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ABSTRACT

A study investigated connections between reading difficulties and short term memory processes in order to explore the psychological basis for some individual differences in reading comprehension skills. Drawing on previous research indicating that poor readers were inferior to normal ones in judging whether two patterns of long and short tones were the same, the study examined whether the groups differed in ability to accurately encode patterns into auditory short term memory or in ability to maintain patterns in memory after they have been stored. The study also investigated the relationship among performance on a verbal sequential memory task, auditory digit span, and reading skill. Subjects, 35 normal and 63 poor fifth grade readers, were presented with pairs of Morse Code-like patterns separated by 1-, 2-, 5-, and 10-second intervals, and asked to judge if the patterns were the same. Results showed that poor readers performed significantly worse on pattern comparison only at the longest interval, suggesting an inability to maintain properly encoded patterns and that poor retention of information in short term memory probably results in both semantic and syntactic processing breakdowns during reading. Digit span correlated significantly with reading ability, but not with pattern-comparison performance. Digit span may be correlated with reading skill because of a common dependency on rapid coding of verbal stimuli. (FL)

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Short-term Memory for Auditory Sequences and Reading Skill

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Abstract

Previous research indicated that poor readers were inferior to normal readers in judging whether two patterns of long and short tones were the same. The current study investigated whether the groups differed in ability to accurately encode patterns into auditory short-term memory or in ability to maintain patterns in memory after they are stored there. Normal and poor fifth-grade readers were presented with pairs of Morse code-like patterns separated by 1-, 2-, 5-, and 10- sec intervals. Subjects judged whether the patterns were the same. The study also investigated the relationship between a verbal sequential memory task, auditory digit span, and reading skill.

Poor readers performed significantly worse on pattern comparison only at the longest interval, suggesting an inability to maintain properly encoded patterns. Poor retention of information in short-term memory probably results in both semantic and syntactic processing breakdowns during reading.

Digits span correlated significantly with reading ability, but not with pattern-comparison performance. Digit span may be correlated with reading skill because of a common dependency on rapid coding of verbal stimuli.

Short-term Memory for Auditory

Sequences and Reading Skill

Reading disabilities pose a serious problem for our schools. Our schools are not in a good position to rectify these deficiencies because their cognitive underpinnings are not well understood. The current study investigated connections between reading disabilities and short-term memory processes in an attempt to explore the psychological basis for some individual differences in reading-comprehension skill.

Birch and Belmont (1964) asserted that the difficulties of retarded readers derive from their inability to form connections between visually and auditorially coded information in short-term memory. Clearly, reading instruction concentrates on the translation of visually presented materials into sounds and vice versa, so cross-modal integration would certainly be a reasonable place to look for individual differences affecting reading comprehension. However, Birch and Belmont's investigation was flawed in that it confounded the temporal and sensory properties of the stimuli. The visual stimuli in their experimental task were presented simultaneously, and the auditory stimuli were presented sequentially.

More recent research has suggested these individual differences reported by Birch and Belmont in reading comprehension derive largely from variations in the ability to process sequential information, per se, rather than from differences in intersensory integration skills.

Corkin (1974) found that inferior elementary school readers performed less well than adequate readers on tasks requiring serial recall of auditorially presented digits or reproduction of a series of taps on cubes at different spatial locations. Similarly, Zurif and Carson (1970) found that normal and poor readers could be distinguished by their ability to discriminate between successively presented sets of rhythmic taps from the rhythm subtest of the Seashore Measures of Musical Talents. Likewise, normal readers performed more accurately on an analogous visual test that used rhythmic patterns of light.

These differences between reading-ability groups in short-term memory for sequential patterns are particularly strong and consistent when the sequential patterns are presented auditorially (Badian, 1977; Jones, 1974; Payne, Davenport, Domague, & Soroka, 1980). Payne et al. demonstrated the importance of sequential auditory short-term memory in a study of Birch and Belmont's (1964) hypothesis about the role of intersensory integration in reading ability. Payne et al. eliminated the confounding of intersensory integration with sequential versus simultaneous presentation by presenting all stimuli sequentially. Subjects had to verify whether two sequential patterns of long and short pulses and pauses were the same or different. These Morse code-like patterns were presented auditorially as series of beeping tones, visually as different durations of activation of a light, and tactually as different length vibrations of a plastic disc on which the subject's finger was placed. All nine possible combinations of the three sensory modalities in two temporal positions (first and second positions in the

comparison pair) were presented to normal and poor readers in the third, fourth, fifth, and sixth grades.

Payne and his colleagues found that cross-modal comparisons were more difficult than intramodal comparisons, but this effect did not interact with grade level or reading-comprehensions level and thus was not a source of individual or developmental differences. It was the auditory mode that discriminated between reading levels. Poor readers performed significantly worse than normal readers when the first pattern was presented auditorially, regardless of the modality of presentation of the second pattern. Performances of the two groups did not differ if the presentation of the first pattern was visual or tactual. Thus the results of Payne et al.'s study indicated that auditory short-term memory was related to the reading-comprehension levels of their subjects. However, they did not determine whether normal and poor readers differed in their ability to accurately encode the tonal patterns into auditory short-term memory or in their ability to maintain the patterns in memory after they were stored there. The current study attempted to resolve this issue.

