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The association between comprehension of spoken sentences and early reading ability: the role of phonetic representation*

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ABSTRACT

When repeating spoken sentences, children who are good readers tend to be more accurate than poor readers because they are able to make more effective use of phonetic representation in the service of working memory (Mann, Liberman & Shankweiler 1980). This study of good and poor readers in the third grade has assessed both the repetition and comprehension of relative-clause sentences to explore more fully the association between early reading ability, spoken sentence processing and use of phonetic representation. It was found that the poor readers did less well than the good readers on sentence comprehension as well as on sentence repetition, and that their comprehension errors reflected a greater reliance on two sentence-processing strategies favoured by young children: the minimum-distance principle and conjoined-clause analysis. In general, the pattern of results is consonant with a view that difficulties with phonetic representation could underlie the inferior sentence comprehension of poor beginning readers. The finding that these children place greater reliance on immature processing strategies raises the further possibility that the tempo of their syntactic development may be slower than that of good readers.

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INTRODUCTION

There is evidence that reading disability among children in the early elementary grades reflects some rather specific problems in the area of language. The evidence can be found in a number of studies that have compared the performance of good and poor beginning readers on parallel language and nonlanguage tasks. Poor beginning readers are typically inferior to good beginning readers in the ability to identify spoken words that are partially masked by noise, although they are equivalent to good readers when the masked items are nonspeech environmental sounds (Brady, Shankweiler & Mann 1983). Likewise, they are inferior to good readers in performance on a memory task that involves recognizing printed nonsense syllables, but not when the task involves recognizing photographs of unfamiliar faces (Liberman, Mann, Shankweiler & Werfelman 1982). They are inferior to good readers in ordered recall of word strings, but not in ordered recall of nonverbal sequences in a block-tapping task (Mann & Liberman, in press). Finally, poor readers are inferior in ordered recall of nameable pictures, but not in ordered recall of visual patterns that do not readily lend themselves to verbal labelling (Katz, Shankweiler & Liberman 1981). It is thus apparent that in young children with reading disability we do not ordinarily find general impairment in learning and memory or an overall retardation in language. Instead, we find deficits in specific language functions.

Our attention has focused on a deficiency that we believe is basic to reading and other language skills, namely, the use of phonetic representation in working memory. Poor readers' problems with verbal short-term memory are evident in their performances on a variety of tasks that require retention of ordered strings of visually presented or spoken words and other stimuli that lend themselves to verbal labelling (Liberman, Shankweiler, Liberman, Fowler & Fischer 1977, Shankweiler, Liberman, Mark, Fowler & Fischer 1979). Insight into the underlying basis of deficient memory performance is gained from the special case in which the stimulus items rhyme. Under this condition, the good readers' advantage is greatly reduced or even eliminated, presumably because of inter-item interference. The poor readers, in contrast, do not show much interference as a result of rhyme. This result, originally demonstrated for randomly ordered material, also obtains for spoken sentences (Mann *et al.* 1980). It is apparent that in children who are good readers, but not in those who are poor readers, memory performance depends critically on the phonological properties of the stimulus material. The discrepancy between the two groups in response to rhyming and nonrhyming items, together with the poor readers' inferior performance on the latter, suggests that poor readers are somehow impaired in their ability to retain the full phonetic representation in working memory.

In addition to the studies of working memory, additional research conducted in our laboratory indicates that poor readers also perform less adequately than good readers on other tasks (for example, certain speech perception tasks, Brady *et al.* (1983), and tests of object naming, Katz (1982) that involve accessing a phonetic representation. These further findings support the view that the basic deficit involves primarily the phonological component of language.

The research we report here is concerned with ramifications of this problem for processing sentences. It was motivated by the suggestion of some of our colleagues (Liberman, Mattingly & Turvey 1972) that, owing to its role as a vehicle for working memory, phonetic representation has a crucial role in sentence processing. Previous research has shown that poor readers fail to repeat spoken sentences as accurately as good readers (Perfetti & Goldman 1976, Weinstein & Rabinovitch 1971, Wiig & Roach, 1975). Our research (Mann *et al.* 1980) confirms these findings and further reveals a difference between good and poor readers that is dependent on the make-up of the test sentences. In particular, we have found that while manipulations of syntactic structure and meaningfulness of sentences affected the performance of both good and poor readers equally, manipulations of phonetic confusability affected good readers more strongly than poor readers (Mann *et al.* 1980). The poor readers' performance was unaffected by the presence of a high density of phonetically confusable words in the test sentence being repeated – a condition that so extensively penalizes good readers as to make their repetition performance equivalent to that of poor readers. We have argued that the observed tendency of poor readers towards inaccurate repetition of normal sentences is an expression of the same underlying deficit that makes them relatively tolerant of a high density of rhyme in sentences and word strings. In other words, their difficulties with repeating a sentence reflect their failure to make effective use of the phonetic structure of that sentence as a means of retaining a verbatim representation of it in working memory. Out of this failure comes a difficulty with retention not only of the words themselves, but also of their order of occurrence.

