

Memory for Item Order and Phonetic Recoding in the Beginning Reader

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A defect in immediate memory for item order is often attributed to poor beginning readers. We have supposed that this problem may be a manifestation of an underlying deficiency in the use of phonetic codes. Accordingly, we expected good and poor readers to differ in their ability to order stimuli that can be easily recoded as words and stored in phonetic form, but not in their ability to order nonlinguistic stimuli that do not lend themselves to phonetic recoding in short-term memory. The purpose of the present study was to test this hypothesis by examining the ability of good and poor readers to reconstruct the order of sets of briefly presented stimuli that varied in the extent to which they could be distinctively recoded into phonetic form: pictures of common objects versus nonrepresentational, "doodle" drawings. As expected, an interaction between reading ability and type of stimulus item was found, demonstrating the material-specific nature of poor readers' ordering difficulties. These findings support the hypothesis that a function of the phonetic representation is to aid in retention of order information, and that poor readers' ordering difficulties are related to their deficient use of phonetic codes.

Certain commonly occurring memory problems of poor beginning readers have been regarded as manifestations of an underlying deficiency in the use of phonetic codes. Several studies have shown that children who are poor readers tend to make ineffective use of phonetic coding in short-term recall of linguistic material (Lieberman, Shankweiler, Liberman, Fowler, & Fischer, 1977; Mann, Liberman, & Shankweiler, 1980; Shankweiler, Liberman, Mark, Fowler, & Fischer, 1979). However, special difficulties with recall and recognition arise only when the stimulus items are words or other items that can readily be labeled linguistically and retained phonetically in working memory (Holmes & McKeever, 1979; Vellutino, Pruzek, Steger, & Meshoulam, 1973; Vellutino, Steger, &

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Kandel, 1972). When the stimuli do not lend themselves to phonetic coding, the performances of good and poor readers cannot be distinguished. For example, we (Liberman, Mann, Shankweiler, & Werfelman, in press) tested recognition memory with two sets of stimuli that could not be easily labeled: unfamiliar faces and abstract, nonrepresentational line drawings (Kimura, 1963). It was found that good and poor readers were indistinguishable on memory for both faces and nonsense drawings.

The question we ask here is whether children's memory for the *order* of occurrence of stimulus items would also vary with their phonetic recodability. Repeatedly, the literature has suggested that poor readers have difficulty in retaining the order of items in tests of serial recall (Bakker, 1972; Benton, 1975; Corkin, 1974). There are indications, as we noted, that the poor readers' deficits in item recall may be a manifestation of their deficient ability to use phonetic codes. We should now ask whether the deficits they might have in remembering the order of stimuli would also vary with the phonetic recodability of the items. This is what we would expect in light of suggestions that one function of phonetic memory codes is to preserve item order (Baddeley, 1978; Crowder, 1978). Consequently, we would suppose that the poor reader's difficulty in retaining order information is material-specific and not a global memory deficit for item order.

To pursue this question experimentally, we needed to discover how poor readers would fare with order memory for nonlinguistic material. While it is true that some studies (Corkin, 1974; Noelker & Schumsky, 1973; Stanley, Kaplan, & Poole, 1975) have reported inferior performance by poor readers in ordering nonlinguistic stimuli, the interpretation of the findings in each case is open to some question either because the items used were such as to be readily labeled or were presented for long exposure times. In either instance, even though the stimuli presented were nonlinguistic, the effect of the procedure might be to accentuate the differences in performance between the reader groups by encouraging linguistic recoding on the part of the good readers who habitually recode phonetically. Moreover, good and poor readers have been found to be equivalent in ordering other nonlinguistic items, such as photographed faces (Holmes & McKeever, 1979). At all events, there has been no direct test of the hypothesis that the poor readers' problem with order memory may be linked to a deficiency in the use of phonetic codes. The present experiment was designed to provide direct evidence for such a link. By controlling for the ease with which linguistic labels can be given to test items, we expected to find that differences in the performances of good and poor readers would depend on the phonetic recodability of the stimulus material.

The experiment compared good and poor readers' memory for order for two sets of controlled stimuli: a set consisting of items that are easily

labeled—line drawings of common objects and a set containing items presumed to be very difficult to label—Kimura's (1963) nonsense drawings. The latter were chosen for use in this study because good and poor readers performed equally well with these stimuli in the test of recognition memory to which we referred earlier (Lieberman et al., in press).

