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REVIEW

Reading Skill and Language Skill

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To learn to read is to acquire a visual language skill which 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 visual perception to general cognition. 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. This article reviews some of the many studies which have explored the association between early reading skills and spoken language skills. The focus will be on findings which reveal that when the linguistic short-term memory skills of good and poor beginning readers are critically examined, considerably many, though perhaps not all, poor readers prove to possess subtle deficiencies which 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 in 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 begin a discussion of those studies with a consideration of the short-term storage requirements of normal language processing, and a summary of some recent findings as to how these requirements are met by mature language users. These pertain to both written and spoken language and provide a necessary introduction to discussion of linguistic short-term memory skills among beginning readers.

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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). For precisely this reason, 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). Current psychological theory has it that humans most likely meet the short-term storage demands of sentence parsing through the use of phonetic representation—that is, by relying on an abstract representation of the articulatory gestures which constitute the phrase or utterance being parsed (Liberman, Mattingly, & Turvey, 1972). Experimental evidence which corroborates this view ranges from findings that phonetic representation mediates such ecologically invalid tasks as recall of strings of letters or words (Conrad, 1964; Drenowski, 1980) to findings that directly link phonetic representation to 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 for printed words access to the mental lexicon may not necessarily require reliance on phonetic representation (cf. Baron, 1978; 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 nonphonetic, 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).

Thus for adult subjects, phonetic representation is clearly involved in both written and oral language comprehension. Having made this point, let me now proceed to a review of some of the studies of good and poor beginning readers which my colleagues and I have conducted. These studies 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.

An appropriate way of beginning such a review is to provide some basic information about the beginning readers who have been the subject of our experiments. The readers have been first, second, and third graders who are native speakers of English with intelligence quotients between 90 and 145 and have attended public schools. They are identified by their teachers as being "good," "average," or "poor" readers, and we have confirmed these rankings 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 Subtest of the Wide Range Achievement Test, Jastak, Bijou, & Jastak, 1979), which typically reveal the "good" readers to be reading at a level of 1 or more years above their grade placement, the "average" readers at a level between 1 year above and one-half year below placement, and the "poor" readers at a level one-half year or more below grade placement.

One of the more general findings to emerge from our work is that children who differ in reading ability may differ in memory for some types of material, but not for other types (Katz, Shankweiler, & Liberman, in press; Liberman, Mann, Shankweiler and Werfelman, in press; Mann & Liberman, in press). As a case in point, consider the results of a study which assessed recognition memory skill among good and poor beginning readers in a second grade classroom (Liberman, Mann, Shankweiler, & Werfelman, in press). That study employed the recurring recognition memory paradigm of Kimura (1963) as a means of evaluating children's memory for several different types of material. The types of material included two nonlinguistic materials—photographs of unfamiliar faces and nonsense "doodle" drawings—and one linguistic material—printed nonsense syllables. The procedure involved having each child inspect a set of stimuli and subsequently indicate whenever any of the inspection items recurred in a recognition set. As may be seen in Fig. 1, there was an interaction between reading ability and the type of item being recognized (which was obtained in an analysis of covariance that adjusted for any effects of age or IQ differences). 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.

Clearly, this experiment cannot support a conclusion that poor readers suffer from some general memory impairment. Rather, they appear deficient only in the ability to remember linguistic material. Other findings

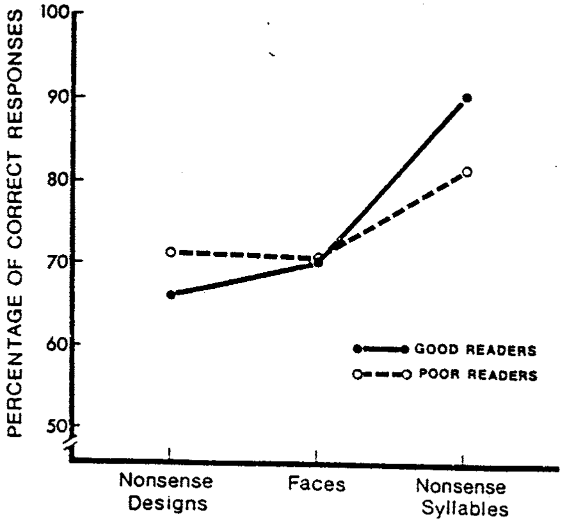

FIG. 1. Good and poor readers' mean percentage of correct responses on nonsense designs, faces, and nonsense syllables.

