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FAILURE IN BEGINNING READING: PROBLEMS IN MASTERING A COMPLEX COGNITIVE TASK

by

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Abstract

FAILURE IN BEGINNING READING: PROBLEMS
IN MASTERING A COMPLEX COGNITIVE TASK

By

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Children's problems in mastering beginning reading skills were studied by examining the correlates of the performance of second and third grade average and poor readers on a list of words commonly found in basal readers in grades one through four. The approach taken was to use characteristics of persons (such as, their phonemic segmentation skill) to predict their performance reading the word list and to use the characteristics of words such as, the complexity of their letter-sound correspondences to predict the number of errors made on each word.

The results suggest, as hypothesized, that the complexity of letter-sound correspondences within words is a critical factor in beginning reading failure. Students who had not mastered the complex letter-sound correspondence system were less likely to read words correctly than students who had mastered the correspondences. Also, words which are more complex in terms of the number and difficulty of their letter-sound correspondences were less likely to be read correctly than words with few and simple correspondences.

Grade level also emerged as an important variable. As hypothesized, the categorization of the words according to the grade level at which they are typically included in basal readers was a

powerful predictor of reading errors on individual words and the grade level of the subjects was also a good predictor of subjects' success on the word list. Third-grade subjects read 85 percent of the words correctly, while second-grade subjects read only 58 percent correctly. This suggests that instruction may play a role in beginning reading failure.

Other variables were not found to be related to beginning reading failure. As hypothesized, phonemic segmentation skill was not related to performance on the word list. Contrary to what was hypothesized, however, vocabulary knowledge, and intellectual ability, as represented by a score on the Cognitive Abilities Test, were not related to the subjects' performance on the word list.

Taken together, the analyses of both person and task characteristics suggest that failure in beginning reading results from the increasing complexity of letter-sound correspondences in words and students' problems mastering that complexity through instruction.

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CHAPTER 1

INTRODUCTION

A topic which is prominent in current reading research is phonemic segmentation. It has been suggested that many children do not learn to read because they do not realize that the single accoustic segment of a syllable such as "cat" is actually composed of three individual abstract phonemes. As a consequence children have problems learning letter-sound correspondences and have problems learning to read. Williams (1980) and others have incorporated this hypothesis into reading programs designed to remediate reading failure by including training in phonemic segmentation. Vellutino (1980) recommends that practitioners working with poor readers teach the skills of phonemic segmentation and awareness.

However, as recently as fifteen years ago researchers and practitioners alike held quite a different notion of reading failure. Phonemic segmentation had not yet been "discovered;" perceptual deficits were ascribed a major role in reading failure. These perceptual deficits were thought to be manifested in children's inability to accurately copy geometric figures, their tendency to reverse and confuse some letters, in their problems with duplicating sound patterns and making same/different judgements about words that differed in only one phoneme. A typical training program then in vogue, such as the Frostig program, offered children practice in visual motor coordination to improve their reading skills.

To return to the present, at the same time that reading programs based upon phonemic segmentation training are being introduced into classrooms, there have appeared in recent literature some indications that the importance of phonemic segmentation might be limited to the initial stages of beginning reading instruction only and that other verbal factors such as the ability to deal with the complexity of letter-sound correspondences and knowledge of vocabulary might be more important.

The purpose of the present paper is to review critically various notions of reading failure that have held sway in this century and to report research designed to clarify the role of phonemic segmentation, the complexity of letter-sound correspondences and other factors thought to play a role in the failure of students to read words presented in lists. A unique feature of the present study is that these variables are examined both as they are manifest in characteristics of persons and in characteristics of the task of reading words. In other words, the following related sets of questions are examined: what characteristics of persons, i.e., what abilities or skills are responsible for success or failure in decoding; and what is it about the task of reading words, i.e., what characteristics of words make them difficult to read? The simultaneous examination of both person and word characteristics provides an advantageous perspective from which to evaluate various hypothesized causes of reading failure.

As is apparent from the range of variables studied, the present study will not assume the existence of a single major factor responsible for word reading failure but will instead be based upon a model of the reading process which incorporates various skills and sources of knowledge, any combination of which might be responsible for beginning reading failure. To identify possible causes a broad spectrum of literature was reviewed.