The issue we raise in the present study is whether difficulties with phonetic representation penalize the comprehension of a sentence as well as its repetition. Certainly in the case of a language such as English, in which the sequential order of words tends to convey syntactic structure, an ineffective use of phonetic representation could, in principle, lead to difficulty in sentence comprehension. The literature does, in fact, contain evidence that poor readers do not comprehend certain classes of spoken sentences as well as good readers (Byrne 1981*a*, Satz, Taylor, Friel & Fletcher 1978). Our concern is with the extent to which the comprehension difficulties of these children can be understood as a product of an ineffective phonetic representation, and the extent to which the difficulties reflect problems with syntactic structure as such. Certainly, poor readers may fail to comprehend certain sentences because they fail to remember the component words sufficiently and for that reason fail to recover syntactic structure. But in addition their comprehension might also be limited by a deficient ability to apprehend the structure (Byrne 1981 *a*, *b*).

In the present study we have sought to confirm that differences in comprehension of spoken sentences can indeed distinguish good and poor begining readers. We have also attempted to discover the extent to which such differences, provided they are reliable, turn primarily on effectiveness of phonetic representation, and the extent to which they reflect differences in syntactic competence as such. Our approach has been to study the repetition and comprehension of several types of sentences among a population of good and poor third-grade readers. A preliminary study (in preparation) assessed the performance of these children on an oral sentence comprehension test, the Token Test of De Renzi & Vignolo (1962), which has proved to be a sensitive diagnostic of even minor disturbances of sentence compehension associated with aphasia in adults (see, for example, De Renzi & Faglioni 1978, De Renzi & Vignolo 1962, Orgass & Poeck 1966, Poeck, Orgass, Kerschensteiner & Hartje 1974). We found that the good readers surpassed the poor readers on comprehension of those later Token Test items that could be expected to tax working memory. Thus it was established that poor readers do indeed exhibit a greater degree of difficulty in comprehension of certain spoken sentences than good readers. However, we found nothing to suggest that the poor readers' errors on the Token Test involved a syntactic deficit as such. In general, those sentences that proved difficult for the poor readers also proved difficult for the good readers.

A second study (Shankweiler, Smith & Mann, in press), using the same group of children, focused on the reception and comprehension of sentences containing reflexive pronouns, such as those in (1 *a*) and (1 *b*). These, like the Token Test items, have proven difficult for aphasic adults to comprehend (Blumstein, Goodglass, Statlender & Biber 1983):

(1 *a*) The clown watched the boy spill paint on himself.

(1 *b*) The clown watching the boy spilled paint on himself.

In such sentences, syntactic structure rigidly determines the antecedent of the reflexive pronoun, and by probing the subjects' comprehension of that antecedent, one can assess their ability to recover syntactic structure. Whereas our good readers surpassed the poor readers in repeating sentences like (1 *a*) and (1 *b*), they did not surpass them on a picture-verification test of comprehension that required them to choose a drawing whose meaning best matched that of a spoken sentence. Children in both groups made few errors in identifying the antecedents of pronouns in single-clause sentences. They also made fewer errors on sentences like (1 *a*) than on sentences like (1 *b*), in which the anaphoric referent could not be correctly assigned by adopting a minimum-distance strategy. However, the number and pattern of errors were similar for good and poor readers, suggesting that they had equal mastery – or lack of mastery – of at least this aspect of syntactic structure.

Thus far, then, our findings give no reason to postulate a specific syntactic competence problem on the part of poor readers. Yet we must be cautious about reaching a more general conclusion with regard to syntactic competence, because in our earlier research we employed only a very limited set of syntactic constructions. Therefore, as a follow-up to our previous study, we studied the repetition and comprehension of a new set of spoken sentences. In choosing materials for this study, we were guided in part by research on language acquisition. Embedded constructions having a basic Subject–Verb–Object (SVO) construction and either a subject-relative or object-relative embedded clause are of special interest to students of syntactic development. Examples of such sentences appear in (2*a*)–(2*d*), where the first code letter refers to the role of the relativized noun in the matrix clause, and the second letter refers to the role of the head noun within the relative clause itself:

(2*a*) (SS) The dog that chased the sheep stood on the turtle.
(2*b*) (SO) The dog that the sheep chased stood on the turtle.
(2*c*) (OS) The dog stood on the turtle that chased the sheep.
(2*d*) (OO) The dog stood on the turtle that the sheep chased.