which support this conclusion include the fact that 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. Moreover, good readers also excel at recall of spoken strings of letters (Shankweiler et al., 1979) and words (Bauer, 1977; Byrne & Shea, 1979; Katz & Deutsch, 1964; Mann, Liberman, & Shankweiler, 1980; Mann and Liberman, in press) and even of spoken sentences (Mann et al., 1980; Perfetti & Goldman, 1976; Wiig & Roach, 1975; Weinstein & Rabinovitch, 1971). At this point it is important to note that, since the advantage of good readers holds for both written and spoken materials, 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 specific difficulty with use of phonetic representation. This was tested by using a modification of Conrad's (1964) procedure for examining the involvement of phonetic representation in memory for written letter strings. The subjects included good, average, and poor readers from a second-grade population that was homogeneous with respect to age and IQ. The task required them to recall strings of five consonants which either had phonetically confusable names (i.e., rhyming names, as in the letter strings "BVTCP") or phonetically nonconfusable ones (i.e., nonrhyming names, as in the string "XWQRH"), and there were three different conditions of letter string presentation: visual simultaneous, visual successive, and auditory.

On the basis of Conrad's findings, it was predicted that nonrhyming letter names would generate fewer phonetic confusions than rhyming ones, and, thus, facilitate recall in subjects who rely on phonetic representation of letter names when 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 he or she might have made less-effective use of phonetic representation as a mnemonic device. Good, average, and poor readers' performances on the two types of letter strings are compared in Fig. 2, where the three panels contain the results for the three different modes of presentation. The good readers, in general, made fewer errors than the poor readers, and the average readers fell in between. However, the performance of the good readers was 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

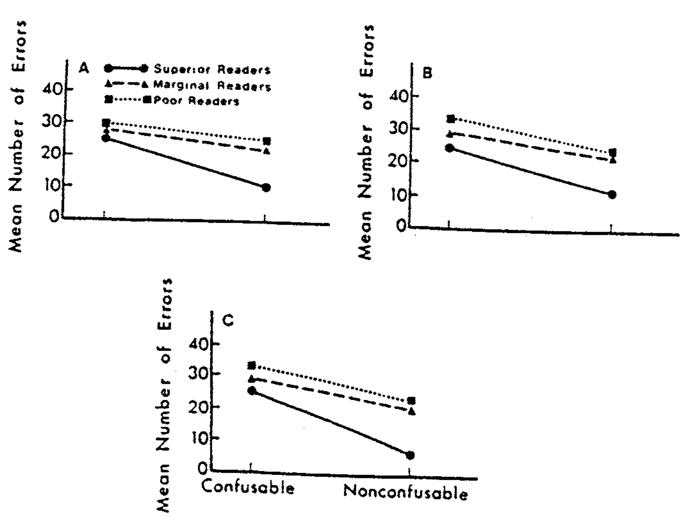

FIG. 2. Mean errors of superior and good readers on recall of letter strings, summmed over serial positions. (Means from delay and nondelay conditions are averaged, max = 40.) A, Visual simultaneous; B, visual successive; C, auditory successive.

the better readers to a greater extent than children in the other two reading groups, and this was the case for all three modes of presentation, regardless of whether letters were heard or seen.

It is important to underscore the fact that reading ability was the only variable which interacted with the effect of phonetic confusability on letter recall. Those 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 for phonetically confusable letter strings as for 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 subsequently conducted a study of the role of phonetic representation in recall of other, more ecologically valid, material (Mann et al., 1980). The subjects were again good and poor readers from a second-grade classroom, but this time the experiment examined the influence of phonetic confusability on the ability to repeat strings of five spoken words, and also on the ability to repeat sentences which were either meaningful or semantically anomalous. Thus the materials included phonetically confusable word strings (i.e., "sing ring sting king wing") and phonetically confusable sentences which were either meaningful or semantically anomalous (i.e., "Kate ate a steak and a plate of date cake that Jake baked" and "Lou threw a glue and a shoe of blue stew that Sue grew"). These were matched to phonetically nonconfusable word strings and sentences (i.e., "slip time thought pill top," "Sam drank a coke and a glass of fruit punch that Joan made," and "Joe brushed a watch and a piece of blue shirts that Anne tied"). The results obtained with word strings and sentences appear in Figs. 3 and 4, respectively, where it may be seen that, for word strings, as well as for both meaningful and semantically anomalous sentences, good readers made less errors than poor readers—but only as long as the material was phonetically nonconfusable. 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 possess 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 which adjusted for any differences in IQ.

