & Carpenter, 1980; Kleiman, 1975; Levy, 1977; Slowiaczek & Clifton, 1980). Even readers of Chinese logography, an orthography in which access to the lexicon is necessarily mediated by non-phonetic representation, appear to make use of phonetic representation when their task involves recovering the meaning of written sentences and not simply words alone (Tzeng et al., 1977).

For adult subjects, phonetic representation is clearly involved in both written and oral language comprehension. Having made this point, let me return to the primary concern of this paper, which is a review of some recent studies of good and poor beginning readers. These provide another form of support for the involvement of phonetic representation in all language processing, by revealing that effective use of phonetic representation is associated with, and may even presage success in, learning to read. I intend to review some of the many findings that support this conclusion; however, it might be useful first to provide some basic information about the population of beginning readers whom my colleagues and I have studied, since they have provided much of the data to which I will refer.
Most frequently our subjects have been first, second, and third graders who attend public schools. All of them are native speakers of English who suffer from no known neurological impairment. They are identified by their teachers as being "good," "average," or "poor" readers, a status that we confirm by administering standard reading tests to each child (typically the Word Attack and Word Recognition Subtests of the Woodcock Reading Mastery Tests, Woodcock, 1973; or the Word Recognition Subtests of the Wide Range Achievement Test, Jastak, Bijou, & Jastak, 1965). Administration of these tests has typically revealed the "good" readers to be reading at a level one or more years above their grade placement, whereas the "average" readers are reading at a level between one year above and one-half year below placement. The "poor" readers tend to be reading at a level one-half year or more below grade placement. Aside from administering standard reading tests, we have also usually given our subjects intelligence tests (either the Peabody Picture Vocabulary Test, Dunn, 1959; or the Slosson Intelligence Test for children, Slosson, 1963; or the WISC-R), and have excluded those children in either reading group who score below 90 or above 145.

One of the more general findings to emerge from our work is that good and poor readers may differ in temporary memory for some types of material, but not for other types (Katz, Shankweiler, & Liberman, in press; Liberman, Mann, Shankweiler, & Werfelman, in press; Mann & Liberman, in press). An example of this trend may be seen in the results of a study that assessed recognition memory skill among good and poor beginning readers (Liberman et al., in press). The subjects were second graders who differed in reading ability, but not in mean age or mean IQ. They participated in an experiment that employed the recurring recognition memory paradigm of Kimura (1963) as a means of evaluating memory for several different types of material. The material we studied included two non-linguistic materials—photographs of unfamiliar faces and nonsense "doodle" drawings—and one linguistic material—printed nonsense syllables. For each of these, the children inspected a set of stimuli and proceeded to indicate any of the inspection items that recurred in a subsequent recognition set. As may be seen in Figure 1, the poor readers were equivalent to the good readers in memory for faces and even somewhat better than the good readers (although not significantly so) in memory for the nonsense drawings. However, they were significantly inferior to good readers in memory for the nonsense syllables. Thus there is an interaction between reading ability and the type of item being remembered; an interaction that prevailed in an analysis of covariance adjusting for any effects of age or IQ differences.

Clearly, this experiment cannot support a conclusion that poor readers suffer from some general memory difficulty. Rather, they appear deficient only in the ability to remember linguistic material. Many findings that concern short-term memory lend further support to this conclusion. Good readers typically surpass poor readers in short-term memory for printed strings of letters or printed words (cf. Shankweiler, Liberman, Mark, Fowler, & Fischer, 1979; Mark, Shankweiler, Liberman, & Fowler, 1977) as well as for printed nonsense syllables. However, good readers also excel at recall of spoken strings of letters (Shankweiler et al., 1979), spoken strings of words (Bauer, 1977; Byrne & Shea, 1979; Katz & Deutsch, 1964; Mann, Liberman, & Shankweiler, 1980; Mann & Liberman, in press), and even spoken sentences (Mann et al., 1980; Perfetti & Goldman, 1976; Wiig & Roach, 1975; Weinstein &
Figure 1. Good and poor readers' mean percentage of correct responses on nonsense designs, faces, and nonsense syllables.
Rabinovitch, 1971). At this point it is important to note that, since the advantage of good readers holds for both written and spoken material, it must extend beyond processes involved in reading, as such, to the broader realm of language processing.