In the present procedure, a linear array of five figures is tachistoscopically presented, after which copies of the five figures are presented on cards, one figure per card, in random order. Subjects are asked to rearrange the cards, reconstructing the order in the previous display. Since poor readers tend not to make full use of phonetic coding in working memory, we expected them to be less accurate than good readers in ordering the phonetically recodable pictures of common objects, but not to differ from the good readers in ordering the nonrecodable, doodle drawings. Thus we expected an interaction between reading ability and stimulus type, attributable to differences in the degree of reliance on phonetic recoding.

METHOD

Subjects

Subjects were selected from four second-grade classes in the Tolland, Connecticut, public school system. Candidates for the poor reader group were selected for screening if they were so designated by their teachers or if they scored at the 40th percentile or lower on both word recognition subtests of the *Comprehensive Test of Basic Skills* (CTBS) (1974), which had been administered in the seventh month of the first grade. Candidates for the good reader group either received a superior evaluation from the teachers or ranked at or above the 80th percentile on both CTBS subtests.

Subjects selected for screening were administered the *Slosson Intelligence Test* (Slosson, 1963) and the word identification and the word attack subtests of the *Woodcock Reading Mastery Tests* (Woodcock, 1973) in the fifth and sixth months of the school year. The final good reader group consisted of those subjects who attained a combined raw score of at least 115 on the two Woodcock subtests, while the poor reader group included subjects with a combined score of less than 85. Subjects with extreme IQ scores (below 90 or above 135) were ineligible for further testing. In addition, one poor reader had to be dropped due to prolonged absence and ensuing scheduling difficulties. By these criteria, 21 good readers (10 females, 11 males) and 21 poor readers (7 females, 14 males) were selected. The good readers had a mean age of 95.1 months compared to the poor readers' mean age of 97.2 months, $t(40) = 1.7$, $p = .10$. The good readers had a mean IQ of 115.3 while the poor readers had a mean IQ of 107.4, $t(40) = 2.7$, $p = .012$. The mean combined raw score on the Woodcock was 134.6 for the good

readers (range, 118 to 153) and 53.0 for the poor readers (range, 22 to 77).

Stimuli and Apparatus

Two sets of 50 drawings comprised the stimuli of this study. The first set consisted of the 50 nonsense drawings of Kimura (1963), which we designate "phonetically unrecodable" because they are difficult to label distinctively. The second set, which we call "phonetically recodable," included 50 line drawings of common objects. The latter had been shown in earlier pilot studies to be easily recognized by second graders, typically eliciting a single response which was a monosyllabic word. Each stimulus condition required 20 test trials. Each trial consisted of a tachistoscopic presentation of a different horizontal array of five stimuli mounted on 2×2 -in. slides. The stimuli for each of the 20 arrays were selected by random drawing without replacement from the set of 50 stimuli for that condition. This procedure yielded the first 10 arrays; the second 10 were generated by a second drawing from the same set of stimuli. One set of three stimuli not used in the test trials was prepared for each stimulus condition to be used as a practice trial. A sample array for each stimulus condition is displayed in Fig. 1.

The stimuli were projected onto a white screen for 4.0 sec using a carousel projector equipped with a tachistoscope attachment and a decade interval timer. The projected array was viewed from about 55 in. and extended a horizontal distance of about 15 in. (15.5° visual angle). Each stimulus item subtended a visual angle of 1.5 to 2.3° horizontally and 1.0 to 2.3° vertically. A permanent focal point of reflective tape was attached to the left of the projected stimulus array.

For the ordering task, each stimulus item was individually reproduced on a laminated, white 3×5 -in. card.

UNRECODABLE STIMULUS ARRAY



RECODABLE STIMULUS ARRAY



FIG. 1. The upper portion of the figure gives a sample stimulus array consisting of five nonrepresentational line drawings (adapted from Kimura, 1963) for which ready verbal labels are not available. The lower portion gives a sample array for the comparison condition in which the items are easily named common objects (adapted from Makar, 1969).

