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CHILDREN'S MEMORY FOR RECURRING LINGUISTIC AND NONLINGUISTIC MATERIAL IN RELATION TO READING ABILITY

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The performance of good beginning readers on certain language-based short-term memory tasks, like their performance on many other language-related tasks, tends to be better than that of children who encounter difficulty in learning to read. The association between reading ability and such short-term memory skills is by now well-documented. For example, children who are good readers tend to have a better memory for strings of written or spoken letters (Shankweiler, Liberman, Mark, Fowler and Fischer, 1979). They are also more successful at recalling strings of spoken words, and even at recalling the words of spoken sentences (Mann, Liberman and Shankweiler, 1980).

However, our concern has been not simply to document this performance difference but instead to uncover the probable cause of the difference. We first approached this problem by turning what appeared to us to be the special advantages of good readers against them. Since we knew that for adults, the presence of a high density of phonetically-confusable items hinders the use of speech-related processes in short-term memory, we were led to examine the effect of the same manipulation on the performance of good and poor readers. We found that like adults, good beginning readers appear to make effective use of phonetic coding in short-term memory, whereas poor readers do not. Thus we have shown that the memory performance of good readers falls sharply, even to the level of that of the poor readers, when they are asked to remember a letter string, word string, or sentence containing a high density of phonetically-confusable items (letters with rhyming names, or words that rhyme with one another), whereas the performance of poor readers remains little changed by this type of material.

At this point in our investigations, we were led to ask whether there are any other differences between the memory capacities of good and poor readers, beyond those that reflect differential use of a speech code. After all, studies of patients with lateralized brain disease have revealed

that verbal and nonverbal short-term memory abilities may be relatively independent (see, for example: Kimura, 1963; Milner and Taylor, 1972; Warrington and Shallice, 1969). Hence it seemed at least possible that the ability of poor readers to use nonverbal term-short memory processes could be equal to that of good readers. While this possibility is supported by findings that good and poor readers are equally successful at remembering unfamiliar (Hebrew) orthographic designs (Vellutino, Steger, Kaman and DeSetto, 1975), it might seem inconsistent with findings that good readers surpass poor readers in remembering abstract figural patterns (Morrison, Giordani and Nagy, 1977) and spatial-temporal patterns (Corkin, 1974). In our opinion, however, neither of these latter findings can be regarded as conclusive evidence that poor readers have difficulty with nonlinguistic memory, *per se*, since both derive from materials that lend themselves to verbal labeling and to the use of linguistic memory strategies (Liberman, Mark and Shankweiler, 1978). Therefore, it remained to be determined whether or not poor readers encounter difficulty with memory processes other than those requiring use of a speech code. We sought to investigate this question in the present study by comparing the ability of good and poor readers to remember linguistic material with their ability to remember material that is not only nonlinguistic but also not readily susceptible to linguistic coding.

Our subjects were good and poor readers in a second-grade classroom, whose memory abilities were tested with an adaptation of the continuous recognition memory paradigm of Kimura (1963). Using that paradigm, we assessed the children's ability to remember each of three types of materials: nonsense designs, photographs of unfamiliar faces, and printed CVC nonsense syllables. Whereas the nonsense designs were those employed in Kimura's original study (1963), the facial photographs and nonsense syllables were our own innovation. Studies of adult patients with focal brain damage reveal that the ability to encode and remember the nonsense designs that Kimura employed suffers as a consequence of right-hemisphere temporal-lobe excision but is relatively unimpaired by comparable excisions to the left, language-dominant, hemisphere (Kimura, 1963; Milner, 1974; Milner and Teuber, 1968). Likewise, the ability to encode and subsequently to recognize unfamiliar faces has been determined to be a right-hemisphere capacity which does not demonstrably depend on the language mediation skills of the left hemisphere (Leehey, Carey, Diamond and Cahn, 1978; Yin, 1970). In contrast, the encoding and recognition of English-like nonsense syllables is a linguistic ability that suffers as a consequence of damage to the left hemisphere (Coltheart, 1980; Patterson and Marcel, 1977; Saffran and Marin, 1977).