Each of these four sentences contains the same ten words; thus any differences in their meanings must be marked by word order and such phonological features as pitch contour, the juncture pause between words, and the stress on individual words. Because sensitivity to word order and phonological features might be expected to place a certain demand on the use of phonetic representation as a means of temporarily holding an utterance in working memory, we speculated that comprehension of sentences like those in (2*a*)–(2*d*) might distinguish good and poor readers.

We were additionally interested in such sentences, moreover, because of the wealth of evidence about the errors young children tend to make, and because of current views about the emerging syntactic competence that those errors may reflect. Let us briefly consider some of that evidence. Many investigators have found that young children in the 3- to 8-year-old range tend to make more comprehension errors on SO constructions than on types SS, OS or OO (deVilliers, Tager-Flusberg, Hakuta & Cohen 1979, Sheldon 1974, Tavakolian 1981). A few investigators have also claimed that performance on OS constructions is poorer than on SS ones (Brown 1971, Sheldon 1974, Tavakolian 1981). Smith (1974) attributes the relative difficulty of SO to the fact that it violates two common properties of English sentence configuration, notably the 'SVO configuration' (Bever 1970) that holds that the sequence 'N–V–N' is typically 'subject-verb-object', and the 'minimum-distance principle' (Chomsky 1969, Rosenbaum 1967) that holds that the missing subject of a given verb is the noun most proximal to it. In contrast to SO, the SS construction violates only the minimum-distance principle, OO violates only the SVO configuration, and OS violates neither.

One might note, however, that superior performance on SS as compared to OS cannot be explained in terms of the number of violations of expected sentence configuration, since SS violates one expectation, whereas OS violates none. A solution to this difficulty was proposed by Tavakolian (1981), who suggested that children tend to treat the two clauses of sentences such as (2*a*)–(2*d*) as being conjoined clauses rather than as a relative clause embedded within a matrix clause (Tavakolian 1981). Such a 'conjoined-clause analysis' predicts that both sentences (2*a*) and (2*c*) will be interpreted as meaning 'The dog stood on the turtle *and* chased the sheep' – a strategy that leaves the meaning of (2*a*) intact, but alters the meaning of (2*c*) so that it becomes equivalent to (2*a*). When young children act out the meaning of sentences with relative clauses like those in (2*a*)–(2*d*), their responses meet with this and other predictions of a conjoined-clause analysis (Tavakolian 1981).

These accounts of children's erroneous responses to relative-clause sentences are highly germane to our interest in the sentence-processing skills of good and poor beginning readers. Certainly ineffective phonetic representation might lead to impaired sentence comprehension because neither the words nor the order of occurrence are available for correct parsing. A child may assume, therefore, that the subject of a recently heard verb is the most proximal noun because of an impoverished representation of the words and their order, and thus adhere to the minimum-distance principle. However, ineffective phonetic representation, in and of itself, would not necessarily lead a child to link a verb to a noun that occurred at some remove in the sentence, as happens in a conjoined-clause analysis. We therefore anticipated that the poor readers' inefficient phonetic processing and their consequent weakness in short-term retention might lead them to make more errors than good readers that reflect adherence to the minimum-distance principle. If, further, the poor readers were to make both more minimum-distance errors and also more conjoined-clause analysis errors than the good readers, then it might be argued from the fact that such errors are typical of younger children that the poor readers are indeed on a slower schedule of syntactic development (Byrne 1981 *a*, *b*, Satz *et al.* 1978), even though the trend of the development might be normal. If, on the other hand, poor readers make errors that are qualitatively different from those of good readers and other young children, we would have strong reason to entertain the possibility of a primary deficiency in syntactic competence as such. A finding that the pattern of poor readers' performance across the four different constructions exemplified in (2*a*)–(2*d*) is different from that of good readers likewise would also suggest that in addition to problems involving the working memory, there is further an underlying syntactic deficiency.