Procedure

Subjects were tested individually in two separate sessions, one session for each stimulus condition. The two sessions were conducted on separate days. To guard against transfer of a phonetic recoding strategy from one session to the next, the initial session was always devoted to the phonetically unrecodable condition.

Subjects were informed that they would see five figures on the screen for a brief period of time after which they would have to rearrange copies of the figures on the table in the same order. To provide some control for the direction of eye movements, subjects were instructed to fixate on the taped focal point before each trial. Immediately after each tachistoscopic presentation, a sheet of cardboard on the table was removed to reveal the five stimulus cards appropriate to that trial, arranged in a predetermined random order. The same order was used for corresponding trials across the two conditions. No time limit was placed on the subject's performance. A rest period of approximately 2 min followed the 10th trial in both conditions.

A practice set of three stimuli was presented before the 20 test trials in each condition. If the subject failed to order the stimuli correctly on the first presentation of the practice trial, it was repeated. In any case, the practice set was always reviewed with the subject to insure that the task was understood.

RESULTS

The number of stimuli correctly ordered by each subject for each condition was tallied for all serial positions. To be considered correct, a stimulus item had to be placed in the serial position that corresponded to its original position on the slide. Figure 2 shows the mean number correct at each serial position for each group of subjects. It is clear from inspection of the group data depicted in the figure that both good and poor readers performed better with the easily recodable stimuli. This result obtained for every individual subject as well. It is also apparent from the figure that the average difference between the good and poor readers' performances was small in the unrecodable condition compared to the corresponding difference in the recodable condition. In the phonetically unrecodable condition, poor readers correctly ordered a mean of 5.6 stimuli per serial position compared to the good readers' average of 6.7, while in the phonetically recodable condition, poor readers averaged 11.1 correct compared to the good readers' 14.1.

The data were subjected to an analysis of variance with one between-groups measure (reading ability) and two within-groups measures (stimulus recodability and serial position). All three main effects were highly significant: reading ability, $F(1, 40) = 22.4$, $p < .001$; stimulus recodability, $F(1, 40) = 236.1$, $p < .001$; and serial position, $F(4, 160) = 30.9$,

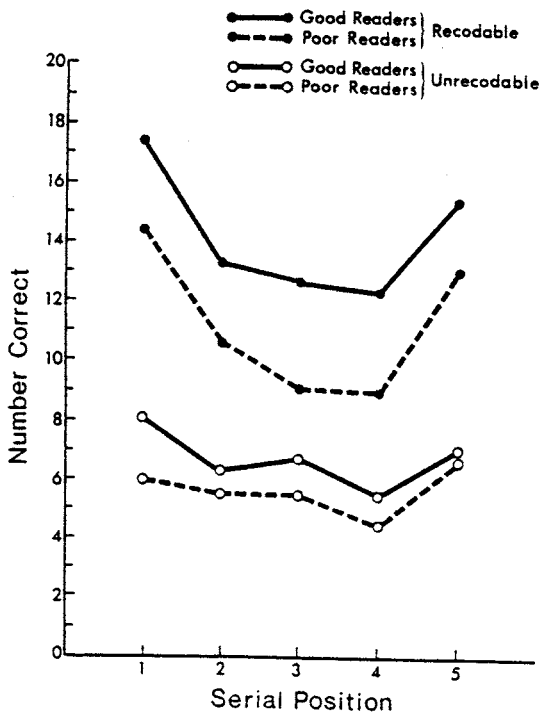


FIG. 2. The mean number of items correctly ordered is plotted by serial position in the stimulus array. Separate curves are shown for each group on each task.

$p < .001$. The variation in shape of the serial position curves with a change in stimulus recodability is indicated by the interaction between stimulus recodability and serial position, $F(4, 160) = 11.2$, $p < .001$. Of special interest was the interaction between reading ability and stimulus recodability, $F(1, 40) = 5.1$, $p = .03$, confirming that the difference in performance between good and poor readers varies with recodability of the stimuli. A more fine-grained analysis of the interaction using a protected t test (Cohen & Cohen, 1975) demonstrated that the mean performances of good and poor readers in the unrecodable condition were not significantly different, $t(40) = 0.8$, $p = .58$. In contrast, a significant difference was found in the recodable condition, $t(40) = 2.3$, $p = .028$.

