Effects of Grapheme Substitutions in Connected Text Upon Reading Behaviors

Richard L. Allington and Michael Strange

It has been suggested that good readers make better use of semantic/syntactic information than do poor readers and that the former group uses relatively less graphic information compared to the latter group. To test these hypotheses, minor visual alterations were inserted in words in connected text. Fifteen good and 15 poor readers at the fourth grade level orally read two of these altered passages. Results indicated the good readers' rate of reading was significantly faster and that this group made fewer miscalls in overall word identification. However, there were no differences in ratio of textually acceptable miscalls, and poor readers' responses to altered words seemed less bound to graphic cues than those of the good readers. Neither comparison supported the above hypotheses.

In processing print at least two distinct types of information are available to the reader. The first of these we have chosen to call orthographic information in that it is carried by the printed symbols. In alphabetic languages this orthographic information can be used to recognize instantly a word based only upon visual characteristics (e.g., sight word recognition) or used in mediated word recognition to produce a phonemic approximation (e.g., sounding out). A second type of information in connected text can be considered non-orthographic in that it is based in the reader's tacit knowledge of language. The semantic and syntactic information in connected text limits the possible alternatives, or in other words, reduces the reader's uncertainty when confronted with a decision on word identification. That is, at any point in any given sentence only a limited number of words can be considered since the contextual information indicates words of a certain syntactic class and appropriate semantic content. The importance of this language based information has only recently been emphasized (Weber, 1968; Ryan and Semmel, 1969; Goodman, 1969; Smith, 1971).

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Dr. Allington's address: Department of Reading, SUNY at Albany, Albany, NY 12222.

A variety of research studies have been conducted to examine the role of this information in the reading process. Biemiller (1970) and Clay (1972), for instance, have found developmental changes in the use of these types of information in beginning readers, and Barr (1975) has demonstrated the effects instruction has upon their utilization. However, controversy exists on the particular roles orthographic and contextual information play in the development of fluent reading.

Several problems plague this literature. First, as Weber (1968) points out, far too many studies in this area suffer from a naivete concerning "linguistic variables." That is, reading errors have often been considered only in terms of erroneous processing of orthographic information without consideration to the possible influences that might have been exerted by semantic-syntactic information. Second, a bulk of the studies have been descriptive in the sense that error patterns were not experimentally manipulative. Thus, while a number of researchers (K. Goodman and Burke, 1973; Y. Goodman, 1971) have examined oral reading performances and performed comprehensive analyses of reading errors, the materials typically did not allow the researchers to manipulate experimentally specific types of orthographic and contextual information.

The central issue in the controversy is the extent of utilization of orthographic and contextual information by good and poor readers. Smith (1971, 1975) and Goodman (1967, 1969) suggest that as reading fluency develops relatively less orthographic information is employed, and as dependence on graphic information decreases reliance upon contextual information increases. A correlate to this position is that good readers make better use of contextual information than do poor readers and that the latter group relies more heavily upon orthographic information.

On the other hand, Weber (1970), Clay (1972), and Biemiller (1970) report that use of contextual information does not typically differentiate between good and poor readers but rather that all readers make use of this information. These authors report that the errors of good readers were more likely to have a higher degree of graphic similarity to the printed word than the errors of the poor readers. However, in each of these studies the subjects were in their first years of reading instruction.

This position has recently received support from a study conducted by Kolers (1975) with older subjects. He presented good and poor readers at the seventh grade level with a sentence memory task and concluded good readers were more sensitive to orthographic features of text than were poor readers.

The primary research question in the present study, then, was whether good and poor readers differ in their use of orthographic and contextual information available in printed text. The experimental technique employed was originally reported by Pillsbury (1897) and recently employed by Rayner and Kaiser (1975) and Strange (1976). In each study letters within words were altered. However, only the two more recent studies presented altered words in connected text. Position of alteration within the word (initial, medial, final) as well as type of alteration (similar vs. changed configuration) were manipulated in both studies. The results of each demonstrated that altering configuration disrupted reading rate. However, Rayner and Kaiser were primarily interested in assessing the relative importance of different types of graphic information for word recognition in reading connected text. Therefore, subjects were made aware alterations existed and were told to try and ignore them and respond with "the words they thought should be there rather than the strange words" (p. 302). Furthermore, 18% of the characters were altered. Thus, the directions for the task and the quantity of alterations seemed to ensure a rather disruptive effect. Strange (1976) on the other hand employed silent reading rate as the metric, thus eliminating a measure of word identification accuracy as an experimental variable.

