Phonological Awareness and Verbal Short-Term Memory

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Many studies have established an association between early reading problems and deficiencies in certain spoken language skills, such as the ability to become aware of the syllabic structure of spoken words, and the ability to retain a string of words in verbal short–term memory. A longitudinal study now shows that inferior performance in kindergarten tests of these same skills may presage future reading problems in the first grade. Based on these findings, procedures are suggested for kindergarten screening and for some ways of aiding children who, by virtue of inferior performance on these tests, might be considered at risk for reading failure.

The deficiencies of poor beginning readers in certain language skills have now been amply documented. As compared to successful beginning readers, for example, these children tend to be less aware of the phonological structure of spoken words (Fox & Routh, 1975; Golinkoff, 1978; Liberman, Shankweiler, Fischer, & Carter, 1974; Rosner & Simon, 1971). They may also fall behind good readers in their short–term memory for such linguistic material as a string of letters (Liberman, Shankweiler, Liberman, Fowler, & Fischer, 1979), a string of words (Mann, Liberman & Shankweiler, 1980), or even the words of a sentence (Mann et al., 1980; Wiig & Semel, 1976).

In previous work, our concern has been the association between deficiencies in these skills and reading disability in the elementary grades. Now we turn to the question of whether a deficiency in either skill not only characterizes disabled readers in the primary grades but may indeed be found to be an early sign of reading problems. More specifically, we ask whether reading problems in the first grade may be signalled by deficient language skills in kindergarten. We ask this question out of a consideration of the role that each skill might play in the process of reading acquisition. First, it seems likely to us that an awareness of the phonological structure of speech is necessary if one is to "crack the code" of an alphabetic system. As we have noted previously (Liberman, 1971, 1973; Liberman, Liberman, Mattingly, & Shankweiler, 1980; Liberman & Mann, 1981), the alphabet does represent the phonological structure of words more or less accurately, and a child who is unaware of that structure must be at a serious disadvantage in reading new words. Second, it seems obvious to us that the comprehension of a sentence, whether written or spoken, requires the short–term retention of many of the component words of that sentence. Therefore, we would expect that the processing of either spoken or written language would demand an ability to store verbal material efficiently in short–term memory (Liberman, Mattingly, & Turvey, 1972).

Considerable indirect evidence from widely diverse subject populations shows that a strong positive relation exists between children's awareness of the phonemic and syllabic structure of speech and their success in learning to read (Fox & Routh, 1975; Golinkoff, 1978; Liberman et al., 1974; Rosner & Simon, 1971). There is even some evidence that a deficiency in phonological awareness in a kindergartener may presage problems in beginning reading (Goldstein, 1976; Liberman et al., 1974). Less is understood, however, about the relation between early reading proficiency and short–term memory for verbal material. Moreover, even less is known about whether awareness of phonological structure and verbal short–term memory skill are correlated. On the one hand, it seems entirely possible that deficiencies in these two abilities may be relatively independent. It is also possible, however, that an adequate means of storing an utterance in short–term memory is necessary if one is to manipulate the syllabic or phonemic structure of that utterance. It is even conceivable that conscious awareness of phonological structure may somehow facilitate the use of phonetic representation in short–term memory.

In an attempt to clarify the interrelationships among phonological awareness, verbal short–term memory, and beginning reading ability, we have conducted a two–year longitudinal study in which we tested children first as kindergarteners and subsequently as first graders. As kindergarteners, each of our subjects received a series of four different tests: a test of phonological awareness, a test of verbal short–term memory, a test of nonverbal short–term memory, and a test of IQ. As first graders, they again received the verbal and nonverbal short–term memory tests, and were, in addition, given a test of reading ability.

As our test of phonological awareness, we chose a syllable counting test (Liberman et al., 1974). In that test, children "tap out" the number of syllables in spoken words such as "bag" and "butterfly." Performance on this test has been found to be a fairly adequate predictor of reading success in the first grade, if not quite so successful as the analagous phoneme counting test (Liberman et al., 1974). We chose to test syllable segmentation rather than phoneme segmentation because syllable segmentation ability is not easily confounded by reading instruction, whereas phoneme segmentation may to some degree be reciprocally related to reading skill (Alegria, Pignot, & Morais, in press; Morais, Carey, Alegria, & Bertelson, 1979). That is, whereas phoneme segmentation ability may be helpful in the development of reading skill, increased reading skill may itself also accelerate development of phoneme awareness.