However, the review should not be construed as an all inclusive survey of possible causes of reading failure. It will not deal with variables such as: the special problems associated with learning English as a second language, the problems speakers of non-standard English might have learning to read and problems associated with poverty and low educational aspiration. Further, it should be noted that the review and the research presented is limited to the beginning phase of the process of learning to read: it is concerned with students' ability to read individual words; it is concerned with students' decoding skills. This focus was adopted to limit the scope of the study. However, this approach is consistent with the view of many researchers (e.g., Shankweiler and Liberman, 1972 and Stanovich, 1980) that the major problem in beginning reading is with decoding, instead of the view that non-readers are competent decoders but have problems with comprehension.

The review will begin by examining some notions about reading and approaches to reading instruction which have been popular since 1900. The notion that reading failure can be ascribed to perceptual deficits will be examined in detail and rejected. Next, selected research undertaken in the 1970's will be examined. This research attempted to understand beginning reading failure given the rejection of the primary role of perceptual factors. Examination of this research will lead to the questioning of the assumption that phonemic segmentation poses a major stumbling block to reading acquisition and will lead to the examination of the role of the complexity of letter-sound correspondences and other processes which have received attention from researchers looking at what have been called "top down" processes.

Interestingly enough, cognitive abilities, or intelligence, a crucial variable in the process of learning to read, has received only limited attention. Researchers have generally accepted the assumption that some children could not learn to read because they were not "smart" enough and they made little or no attempt to understand why children of limited intelligence had trouble learning to read. The intellectual ability variable was treated as a contaminating variable. Samples of good and poor readers differed in their intellectual ability; thus, a researcher had to control for intelligence. This made sense since the processes under study were perceptual and these processes are not closely related to intelligence. However, with the recent focus on verbal and not perceptual factors, the methodology of controlling for intelligence has been questioned since the verbal factors under study are closely related to tasks used to measure intelligence. Thus, the last section of the review will examine recent data on the effect that the procedure of controlling for intelligence has on the results of a study. The research presented will not employ a methodology which controls for intelligence.

To summarize, the review will document the dramatic changes in the teaching of reading and conceptions of reading failure, and will conclude that: phonemic segmentation skills, the complexity of letter-sound correspondences, vocabulary and intelligence are variables which should be examined as possible causes of failure in beginning reading.

The review of the literature is followed by an experiment designed to clarify the relative importance of the variables suggested as possible causes of beginning reading failure. As mentioned above, a unique feature of the present research is the examination of relevant variables as they are manifested in persons and as they are manifested in the task. For example, consider the vocabulary variable. As a person characteristic it represents a subject's knowledge of the meaning of a set of words. Analysis can then determine if subjects who know the meaning of many vocabulary words on a list can read more words correctly on that list than subjects who know the meaning of few words.

Vocabularly can also be examined as a task variable, that is, as a characteristic of words. By having all the subjects in the study give the meaning of the words a rating of the semantic difficulty of each word can then be developed. Analysis can then determine if words with high semantic difficulty (that is, words for which few subjects knew the meaning) are also hard to read.

Specific hypotheses are proposed and tested. For example, it is hypothesized that phonemic segmentation skills are a stumbling block only in the initial stages of beginning reading instruction, and that the complexity of letter-sound correspondences in words assumes a much greater role in beginning reading failure than phonemic segmentation.

Since the review of the research will reveal that little work has been done on quantifying the complexity of letter-sound correspondences, and what work that does exist is plagued by problems, a major contribution of the present research effort is the development of a rationale and a system for quantifying the various complex aspects of letter-sound correspondences which cause difficulty for the child in reading. The crucial test of the development effort, is whether, and to what degree the newly developed index of orthographic difficulty can predict error rates for lists of words.

The final chapter will combine information from the separate analyses of person and word characteristics in an attempt to answer the question of why students are having problems learning to read individual words.

Limitations and assumptions

The following items describe a number of limitations of the present study in terms of its scope and the methodology employed. Also described is an assumption about the role of phonetic coding in reading.

1) As mentioned above, the review of the literature and the reported research is limited to beginning reading which is defined to mean the skills involved in translating the printed letters in a word into sound, that is, beginning reading refers to that stage of the reading process when students learn to decode words.