To account for the linguistic memory distinctions between good and poor readers, some of my colleagues (Liberman & Shankweiler, 1979; Shankweiler et al., 1979) offered the hypothesis that poor readers have some difficulty that specifically compromises effective use of phonetic representation. Therefore, they used a modification of Conrad's (1964) procedure for examining the involvement of phonetic representation in memory for written letter strings, to test a group of good, average, and poor readers from a second-grade population that was homogeneous with respect to age and IQ. As was the case in Conrad's procedure, the children were asked to recall strings of five consonants that were of two basic types. Half of the strings were composed of consonants with phonetically confusable (i.e., rhyming) names, whereas the other half contained letters with phonetically nonconfusable (i.e., nonrhyming) names. During testing, the children saw a letter string with all of its letters printed in upper case on a single line in the center of the visual field. After a three-sec inspection period, when the letters could no longer be seen, they wrote down any letters that could be remembered, preserving the sequence as closely as possible.

On the basis of Conrad's findings, Liberman, Shankweiler, and their colleagues predicted that nonrhyming letter names would generate fewer phonetic confusions than rhyming ones, and thus facilitate recall in subjects who rely on phonetic representation as a means of retaining letters in short-term memory. It was felt that if a subject's level of performance failed to profit from reduced phonetic confusability, then that subject might have made less effective use of phonetic representation as a mnemonic device. The performance of good, average, and poor readers on the two types of letter strings is compared in the top section of Figure 2. Good readers, in general, made fewer errors than poor readers, and the average readers fell in between. The performance of the good readers, however, was also more significantly affected by the manipulation of rhyme than was that of the average or poor readers. In fact, the advantage of the superior readers was virtually eliminated when the letter strings contained letters with phonetically confusable names. In other words, phonetic confusability penalized the better readers to a greater extent than children in the other two reading groups.

These findings were extended by two subsequent experiments involving the same group of subjects and the same set of letter strings. In the first of these, the letters of each string were presented visually, but successively rather than simultaneously. In the second experiment, the letters were presented successively, but auditorily rather than visually. The results of these experiments are also displayed in Figure 2, where it may be seen that, once again, the interaction between reading ability and the effect of phonetic confusability was upheld. Indeed, it prevailed even when the letters were heard instead of seen. It is important to underscore the fact that reading ability was the only variable that interacted with the effect of phonetic confusability on letter recall. The children with higher IQ scores did tend to perform at a higher level than those with lower scores; however, the extent of their superiority was the same regardless of whether the comparison
Figure 2. Mean errors of superior and good readers on recall of letter strings, summed over serial positions. (Means from delay and nondelay conditions are averaged. Maximum = 40.)
involved phonetically confusable letter strings or phonetically nonconfusable ones. Thus, the interaction between reading ability and the effect of phonetic confusability was unaltered when the analysis of the data covaried for any effects of IQ.

To strengthen these findings about poor readers' ineffective use of phonetic representation, my colleagues and I followed the study of letter-string recall with a study of the role of phonetic representation in recall of other, more ecologically valid material such as spoken word strings and spoken sentences (Mann et al., 1980). In that study, the subjects were again good and poor readers from a second-grade classroom. This time, however, the good readers had a slightly higher mean IQ than the poor readers. The experiment involved having the children in each group repeat strings of five spoken words, and also the words of 13-word sentences that were either meaningful or semantically anomalous. The materials included many different items of each type, but for word strings and both types of sentences, half of the items contained a high density of phonetically confusable (i.e., rhyming) words, whereas half contained phonetically nonconfusable words instead. Children's performance on the word strings is compared in Figure 3, and that on sentences is compared in Figure 4. As can be seen in those figures, for word strings, as well as for both meaningful and semantically anomalous sentences, good readers made fewer errors than poor readers as long as the material was phonetically nonconfusable. For all three types of material, however, they fell to the level of the poor readers when the material contained a high density of phonetically confusable words. In this experiment, although good readers tended to have higher IQ's, a significant interaction between reading ability and the effect of phonetic confusability was obtained when the results were subjected to an analysis of covariance that adjusted for any differences in IQ. Once again, intelligence alone was not the source of the good readers' more effective use of phonetic representation.