METHOD

Subjects

The subjects were third-grade pupils attending public schools in East Hartford, Connecticut. All were native speakers of English with no known speech or hearing impairment and had an intelligence quotient of 90 or greater (as measured by the Peabody Picture Vocabulary Test; Dunn 1965). Inclusion in the experiment was based jointly on teacher evaluations of reading ability and scores on the verbal comprehension subtest of the Iowa Test of Basic Skills (Hieronymus & Lindquist 1978), which had been administered four months previously. The 18 good readers included three boys and fifteen girls (mean Iowa grade-equivalent score 4·59; range 4·1–5·2). The 17 poor readers included nine boys and eight girls (mean grade-equivalent score 2·32; range 1·7–2·6). The mean IQ for the good readers (109·3) was not significantly greater than that of the poor readers (107·7). The poor readers (mean age 9·21 years) were slightly (but not significantly) older than the good readers (mean age 8·95 years) at the time of testing.

Materials

The test materials consisted of eight tokens of each of the nonrestrictive relative clause constructions illustrated in (2*a*)–(2*d*). These four constructions represent the orthogonal variation of two parameters: the role of the relativized noun in the main (matrix) clause – i.e. whether the clause was subject-relative (S–) or object relative (O–) – and the role of the relative agent (the head noun) within the relative clause – i.e. whether it was the subject (–S) or the object (–O). They include:

SS – a centre-embedded construction of the form 'N1 that V1 N2 V2 N3', in which the subject of the main clause is also the subject of the relative clause;

SO – a centre-embedded construction of the form 'N1 that N2 V1 V2 N3', in which the subject of the main clause is the object of the relative clause;

OS – a right-branching construction of the form 'N1 V1 N2 that V2 N3', in which the object of the main clause was the subject of the relative clause;

OO – a right-branching construction of the form 'N1 V1 N2 that N3 V2', in which the object of the main clause is also the object of the relative clause.

Eight common animal names served as nouns: *turtle, owl, alligator, horse, dog, gorilla, cat* and *sheep*. Their position and occurrence were randomized within each sentence type with the restriction that *cat* and *dog* never occur in the same sentence, since their stereotypical roles might bias children's response. Eight easily depicted action verbs were used: *hit, kick, run after, chase, jump on, kiss, stand on* and *push*. Their position and occurrence within each set of sentences was randomized with the restriction that actions that could be visually confusing to the test administrator did not occur in the same sentence (i.e. *hit* and *kick*, or *hit* and *push*). To further facilitate the scoring, none of the nouns and verbs in a sentence began with the same letter.

The test sentences were randomized and recorded on audiotape by a male native speaker of English who used natural intonation at a comfortable rate of delivery. At the time of recording, each sentence was preceded by an alerting signal (a bell). Small plastic animals were used for the toy manipulation task that provided the measure of sentence comprehension.

Procedure

Each subject was tested individually in two thirty-minute sessions during which the previously mentioned experiments were also conducted. The first session began with the experimenter placing the small plastic animals in a row on the table in front of the subject, and requesting the subject to name each one. Any incorrect or nonstandard response, such as calling the cat a *kitty*, was corrected. The experimenter then read three single-clause sentences to the subject, who was asked to enact each one. These practice items included three of the eight test verbs along with the names of any animals that had been misnamed. Successful completion of the practice items was followed by presentation of the pre-recorded test materials over a loudspeaker. Before playing each test sentence, the experimenter selected the appropriate trio of animals and placed them in a predetermined random order, two inches apart, on the table in front of the subject. The subject was instructed to listen carefully to the entire tape-recorded sentence, which would be preceded by a bell, and then to act out its meaning. Emphasis was placed on listening to the entire sentence before starting to respond. Sentences were repeated only on the subject's request, and the incidence of repetitions was noted. The subject's manipulation of the animals was transcribed in terms of which animal did what action to whom.

In the second session, which was conducted at least one week after the first, the subject was instructed to listen to the sentence and to repeat it into a microphone. Each test sentence was presented only once. Responses were transcribed by the examiner, and were also recorded on audiotape for further analysis.

RESULTS

This experiment was designed to corroborate previous findings that indicated that good and poor readers tend to differ in the use of phonetic representation both during sentence repetition and in spoken sentence comprehension. Further, we sought to determine whether good and poor readers differ in their ability to both repeat and comprehend a given set of spoken sentences, and to clarify the basis of any comprehension differences that were found. In order to accomplish this aim, error scores were obtained, and separate analyses performed on the data from the sentence repetition and sentence comprehension tests.