We anticipated that the results obtained with good and poor readers in the case of nonsense designs and faces would differ from those obtained

with nonsense syllables. Good readers were not expected to surpass poor readers in memory for either the nonsense designs or the faces, since neither of these sets of items lend themselves readily to the use of language coding. In the event, however, that good readers should excel at recognizing either of these materials, it would be taken as evidence that the poor readers do indeed have broader deficiencies in remembering. We expected good readers to surpass poor readers in memory for nonsense syllables, on the assumption that their use of phonetic coding as a mnemonic device would be superior to that of poor readers.

MATERIALS AND METHOD

Subjects

The subjects in this experiment were 36 second-grade children who attended the public schools in Mansfield, Connecticut. An initial pretest group was selected on the basis of the children's Total Reading Score on the Stanford Achievement Tests, which had been administered earlier in the same school year. Candidates for the good reading group had received grade scores of from 3.1 to 5.0, whereas candidates for the poor reading group had received scores of 1.5 to 2.4. Final selection of 18 good readers and 18 poor readers was made on the basis of scores on the Word Recognition Subtest of the *Wide Range Achievement Test* (WRAT) (Jastak, Bijou and Jastak, 1965). Children selected as good readers had WRAT reading grade equivalents ranging from 3.1 to 5.0, with a mean score of 4.0; children selected for the poor reading group received grade equivalents from 1.5 to 2.4, with a mean score of 2.1.

Mean ages for good and poor readers were 94.0 months and 94.2 months, respectively, and were not significantly different. Individual administration of the WISC-R revealed good readers to have a mean Full Scale IQ of 113.6, with mean Verbal and Performance IQ's of 112.1 and 112.9, respectively. Poor readers received a mean Full Scale IQ of 107.7, with Verbal and Performance IQ's of 104.9 and 109.1, respectively. There were no significant differences between good and poor readers on any of the IQ measures.

Materials

There were three different types of materials: nonsense designs, faces and syllables. The tests using these three types of items were identical in manner of construction and presentation, each modeled on Kimura's (1963) recurring recognition memory task.

Nonsense Designs

There were 80 nonsense-design stimuli, each of which was one of the 52 irregular line drawings of Kimura (1963). Four of the designs were used eight times each (the recurring designs), and the remaining 48 once each (the non-recurring designs). Each stimulus was drawn on a 3 × 5 card. For the purpose of

testing, the stimuli were divided into eight sets of ten; within each set of ten, the four recurring designs were randomly interspersed with six of the nonrecurring designs. The first set of ten stimuli constituted the inspection set; the remaining seven sets contained the actual test stimuli.

Faces

Face recognition stimuli were constructed using 52 black and white photographs, half of which were adult female faces and half adult male faces. In both the male and female stimuli sets, half were photographed looking to the left and half looking to the right. To minimize distinguishing details that might lend themselves to verbal labeling, no faces were used which displayed hair, eyeglasses, jewelry or distinctive markings such as scars, distinctive makeup, etc. In addition, a uniform mask was applied to each picture to cover hair and background detail as well as to ensure a uniform size.

Again, a set of 80 stimuli was constructed. Four photographs occurred eight times each (two male faces and two female faces, two looking to the left and two looking to the right) whereas the remaining 48 occurred once each. The stimuli were divided into eight sets each, with each set of ten containing the four recurring photographs randomly interspersed among six nonrecurring ones. The first set served as the inspection set, the remaining seven sets contained the test stimuli.

Nonsense Syllables

Stimuli for this part of the experiment were constructed from a set of 52 CVC nonsense syllables which had been selected from Hilgard (1962) to have a moderately low association value. Across the different syllables, frequency of occurrence of each letter was controlled as much as possible. The vowels *a*, *e*, and *u* appeared 11 times each, *i* appeared nine times and *o* appeared ten times. Every consonant (with the exception of *q*, *x* and *y* in initial position and *q*, *y*, *h* and *w* in final position) occurred at least once, with some consonants occurring as often as six times.