The study also investigated the relationship between auditory digit span and reading disabilities. Both digit span and Payne et al.'s (1980) auditory pattern-comparison task involve short-term memory for sequentially presented auditory patterns. However, because digit span involves verbal stimuli and the experimental pattern-comparison task does not, these two tasks may assess different components of

comprehension skill.

Method

Subjects

Subjects were fifth-grade students attending Atlanta public schools. They were divided into two groups on the basis of scores on the Reading Comprehension subtest of the California Achievement Tests. Each of 35 subjects in the Normal Reader group scored within 1 standard error of measurement of the national norm, and each of 63 subjects in the Poor Reader group scored at least 2 years below grade level.

Procedure

Subjects were individually examined on the WISC-R Digit Span subtest and the auditory pattern-comparison task. The pattern-comparison task consisted of pairs of tonal patterns recorded on audio tape which the subjects had to identify as being the same or different. Each pattern was composed from three to five elements which were either long (0.75 sec) or short (0.25 sec) tones or pauses (0.25 sec).

Patterns within a pair were separated by a 3 sec interval in the study of Payne et al. (1980). In the current study retention intervals of 1, 2, 5 and 10 sec were employed. Each subject within each reading group was assigned to one of these four time-interval conditions. If the comprehension difficulties of poor readers derive from an inability to accurately encode information into auditory short-term memory, then the two reading groups' accuracies should differ at all intervals. However, if poor readers suffer primarily from an inability to maintain

an accurately encoded trace, the differences between reading groups would be expected to be a function of interval length.

Two sets of practice patterns were recorded for each time-interval condition, one set without pauses and one set with pauses. Each subject practiced with each set until a criterion of three consecutive correct responses occurred. The subject was then presented with test pairs that were the same 36 pairs of patterns employed by Payne et al. (1980).

Results

The results for the pattern-comparison task are summarized in Figure 1. Analysis of variance revealed significant effects for Reading Groups $F(1, 82) = 15.02$, $p < .001$, Time Intervals, $F(3, 82) = 4.15$, $p < .01$, and Reading Groups X Time Intervals interaction, $F(3, 82) = 3.00$, $p < .05$. A test for simple effects of time intervals showed that they significantly influenced poor readers, $F(1, 82) = 6.58$, $p < .01$, but not normal readers. The difference in accuracy between the two groups of subjects was significant only at the 10-sec interval ($p < .01$) when compared by Tukey's HSD procedure.

Consistent with previous research, (e.g., Badian, 1977; Naidoo, 1972), a positive relationship was found between reading ability and digit span, as indicated by a significant biserial correlation between Reading Group and WISC-R Digit Span ($r_{bis} = .52$, $p < .001$). However, the full set of total (combined forward and backward) digit spans did not correlate significantly with the full set of scores on the non-verbal pattern comparison task. When forward, backward, and total

digit spans were examined separately for each reading group, forward digit span was found to correlate significantly with pattern-comparison performance for the Poor Reader group (r = .33, p < .01), and total digit span was found to correlate significantly with pattern-comparison performance for the Normal Reader group (r = .31, p < .05).

Conclusions

Although both digit span and auditory pattern comparison involve short-term memory for sequential auditory patterns, their relationship to each other does not appear to be very strong or consistent. Both tasks discriminated between normal and poor readers, but they seemed to assess somewhat different components of reading comprehension. Recent research (e.g., Chi, 1976; Dempster, 1981; Perfetti & Lesgold, 1977; Torgesen & Houck, 1980) has suggested that perhaps the most critical determinant of individual differences in digit span is proficiency in identifying or coding the digits themselves. LaBerge and Samuels (1974) have underscored the importance of automatic coding of stimuli for reading comprehension. Digit span and reading comprehension may be interrelated because of a common dependency on rapid verbal coding.

Verbal coding efficiency may not account fully for observed differences in reading-comprehension skill, however. Hess and Radtke (1981) have asserted that short-term memory processes occurring after the completion of encoding also contribute to comprehension proficiency. The nonverbal pattern comparison task appears to discriminate between normal and poor readers by revealing differences in their ability to maintain information in auditory short-term memory following encoding.

If encoding proficiency had been different between the reading groups on the pattern-comparison task, performance of normal readers should have been superior to that of poor readers even at the shortest time interval. Although some differences did occur between groups at each time interval, the only significant difference occurred at the longest interval. Normal readers' performance appeared to be unaffected by the retention interval, but poor readers' performance deteriorated at the 10-sec interval. Obviously, an inability to maintain information in short-term memory could influence reading-comprehension levels. In order to understand a proposition in a text, the reader must be able to relate newly read parts of the proposition to earlier read parts. Likewise, the reader must be able to relate new propositions to previously read propositions in order to develop a meaningful schema for the text. How effectively one can do this depends on how well the earlier propositions are maintained in short-term memory (Kintsch & van Dijk, 1978).