2) Although the focus of the review is to identify the "causes" of failure in beginning reading, the reported experiment is correlational in nature. It is understood that significant correlations do not imply causality. The height of a young child and vocabulary size are certainly correlated. Yet, no one would claim that an intensive course in vocabulary development would cause a growth spurt or vice versa.

However, correlational analysis can play a role in establishing causality. If, for example, the significant correlation between reading achievement and phonemic segmentation ability disappears as one examines correlations from kindergarten to third grade samples, that is, if even poor readers master phonemic segmentation by third grade and still can't read, then the correlational analysis has played a role in eliminating a variable as a possible major cause of reading failure after first grade. Further correlational analyses must then be used to identify other variables which might be involved in students' failure to learn decoding skills.

Thus, although the limitations of correlational analysis are recognized, also recognized are its efficacy in eliminating variables as possible causes and its potential for identifying variables which co-vary with beginning reading failure as a necessary first step in establishing causality.

3) For the purposes of this study it is assumed that beginning readers make use of letter-sound correspondences in reading in deriving meaning from print. Although there is considerable debate on the role of phonetic coding in skilled reading (e.g. see Baron, 1976), there is much more agreement that phonetic coding plays a role in beginning reading (e.g. see Weaver and Resnick, 1979; Resnick, 1979 and Vellutino, 1980).

Indeed, if one of the hypotheses of the present study is supported by the data collected, that is, if the complexity of letter-sound correspondences is related to beginning reading failure, then further support would be offered to the assumption that phonetic coding does play a role in beginning reading.

CHAPTER 2

The Rejection of the Perceptual Deficit Hypothesis

It is likely that problems with learning how to read began when the first humans decided upon a set of symbols to represent words or ideas in their spoken language. Attempts to develop written language took many forms. Some systems used symbols to represent words or ideas as does the Chinese language today. Other systems used symbols to represent syllables. One system used meaningless letter symbols to represent the individual sounds in the language. As Gleitzman and Rozin (1977) noted, a writing system using letters to represent sounds (employing the alphabetic principle) was invented last and only once. An alphabetic system represents an improvement over other written languages because it reduces the load on long term visual memory for symbols. An English speaking child has to memorize 26 symbols and a Chinese child, thousands. However, the alphabetic principle of written language also poses a problem in that its symbols are in no way directly related to meaning as were early systems of written language.

The process of teaching someone to read differs according to the characteristics of the language taught. In Chinese, for example, since the characters directly symbolize ideas or words, people learn to read Chinese by memorizing the characters. With written languages which employ an alphabetic principle, the teacher of reading has an option: letter-sound correspondences can be taught, or, students can memorize the visual characteristics of words (shape, letter sequences, etc.). Venezky and Massaro have asserted that, "From preclassical Greece to the present day, most literate people in the Western world have been introduced to reading through correspondences of letters and sounds."

(Venezky and Massaro, 1979, page 85). They cited, for example, The American Primer, used in the early 1800's, in which children learned individual and letter cluster sounds before being introduced to words. They indicated that by the 1900's this approach had evolved into a comprehensive phonics program with deliberate sequencing of letter-sound patterns, word families, and separate teaching of sight words, (see Beacon Phonetic Chart, 1912).

However, in the period from the turn of the century to the 1920's, a number of factors combined to alter this approach which emphasized phonics. One factor involved the fairly sophisticated research on the perception of letters and words conducted by psychologists around the turn of the century. Cattell (1886) and Huey (1908/1966) among others concluded that the perception of an entire word was just as quick as the perception of a single letter. The obvious conclusion was that people read by whole words and not by individual letters.

Another factor concerned the expectations for a skilled reader. As Matthews (1966) has noted skilled reading in the 18th century was considered to be the ability to read aloud, with correct phrasing and emphasis, a familiar text such as the Bible. There was little concern for the meaning of what was read. However, as a result of the increase in psychological testing particularly the testing of army recruits in World War I, it was discovered that many people could read aloud but had difficulty deriving meaning from a text (Weaver and Resnick, 1979). Thus, the expectations for skilled reader performance were raised; the reader was expected to be able to gain information and learn from what was read in addition to being able to say the words aloud.

Finally, the progressive education movement had an effect on reading instruction as the focus of education shifted from drill and extensive memorization to concern with function and meaning.