Thus, whether the material is apprehended by ear or by eye, and whether it involves letter strings or meaningful sentences, the performance of good readers tends to be both superior to that of poor readers and also more strongly affected by manipulations of phonetic confusability. For most good readers, as for most adults, phonetic confusability of the material to be recalled makes reliance on phonetic representation a liability rather than an asset. In contrast, phonetic confusability has little effect on the memory performance of most poor readers, a fact that we interpret as evidence that they are, for some reason, encountering difficulty with phonetic representation.

CLARIFYING THE BASIS OF POOR READERS' PROBLEMS WITH LINGUISTIC SHORT-TERM MEMORY

At this point, it becomes appropriate to consider why good and poor readers might differ in performance on tasks that involve reliance on phonetic representation. We can lay aside the possibility that memorial representation, in general, is a problem, since if this were so, poor readers would have been inferior on other tests of temporary memory and not merely on those that involve reliance on phonetic representation. A general cognitive deficiency would also seem an unlikely basis, given our findings that IQ scores are not
Figure 3. Mean error scores of good and poor readers on recall of word strings, in nonrhyming and rhyming conditions. (Maximum = 5.)
Figure 4. Mean error scores of good and poor readers on recall of meaningful and meaningless sentences in nonrhyming and rhyming conditions. (Maximum = 13.)
significantly associated with sensitivity to manipulations of phonetic confusability. Two other possibilities seem more plausible. On the one hand, poor readers might not resort to phonetic representation at all, relying instead on visual or semantic modes of representation. However, it is likewise possible that they do attempt to employ phonetic representation, but for some reason their representations are less effective.

One piece of evidence that is relevant to this issue is provided by the results of an experiment in which I extended Liberman and Shankweiler's study of letter string memory to a population of second- and third-grade children who were learning to read Dutch. The subjects were the ten best readers and the ten worst readers in each grade; their mean ages and reading abilities are given in Table 1. The procedure was the same as in the first experiment of Shankweiler et al. (1979) with one innovation. In constructing the letter strings, I separately manipulated phonetic and visual confusability, since this was more feasible in Dutch than in English. Thus it was possible to examine recall of three different types of upper-case consonant strings: strings of letters that were phonetically confusable but not visually confusable; strings of letters that were visually confusable but not phoneti-
cally confusable, and strings of letters that were minimally confusable along both the visual and phonetic dimension. In all cases, the measure of phonetic confusability was the density of letters with rhyming names, since that measure had been employed by the Conrad (1964) study on which the Shankweiler et al. (1979) study had been based. The measure of visual confusability was derived from the upper-case letter confusion matrix compiled by Townsend (1971), and was the summed probability of visual confusion for each possible pair of letters in a given string. Computed in this way, the mean confusability for the ten visually confusable strings was 0.81, and was significantly greater than that for either the ten phonetically confusable or the ten minimally confusable strings (0.27 and 0.31, respectively, t(18)=3.1, p<.01, and t(18)=2.8, p<.01, respectively).

As no children’s IQ test was available in Dutch, I controlled for nonlinguistic short-term memory rather than for general intellectual ability. The test of nonlinguistic memory that I administered was the Corsi test (Corsi, 1972). The materials for that test consist of a set of nine wooden cubes attached in a random fashion to a flat wooden base. The entire apparatus is painted black; there are identifying numbers on the rear surface of the cubes that can be seen by the experimenter although not by the subject. During testing, the subject watches the examiner tap out a sequence of blocks and then attempts to reproduce that sequence. Practice sequences of two and three blocks are given first, followed by eight test sequences of four and eight of five blocks each. The suitability of this test as a measure of nonlinguistic short-term memory is indicated by clinical studies revealing that whereas performance on linguistic short-term memory tests is selectively impaired by damage to the left or language-dominant hemisphere, that on the Corsi blocks shows the opposite pattern of selective impairment as a consequence of damage to the right, or language-nondominant hemisphere (Corsi, 1972; Milner, 1972).