A primary assumption underlying the present study was that a similar strategy could be employed to assess good and poor reader's utilization of orthographic and contextual information. However, while a similar strategy was employed, a number of changes seemed necessary. First, all alterations maintained the configuration of the original word, since these had been shown to be the least disruptive. Second, the proportion of alterations was tremendously reduced. Third, the subjects were not alerted to the existence of alteration by the experimenter. These procedural changes then provided a design which allowed analyses of the

relative utilization of graphic and contextual information by the subjects. Further, the design also allowed direct comparisons between good and poor readers relative to their utilization of these information sources.

Method

Subjects. All fourth graders in an elementary school were screened on reading ability on the word identification subtest of the *Woodcock Reading Mastery Tests* approximately two weeks prior to the initial experimental sessions. This individual achievement test presents words in isolation for oral pronunciation. The correlation between this subtest and the total test score was .94 for fourth grade subjects, the highest correlation attained between any subtest and total test score.

Students with raw scores between 50 and 98 (2.0 to 3.6 grade equivalents) were classified as poor readers since achievement lagged at least one year behind grade placement and 15 subjects were randomly selected from this pool. Students with raw scores between 108 and 127 (grade equivalents 4.6 to 7.0) were classified as good readers and 15 subjects were again randomly selected. The mean raw score of the poor readers was 79.0 (2.9 grade equivalent), while the mean of the good readers was 112.2 (4.9 grade equivalent). Following the random selection, lists of subjects (identified by group) were presented to the classroom teachers responsible for each subject's reading instruction. Teachers were asked to draw a line through the names of any subjects which seemed to be placed inappropriately. No subject was identified as inappropriately grouped.

The mean chronological age for both the good and poor reader groups was 9.6 years. Sex distribution for the poor readers was 10:5 male to female while for the good readers the male to female ratio was 7:8.

Materials. The experimental passages were developed by graduate students following written directions. The materials were to be approximately 200 words in length and suitable for subjects with second grade reading ability. After the selection of a passage, grapheme substitutions (or alterations) were to be introduced

Figure 1. Illustration of experimental materials.

He leaned too fan over the edge of the well.	(far)
A green frog came hopping oven the snow.	(over)
Just them an owl came down.	(then)
Each stands on its back logs and leans on its tail.	(legs)
Bill jumped off the bus and ram to the river.	(ran)

following a series of constraints.[1] Briefly, approximately 5% modification (or single-letter changes in ten words) was to be introduced, but each change had to result in another real word (e.g., change *a* in *came* to *o* resulting in *come*, or change the *m* to *n* resulting in *cane*). The following alphabet characters were allowed to be interchanged: e, a, o, c; n, m, h, r; b, d, p; t, b, l. These letters were selected because of their high visual similarity according to several rankings (Dunn-Rankin, 1968; Niles, 1974). In one passage the developer ignored the constraints on a single occasion—substituting *what* for *that*—however, recent research (Allington, in press) has demonstrated that these words are often confused on discrimination tasks, thus this misalteration was not deleted. Figure 1 presents several example sentences drawn from the experimental materials. The altered word is underlined and the original words appear in parentheses to the right of the sentences; the altered words were *not* so marked in the experimental materials.

A total of four passages were constructed, all of which had been selected from different basal reader series. All passages were rated between 2.5 and 3.0 grade level difficulty prior to the grapheme substitutions (Spache, 1953).

Procedure. One passage was randomly selected as the standard experimental passage and administered to all subjects; one of the remaining three passages was randomly assigned to each subject in an attempt to ensure greater generalizability of results (Coleman and Miller, 1974). Thus, two passages were administered to each subject with one passage being common to all subjects.

Subjects were tested individually in a small room adjacent to the classrooms. Subjects were told they were to read two passages orally. Since a microphone was conspicuously present, the subjects were told that a recording was being made for the experimenter to listen to later. No subject expressed undue concern about the presence of the microphone. Operation of the recording equipment was controlled by a foot pedal switch, thus making the mechanical operations unobtrusive.

Prior to beginning reading, each subject was orally given a single sentence introduction to the story which contained a general prelude to the passage. Several of the less skilled readers needed a word or two pronounced early in the passage. In no case was a word which immediately preceded an altered word pronounced for a subject. Every attempt was made to limit the number of words pronounced for subjects.

Subjects who made mention of the character substitutions or to the fact that a word did not make sense, were simply told: "Read it the best you can."

Time required to read each passage was measured with a stopwatch during the experimental sessions. The sessions typically lasted less than 15 minutes.

Scoring. A written transcription of the oral reading performance was made from the taped recordings. Particular emphasis was given to responses to words containing the grapheme substitutions. In the case of multiple responses each was coded in the sequence of occurrence. The analyses that follow report the responses to the altered words in categories such as first response, second response, etc. Two responses were of particular interest; first responses which seemed to indicate whether the subject was employing orthographic or contextual information at that point, and final responses, which seemed to be indicative of the order imposed by the subject if an attempt was made to produce meaningfulness.