To summarized, then, whether verbal 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, a high density of rhyme in the material to be recalled makes reliance on phonetic rep-

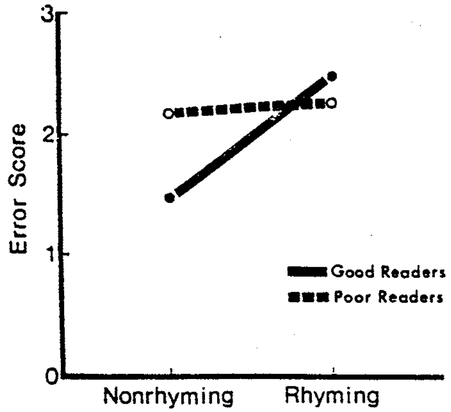

FIG. 3. Mean error scores of good and poor readers on recall of word strings, in nonrhyming and rhyming conditions (max = 5).

resentation a liability rather than an asset. In contrast, the density of rhyme has little effect on the memory performance of most poor readers, a fact which we interpret as evidence that they, for some reason, encounter 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 which involve reliance on

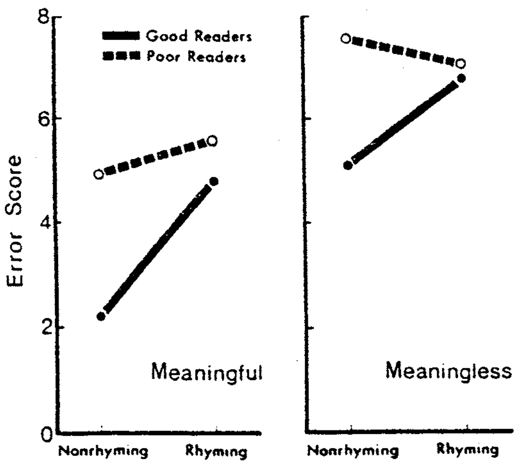

FIG. 4. Mean error scores of good and poor readers on recall of meaningful and meaningless sentences in nonrhyming and rhyming conditions (max = 13).

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, nonverbal, tests of temporary memory as well as verbal ones. A general cognitive deficiency would also seem an unlikely basis, given our findings that IQ scores are not 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 semantic or some other modes of representation. On the other hand, they may attempt to employ phonetic representation, but for some reason their representations are less effective.

Some direct evidence 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 difficult string of spoken words. Some of my colleagues and I have analyzed the errors made by good and poor readers from a third-grade classroom who were asked to repeat strings of five words which were phonetically nonconfusable. As in the past, the good readers tended to excell with respect to the poor readers. Moreover, although children in both reading groups made many substitution errors, the poor readers tended to make more of these errors than the good readers. Yet the pattern of substitution errors was the same for good and poor readers alike. Almost no substitutions were semantic associates of the correct responses. Instead, the majority of them were composed of a subset of the phonemes which had constituted the words of the string being remembered. A considerable proportion of the errors contained an appropriate initial consonant and even more contained an appropriate vowel or final consonant. It therefore seemed as if the children in both reading groups had remembered many of the phonemes which they had heard. The poor readers 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. The poor readers might also have suffered from a less-effective guessing strategy or from less-effective use of partial information (Wolford & Fowler, 1984).

Thus, in at least some circumstances, it seems that poor readers rely on phonetic representation to some extent. otherwise they would not have tended to make substitution errors which preserve phonetic aspects of the original word string. Before leaving this topic, it is 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 recall errors among either good or poor readers, this has not been the case in another study of recognition errors (Bryne &

Shea, 1979). That study 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. Children in the two groups, however, tended to make different types of errors. Whereas poor readers made proportionately more false recognition errors on semantic associates of the correct items (i.e., confusing "house" with "home"), good readers tended to make more of their errors on phonetic associates (i.e., confusing "comb" with "home"). When the materials were nonsense syllables instead of words, children in both reading groups made many errors on phonetic foils. Once again, however, good readers appeared to make more effective use of phonetic representation, as evidenced by their tendency to make fewer errors, 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, a possible answer is offered by the finding that, when speech perception is stressed by the presence of background noise, short-term memory span is inordinately penalized (Rabbit, 1968). This led some of us to consider the possibility that the short-term memory difficulties of poor readers might be associated with some subtle 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 (Brady et al., in press). The subjects were third graders, who did not differ in age or IQ, but did differ in reading ability and in memory for strings of spoken words, and showed the usual interactions between reading ability and the effect of phonetic confusability. Their task was to identify a series of prerecorded spoken words which comprised an equal number of high- and low-frequency words balanced for phonetic constituents and syllabic structures. They performed this task under two different conditions, first hearing the words partially masked by signal-correlated white noise and later hearing them under more optimal listening conditions.