Because of my experience with American children, which had revealed no significant relation between reading ability and non-linguistic memory, I did not anticipate finding that good and poor beginning readers of Dutch would differ in performance on the Corsi test. There seemed to be no reason to anticipate that children in the two reading groups would differ in nonlinguistic abilities. It did seem possible, however, that poor readers would do less well than good readers on the letter-string memory test, and that they might also be differently affected by the manipulations of phonetic and visual confusability. Proceeding from the fact that phonetic confusability penalizes recall in subjects who rely on phonetic representation, I speculated that if poor readers rely on visual representation, then they might be inordinately affected by the manipulation of visual confusability.

The results of the study are given in Table 2, where all memory test scores are error scores that include errors of item omission and substitution, as well as of incorrect order. In that table, it may be seen that despite any differences in the Dutch and English languages or in the educational practices by which they are taught, the memory profiles of good and poor readers in the two countries prove quite similar. As we have found to be the case for American children, Dutch children who are poor readers are equivalent to good readers in performance on the nonlinguistic short-term memory test: F(1,39)=1.6, p>.10, although older children tend to do better than younger
ones: \( F(1,39) = 4.9, \ p < .05 \). Older children also tended to do better on the letter string test: \( F(1,39) = 11.8, \ p < .005 \). More importantly, the good beginning readers of Dutch tended to surpass the poor readers in memory for consonant strings, and they did so at both age levels tested: \( F(1,39) = 45.0, \ p < .0001 \).

\[\begin{tabular}{|c|c|c|c|}
\hline
   & Corsi & Letter Strings & \\
   Blocks & Phonetically Confusable & Visually Confusable & Non-confusable \\
\hline
Second grade: & & & \\
  good readers & 20.5 & 15.4 & 23.4 & 16.4 \\
  poor readers & 24.5 & 29.8 & 29.8 & 30.9 \\
\hline
Third grade: & & & \\
  good readers & 15.9 & 11.0 & 20.7 & 8.5 \\
  poor readers & 18.2 & 24.5 & 26.9 & 26.2 \\
\hline
(Max. = 72) & (Max. = 50) & (Max. = 50) & (Max. = 50) \\
\end{tabular}\]

In these data, there is, further, the anticipated interaction between reading ability and the effect of the various manipulations of letter confusability: \( F(2,72) = 28.3, \ p < .0001 \). The better readers surpassed the poorer ones in memory for the minimally confusable letter strings, this being true for both second: \( t(18) = 4.8, \ p < .001 \), and third graders: \( t(18) = 10.3, \ p < .001 \). However, the good readers at both ages fell to the level of poor readers when they attempted to recall phonetically confusable strings. A further twist to these data involves the effect of visual confusability, or rather, its non-effect. Neither good nor poor readers were affected by the presence of a higher density of visual confusability. That is to say, for both groups of subjects at both age levels, performance on the visually confusable strings was no different from that on the nonconfusable ones. This gives us no reason to believe that in this task the poor readers opted for a purely visual representation of the letter strings. Either they relied on some as yet undetermined form of representation, or they relied on phonetic representation and for some reason failed to profit from reduced phonetic similarity among the letter names.
Some direct evidence in support of the possibility that poor readers do sometimes rely on phonetic representation may be found in the pattern of errors these children make when they attempt to recall a phonetically confusable string of spoken words. Some of my colleagues and I recently analyzed the responses made by good and poor readers who were attempting to recall such a string (Brady, Shankweiler, & Mann, 1982). The subjects were participating in an experiment that will be described in more detail below; they were good and poor readers from a third-grade classroom and they did not significantly differ in IQ. They were asked to repeat strings of five words that were either phonetically confusable or phonetically nonconfusable. As in the past, the good readers tended to excel with respect to the poor readers, but also tended to be more greatly affected by the manipulation of phonetic confusability. We also found, however, that although children in both reading groups made many substitution errors, the poor readers tended to make more of these than the good readers. We therefore turned to analyzing the composition of the substitution errors and their relation to the words of the original string.