The materials used for testing children's verbal short-term memory skill were four-item word strings designed along the lines of those used in Mann et al. (1980). That study had involved a procedure in which children's performance in recalling strings of phonetically confusable (rhyming) words is compared with that for strings of phonetically nonconfusable (nonrhyming) words. Whereas the phonetically nonconfusable words allow subjects to make optimal use of the mature strategy of using phonetic representation as a means of retaining verbal material in short-term memory, the phonetically confusable words penalize the use of phonetic representation (Baddeley, 1978; Conrad, 1964). Thus the difference between performance on the two types of word strings may provide an index of the extent to which subjects rely on phonetic representation in short-term memory. Our past results reveal that good beginning readers typically surpass poor beginning readers in recall of phonetically nonconfusable word strings, but at the same time are more penalized by the manipulation of phonetic confusability. We have interpreted this finding as evidence that the inferior recall of poor readers may be due to an inability to make effective use of phonetic representation in working memory—a conclusion that we first offered to account for findings obtained in a study of letter-string recall (Liberman et al., 1977; Shankweiler et al., 1979) and subsequently extended to findings obtained in a study of sentence recall (Mann et al., 1980). Our question in the present longitudinal study is whether, among kindergarteners, a relatively poor memory for word strings, coupled with a relative tolerance for the effects of phonetic confusability, will presage reading difficulty in the first grade.

Elsewhere (Katz, Shankweiler, & Liberman, 1981; Liberman, Mann, Shankweiler, & Werfelman, in press), we have argued that the short-term memory difficulties of poor beginning readers are limited to the domain of verbal memory (perhaps as a specific consequence of a problem with the use of phonetic representation). Consistent with this view, there is evidence that though good and poor readers differ in verbal short-term memory, they are equivalent in recall of nonverbal material as "doodle" designs (Katz et al., 1981; Liberman et al., in press) and photographs of unfamiliar faces (Liberman et al., in press). The present study afforded us an opportunity to gain further evidence pertinent to this issue. To that end, we included a nonverbal short-term memory test, the Corsi block test (Corsi, 1972), in our test battery. That test, which requires subjects to recall sequentially presented visuospatial information, has been used successfully in differentiating patients with lesions of the right and left hemispheres. Whereas verbal short-term memory performance has been found to suffer a consequence of damage to the left or language-dominant hemisphere, memory performance on the Corsi blocks is impaired by damage to the right or nondominant hemisphere (Corsi, 1972; Milner, 1972).

METHOD

Subjects

The subjects in this study attended the public schools in Tolland, Connecticut. Each of them was first seen during May of kindergarten and again during May of first grade. Of the initial subject pool, which consisted of all pupils in each of four kindergarten classes, only eight children were not available for subsequent testing as first graders. The final population consisted of 62 children, 31 girls and 31 boys, whose mean age at the time of the first experimental session was 70.3 months.

Materials

As kindergarteners, the subjects received four different tests: a syllable counting test (Liberman et al., 1974), a test of memory for phonetically confusable and phonetically nonconfusable word strings (Mann et al., 1980), the Corsi block test (Corsi, 1972), and the Peabody Picture Vocabulary Test (Dunn, 1959). As first graders, they again received the word-string test and the Corsi block test and were further given the Word Recognition and Word Attack subtests of the Woodcock Reading Mastery Test (1973). Materials for the experimental tests are described below.

Syllable-Counting Test

Training and test materials for this test are described in full in Liberman et al. (1974) and are listed in Appendix A. The training materials consisted of four three-word items in which the first word has one syllable, the second has two syllables, and the third has three syllables (e.g., "but," "butter," "butterfly"). The test materials consisted of a randomized list of 42 common words, with one-, two-, and three-syllable words equally represented in random order.

Word-String Memory Test

Materials for this test consisted of 16 different word strings, each of which contained four words. Eight of the strings contained words that rhymed with each other (the phonetically confusable strings) and eight contained words that did not rhyme (the phonetically nonconfusable strings). Each of the eight phonetically confusable strings consisted of four one-syllable words drawn from the Thorndike and Lorge A and AA frequency class (Thorndike & Lorge, 1944). The four words rhymed with each other but were not semantically related. To construct the phonetically nonconfusable strings, the phonetically confusable strings were divided into two sets of four strings each, and the words within each set were then randomized so as to form four phonetically nonconfusable strings in which none of the four words rhymed. From the total corpus of phonetically confusable and phonetically nonconfusable word strings, we then composed two lists (Lists A and B) of eight word strings each. These lists are given in Appendix B. Each list contained one of the two sets of phonetically confusable strings interspersed with the complementary set of phonetically nonconfusable word strings. Thus, those words that occurred as part of a rhyming string in one list occurred as part of a nonrhyming string in the other list, and no word occurred twice within a single list.

