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Developmental Relations between Reading Ability and Knowledge of Orthographic Structure

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First, second, and third grade readers were asked to pick the item that "looked more like a word" from a pair of letter strings. The items to be discriminated differed in terms of a rule-governed description of orthographic structure. Task performance improved with school experience, averaging 58, 69, and 79% correct for first, second, and third grade readers, respectively. More importantly, reading ability, as assessed by vocabulary and comprehension, accounted for 17% more of the variance than that accounted for by grade level. Reading ability is positively correlated with knowledge of orthographic structure for young readers. To what extent this knowledge is responsible for differences in reading ability remains to be determined.

Readers comprehend print by the active process of deriving meaning from it. A knowledge of orthographic structure provides one important source of information that readers use to derive such meaning. Readers do this by applying their knowledge of orthographic structure—redundancies and constraints in written English—as a supplement to other sources of information and knowledge they use in their efforts at finding meaning. In earlier work, we evaluated how well various descriptions of orthographic structure capture the reader's knowledge and utilization of this structure in letter and word recognition (Massaro, Venezky, & Taylor, 1979; Massaro Taylor, Venezky, Jastrzembski, & Lucas, 1980). Other work addressed the issue of how use of this structure facilitates reading performance (Massaro, 1979, 1980). Developmental concerns are the focus of the present study: To provide information on the beginning reader's knowledge of orthographic structure and to relate this knowledge to reading ability.

To assess knowledge of orthographic structure among young readers, we asked first, second, and third graders to pick the item that "looks more like a word" from a pair of letter strings. Our assessment method was based on previous research. Rosinski and Wheeler (1972) asked children in these grades to choose which of two groups of letters "was more like a real word." The test items were nonsense words which could or could not be pronounced (Gibson, Pick, Osser, & Hammond, 1962; Gibson, Osser,

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& Pick, 1963). First graders could not discriminate pronounceable from unpronounceable items whereas both third and fifth graders could do so over 80% of the time. In a follow-up study (Golinkoff, Note 1), second graders were significantly above chance on a modified version of the task. In contrast to the forced-choice task employed in these studies, Lott and Smith (1970) and Niles (1975–1976) found that orthographic structure contributed somewhat to first grade readers' performance on a tachistoscopic recognition task. Finally, Niles, Grunder, and Wimmer (1977) studied the ability of children from kindergarten through sixth grade to discriminate well-structured from poorly structured test strings. Zero- (ijhbwatt) and fourth-order (afeditol) approximations to English (taken from Miller, Bruner, & Postman, 1954) were used. They found that kindergarteners could not make reliable forced-choice decisions between these two classes of items. Decisions of students at the end of first grade, however, were about 63% correct, and performance continued to improve up to fourth grade where it became asymptotic.

Prior research also led us to use test items which would be discriminated on the basis of rule-governed descriptions of orthographic structure. Venezky and Massaro (1979) and Massaro *et al.* (1979, 1980) have distinguished two ways of describing orthographic structure: *Statistical redundancy* and *rule-governed regularity*. The first description derives solely from the frequency of occurrence of letters and letter sequences in written texts. The second description derives from phonological constraints in English and scribal conventions for sequencing the letters in words. Massaro *et al.* (1979, 1980) contrasted a specific statistical-redundancy description with a specific rule-governed description in a series of experiments. The statistical-redundancy description was the summed single-letter positional frequency of the letters in the test string. This frequency measure was derived from counts which give the number of occurrences of each letter by word position and length in a sample of written text. For test strings of Length 6, the frequency measure would be equal to the sum of the frequency of the string's first letter as the first letter in six-letter words plus the second letter's frequency as the second letter in six-letter words, and so on. For the rule-governed description, a set of rules was formulated to classify strings as orthographically regular or irregular. In addition, each irregular item could be specified in terms of the number of violations it contained.

Massaro *et al.* (1979, 1980) carried out a series of rating and two-alternative forced-choice experiments assessing to what extent knowledge of orthographic structure is consciously available and capable of being reported. The experiments evaluated not only whether readers could reliably assign ratings of orthographic structure to the items, but also whether readers would discriminate among the items in terms of statistical redundancy, rule-governed regularity, or both. The results

showed that subjects discriminated among the items primarily in terms of the rule-governed description, even when specific statistical redundancy instructions were given. Given the results of these experiments, the items to be discriminated in the present experiment were made to differ in terms of the rule-governed description.

METHOD

For the test items 60 pairs of six-letter items were created. Each letter string was described in terms of the number of violations of orthographic structure. The rules for determining the irregularity count are given in Massaro *et al.* (1980). One item of each pair had no violations of orthographic structure. The other item had either 1, 2, or 3 violations. Both members of a pair were typed on the same line and the irregular item was equally likely to be on the right or left. The items were given on the test in order of roughly increasing difficulty with respect to the number of violations of the irregular member of the pair. This format was used to discourage an early "giving up" on the part of students who found the task difficult and to compensate for learning during the task itself. The students were asked to play a game of picking possible words over nonwords. The children had the written instructions in front of them and they were also read aloud by the experimenter. Examples of the test items are given in Table 1 along with the number of violations of each of the irregular items.

One of the authors (J.H.) administered the test in the classroom with the teacher present. The students were told that they would be asked to play a game which would help us understand how children learn to read. The test was handed out and the students followed along as the experimenter read the instructions. When the first example question was reached, the students were asked to put their finger on it. After checking to see that all children had found the question, the experimenter spelled each item and asked which group looked more like a word. Given the appropriate response, the students were asked to circle the correct word. The experimenter repeated this for each of the remaining three examples. Students were then told to start the test and work until it was completed. Testing time never exceeded 20 min.