An analysis of covariance using IQ as the covariate indicated that IQ was not significantly correlated with performance on the experimental task. The significant interaction between reading ability and stimulus recodability with IQ controlled, $F(1, 39) = 5.0$, $p = .032$, argues against attributing the obtained differences in performance to differences in intelligence between the good and poor readers of our sample.

However, the rather low level of performance of all the subjects on the unrecodable condition raises the question as to whether the inter-

actions obtained may have been falsely inflated by a floor effect. A floor effect would be expected to constrain the variance of the scores on the more difficult task. Therefore, the standard error of the means of the scores at each serial position on the two tasks was examined for indications of heterogeneity. It was found that the standard error for the scores on the unrecodable condition ranged from 0.31 to 0.66, whereas for the recodable condition, the standard error ranged from 0.55 to 0.78. Thus, since the ranges of these measures of variability differed for the two tasks, it is possible that the reading ability \times stimulus recodability interaction that had been obtained might indeed have been falsely inflated.

This finding prompted us to do a further analysis, this time on the final 10 trials alone. This portion of the data was selected on the assumption that previous practice may have brought the performances sufficiently above chance on the unrecodable condition to remove any constraining effects on the variance. As can be seen in Table 1, the number of correct placements (averaged over serial position) did increase for both groups in the unrecodable condition. Moreover, the heterogeneity of variance is completely eliminated in these final 10 trials. For these trials, the standard error of the mean for the scores on the unrecodable condition ranged from 0.22 to 0.50 (poor readers, 0.30 to 0.45; good readers, 0.22 to 0.50); for the recodable condition, the standard error ranged from 0.26 to 0.49 (poor readers, 0.31 to 0.47; good readers, 0.26 to 0.49). Since heterogeneity of variance is clearly not a problem here, we can be more confident that any possible interactions involving the recodability factor would not be artifactual.

Performances of good and poor readers on the final 10 trials were then subjected to the same analysis as had been carried out on the full data set. An analysis of variance was computed with one between-groups measure (reading ability) and two within-groups measures (stimulus recodability and serial position). This analysis again revealed significant main effects of reading ability, $F(1, 40) = 28.7, p < .001$, stimulus recodability, $F(1, 40) = 200.8, p < .001$, and serial position, $F(4, 160)$

TABLE 1
NUMBER OF CORRECT PLACEMENTS IN EACH CONDITION (AVERAGED OVER SERIAL POSITION)
FOR THE INITIAL 10 TRIALS AND THE FINAL 10 TRIALS

Stimulus condition	Trials 1-10		Trials 11-20	
	Poor readers	Good readers	Poor readers	Good readers
Unrecodable	2.7	2.9	2.9	3.9
Recodable	5.8	6.9	5.3	7.2

= 24.8. $p < .001$. In addition, the interaction between stimulus recodability and serial position was again obtained. $F(4, 160) = 3.8$, $p = .006$. Finally, and most importantly, the interaction between reading ability and stimulus recodability was once more significant, $F(1, 40) = 5.5$, $p = .025$. Moreover, with IQ controlled in an analysis of covariance, the latter interaction remained significant, $F(1, 39) = 5.3$, $p = .027$. Post hoc analyses using protected t tests (Cohen & Cohen, 1975) once more demonstrated that the performances of good and poor readers in the unrecodable condition were not significantly different, $t(40) = 1.6$, $p = .12$, whereas a significant difference was found in the recodable condition, $t(40) = 3.0$, $p = .004$.

DISCUSSION

We have raised the possibility that the problems in memory for order often imputed to poor readers may be a consequence of deficient use of phonetic memory codes. This possibility was explored by requiring subjects to reconstruct from memory the order of one set of stimuli consisting of drawings of easily named, common objects and another set consisting of nonrepresentational, doodle drawings that do not readily lend themselves to linguistic labeling. The results confirmed our expectations: the performances of good and poor readers did not differ significantly when the task required them to order stimuli that are difficult to label, but good readers were significantly better than poor readers in ordering stimuli that are amenable to labeling. Since items that are labeled by words would be available to a phonetically based working memory, the results are consistent with earlier indications of good readers' superior ability to make use of phonetic coding in working memory (Lieberman et al., 1977; Mann et al., 1980; Mark, Shankweiler, Liberman, & Fowler, 1977; Shankweiler et al., 1979).