Corsi Block Test

Materials for this test, as described in Milner (1972), consist of a set of nine 3 cm wooden cubes, mounted onto a 28 by

23 by 1 cm base. The cubes are placed in a semi-random array and the entire apparatus is painted black so as to eliminate all surface detail. Identifying numbers, which are painted on one side of the base, are visible only to the examiner.

Procedure

For the kindergarten phase of testing, two 20–minute sessions were required, whereas first-grade testing was accomplished in a single 30–minute session. All children were tested individually and received the tests in the same order. Standard procedures were followed for administering the Peabody and the Woodcock tests; procedures for the other tests are given below.

Syllable Counting Test

The procedure for this test has been described in Liberman et al. (1974). Under the guise of a "tapping game," the child was required to repeat a word spoken by the examiner and to indicate the number (from one to three) of syllables in that word by tapping a small wooden dowel on the table. During training, each of the training sets of three words was first demonstrated by the examiner in order of increasing syllables. When the child was able to repeat and correctly tap each item in the set in the order demonstrated during initial presentation, the items of the triad were then presented in scrambled order without prior demonstration. The child's tapping was corrected as needed. In the test trials that followed, each word was given without prior demonstration and corrected by the examiner as needed. Testing continued through all 42 items. Two scores were computed for each child: a pass/fail score based on whether or not a child had at any point during testing performed six consecutive items correctly, and an error score reflecting the total number of words missed.

Word–String Memory Test

The examiner began this test by telling the child that some words would be spoken, one at a time, and that the child's job was to listen carefully and try to repeat the entire word string in the order heard. A practice item consisting of the string "cat, house, foot, tree" was then given, the words being spoken at the rate of one per second. A second practice item followed, consisting of the sequence "egg, brush, leaf, dog." At this point, actual testing began. The child now listened to a loudspeaker that played a taped sequence of the examiner saying the test word strings. The delivery rate was one word per second. The tape was stopped after each word string to permit the child to respond, and all responses were immediately transcribed and also recorded for later re-analysis. During kindergarten testing, the subjects heard the two lists in different sessions; as first graders, they completed both lists in a single session, separated by a 20–minute break.

In scoring the children's responses, phonetically confusable and phonetically nonconfusable strings were treated separately. For each string, an error score was computed by counting a word as incorrectly recalled if it was omitted of if it occurred in the improper sequence relative to the first correctly–recalled word that preceded it. Only the first four responses given to each string were considered. Since there were eight strings in the phonetically confusable and phonetically nonconfusable sets, the total possible error score was 32 for each set. Whereas scores on individual strings were entered into analyses of covariance, total error scores were entered into multiple regression.

Corsi Block Test

Seated opposite the child and facing the numbered side of the base, the experimenter explained that some blocks would be tapped, one at a time. The child was instructed to watch the examiner tap the blocks and then to try to touch the same blocks in the same order. The experimenter used a randomized digit sequence as a guide to which block sequences to touch, and tapped each block at the rate of one per second. As the subject responded, the sequence was recorded in terms of the corresponding digits. Eight practice items were given first, which consisted of four two–block sequences and four three–block sequences. The test followed and consisted of eight items: four four–block sequences and four five–block sequences. Response feedback was not provided during testing. In scoring each child's responses, an error score was computed for each test sequence. A block was considered incorrectly recalled if it was omitted or recalled in the improper sequence relative to the first correct block that preceded it. Error scores were then summed for the eight test sequences, with the maximum score being 36.

RESULTS

In assessing the results of our study, the first question of interest was whether performance on any of our tests would be significantly related to reading ability in the first grade. We began answering this question by dividing the children into three reading groups according to their first–grade teachers' recommendations. There were 26 good readers, 19 average readers, and 17 poor readers. As a means of corroborating these ratings, we next computed the sum of each child's score on the Word Attack and Word Recognition subtests of the Woodcock. We found the mean sum of scores for good readers (109.1) to be significantly higher than that of average readers (65.1), $t(43) = 8.85$, $p < .005$, which was in turn significantly higher than that of the poor readers (34.5), $t(34) = 6.75$, $p < .005$. Children in the three different reading groups did not, however, differ in age or in IQ.