A total of 48 first graders, 75 second graders, and 62 third graders were administered the test. One first grader and four second graders did not complete the test and their data were omitted from the analyses. The orthographic test was administered at the end of March, and the beginning of April. The California Achievement Tests (McGraw–Hill, 1978) had just been taken by these students in the beginning of March.

RESULTS

Performance improved with grade level: first, second, and third graders averaged 58, 69, and 79% correct, respectively. Chance performance is 50% correct in the two-alternative forced-choice test.

Performance was also correlated with each student's scores on the

TABLE 1
EXAMPLES OF THE REGULAR AND IRREGULAR TEST ITEMS

Regular	Irregular
movule	plgued (1)[a]
morebs	ydlaes (2)
hemort	cdrtei (3)

[a] The numbers in parentheses indicate the number of irregularities.

California Achievement Tests (McGraw–Hill, 1978). The first, second, and third graders had taken Form C, Levels 11, 12, and 13, respectively. The first grade test included phonic analysis, reading vocabulary, reading comprehension, and language expression. The second and third grade tests included all of the areas in the first grade test and also structural analysis, spelling, and language mechanics. Table 2 gives the correlations of performance on the orthographic structure test with each test area for each grade. Given the poor performance of the first grade readers, the small correlations are not surprising. For the second and third grade readers, significant correlations were observed between performance on the orthographic structure test and all of the achievement tests. There were relatively high correlations among all of the achievement tests.

To provide an analysis across the three grade levels, a grade equivalent score was derived for each student's combined performance on reading vocabulary and comprehension. The correlation of this measure with performance on the orthographic structure test was .663, $p < .001$. To assess the magnitude of this correlation, grade level in school was also correlated with performance on the orthographic structure test; this gave a correlation of .504. Therefore, reading achievement as measured by comprehension and vocabulary accounts for 17% more of the variance than the 25% accounted for by grade level alone. A multiple correlation showed that reading achievement accounted for all of the variance accounted for by grade level. Figure 1 shows the scatterplot of the orthographic structure test performance as a function of reading grade level as measured by the achievement tests.

DISCUSSION

Our findings demonstrate that reading ability is positively correlated with knowledge of orthographic structure among young school children.

TABLE 2
CORRELATIONS OF ORTHOGRAPHIC STRUCTURE TEST PERFORMANCE WITH SCORES ON THE CALIFORNIA ACHIEVEMENT TESTS (CAT) FOR THE FIRST, SECOND, AND THIRD GRADE READERS

Achievement tests	Grade		
	First	Second	Third
Phonic analysis	.173	.526	.580
Reading vocabulary	.104	.438	.472
Reading comprehension	.267	.536	.532
Language expression	.203	.440	.548
Structural analyses	—	.433	.369
Spelling	—	.317	.543
Language mechanics	—	.456	.433

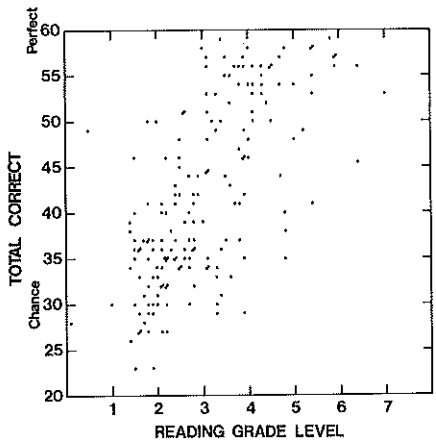

FIG. 1. Scatterplot of performance on the orthographic structure test as a function of reading grade level as measured by comprehension and vocabulary achievement tests.

Thus, the acquisition of an ability to use rule-governed regularities in the printed word appears to develop during the course of learning to read. Two other studies report similar results.

Allington (1978) required good and poor second and fourth graders to discriminate zero-order from fourth-order approximations to English (Miller *et al.*, 1954). Performance was primarily a function of reading ability rather than grade level. Katz (1977) provided some evidence that good fifth grade readers are better at reporting certain constraints in written English than are their poor reader peers. The task was to report a letter's most frequent position in a five-letter string. For example, given e_ _ _ _ and _ _ _ e _, which string has the letter e in its most frequent position in five-letter words? These studies provide a measure of the extent to which knowledge of orthographic structure is available and capable of being reported; they do not address the issue of whether or how orthographic structure is used in perceptual recognition in reading. Although the results reveal that knowledge of this structure does vary with reading level, it is still necessary to determine if a similar relationship holds for use of this structure in perceptual recognition.

Massaro and Taylor (1980) studied the role of reading ability in the utilization of orthographic structure in perceptual recognition. Good and poor college readers showed equally large effects of orthographic structure on perceptual recognition. However, poor sixth grade readers showed a smaller effect of orthographic structure than did good sixth grade readers or college sophomores. Correlations of the use of orthographic structure and measures of reading ability revealed similar results. That knowing and using orthographic structure is correlated with reading

ability among young readers seems clear. It remains to be determined, however, whether differences in this skill are partially responsible for differences in reading ability.

Reading instruction seldom addresses orthographic structure directly. Hence it is difficult to assess whether knowledge of this structure plays a causal role in learning to read or whether it is only a concomitant outcome of the same instructional processes used in learning to read. Varying instructional offerings on orthographic structure, as a prelude to reading instruction itself, would permit an experimental assessment of the potential role orthographic structure may play in beginning reading. Massaro and Taylor (1980) discuss salient properties of orthographic structure, and also illustrate how these properties might be taught within the context of letter and word games.

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REFERENCE NOTE

1. GOLINKOFF, R. *Children's discrimination of English spelling patterns with redundant auditory information*. Paper presented to the American Educational Association, February 1974.