Our analysis revealed that the pattern of substitution errors was the same for good and poor readers alike. Almost no substitutions were semantic associates of the words in the string being recalled; instead, the majority were composed of a subset of the phonemes that had constituted the words of the string being remembered. For example, a great proportion of the errors contained an appropriate initial consonant and even more contained an appropriate vowel or final consonant. Thus it seemed as if the children in both reading groups had remembered many of the phonemes they had heard. The poor readers, for some reason, had merely made more errors in recalling the original word strings, perhaps because their phonetic representations were less well formed, or perhaps because their representations decayed more rapidly than those of the good readers.

Thus, in at least some circumstances, it seems that poor readers may rely on phonetic representation to some extent; otherwise they would not have tended to make substitution errors that preserve phonetic aspects of the original word string. Before leaving this topic, it would be pertinent to mention the possibility that problems with phonetic representation may force the poor readers to rely on semantic representation during certain memory tasks. Although my colleagues and I have seen almost no semantically-based substitution errors among either good or poor readers, this has not been the case in another study done by Byrne and Shea (1979). These investigators compared the performance of good and poor beginning readers on a spoken-word recognition memory test, and found that, in general, good readers performed at a higher level than poor readers. They also discovered that children in the two groups tended to make different types of errors. Whereas poor readers made proportionately more false recognition errors on semantic associates of the correct items, good readers tended to make more such errors on words that were phonetic associates. For example, when asked to remember and subsequently recognize "home," poor readers tended erroneously to recognize "house," but good readers, "comb." Yet when the task was to remember nonsense syllables instead of words, children in both reading groups made many errors on phonetic foils. Once again, however, good readers somehow made more effective use of phonetic representation, as evidenced by their tendency to make fewer errors, in general, coupled with their tendency to make disproportionately many errors on phonetically-similar foils.
Turning now to the question of why the phonetic representations of poor readers may be less effective than those of good readers, let me return to the above-mentioned study by Brady et al. (1982). In that study an approach to the problem of phonetic representation was inspired by the finding that, when speech perception is stressed by the presence of background noise, short-term memory span is inordinately affected (Rabbitt, 1968). This finding led us to consider the possibility that the short-term memory difficulties of poor readers might be associated with some difficulties in encoding speech. Therefore, we designed an experiment to compare the ability of good and poor readers to identify spoken words that were partially masked by white noise.

The third graders who were subjects of this study did not differ in age or IQ, but did differ in reading ability, and also in memory for strings of spoken words. Their performance showed the usual interaction between reading ability and the effect of phonetic confusability. They were asked to identify a pre-recorded set of spoken words that contained an equal number of high and low frequency words and was balanced for phonetic constituents and syllabic structure. Each child heard the words under two different conditions: first partially masked by signal-correlated white noise, and later under more optimal listening conditions.

The results revealed that although the poor readers were not significantly different from good readers in performance under the optimal conditions, they made about 35% more errors when the words were partially masked. That this problem could not be attributed to some basic vocabulary deficiency could be seen from the fact that differences between children in the two reading groups obtained equally for high and low frequency words, and also from the fact that the subjects of our study had performed at the same level on the Peabody Picture Vocabulary Test (Dunn, 1959). It is also consistent with this observation that an interaction between reading ability and the effect of partial-masking was obtained with an analysis that covaried for the effects of age and IQ.

To determine whether the findings of this experiment were specific to speech perception, as opposed to being an attribute of general auditory perception, we conducted a second experiment. In it, the same subjects were asked to identify a set of environmental sounds taken from a standard clinical test, including such sounds as a cat meowing and a door slamming. The procedure was analogous to that in the previous experiment with spoken words; the subjects first identified the sound when partially masked by white noise, and later when presented under more optimal listening conditions. The pattern of results for this second experiment proved distinct from that obtained in the first one. Many of the poor readers were actually better than the good readers at identifying the partially-masked sounds, although this difference is not significant. An analysis of covariance that adjusted for age and IQ effects reveals that, although the noise penalized the overall level of performance, there was neither an effect of reading ability nor an interaction between reading ability and the penalizing effects of the noise masking.