From the syllables, a set of 80 stimuli was constructed. Four of the stimuli occurred eight times, while each of the remaining 48 occurred once. The stimulus cards were again divided into eight sets of ten each; within each set of ten the four recurring syllables were randomly interspersed with six nonrecurring ones. The first set of ten constituted the presentation trials, the remaining seven sets contained the test stimuli.

Procedure

Each child was tested individually, with the nonsense designs being presented on the first day of testing, and the faces and syllables on a second day. The procedure for the recurring recognition memory paradigm was adapted from Kimura (1963) and was the same for all three types of material.

The experimenter began each test by telling the child that some designs (or faces or syllables), would be shown, one at a time, and that the task was to look at each one very carefully and try to remember it. She then presented the inspection set of ten cards, showing each card for approximately three seconds. Subsequently, the child was told that more cards would follow, some of which would be

identical to those presented in the inspection set, and some of which would be new cards. The instruction was to say "Yes" if a card had been seen before, and "No" if it had not. The test items were then presented to the child, who was required to respond to each one before being shown the next.

RESULTS

In order to evaluate the performance of the subjects, we first computed the percentage of correct responses made by each subject, separately for each of the three types of materials (nonsense designs, faces, and syllables). This was done by summing the number of correct recognitions and correct rejections, and dividing by 70 (i.e., the total number of test items presented in each condition). After first noting that the performance of the subjects on all three types of material was consistently above the chance level of 50 percent correct, we turned to the major purpose of our study, which was to evaluate the extent of difference between the performance of good and poor readers on each of the three different types of items.

The results of an ANOVA computed on the variables of reading ability (good versus poor readers) and material type (designs versus faces versus syllables) revealed a significant effect of material type ($F = 73.3$; $d.f. = 2, 68$; $p < .001$) reflecting the fact that designs and faces were typically harder to remember than syllables. There was further the anticipated interaction between the effect of item type and reading ability ($F = 8.3$; $d.f. = 2, 68$; $p < .001$). As can be seen in Figure 1, good readers were not significantly better than poor readers at remembering either nonsense designs or faces. (For nonsense designs, $t = 1.4$; $d.f. = 34$, $p > .1$; for faces, $t = 0.1$; $d.f. = 34$, $p > .6$). In fact, poor readers were slightly (although not significantly) better at remembering nonsense designs. Good readers, however, were significantly better than poor readers at remembering the nonsense syllables, $t = 3.2$, $d.f. = 34$, $p < .005$.

DISCUSSION

The results, then, upheld our predictions. Poor readers were equal to good readers in ability to remember both nonsense designs and faces. In contrast, poor readers made significantly more errors than good readers in recognizing the nonsense syllables. Thus we find no evidence that children in the two reading groups differ in general memory ability. Rather, we again find them to differ only in memory for linguistic items. These findings help us to place in perspective two claims that are frequently made regarding the origins of many childhood reading problems. One claim sees a "general memory deficit" as central (Morrison et al., 1977). According to that hypothesis, which views poor readers as having difficulty with memory, *per se*, poor readers might be expected to show inferior

performance for linguistic material and figural material alike. Clearly, our results are incompatible with this view, since it was found that good and poor readers differed solely in memory for the syllables.

A second theoretical claim suggests that failure of serial order memory is the core problem (Bakker, 1972; Corkin, 1974; Holmes and McKeever, 1979). Our task did not require that subjects remember the order of items in the inspection set, yet we nonetheless obtained a difference between good and poor readers' ability to remember nonsense syllables. Thus the poor readers' memory problem goes beyond serial order alone. In this respect, the present findings confirm earlier results by Mark, Shankweiler, Liberman and Fowler (1977) and Byrne and Shea (1979). We do realize, however, that a material-specific deficit in order memory could be a consequence of failure to make effective use of phonetic coding. Indeed, in a recent study (Katz, Shankweiler and Liberman, 1981) some of us found that good and poor readers selected by the same criteria as in the present study differed in ability to recall order of the items. But the good readers excelled only when their task was to recall the order of items that could be coded in terms of linguistic labels. No difference was found in memory for the order of nonrecodable items. Thus the problem of poor