Sentence repetition

In scoring the data from the sentence repetition task, we considered any response that departed from the test sentence as incorrect. The number of incorrect sentences (out of a maximum of eight) was then computed for each construction (SS, SO, OS, and OO); mean values for good and poor readers appear in Table 1. We found, as expected, that good readers made fewer errors

TABLE 1. *Mean number of incorrect sentences on the sentence repetition test (maximum number of possible errors = 8)*

Sentence type	Good readers	Poor readers
SS	2·22	3·71
SO	2·67	3·94
OS	2·39	3·71
OO	1·78	3·65

than poor readers, $F(1, 33) = 4{\cdot}84$, $P < 0{\cdot}03$. There was, however, no significant effect of either orthogonal variation in sentence structure – the role of the relativized agent in the main clause (i.e. S– vs. O–), and the role of the head noun in the relative clause (i.e. –S vs. –O). Moreover, there was no interaction of reading ability with either structural variation. As can be seen in Table 1, errors scores are relatively constant across the four different types of structure, as is the extent of difference between good and poor readers. A further analysis of the pattern of children's errors within each sentence also fails to reveal any qualitative differences between good and poor readers. As can be seen in Table 2, where mean errors appear for nouns and verbs as a

TABLE 2. *Mean number of incorrect words during sentence repetition as a function of word class and word position*

Class	Position	Good readers	Poor readers
Noun	1	1·89	3·29
	2	2·67	5·06
	3	2·72	5·59
Verb	1	1·22	3·18
	2	3·11	4·24

function of their order of occurrence in the sentence, children in both groups were more likely to repeat later parts of the sentence incorrectly, $F(2, 66) = 6{\cdot}95$, $P < 0{\cdot}002$ for nouns, and $F(1, 33) = 16{\cdot}11$, $P < 0{\cdot}005$ for verbs. While good readers made fewer errors than poor readers both on nouns $F(1, 33) = 4{\cdot}26$, $P < 0{\cdot}05$, and verbs $F(1, 33) = 4{\cdot}53$, $P < 0{\cdot}05$, there was no interaction of word position and reading ability.

Sentence comprehension

Having confirmed that good readers made fewer errors in recall of the test sentences than poor readers, we now turn to the results of the toy manipulation task, which was our measure of sentence comprehension. These data consist of the experimenter's transcriptions of the responses each child made in manipulating the various toy animals. A response was scored as correct if each of the three nouns had been assigned its proper role(s) as subject or object of the appropriate verb, otherwise it was scored as incorrect. Each child's comprehension error score is the total number of incorrect sentences. These scores proved to be positively correlated with error scores on the sentence repetition test, $r(35) = 0.40$, $P < 0.02$. They are also significantly correlated with the grade-equivalent scores on the Iowa Reading Test, $r(35) = -0.43$, $P < 0.01$.

Individual errors scores on the four different sentence types (i.e. SS, SO, OS and OO) were computed and incorporated into an analysis of variance that included the factors reading level, role of relativized noun in the matrix clause, and role of the head noun in the relative clause. The results are displayed in Fig. 1, and may be summarized as follows: the role of the

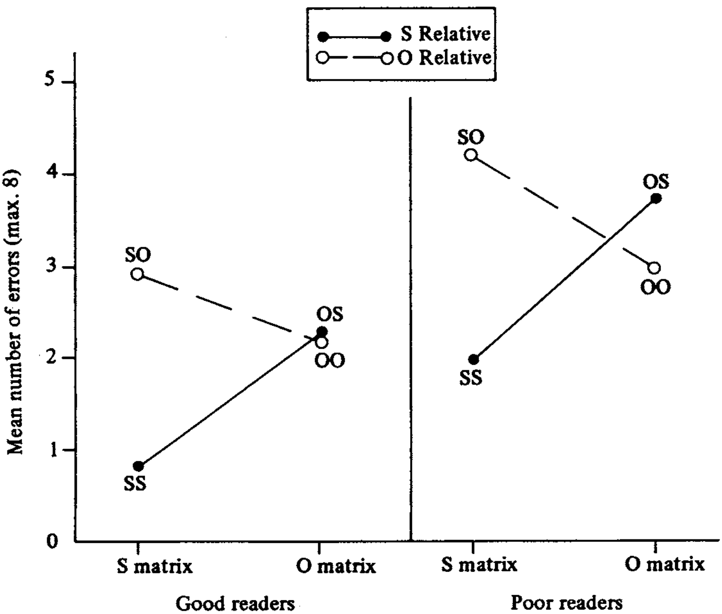

Fig. 1. The performance of good and poor readers on comprehension of relative clause sentences, plotted in terms of the number of incorrect sentences as a function of the role of the relativized noun in the matrix clause (S, matrix vs. O matrix) and the role of the head noun within the relative clause (S relative vs. O relative).