Having thus subdivided our subjects according to reading ability, we conducted a series of analyses of covariance which adjusted for any effects of age and IQ. We examined whether reading level was significantly related to performance on any of our three tests—the syllable counting test, the word–string memory test, and the Corsi block test.

Syllable Counting

With regard to the syllable counting test, of the 26 children classified as good readers in the first grade, 85% had reached the criterion of six consecutive items correct as kindergarteners. In contrast, only 56% of the average readers and only 17% of the poor readers had done so. An analysis of covariance performed on children's error scores confirms the significance of these differences, $F(2,56) = 7.98$, $p < .001$.

Word–String Memory

Children's mean error scores on the word–string memory test are given in Table 1, with scores obtained during the kindergarten phase of testing separated from those obtained in the first–grade phase. In general, children made more errors as kindergarteners, $F(1,58) = 30.28$, $p < .001$. On the average, they also made more errors on the phonetically confusable word strings than on the nonconfusable ones, $F(1,58) = 76.9$, $p < .001$.

Differences among the three reading groups are most important to our predictions. On the average, the number of errors was inversely related to a child's reading ability, $F(2,56) = 6.29$, $p < .004$. In addition, as we had discovered in the past, the extent of difference among children in the three reading groups was greater in the case of phonetically nonconfusable word strings than in the case of confusable ones, $F(2,58) = 14.0$, $p < .01$. This interaction reflects the fact that good readers were more penalized by the presence of phonetic confusability than were children in the other two reading groups.

It is clear from Table 1 that as first graders, good readers made significantly fewer errors than poor readers. This would be expected, of course. One is also not surprised to find, in addition, that differences in the verbal memory performance of the three reading groups were greater when the children were first–graders than when they were kindergarteners, $F(2,58) = 4.5$, $p < .02$. However, it is particularly important, in our view, to note that the differences were nonetheless present before children entered the first grade. As kindergarteners, the future good readers had made significantly fewer errors, in general, than poor readers, $t(41) = 4.52$, $p < .001$; as first–graders, these differences remained, $t(41) = 2.56$, $p < .02$. Average readers fell somewhere in between—closer to poor readers in kindergarten and closer to good readers in first grade.

As to phonetic confusability, when they were kindergarteners, both the future good and average readers had made significantly more errors on confusable strings than on nonconfusable ones [$t(25) = 5.8$, $p < .001$ for the good readers; $t(18) = 2.7$, $p < .05$ for the average ones], whereas poor readers showed the same level of performance on both string types [$t(16) = 1.42$, $p < .10$]. As first graders, the good and average readers again made more errors on phonetically confusable strings [$t(25) = 9.6$, $p < .001$ and $t(18) = 2.23$, $p < .05$], whereas poor readers actually made an equivalent number of errors on the two word–string types [$t(16) = 1.01$, $p > .10$].

Corsi Blocks

Mean scores on the Corsi block test are also displayed in Table 1. As can be seen in that table, any differences among children in the three reading groups were minimal. Analysis of covariance reveals no significant effect of reading level, or of age at testing. Although poor readers averaged slightly lower than other children, a series of t–tests revealed that the scores of poor readers are equivalent to those of children in the other two reading groups.

Regression Analysis

As a final and alternative means of analyzing the data, we computed linear regressions of reading ability (as measured by the sum of Woodcock scores) onto the scores of our various experimental tests. Two separate regressions were computed, one for results obtained during kindergarten testing, and one for those obtained during first grade testing. In the case of kindergarten testing, two scores were significantly correlated with reading ability at the .01 level—syllable counting [$r(58) = .40$], and memory for the phonetically nonconfusable word strings [$r(58) = .39$]. Performance on the phonetically confusable words was correlated with reading ability at the 0.5 level [$r(58) = .33$]. We were also interested to discover that performance on syllable counting was somewhat correlated with memory for the phonetically nonconfusable words strings, $r(58) = .26$, $p < 0.5$. (As might be expected, performance on the nonconfusable word strings was also correlated with that on the confusable ones, $r(58) = .66$, $p < .001$). Taken together, error scores on syllable counting and memory for phonetically nonconfusable word strings account for 24% of the variance in reading scores; each uniquely accounts for 9% of the variance. The analagous regression computed on the first–grade scores upheld the kindergarten results, revealing a strong correlation between reading ability and performance in memory for the phonetically nonconfusable word strings, $r(58) = .61$, $p < .001$. (Once again, performance on the nonconfusable strings also correlated with that on the confusable ones, $r(58)$, $= .52$, $p < .01$.) Performance on the phonetically nonconfusable word strings accounted for 40% of the variance in reading ability, 25% of which was unique.