Results

Reading Time. Poor readers took considerably longer to read each passage than did good readers. An analysis of the time data for the first passage indicated that mean reading time for good readers,

121.2 seconds, was significantly different ($F(1, 28) = 9.43$, $p < .01$) than that of poor readers, 249.4 seconds. Similar differences existed on reading time for the second passage with the mean of good readers, 119.4 seconds, again significantly faster ($F(1, 28) = 10.81$, $p. < .01$) than that of poor readers, 243.3 seconds. Poor readers required approximately twice as long to read each passage as did good readers. These longer times seemed not so much attributable to long isolated pauses as to simple word by word reading which was much more predominant among poor readers.

Responses to non-target words. The two groups exhibited significant differences ($F(1, 28) = 12.87$, $p. > .01$) in general (non-target) word identification accuracy, the good reader group performing at a near perfect 99.5 percent accuracy level and poor readers at 95.6 percent accuracy (remember the experimental materials were selected to approximate reading level of the poor reader group). Poor readers then, exhibited less accurate word identification skills. However, in addition to frequency, misread words were evaluated for contextual appropriateness. These analyses indicated that while poor readers exhibited a greater percentage of misread non-target words, there was no significant difference between groups ($F(1, 28) = 1.23$, $p. < .27$) on the percentage of misread words which made sense in relation to preceding contextual constraints. Thus, while good readers were more accurate on non-target words, poor readers cannot be characterized as responding primarily to orthographic information; the data seem to point to a reliance by the poor readers on contextual information. This is congruent with the results of others (Weber, 1970) who have found no differences between good and poor readers' use of preceding contextual information when reading aloud.

Responses to target words. Table 1 summarizes the data for initial responses to target words containing an altered character. Responses for each passage read were quite similar to overall performance, indicating good readers responded with the altered word 40% of the time (120 responses of 300 total responses) while poor readers responded with the alteration only 27% of the time

TABLE I. Initial responses to target words.

		PASSAGE 1		PASSAGE 2		BOTH PASSAGES	
Read alteration		*Good*	*Poor*	*Good*	*Poor*	*Good*	*Poor*
first response	Σ	64	42	56	41	120	83
	$\bar{X}$	4.26	2.80	3.73	2.73	8.0	5.53

(83 of 300 responses). Both groups at times ignored the semantic and syntactic constraints (assuming of course this information was always strong enough to cue a prediction), responding instead to the graphic information.

Application of an analysis of variance found that while not reaching traditionally accepted levels of significance—$F\ (1,28) = 3.19$, $p.<.08$ and $F\ (1, 28) = 2.92$, $p.< .10$—the differences between groups on both passages suggested that good readers were more likely to be attending to graphic information than were poor readers. The poor readers read what could logically have been expected based upon the contextual information. However, it should be noted that subjects in both groups were generally responding not to the graphic information in the altered words but more often supplied the contextually appropriate original word (the word in the passage prior to the alteration of a character). In fact both groups responded with the original word 56% of the time, thus all the available graphic information was ignored more than half the time by both groups of subjects. Poor readers, however, were more likely to respond with some other contextually appropriate word than good readers, ignoring graphic information to an even greater extent.

A second comparison was labelled attempts at meaning; this was a simple tally of the number of responses to the target words. That is, subjects often responded more than once to the altered words. For instance, a subject might have first read the target as printed (ignoring contextual constraints and responding instead to graphic information), reread again as printed after a regression and finally regressing once more rejecting graphic information and responding with the original word which was, of course, contextually appropriate. This sequence would have provided a score

of two on the attempts at meaning; that is, two attempts beyond the first response were elicited. The good readers had a mean of 8.33 attempts at meaning across both passages while the corresponding value for poor readers was 7.13. An analysis of variance indicated the groups did not differ on this characteristic ($F(1, 28) = .57$, $p. < .45$).

Discussion

These results are highly congruent with those reported by Rayner and Kaiser (1975) who used somewhat older subjects (reported only as sixth grade, junior and senior high school students). Though a similar research paradigm was employed, they reported no direct statistical comparisons for the more and less skilled readers. The several modifications of procedures and materials in the present experiment, in addition to the statistical tests, seem to add to the generalizability of our data.