Thus it would appear that any deficiency in auditory perception on the part of the poor readers is limited to the realm of speech perception. Although more research is needed to clarify the relation between this speech perception deficiency and poor readers' problems with phonetic representation,
the fact of its existence is certainly provocative and most pertinent to the view that reading skill is associated with language skill.

**LINGUISTIC SHORT-TERM MEMORY SKILL MAY PRESAGE READING SUCCESS**

Having made a link between reading skill and effective use of phonetic representation in linguistic short-term memory tasks, and having reviewed some of the evidence as to why poor readers may have difficulty with phonetic representation, I will now concentrate on some ramifications of this difficulty. According to the view introduced in the beginning sections of this paper, phonetic representation is crucially involved in all normal language processing. Since spoken language antedates written language, and insofar as phonetic representation is involved in spoken language processing, difficulty with phonetic representation should often be found as an antecedent of reading failure.

A study completed only a short time ago speaks to this point, revealing that those kindergarten-aged children who make less effective use of phonetic representation in a word-string recall task are likely to become the poorer readers of their first-grade classrooms (Mann & Liberman, in press). The subjects for that study were a population of kindergarteners whom we followed longitudinally for one year. During May of the kindergarten year we assessed their memory for spoken strings of phonetically confusable and nonconfusable words, their memory for nonlinguistic material (the Corsi block sequences), and their awareness of the syllabic structure of spoken words. The following year, as first graders, these same children again received all of the memory tests, and a standard reading test. At this time they were rated by their teachers as "good," "average," or "poor" in reading ability.

The findings for the two years of the study are given in Table 3. Note first that the children in the three reading groups had equivalent IQ scores; we found no correlation between IQ scores and our measures of reading achievement. The children in the three groups also performed equivalently on the Corsi test of nonlinguistic memory; neither their kindergarten nor their first grade scores on this test were correlated with our reading measure. In contrast, however, both of our linguistic measures proved able to distinguish between children in the three different reading groups. Elsewhere we have discussed the relation between success at learning to read and the ability to realize the syllabic structure of spoken words (see, for example, Liberman & Mann, in press; or Mann & Liberman, in press). Here I will focus on the relation between effective use of phonetic coding and reading skill. It can be seen in Table 3 that children in the three reading groups were strongly and significantly differentiated by their performance on the phonetically nonconfusable word strings. As first graders, children's performance on this type of word string was significantly correlated with their reading ability—more importantly, a significant correlation also existed between their kindergarten performance on the phonetically nonconfusable word strings, and their first-grade reading ability. Note further that both as kindergarteners and as first graders, the poorer readers tended not only to perform at the lower levels on the word string memory test, but also to be among those least affected by the manipulation of phonetic confusability. Thus, their ineffective use of phonetic representation not only associated with their difficulty in learning to read, but actually presaged it.
TABLE 3
Mean error scores of good, average and poor readers on memory tasks: A longitudinal study (IQ determined in kindergarten, reading achievement in first grade).

<table>
<thead>
<tr>
<th>READING ABILITY</th>
<th>VERBAL MEMORY</th>
<th>NONVERBAL MEMORY</th>
<th>SYLLABLE SEGMENTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max = 32</td>
<td>Max = 32</td>
<td>(Percent passed in Kdgn.)</td>
</tr>
<tr>
<td></td>
<td>Nonrhyming Word Strings</td>
<td>Rhyming Word Strings</td>
<td>Corsi Blocks</td>
</tr>
<tr>
<td>GOOD READERS</td>
<td>8.1 13.4</td>
<td>8.4</td>
<td>85%</td>
</tr>
<tr>
<td>N = 26</td>
<td>5.5 12.1</td>
<td>8.7</td>
<td></td>
</tr>
<tr>
<td>KDGN IQ 114.7</td>
<td>1st GRADE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVERAGE READERS</td>
<td>12.8 15.4</td>
<td>9.0</td>
<td>56%</td>
</tr>
<tr>
<td>N = 19</td>
<td>9.2 11.3</td>
<td>8.1</td>
<td></td>
</tr>
<tr>
<td>KDGN IQ 114.7</td>
<td>1st GRADE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POOR READERS</td>
<td>13.2 15.0</td>
<td>10.1</td>
<td>24%</td>
</tr>
<tr>
<td>N = 17</td>
<td>13.7 12.7</td>
<td>10.1</td>
<td></td>
</tr>
<tr>
<td>KDGN IQ 115.5</td>
<td>1st GRADE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The finding that effective use of phonetic representation can be a precursor of reading success is consistent with the view that reading skill derives from language skill, given the position that effective language comprehension is linked to effective phonetic representation, and the presumption that successful comprehension is essential to learning to read well. Clearly, one final demonstration is called for. If poor readers tend to make less effective use of phonetic representation than good readers, and consequently encounter difficulty retaining the words of sentences, then we may be able to demonstrate that they are less able to comprehend spoken sentences, especially if comprehension demands reliance on an effective short-term memory store.