As Weaver and Resnick (1979) have noted, these factors combined in the 1920's to produce a radical change in reading pedagogy. Basal reading series were introduced in which reading for meaning was the focus from the beginning of instruction. The basal reader largely ignored letter-sound relationships and taught children to read using whole words which were slowly introduced and reinforced by repetitive use. Students read stories which had carefully controlled vocabularies including previously learned words and a few newly introduced words. By the 1950's the basal, whole word approach completely dominated the teaching of reading.

However, the teaching of reading through the learning of letter-sound correspondences began to make a comeback in the 1950's. Flesch's (1955) best seller, Why Johnny Can't Read and What You Can Do About It, laid the blame for reading failure on the use of the whole word method. Chall (1967) writing about the great debate on how to teach reading concluded that phonics instruction and not the whole word method was more effective in teaching beginning reading. Writing again in 1979, Chall noted that phonics instruction was again widespread in the schools.

Thus, the teaching of reading which for centuries had focused on the teaching of letter-sound correspondences underwent a radical change early in the 20th century: phonics instruction was largely ignored in favor of the whole word, basal reader technique. Understanding of this development is crucial in the development of an understanding of the theories of reading and reading failure proposed during this time.

The theories of reading and reading failure which have had influence in the latter half of the 20th century were proposed in the period from the turn of the century into the first half of the century. These theories developed as psychology itself developed as a science with its concern with perception and behavior, and they reflected the changes in the teaching of reading described above.

These theories assumed that reading was primarily a perceptual process; problems in reading were thought to result from a primary perceptual deficit. Orton (1925, 1937) first proposed a comprehensive theory of reading failure although as early as 1896, Morgan, in a case history, attributed reading failure in an otherwise normal child to perceptual dysfunction. Orton proposed that reading disability was caused by visual and spatial confusion which resulted from delayed or deficient lateral dominance. Orientation and sequencing problems evident when students have to identify letters and words were thought to be manifestations of this problem. Others who have advanced hypotheses similar to Orton's include Bender (1957), Hermann (1959) and Birch (1962).

Other examples of conceptions of reading failure included the notion that it was caused by: problems with intersensory integration (Birch, 1962; Beery, 1967), problems with temporal sequencing of auditory stimuli (Johnson and Myklebust, 1967; Kirk and Kirk, 1971 and Bakker, 1970) and problems with auditory discrimination (Wepman, 1960).

However, over the last 10 to 15 years a consensus has developed among researchers: such conceptions of reading failure are not defensible. This consensus of research opinion is remarkable in that it comes from different fields: from reading researchers and from researchers in the field of special education. The research has been characterized by simple yet powerful designs and acknowledgement of the limitations of low levels of correlational relationships.

In the field of reading Vellutino and his associates have been most active in testing the merits of the perceptual deficit hypothesis, (Vellutino, Steger, and Kandel (1972) and Vellutino, Smith, Steger and Kaman (1975)). Working with groups of subjects from grades two through high school who were roughly matched for intelligence and divided into normal and poor reader groups, they studied the subjects' ability to reproduce from memory geometric designs, numbers and letters. The subjects were also tested on copying, naming and pronouncing letters and words. The authors reported that there were no significant differences between the poor and normal readers on the reproduction of the geometric designs. That is, in terms of perceptual and visual motor integration (drawing the figures) the poor readers were not deficient. Poor readers did score significantly lower than normal readers on naming and especially pronouncing letter strings from memory. The clear implication was that poor readers do not have a perceptual deficit but do have problems in associating visual and verbal stimuli.

Other reading researchers have presented data which does not support the perceptual deficit hypothesis. Valtin (1981) working in Germany found that reading failure was not related to disturbances in visual perception. Also, Shankweiler and Liberman (1972) have reached a similar conclusion using a different approach. They constructed a list of words to contain a maximum number of opportunities for reversal and spatial confusion of letters, letter clusters and words. In examining the errors subjects made reading the words, they found that most of the errors were not perceptual in nature: choice of the wrong vowel sound and not reversals was the most frequent error. Again, the obvious conclusion is that verbal and not perceptual problems predominate in reading failure.