Sex Differences

Although our experimental population contained an equal number of boys and girls, the two sexes were not equally distributed among our three reading groups. Of the good readers, 64% were girls, whereas only 35% of the poor readers were girls. Yet, within each reading group, the performance of boys and girls in that group was similar. Although more girls were good readers, their performance was not qualitatively different from boys who were good readers; similarly, although more boys were poor readers, their performance was not qualitatively different from girl poor readers. For a further discussion of sex differences in these data, see Liberman and Mann (1981).

DISCUSSION

Our hypotheses about the interrelationships among beginning reading ability, phonological awareness, and verbal short–term memory were initially motivated by theoretical considerations about the relation of language skill and reading. They were substantiated in experiments that examined either the association between reading ability and phonological awareness, or between reading ability and verbal short–term memory in first– or second–grade children. Now, the results of our longitudinal study show that phonological awareness and verbal short–term memory do more than correlate with early reading ability. They reveal that, among kindergarteners, the adequacy of these two language skills may presage future reading ability in the first grade.

Table 1
Mean Error Scores of Good, Average and Poor Readers on Memory Tasks: A Longitudinal Study (IQ Determined in Kindergarten, Reading Achievement in First Grade).

Reading Ability	Grade Level	Word-string Memory Max=32: Nonrhyming Word Strings	Word-string Memory Max=32: Rhyming Word Strings	Corsi Block Memory Max=32
Good Readers				
N=26	KDGN	8.1	13.4	8.4
IQ 114.7	1st Grade	5.5	12.1	8.7
Average Readers				
N=19	KDGN	12.8	15.4	9.0
IQ 114.7	1st Grade	9.2	11.3	8.1
Poor Readers				
N=17	KDGN	13.2	15.0	10.1
IQ 115.5	1st Grade	13.7	12.7	10.1

They also suggest at least a moderate correlation between phonological awareness and verbal short-term memory.

Some of our earliest work had revealed that phonological awareness is associated with reading success (Liberman, 1973; Liberman et al., 1974). Phonological awareness, as measured by a child's ability to count *phonemes* in a spoken utterance, was found to predict reading success in the first grade. That is, children who failed a phoneme counting test, analagous to the present syllable counting test, were highly likely to become the poorer readers of their classrooms. The results of the present study reveal that the ability to count *syllables* in spoken utterances can also be a predictor of reading success. Moreover, syllabic awareness has the advantage of being less easily confounded by reading instruction. This latter fact can be seen in a recent Belgian study that compared the phonological awareness of children receiving a "phonics" type of reading instruction with that of children receiving a "whole-word" type of instruction (Alegria et al., in press). The "phonics" group showed a greater awareness of phonemic structure than did the "whole-word" group (60 percent correct as opposed to a mere 16 percent correct). The two groups were not very different, however, in their awareness of syllable structure (72 percent correct as opposed to 63 percent correct). Thus, differential reading instruction at the first-grade level apparently has a marked effect on phonemic awareness but not on syllabic awareness.

So much for phonological awareness. In our previous work, as we have noted earlier, we had also found verbal short-term memory skill to be related to beginning reading ability. As compared to poor beginning readers, the good readers were more able to remember a string of letters (Liberman et al., 1977; Shankweiler et al., 1979), a string of words (Mann et al., 1980), and even the words of a sentence (Mann et al., 1980), perhaps because they make more effective use of phonetic representation in short-term memory. The present study confirms this association in the case of first-grade children, but further reveals that the advantage in verbal short-term memory skill actually preceded first-grade reading success. Among the children we tested, kindergarteners who did well in repeating the word strings were likely to become the better readers of their first-grade classrooms. In addition, the future good readers were showing evidence of relying on phonetic representation, as seen in their particular difficulty with repeating strings of phonetically confusable words. The future poor readers, on the other hand, were relatively tolerant of our manipulations of phonetic confusability, and the future average readers fell somewhere in between.