Together with some of my colleagues (Donald Shankweiler and Suzanne Smith) I am currently analyzing the results of a study that asks whether there exists a three-way link between reading skill, effective use of phonetic representation, and spoken language comprehension. Clearly the existence of such an association would further support the view that reading skill is a product of language skill. The subjects of this most recent study are good and poor readers from a third grade population that is homogeneous with respect to age and IQ. They have been given a test of memory for strings of phonetically nonconfusable words, and several different tests of oral language comprehension, including two tests of our own design and one standardized clinical test. Thus far, we have only completed our analysis of the results of the standardized tests, a test called the Token Test (De Renzi & Vignolo, 1962).

In the Token Test, subjects receive a series of oral instructions that specify how they are to manipulate a set of small colored "tokens." It has enjoyed considerable success as a reliable indicator of disorders of oral comprehension both among patients with acquired language deficits (De Renzi & Vignolo, 1962) and children with developmental language disorders (LaPointe, 1976). We chose to use it because it forces reliance on the grammatical structure of a sentence rather than on common-sense knowledge or extralinguistic cues, and also because it poses an obvious stress on short-term memory.

The test itself consists of five basic parts that are graded in complexity. For the first four parts, all of the instructions are simple imperative sentences that contain a constant verb and either one or two noun-phrase objects. The instructions systematically increase from part to part in the number of objects involved and in the adjectival content (one or two adjectives) of the noun phrase. For the fifth part, the instructions contain as many words or more than those in the third and fourth parts, but further contain a series of different verbs and different noun phrase structures in the predicate. Thus the first four parts of the test involve a systematic increase in the number of objects and attributes that the subject must remember, whereas the fifth involves not only a substantial memory load but also an increase in syntactic complexity.
In general, the results of our study of Token Test performance have revealed that poor readers tend to do less well than good readers. In particular, we find that they do as well as good readers on the first three parts of the test, but fall behind on the last two parts. We had anticipated that the fourth and fifth parts might pose relatively more difficulty for the poor readers, simply because they contain the longest instructions. However, we recognize that difficulty on the fifth part of the test could also be a consequence of a more specific difficulty with recovering syntactic structure, aside from a short-term memory deficiency. Thus, while we have indeed established a relation between reading ability and oral comprehension of sentences, it remains to be determined whether ineffective use of phonetic representation can account for this relation in any direct way. We have some indication that for the children whom we tested, performance on the Token Test was at least moderately correlated with word-string memory performance. It also appears possible that for both the good and poor readers, the errors made on part five may have been direct consequences of the memory demands posed by certain instructions. We hope to continue to gain more insight into this issue as we analyze the results of our other two comprehension tests.

As we pursue this and other research, my colleagues and I are entertaining several possible outcomes. On the one hand, ineffective phonetic representation could not only compromise ongoing sentence processing, but also limit the development of linguistic competence. It is also within the realm of possibility that poor readers possess a comprehension deficit that is not so much a consequence as a concomitant of difficulty with phonetic representation. Perhaps reading disability, ineffective phonetic representation, and comprehension deficiencies are all manifestations of some more general language impairment that we have only begun to characterize. Surely the characterization of that impairment will be a productive research objective, since it may both illuminate our understanding of the psychology of reading, and clarify our approach to the current epidemic of reading failure.

REFERENCES