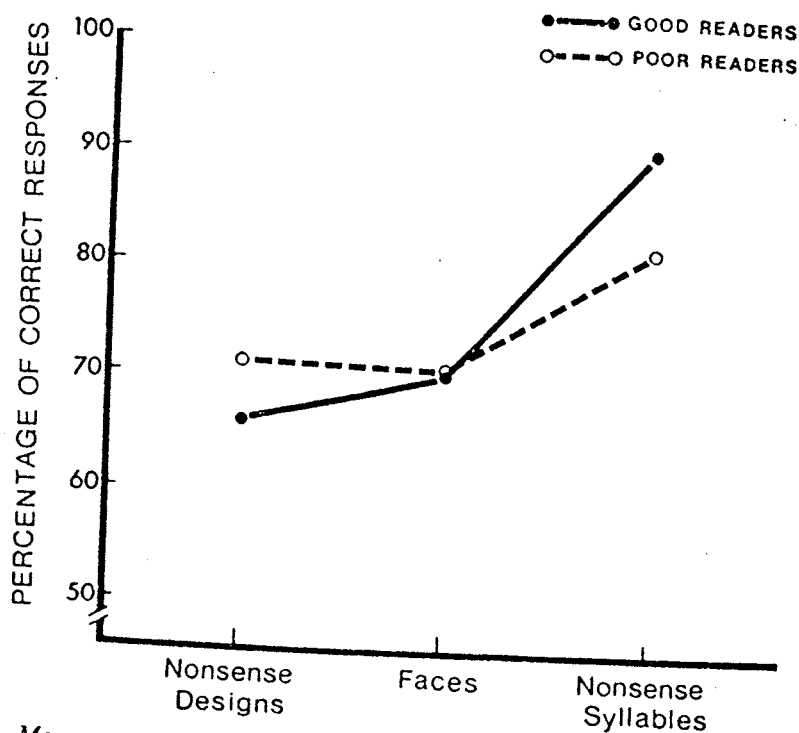


Fig. 1 — Mean percentage of correct responses made by good and poor readers on nonsense designs, faces, and nonsense syllables.

readers in recall of items, *per se*, and in recall of item order appears to be linked to some difficulty with using a phonetic code — either a failure to recode phonetically or a weakened tendency to use this coding principle.

In summary, then, we have discovered an instance in which despite identical procedures, good and poor readers differ in the ability to remember language-based material, but fail to differ in memory for two types of nonverbal material. Thus we conclude that the memory deficits of poor readers appear indeed to be restricted to the domain of phonetic representation in short-term memory. Several questions arise at this point, among them the question of why poor readers fail to make effective use of a phonetic code, and the question of how a deficient linguistic memory comes to be associated with problems in learning to read. At present we are addressing the first of these questions by examining the pattern of memory errors made by poor readers. Our approach to the second, however, is guided by a consideration of the relation between short-term memory and normal language processing (Baddeley, 1978; Liberman, Mattingly and Turvey, 1972), which leads us to ask whether poor readers encounter difficulty on the type of language comprehension tasks used in studying aphasic patients (Caramazza and Zurif, 1978). We suspect that answers to these two questions may bring us closer to an understanding of the reading process as well as of the process of reading acquisition.

ABSTRACT

Good beginning readers typically surpass poor beginning readers in memory for linguistic material such as syllables, words, and sentences. Here we present evidence that this interaction between reading ability and memory performance does not extend to memory for nonlinguistic material like faces and nonsense designs. Using an adaptation of the continuous recognition memory paradigm of Kimura (1963) we assessed the ability of good and poor readers in the second grade to remember three different types of material: photographs of unfamiliar faces, nonsense designs, and printed nonsense syllables. For both faces and designs, the performance of the two reading groups was comparable; only when remembering the nonsense syllables did the good readers perform at a significantly superior level. These results support other evidence that distinctions between good and poor beginning readers do not turn on memory, *per se*, but rather on memory for linguistic material. Thus they extend our previous finding that poor readers encounter specific difficulty with the use of linguistic coding in short-term memory.

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