We should note that it was only the two language skills in our study that proved to relate to success in beginning reading. IQ scores in the range encountered in the normal classroom were not adequate predictors of reading success. Similarly, performance on the *nonverbal* short-term memory test also failed to differentiate poor beginning readers from the more successful readers in their classrooms. In the light of these findings, it would seem that our poor readers were not reading-disabled because of a general intellectual deficiency, nor because they suffered from some general short-term memory deficiency, as has been suggested by some (Morrison, Giordani, & Nagy, 1977). Their problems appear, instead, to be related to language processing.

Suggestions for Kindergarten Screening

A primary contribution of this study, in our view, is to suggest that kindergarten-level performance on language-based tasks—a test of phonological awareness and a test of verbal short-term memory—may presage first-grade reading ability and might therefore be used as part of a kindergarten screening battery. It is true that performance on these tests accounts for only a quarter of the total variance in our subjects' reading ability. These tests would, therefore, not be capable of predicting differences within a group of good readers, for example. Nonetheless, the tests would be very useful in predicting the extremes of reading success in the first grade. That is, a kindergartener who does well on both syllable counting and verbal short-term memory has a significant likelihood of later becoming a successful beginning reader; a child who does poorly on both has a significant likelihood of later becoming a poor reader. That information is surely worth knowing as soon as possible, and anyone interested in screening children to find those at risk for reading problems might therefore do well to consider using these two easily administered tasks as part of a screening battery. The children who fell in the lower quartile of the class on one of these tasks, and certainly those who did so on both, might then be considered at risk.

The Corsi block test might be added as well, as a control for possible problems in attention span. Whereas a child who does poorly on the Corsi block test alone is not necessarily a candidate for possible reading problems, a child who does poorly on the Corsi block test *and* on verbal short-term memory tests may have a language problem, but might also have an attentional deficit that could in itself be expected to lead to learning problems.

Although these tests may be sufficient for most screening purposes, other language-based tests might be considered as well. One that might be suggested is a test of rapid letter-naming ability. This would add a measure of speed of word retrieval to the other measures of language processing. Rapid automatized naming (RAN) of letters (Denckla & Rudel, 1976) has been found on numerous occasions to be related to reading ability. Blachman (1980) recently found that a test that included phoneme segmentation, a measure of verbal short-term memory, and RAN letter naming accounted for a large part of the variance in first-grade reading.

Implications for Prevention of Reading Problems

Having administered these tests to the kindergarteners and having thus identified those children at risk for reading problems, a teacher could then begin to direct efforts toward preventing future reading problems. As every teacher knows, it is one thing to screen for problems, but quite another to do something about them. A critical question, then, is what these tasks might tell us about the form that preventive efforts should take. They certainly suggest that the efforts should be language-based. Beyond that, what else can be said?

In earlier papers (Liberman & Shankweiler, 1979; Liberman, Shankweiler, Blachman, Camp, & Werfelman, 1980) some suggestions relating to the improvement of phonological awareness were outlined. We discussed several prereading techniques there that have been found to facilitate the awareness of the structure of spoken words that is so important for the development of proficiency in reading an alphabetic orthography. To begin with, teachers can use many indirect methods that manipulate phonological structure. For example, they can capitalize on some common forms of word play, such as teaching the children nursery rhymes, encouraging rhyming games that include nonsense words, and promoting "secret" languages such as "Pig-Latin" and "Ubby-Dubby." Later, direct awareness training can be initiated. Since the word and the syllable are more readily extracted from the speech stream than the phoneme, direct phonological training would best proceed from word awareness to syllable awareness and finally to phoneme awareness. To make the word explicit, we favor counting games such as those suggested by Engelmann (1969) in which the teacher instructs the child to repeat and then to count the words in sentences, beginning with such simple statements as "John is happy," to which complexities are added as needed. To impart an awareness of syllabic structure, the elision task described by Rosner and Simon (1971) could then be employed. Children would, for example, be asked to "say 'cowboy' without the 'cow.'" They could even be given explicit training in our own syllable-counting task. Finally, phonemic awareness could be introduced with the procedure of the Soviet psychologist Elkonin (1973).