The results are also quite similar to those of Kolers (1975), who assessed recognition memory for sentences read by good and poor readers. He concluded that "good readers were far more sensitive to typographic characteristics of sentences than poor readers were" (p. 284). Similarly, the poor readers in that study exhibited significantly slower reading times than the good readers and the less skilled group also made more word identification errors. However, like the subjects in the present study the two groups did not differ in substitutions which fit the contextual framework. These similarities are even more striking when one considers that the subjects in these two separate studies differed substantially on age ($\bar{x} = 12.3$ vs. 9.6), grade placement (7th vs. 4th), and reading abilities ($\bar{x} = 9.5$ and 4.7 vs. 4.9 and 2.9). Furthermore, Kolers' transformed text, as an experimental manipulation, presented the letters in reversed orientation as contrasted with our technique of grapheme substitution. Both experimental paradigms required oral reading but Kolers (1975) employed sentences only, while we required subjects to read two separate stories.

As noted at the beginning of this paper, it has been suggested (Smith, 1971; 1975; Goodman, 1969) that as reading ability develops relatively less use is made of orthographic information with the good reader attending relatively more to contextual

information. Conversely, poor readers might then be depicted as making less effective use of contextual information while depending more heavily on orthographic cues. These data do not support such formulations of reading ability. In fact, the similarity of the data patterns to those of Kolers (1975) makes his statement that follows as apt a summary to our study as it was to his: "The results of the present tests are not consistent with such a hypothesis, as shown by the finding that it was the good reader rather than the poor one who was more sensitive to features of typography. . . ."

However, while not wholly consistent with this hypothesis, the fact that more than half of the initial responses (to the target words) of both groups in the present study were the words which had been present prior to alteration indicates that contextual information is a powerful source of information in word recognition. This supports Weber's (1970) contention that "children, no matter what their potential for acquiring literacy skills, bring to the task a fundamental linguistic ability" (p. 154). Reading is a language process but it is also a visual receptive process, thus necessitating attention to both sources of information: contextual and orthographic.

The data suggest complex interactions between the various cues within the reader and the cues (or information) available in printed connected text (Pearson and Studt, 1974). The relative availability, accessibility, and employment of information sources —such as experience, background, oral vocabulary, contextual richness, word frequency—seem to play as an important role as a subject's reading ability. In fact, these results when combined with a variety of other recent data (Allington and Fleming, 1976; Samuels, Begy and Chen, 1975; Kolers, 1975; Rayner and Kaiser, 1975; Guthrie, 1973) seem to suggest that the relative *efficiency* with which these sources are tapped *integratively* may be what distinguishes a "good" reader from a "poor" reader.

Limitations. Several limitations of this study must be noted. First, the experimental task was oral reading. While we feel that this task is an infinitely more acceptable paradigm than tachistoscopic recognition of words or letters, or recall of letters, figures, etc., for

those who would investigate reading ability, oral reading does not seem to be an identical process to silent reading (Mosenthal, 1976). Thus the generalizability must necessarily be viewed within a model of oral reading ability.

Similarly, understanding is the ultimate goal of all reading, but understanding (or comprehension) of the printed message was not required in this experimental setting.

Finally, the task demands may have influenced response patterns. That is, each subject in this study had to decide individually what "read it the best that you can" meant.

Further research. The grapheme substitution paradigm seems an effective method to manipulate experimentally orthographic characteristics of text within a framework quite similar to the task demands normally required when reading. That is, visual exposure time is not manipulated, nor is text orientation, nor typographic clarity. Thus, use of this strategy keeps the research in closer proximity to the natural task demands. Our reduction of character alterations from the level used in the Rayner and Kaiser study (1975) to one letter alteration per 10 words seems to be less disruptive, allowing subjects in some cases to read without noting any of the anomalies.

However, future research might attempt to further constrain alterations. Some of the most promising, in terms of information about visual receptive functioning in reading, would seem to be: (a) limit alterations to words of single syntactic class, (b) alter characters in contextually varied situations, (c) alter characters in relation to phrase boundaries, and (d) vary directions as well as alterations (e.g., alert subjects to anomalies but tell them to attempt to ignore them).

Summary. Using a research paradigm which was felt to more closely approximate the "natural" task demands of reading, this study demonstrated that good and poor readers seem not to differ in their use of contextual information when reading in connected text. Further, good readers seemed to attend more closely to graphic information than poor readers even though they processed text significantly faster. Finally, it was suggested that the data

point to a complex interaction of information sources and that a major difference between good and poor readers may be the efficiency with which the information sources are integratively employed.

1. Though we chose to use the terms grapheme (or character) alteration, it must also be noted that the constraint that text alteration had to result in another word, in effect, simultaneously created a semantic alteration. Thus, a subject who read the altered word as printed produced a response that agreed with the graphic cues but violated semantic constraints. This, of course, was the basis for the hypothesis we hoped to test.

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