Finally, in the field of special education Hammill and Larsen (1974) and Larsen and Hammill (1975) have reviewed a large amount of research on the relationship between reading, and visual and auditory perception. They concluded that the correlations between these skills and later reading achievement were not high enough to be used for educational purposes. Hammill (1975) also concluded that training in perceptual motor skills was not effective in improving reading achievement.

In summary, the research conducted and reviewed by Vellutino, Shankweiler and Liberman, Hammill and Larsen, and others makes it clear that reading failure cannot be attributed to a perceptual deficit in most children who have problems learning to read.

CHAPTER 3

Verbal Processes Involved in Reading Failure

In the early and middle 1970's researchers who had participated in collecting data critical of the perceptual deficit and other hypotheses of reading failure directed their research towards the exploration of variables which might be more closely related to the reading process and reading failure. This chapter of the review of the literature will describe the work of these researchers in detail. The term, "verbal," has been selected as a rubric under which to group this research because the term is used by Vellutino and because it serves to differentiate this research from previous research which focused upon perceptual variables. However, the term, "verbal," should be considered in a broad sense. A partial list of the processes and skills examined by these authors includes segmentation ability, memory for sounds, ability to generate and use letter images in memory for sounds, knowledge of letter-sound correspondences and vocabulary size. All are examined to determine their possible role in beginning reading failure. This chapter will offer a description and critique of the research on these variables in order to determine which variables actually do play a role in reading failure.

As early as 1967, Liberman, Cooper, Shankweiler and Studdert-Kennedy began to study the relationship between phonemes (the individual sounds) in a syllable and the complete sound of a syllable. Using a tape recorder they tried to isolate (segment) the acoustic signal of a syllable into its component phonemes. While they were able to find a definite beginning and end (boundary) between two syllables occurring in a word, they were unable to isolate the individual sounds in a syllable. When, for example, a consonant vowel consonant (CVC) syllable is spoken the initial and final consonants are folded into the medial vowel so that the syllable actually has only one acoustic segment. There is no acoustic criterion by which one can isolate the component phonemes.

Liberman, Shankweiler, Fischer and Carter (1974) provided the first direct evidence that the segmentation of syllables into their component phonemes is a difficult task for young children and that it is more difficult than segmenting words into their component syllables. Liberman and her coworkers began their 1974 article with a discussion of spoken and written language. They noted that spoken language preceded written language and they discussed the various options for the representation of spoken language in written form. Written symbols can be used to represent sentences or phrases, words, syllables or the individual sounds (phonemes) of the language. Historically, word and sentence symbols were developed first; then syllables and finally, symbols were used to represent phonemes, (an alphabet). Liberman et al. saw a parallel between this historical development of language skills and the development of language skills in children.

The authors also noted that difficulties in segmenting syllables are not related to speech perception. Young children do not have difficulty distinguishing between, for example, bad and bat, two words which differ only in the last phoneme. They also cited Eimas, Siqueland, Jusczyk and Vigorito (1971) who presented data which suggested that even infants can discriminate "da" from "ta."

Liberman et al. (1974) tested preschool students (mean age, 59 months), kindergarten students (mean age, 70 months) and first grade students (mean age, 83 months) by asking them to tap with a small wooden dowel to represent the number of syllables or the number of phonemes in words or syllables. The results were reported in terms of the number of trials to criterion, number of errors before criterion and the percent of subjects reaching criterion. The criterion of success was set at six correct answers on consecutive trials. The reported results are presented in Table 1.

The authors concluded that, "explicit analysis of spoken utterances into phonemes is significantly more difficult for the young child than analysis into syllables, and it develops later." (Liberman et al., 1974, page, 209.) Examination of Table 1 reveals that no prefirst graders can segment syllables into phonemes while half of these children can segment words into syllables. At the end of first grade most students are performing well on both tasks with more students being able to master the syllable task.

They also discussed their findings in relation to reading failure suggesting that most children do not have problems with the visual identification of letters and in learning the sounds for individual letters, but they speculate that students' difficulty segmenting syllables might cause reading problems.

Subsequently, Liberman, her associates and others have presented data which established a correlational relationship between problems with phonemic segmentation and later beginning reading achievement. For example, Helfgott (1976), in a study of both phonemic segmentation and blending skills reported a correlation of .72 between kindergarten segmentation skills and reading achievement as measured by the Wide Range Achievement Test given a year later in first grade. In another

Table 1

<u>Percent of Students Reaching Criterion on Segmenting Syllables into Phonemes and Words into Syllables</u>. (From Liberman et al. 1974).