The fact that all subjects performed the ordering of the nonsense designs much less accurately than the ordering of the object drawings raised the possibility that a floor effect may have constrained the differences between the groups on that task and, consequently, inflated the critical interaction of groups \times stimulus type obtained on the full data set. However, the interaction was also obtained on the portion of the data deriving from the second half of the experiment (trials 11 through 20) in which the standard error of the means for the tasks differs very little. Thus, we may suppose that the obtained interaction is genuine and not artificially inflated by a floor effect. It should be noted that these results with second graders parallel those of another recent investigation which demonstrated a material-specific deficit in serial memory in adolescent poor readers (Holmes & McKeever, 1979).

It appears then that poor readers do have a material-specific deficit in memory for order. By way of explanation, two possible alternatives

suggest themselves: The deficit may reflect either the ineffective use of phonetic codes or a preference for different and less efficient coding strategies. There is some evidence that poor readers show both types of problems. A recent study (Byrne & Shea, 1979) indicates that, if given a choice, the poor reader does have a preference for an inefficient semantic strategy in retaining linguistic material, but can use a phonetic code, albeit poorly, when no other option is available.

Given the pattern of results obtained in our study, the difficulty of the poor readers could be interpreted as arising from either of the above-mentioned causes—the choice of an inappropriate strategy or the inefficient use of the appropriate one. As to the first possibility, the poor readers of the present study may have chosen to use a semantic code, for example, to retain the order of the object drawings, whereas the good readers opted instead for phonetic codes since that is their usual strategy. If this were the case, our data indicate that a semantic coding strategy was certainly inappropriate for the task, since the performance of the poor readers was worse than that of the good readers. The second possibility, which seems to us more likely, is that the requirement of retention of item order may have induced both good and poor readers to attempt to use a phonetic memory strategy, but that the poor readers were less able to do so. Evidence supporting this second possibility is found in several studies in which even poor readers show some susceptibility to phonetic confusion in ordered recall of linguistic material, such as letter strings (Lieberman et al., 1977; Shankweiler et al., 1979) or word strings (Mann et al., 1980).

Poor readers, thus, can use a phonetic strategy at times. We must therefore ask what accounts for the greater proficiency of the good readers in tasks, such as ordering the object drawings, where this strategy is clearly both possible and appropriate. An appeal cannot be made to differences in the intelligence of good and poor readers because the pattern of results is unaltered when the effect of IQ is held constant. It is conceivable that good and poor readers differ in the facility with which they can recode visual stimuli linguistically, and that the poor readers' difficulties may arise in part from slowness in the initial conversion from pictorial to phonetic form. This view receives some support from experiments that indicate that poor readers characteristically take more time than good readers to name a set of recurring items (e.g., color patches) when there is a premium on speed of response (Denckla & Rudel, 1976). However, previous experimental findings of our own (Lieberman et al., 1977; Shankweiler et al., 1979) give us reason to believe that the poor readers' problem goes beyond any possible slowness in phonetically recoding a visual stimulus. In those studies, a differential effect for rhyme was found for both good and poor readers in the recall of letters, whether the letters were presented visually as shapes or au-

ditorily as names. Similarly, the Byrne and Shea (1979) study, which involved auditory presentations of stimulus items, also found a deficiency in the poor readers' memory for words and nonwords. Thus, the difficulties of poor readers cannot be due solely to inefficiency in recoding visual stimuli as such. Much the same conclusion was argued on other grounds by Perfetti, Finger, and Hogaboam (1978). We can probably also rule out differences in the rate at which good and poor readers scanned the drawings (Katz & Wicklund, 1971, 1972). In sum, the factors that limit fully effective use of phonetic coding by poor readers have yet to be identified, but some major possibilities can now be eliminated.

With regard to order memory, the present findings are consistent with other indications that children with specific reading disability as a group do not have a general problem in remembering order. Instead, the results suggest that these children do have a general problem in coding information linguistically. In all situations in which phonetic coding would be applicable and desirable, their performance is hampered. In contrast, it is not affected, or less so, when other strategies can be utilized. Insofar as poor readers do have problems with order memory, their difficulties in that domain may be more parsimoniously viewed as further manifestations of their failure to make full use of phonetic coding in working memory.

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