relativized noun in the matrix clause had no main effect, although the effect of the role of the head noun was significant, $F(1, 33) = 21 \cdot 8$, $P < 0 \cdot 005$, as was the interaction between these two structural factors, $F(1, 33) = 17 \cdot 58$, $P < 0 \cdot 005$. These results agree with previous findings in so far as performance on SS items was superior to that on OS and SO (Brown 1971, Sheldon 1974, Tavakolian 1981). However, contrary to what others have found (deVilliers *et al.* 1979, Sheldon 1974, Tavakolian 1981), SO was not more difficult than OO. The discrepancy between our results and previous ones could reflect age differences: other studies have employed subjects aged three to eight; ours were all aged eight and older.

Of central importance is the comparison of children in the two reading groups. The poor readers, as we had anticipated, made more incorrect responses than the good readers, $F(1, 33) = 9 \cdot 41$, $P < 0 \cdot 01$, yet the relative difficulty of the four different constructions was the same for good and poor readers. Thus there is no significant interaction between reading ability and the influence of matrix clause or relative clause structure. Responses to SS items were significantly more often correct than those to OS items, both for good readers, $t(34) = 5 \cdot 15$, $P < 0 \cdot 005$ and poor readers, $t(32) = 3 \cdot 41$, $P < 0 \cdot 005$; although both groups tended to miss SO items more often than OO and OS, the differences failed to reach significance.

These initial analyses were supplemented by a more detailed analysis of the responses in search of some measure that might distinguish between the good and poor readers. Using the procedure described by Tavakolian (1981), children's toy manipulation responses were coded with respect to the linear order of the three nouns in the sentence, so as to denote which nouns were chosen as subject and object of each verb. When coded this way, the response to each sentence is represented by two double-number sequences, the first indicating the nouns taken as subject and object, respectively, of the first verb, and the second indicating those taken as subject and object of the second verb. The correct response to an SS sentence is thus represented as 12, 13; that for SO, is 21, 13; for OS, 12, 23; and for OO, 12, 32.

Two classes of errors are of primary interest: those that reflect a conjoined-clause analysis, as discussed by Tavakolian (1981), and those that reflect application of a minimum-distance principle (Chomsky 1969, Rosenbaum 1967) in which the noun closest to a verb is chosen as its subject. As outlined in Tavakolian (1981), a conjoined-clause analysis would yield the correct response to SS sentences, but an incorrect response of 12, 13 to OS, incorrect responses of either 21, 23 or 12, 13 to SO, and an incorrect response of 12, 13 to OO sentences. An incorrect response of 12, 31 to OO sentences, as discussed by Tavakolian, is also consistent with a conjoined-clause analysis. We computed for each subject the total number of errors on SO, OS and OO that fell into these categories and thus could be taken as evidence for reliance on conjoined-clause analysis. The results, given in Table 3, reveal that for

TABLE 3. *Distribution of errors on the sentence comprehension test (mean number of errors)*

Basis of error	Good readers	Poor readers
Minimum-distance principle (maximum 8)	0·33	1·59
Conjoined-clause analysis (maximum 24)	4·50	7·32
'SOV' Configuration (maximum 16)	0·72	1·35
Other (maximum 32)	2·00	3·76

children in both groups the number of such errors was considerable. Poor readers, however, made significantly more errors of this type than good readers, $t(33) = 2{\cdot}08$, $P < 0{\cdot}05$.

Application of the minimum-distance principle, as opposed to a conjoined-clause analysis, would yield a correct response to OS constructions, but an erroneous response of 12, 23 to SS constructions. When the number of erroneous responses of this type was computed and averaged across subjects, we discovered, as shown in Table 3, that the poor readers made significantly more such errors than the good readers, $t(33) = 2{\cdot}58$, $P < 0{\cdot}02$. For neither group, however, was the raw number of errors involving the minimum-distance principle as great as the raw number reflecting a conjoined-clause analysis, $t(17) = 4{\cdot}6$, $P < 0{\cdot}001$ for good readers; $t(16) = 5{\cdot}24$, $P < 0{\cdot}001$ for poor readers. However, when raw scores are adjusted for the difference in the number of opportunities for errors of each type, only the good readers made significantly more conjoined-clause errors than errors involving the minimum-distance principle, $t(17) = 3{\cdot}8$, $P < 0{\cdot}005$.