A deficiency in the ability to maintain acoustic signals of varying durations may also underlie poor readers' difficulty with syntax. Vogel (1975) and van Etten (1978) found ability to recognize syntax to be the best single predictor of reading comprehension in normal and dyslexic readers. Martin (1972) has asserted that speech is governed by a hierarchically organized rhythm pattern, and Hamill (1976) has demonstrated a relationship between the timing of words spoken or read in a phrase or sentence and the function played by those words.

Hamill found that college readers tended to assign longer temporal durations to high-information words, such as nouns and verbs, than to low-information words, such as articles and prepositions. Thus a child who has difficulty maintaining temporal information in memory might read poorly if temporal patterns are correlated with linguistic syntax in children as they are in college readers.

The correlation between temporal components and linguistic syntax suggests an additional reason for the lack of relationship between digit span and the auditory pattern-comparison procedure. Conventional measures of digit span present digits at a constant rate. Although digits themselves vary somewhat in temporal length, a sequence of digits considered as a temporal pattern would not vary as much from another pattern as the Morse code-like patterns in the present study. For this reason, digit span probably does not measure components correlated with syntax as the auditory pattern-comparison procedure does. Although both procedures discriminate between good and poor readers, they may do so for different reasons.

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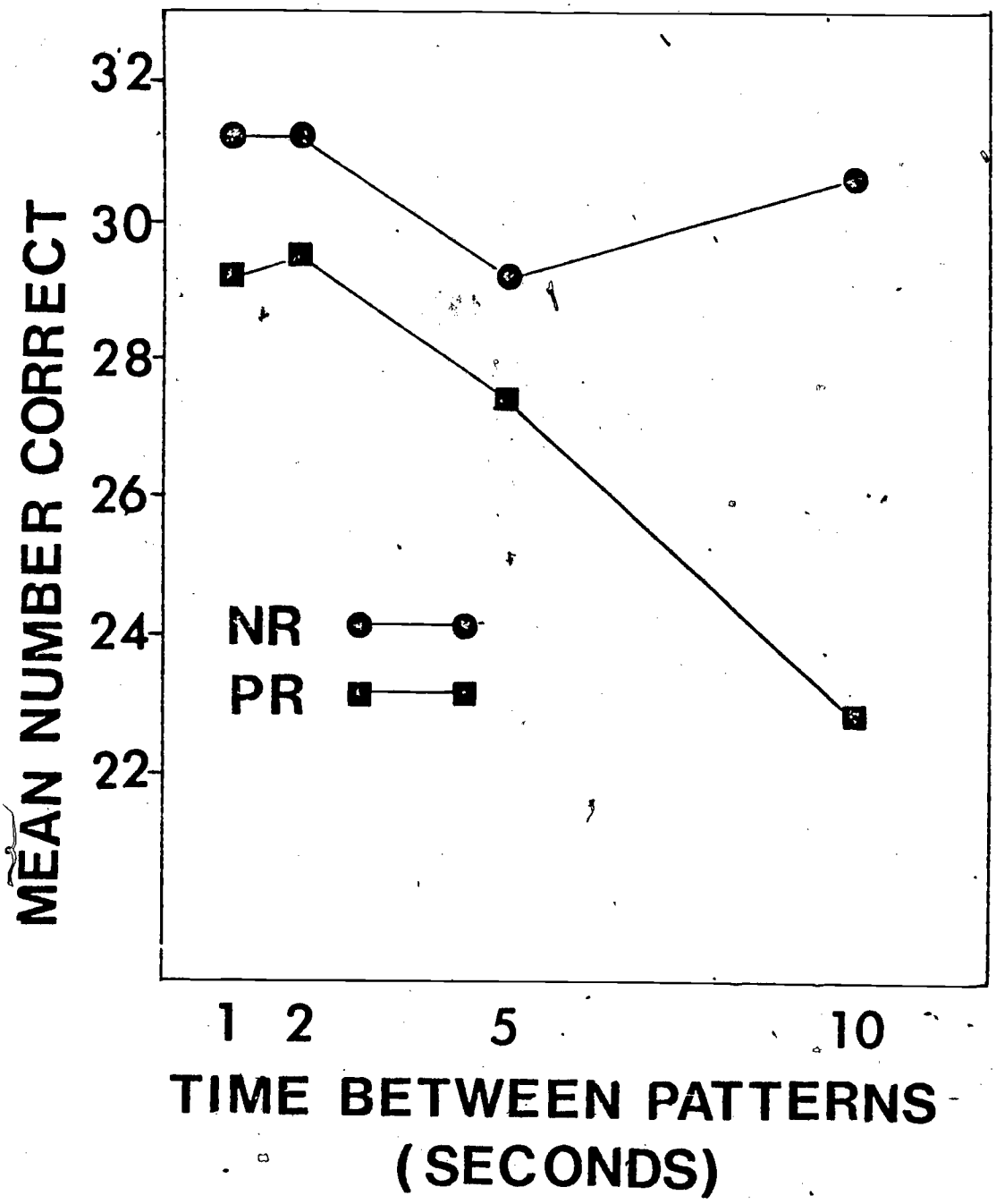

Figure 1. Mean number of correct responses as a function of time between patterns.