The results revealed that although the poor readers were not significantly different from good readers in performance under optimal listening conditions, they made about 35% more errors when the words were partially masked by noise. This problem could not be attributed to some basic vocabulary deficiency, by virtue of the fact that differences between children in the two reading groups were obtained equally for high- and low-frequency words, and the fact that an interaction between reading ability and the effect of parital-masking was obtained with an analysis which covaried for the effects of age and vocabulary differences.

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 which were taken from a standard clinical test that included such sounds as a cat meowing and a door slamming. The procedure was analagous to that in the previous experiment with spoken words; the subjects first identified the sounds when partially masked by white noise and also later when presented under more optimal listening condition. The pattern of results obtained with the environmental sounds proved different from that obtained with spoken words. Most notably, 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 which 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.

Thus it would appear that any perceptual deficiency 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 drawn 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, let me 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 which addresses this prediction has, indeed, revealed 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 preliterate kindergarteners whom we studied over a 2-year period. During spring of kindergarten, we assessed their short-term memory for spoken strings of phonetically confusable and nonconfusable words, their short-term memory for nonlinguistic material (the Corsi block sequences; Corsi, 1972), their awareness of the syllabic structure of spoken words, as well as their IQ (Dunn, 1959). 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 2 years of the study are summarized in Table 1. Note first that the children in the three reading groups were of 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 block-tapping 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 relationship between success at learning to read and the ability to realize the syllabic structure of spoken words, which is another language skill known to associate with early reading success (see, for example, Liberman & Mann, 1981; Mann & Liberman, in press). Here let me continue to focus

TABLE 1
MEAN ERROR SCORES OF GOOD, AVERAGE AND POOR READERS ON MEMORY TASKS: A LONGITUDINAL STUDY[a]

Reading ability/ grade level	Verbal memory (max = 32): Nonrhyming word strings	Verbal memory (max = 32): Rhyming word strings	Nonverbal memory (max = 32) Corsi Blocks	Syllable segmentation task (Percentage passed in kindergarten)
Good				
Kindergarten (*N* = 26)	8.1	13.4	8.4	85
First grade (IQ 114.7)	5.5	12.1	8.7	
Average				
Kindergarten (*N* = 19)	12.8	15.4	9.0	56
First grade (IQ 114.7)	9.2	11.3	8.1	
Poor				
Kindergarten (*N* = 17)	13.2	15.0	10.1	24
First grade (IQ 115.5)	13.7	12.7	10.1	

[a] IQ determined in kindergarten: reading achievement in first grade.

on the relationship between effective use of phonetic coding and reading skill. It can be seen in Table 1 that children in the three reading groups were strongly and significantly differentiated by their performance on the phonetically nonconfusable word strings. As first graders, the children's performance on this type of word strings 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 effected 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.

READING SKILL, LINGUISTIC SHORT-TERM MEMORY, AND SPOKEN SENTENCE COMPREHENSION

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 assumption 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 should 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.

Such a demonstration can be found in some experiments which I conducted with Donald Shankweiler and Suzanne Smith (Mann, Shankweiler, & Smith, in press). The subjects were good and were poor readers from a third-grade population which was homogeneous with respect to age and IQ. They received tests of their ability to recall word strings and sentences, and also received several different tests of their ability to comprehend spoken sentences. Two such tests successfully distinguish children in the two groups: the Token Test (deRenzi & Vignolo, 1962, 1978) and a test of relative-clause comprehension. Each of these tests required that subjects act out the meaning of spoken sentences, and each test proved significantly easier for good readers than for poor readers. Examples of the types of sentences which poor readers found difficult include "Touch the small red square and the large blue circle" (from the Token Test) and "The gorilla stood on the turtle that kissed the dog" (from the relative-clause test).

Thus we are led to explore the relationship 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, certain performance differences may have been the direct product of poor readers' difficulty with holding linguistic material in short-term memory. However, we suspect that a syntactic immaturity on the part of poor readers may also be responsible, since some of the errors that they made on sentences which contained relative clauses were like those made by younger children and were not necessarily the direct product of a decreased memory span. As we attempt to interpret this latter finding, my colleagues and I are entertaining several possible hypotheses. On the one hand, ineffective phonetic representation might limit the development of syntactic knowledge, as well as compromise ongoing sentence processing. It is also within the realm of possibility that poor readers possess a comprehension deficit which is not so much a consequence as a concomitant of their difficulty with phonetic representation. Perhaps reading disability, ineffective phonetic representation, and comprehension deficiencies are all manifestations of some more general language impairment which we have only begun to characterize.

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