Finally, we computed the number of errors made by each child that could not be accounted for either by the application of a minimum-distance principle or a conjoined-clause analysis. Children in both groups made an appreciable number of erroneous responses of 12, 23 on OO and SO sentences, perhaps because they tended to interpret the configuration 'NNV' that appears in such sentences as 'subject–object–verb'. The mean number of errors of this type appears in Table 3 under the heading 'SOV' configuration, and we note that any difference between good and poor readers fails to reach significance. The remaining errors failed to follow any particular pattern. The mean number of such 'other' errors is also given in Table 3. Here also, good and poor readers did not differ significantly ($P > 0{\cdot}05$).

DISCUSSION

Our review of the literature on language-related problems in poor readers led us to conclude that these children tend to perform at a disadvantage on many tasks that require temporary retention of verbal material, including repetition of spoken sentences. We have presented evidence that the working memory problems of poor readers, including their sentence repetition difficulties, are traceable to their failure to make effective use of phonetic representation. The present study explored the prediction that ineffective phonetic representation will also give rise to comprehension difficulties whenever language processing stresses working memory. The study employed an extensive set of relative clause constructions to assess the suggestion (Byrne 1981 *a*, *b*, Satz *et al.* 1978) that reading-disabled children are less proficient than children who are good readers in comprehension of certain spoken sentence constructions that are mastered comparatively late. We chose this set of constructions for two reasons. First, we wished to control for sentence length and vocabulary as we ascertained whether good and poor readers could make equal use of word order and phonological structure as cues to sentence meaning. Secondly, we were aware of regularities in young children's errors in acting out relative-clause constructions, and of interpretations in the literature regarding the emerging syntactic competence that these errors reflect. Given that we found poor readers' comprehension of relative-clause constructions to be less accurate than that of good readers, we could then attempt to clarify the precise reasons for the differences.

In an earlier study, we had tested the same groups of third-grade children on two tests of comprehension, the Token Test and a picture-verification test involving sentences with reflexive pronouns. The poor readers performed significantly worse on the more difficult items from the Token Test, which tend to stress working memory, but the test of comprehension of reflexive pronouns did not differentiate the groups, possibly because the use of pictorial cues in the latter test considerably reduces the demands on working memory. Because the Token Test results did support our expectations, it seemed worthwhile to take another approach to the assessment of sentence comprehension in these children.

The present study of relative-clause constructions assessed good and poor readers' ability to repeat test sentences, and it further compared their comprehension of the same sentence structures, noting both the quantity and nature of the errors that occurred in acting out sentence content. Our primary interest was to discover whether the comprehension difficulties of the poor readers may be regarded as a manifestation of problems with using phonetic representation to store the words of a sentence in some temporary working memory. Alternatively, the difficulties could indicate an inability to analyse certain kinds of syntactic structures.

In regard to the test of sentence repetition, the results of this study are in agreement with our previous research (Mann *et al.* 1980), in finding that good and poor readers were distinguished in the number of errors made on immediate recall but not in the types of errors. The poor readers, then, appear to have had a less effective means of retaining the words of sentences in working memory. The particulars of sentence structure turned out to have little effect on the number of errors made in repetition: whether the relative clause modified the subject or object of the matrix clause, or whether the relativized noun phrase was the subject or object of the relative clause, did not systematically influence the accuracy of children's performance. Moreover, these variations did not affect the magnitude of the difference between the performance of good and poor readers. The poor readers were simply worse in general. This accords well with the view that phonetic memory limitation is an important factor governing difficulty of sentence repetition in poor readers.

Most importantly, the present test of comprehension successfully differentiated between good and poor readers. Poor readers made more errors than good readers, not only in repeating the words of the test sentences, but also in acting out the meaning of these same sentences. In the case of comprehension, however, the type of sentence structure significantly influenced the accuracy of performance: sentences with subject-relative clauses in which the relativized noun phrase also serves as the subject (SS) proved the easiest structure both for good and poor readers, whereas the remaining three sentence types (SO, OS and OO) were equally difficult. Yet, for present purposes the important point is that the relative difficulty of the different types of test sentences was the same for good and poor readers. Thus, while the poor readers made consistently more mistakes than the good readers in their acting out of these sentences, they did so to an equal extent on all four of the constructions. Both in repetition and in comprehension, then, the good and poor readers differed in the number of errors made, but they failed to differ in susceptibility to variations in syntactic structure. This we regard as a major outcome of the experiment.