In Elkonin's procedure, the child is presented with a line drawing of an object that he or she knows well. Below the picture is a rectangle divided into sections corresponding to the number of phonemes in the pictured word. The child is taught to say the word slowly, putting a counter in the appropriate section of the diagram as he or she pronounces the word. After playing this "game" with many different pictured words until the diagram is no longer necessary, the child is introduced to the concept of vowels and consonants. At this time, one color of counter is used for vowels and another for consonants. Finally, proceeding with a single vowel at a time, graphemes are added to the counters. The child then masters the names and sounds of the five short-vowel letters, after which consonant graphemes are gradually introduced. There are many pedagogical virtues to this procedure. First, the diagram provides a linear visuospatial structure to which the auditory-temporal sequence of the word can be related, thus reinforcing the key idea of successive segmentation of the phonemic components of words—an idea intrinsic to an alphabetic system and one best learned as soon as possible. Second, the actual number of segments is provided for the child, so that uninformed guessing of the number of components is not necessary. Finally, the picture keeps the word in front of the child during analysis so that there is minimal stress on verbal short-term memory—something that we already know will be a problem for many children.

That brings us to the question of how to improve verbal short-term memory skill—or whether it can be improved. It could well be that the problems some children have with verbal short-term memory are the consequences of a maturational lag (Satz, Taylor, Friel, & Fletcher, 1978). If so, then we might expect to see some gradual improvement as the children progress through school. It has been reported (Holmes & McKeever, 1979; McKeever & Van Deventer, 1975), however, that a verbal memory deficit characterizes adolescent poor readers, just as it characterized the poor beginning readers we have tested. Perhaps future longitudinal studies will shed more light on this issue.

For the moment we do not know whether or not poor readers will outgrow their language problems. In fact, it is at least possible that their deficits are of a more permanent nature. In that case, the deficiencies we observe among some poor beginning readers could be symptoms of a "subclinical" aphasia that is due to a subtle deficit in the left or language-dominant hemisphere. There are, after all, some interesting parallels between poor beginning readers and adults who have suffered damage to their language-dominant hemisphere. Verbal short-term memory, for example, is often deficient among adult aphasics, whereas Corsi block performance is not (Corsi, 1972; Milner, 1972). Further clarification of the similarities and dissimilarities between early reading disability and acquired aphasia is a project that concerns us at present.

As for remediation of verbal short-term memory problems, we do not have as clear an idea of how to answer this question as we did for phonological awareness. If the problem is not simply ameliorated with time, then we can only suggest practice, practice, and more practice. Having children repeat spoken sentences may be a good idea—and that is something that the Engelmann procedure will require anyway. Learning to repeat nursery rhymes and other poetry may help, and certainly will not hurt. Increased emphasis on language arts in general, and on grammatical skills in particular, may well serve to enhance verbal memory by providing an emphasis on the structural aspects of language. In our view, it is not beyond the realm of possibility that the present epidemic of illiteracy reflects to some degree the decreased emphasis on memorization, recitation, sentence parsing, and rhetoric. Here again, further research may provide some answers.

APPENDIX A

Materials for Syllable Counting Test

Training trials

1. but, butter, butterfly
2. tell, telling, telephone
3. doll, dolly, lollipop
4. top, water, elephant

Test List

1. popsicle	15. children	29. father
2. dinner	16. letter	30. holiday
3. penny	17. jump	31. yellow
4. house	18. morning	32. cake
5. valentine	19. dog	33. fix
6. open	20. monkey	34. break
7. box	21. anything	35. overshoe
8. cook	22. wind	36. pocketbook
9. birthday	23. nobody	37. shoe
10. president	24. wagon	38. pencil
11. bicycle	25. cucumber	39. superman
12. typewriter	26. apple	40. rude
13. green	27. funny	41. grass
14. gasoline	28. boat	42. fingernail

APPENDIX B

Materials for Word-string Memory Test

List A

1. (nonrhyming)	bee	hair	gate	head
2. (nonrhyming)	chair	plate	knee	bed
3. (rhyming)	nail	tail	sail	mail
4. (rhyming)	fly	tie	pie	sky
5. (nonrhyming)	red	tree	bear	state
6. (rhyming)	meat	heat	feet	street
7. (nonrhyming)	thread	pear	weight	key
8. (rhyming)	brain	train	chain	rain

List B

1. (rhyming)	pear	bear	chair	hair
2. (nonrhyming)	tied	rain	heat	tail
3. (rhyming)	state	plate	gate	weight
4. (nonrhyming)	train	sky	feet	sail
5. (rhyming)	bee	tree	knee	key
6. (nonrhyming)	meat	nail	fly	brain
7. (rhyming)	bed	head	thread	red
8. (nonrhyming)	mail	chain	pie	street

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