As to the question we raised concerning the basis of the comprehension differences between the good and poor readers, such an across-the-board decrement as we have observed on the part of poor readers is as one would expect, given the assumption that their phonetic representations of the words of the sentence are less effective than those of good readers. In interpreting these findings, we should stress that the good readers' and poor readers' performance was affected by the experimental variables in the same way. We can probably assume, therefore, that they employ much the same sentence-processing strategies, although the extent of their reliance on a given strategy may differ. What, then, accounts for the overall inferior performance of the poor readers? Given the moderate correlation between sentence repetition performance and sentence comprehension, and our previous demonstration of the importance of phonetic representation in poor readers' sentence repetition (Mann *et al.* 1980), we can assume that effectiveness of phonetic representation is certainly one factor behind the comprehension differences of good and poor readers. But, as we anticipated in both the introductory section of this paper and elsewhere (Liberman, Liberman, Mattingly & Shankweiler 1980, Mann & Liberman, in press), it is not necessarily the only factor. One can plausibly explain preferences for strategies based on the minimum-distance principle by reference to limitations of working memory, but limited memory capacity cannot be invoked to account for every aspect of the error pattern on the comprehension test. Indeed, the frequent adherence of children in both groups to a conjoined-clause analysis, which requires assimilation of words from well-separated portions of the sentence, does not readily lend itself to a memory interpretation.

The occurrence of both kinds of errors, those reflecting use of the minimum-distance principle, and those reflecting a conjoined-clause analysis, has been well documented among normal young children (Chomsky 1969, Smith 1974, Tavakolian 1981), and their occurrence among poor readers fits well with the hypothesis that children who encounter reading difficulties may exhibit a maturational lag in language abilities (Byrne 1981 *a*, *b*, Satz *et al.* 1978). This hypothesis receives support from a study by Byrne (1981 *a*) that we find particularly relevant, since it involved an assessment of good and poor readers' comprehension of relative clause constructions like (3 *a*) and (3 *b*):

(3 *a*) The bird that the rat is eating is blue.

(3 *b*) The bird that the worm is eating is yellow.

Byrne reports that when children are asked to decide which of two pictures correctly depicts the meaning of a sentence, poor readers perform as well as good readers on 'semantically reversible' sentences like (3 *a*), but do less well on 'implausible' sentences like (3 *b*). Thus it would seem that poor readers place a greater reliance on extra-linguistic cues than do good readers. In a discussion of this and another finding involving poor readers' difficulty with sentences such as *John is easy to please*, Byrne (1981 *a*) concludes that a deficient use of phonetic memory coding is not the factor responsible for poor readers' sentence comprehension difficulties. In his view:

> A better characterization is one that places poor readers further down on the linguistic development scale, relatively dependent upon strategies acquired in early language mastery...upon heuristic devices, including knowledge of what is usual in the world (p. 210).

We agree with Byrne that the notion of maturational lag may be an apt way of conceptualizing the problem in many cases of early reading disability, and we have adopted this viewpoint in our studies of linguistic awareness and its relation to reading (Liberman *et al.* 1980, Mann & Liberman, in press).

However, though it is true, as we noted, that working memory problems do not account for all of poor readers' errors in sentence processing, we cannot accept Byrne's conclusion that deficiencies in use of a phonetic memory code are not relevant to the sentence comprehension difficulties of poor readers. Our research leads us to believe that one of the factors underlying the dependency of poor readers (and, perhaps, of young children in general) on an immature grammar and world-knowledge heuristics is that their phonetic representation of the words of a lengthy sentence is often insufficient to support full recovery of syntactic structure. The successful language learner must somehow assess large portions of the phonetic structure of the utterance at hand, and rely on word order and certain phonological features to establish the correct syntactic structure and thus the correct meaning of the utterance. It is for this purpose, we suspect, that phonetic representation in working memory exists in the first place. Thus a deficient capacity to form phonetic representations may limit the development of syntactic competence. In the light of these considerations, we are led to speculate further that ineffective phonetic representation may serve to retard the tempo of syntactic development among children who are poor readers. Although we do not wish to exclude prematurely the possibility that poor readers may also have a specific syntactic deficiency. We find nothing in the data that would specifically indicate such a deficiency. Rather, we would note that the language tasks that best distinguish good and poor readers are most often precisely those that place special demands on phonetic representation.

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