	Phonemes	Syllables
End of preschool	0	46
End of kindergarten	17	48
End of first grade	70	90

study Fox and Routh (1976) reported data on a group of four year old children which indicated that the four year olds could only profit from blending training if they could segment syllables into phonemes.

Shankweiler and Liberman (1972) presented further evidence on the importance of phonemic segmentation skill as part of a comprehensive research program designed to answer the often asked question of what constitutes the major barrier to reading acquisition. This research program will be considered in detail. Their approach to this far-reaching question employed a simple, but apparently powerful design: they compared second and third-grade students of average or above average intelligence in terms of the errors they made in reading words in lists, in reading paragraphs and in repeating words which were spoken to them. They concluded that the primary difficulty was at the level of the word; they found that there were not significant numbers of children who could read connected discourse but who could not read words in isolation. A rationale offered in support of this position was that problems in reading individual words with the resulting time delay caused the decay in primary memory of the preceding section of discourse.

Next, as noted in a previous section of this review, they dismissed the notion that a primary cause of reading failure is problems with the visual aspects of the words, i.e., with orientation and sequence reversals of the letters.

Shankweiler and Liberman went on to look more closely at the errors students made in reading words on a list of 204 one syllable (CVC, CCVC and CVCC) words constructed to give equal representation to most consonants and consonant clusters in initial and final positions and to vowels in the medial position. Each initial consonant or cluster occurred eight times as did the final consonants and clusters; each of eight vowel sounds occurred approximately 25 times. The results indicated that the second and third grade poor readers made the least errors on the initial consonants and clusters, more errors on the final consonants and the most errors on the vowels. By combining the percentages for the poor readers presented separately by Shankweiler and Liberman in their Table 6 and weighting the percentages by the respective n sizes of the various groups, the following percentages of error were obtained by the present author and are presented in Table 2.

They explained these results by concluding that final consonants are more difficult than initial consonants because to read a final consonant a reader must be aware of the fact that the word is composed of rather abstract individual phonemic segments which must be analyzed in order to produce the letter-sound correspondences. Thus, they hypothesized that students are missing the final consonants and clusters because of a lack of phonemic segmentation skill. What might be considered an alternative explanation, namely that orthographic rules are more complex in the final position thus producing more final position errors, is mentioned in a footnote; however, the authors state that they doubt whether it is an important factor in causing errors in the final position.

Another factor not considered by Shankweiler et al. which might contribute to an explanation of initial vs. final position differences is word frequency or prior learning. Although (or perhaps because) the list of 204 words was constructed to equalize the occurrence of the initial and final consonants and clusters, word frequency was not controlled. The list seems to have a preponderence of infrequently used words which

Table 2

Combined Percentages of Errors for the Poor Reader Groups Derived from Data Presented by Shankweiler and Liberman, 1972

Initial Consonants	Final Consonants	Vowels
10.3%	16.6%	24.9%

have difficult consonants or clusters in the final position. For example, the list contains the following words:

palp	talc	culp	whelp
soothe	balk	veldt	fez
plebe	posh	sheathe	

Looking at these words one could hypothesize that the second and third-grade readers had never previously seen these words and that in trying to decode them they would encounter more difficulty with the clusters in the final position since the clusters occur infrequently in the final position and they occur in infrequently occurring words.

In explaining why the vowels account for the largest amount of errors the authors switched from a phonemic segmentation argument to a reference to the complexity of the letter-sound correspondences in vowels. Citing the previous work of Venezky (1968), Weir and Venezky (1968) and Weber (1970) they attributed the difficulty with vowels to their orthographic complexity. The sounds of the letter <u>i</u> are always represented by the letter <u>i</u> in the list while the sounds of the vowel <u>u</u> are represented by seven letters or digraphs: <u>u</u>, <u>o</u>, <u>oo</u>, <u>ou</u>, <u>oe</u>, <u>ew</u>, <u>ui</u>. The correlation between each vowel's rank difficulty and its number of orthographic representations in their word list was .83. Hence, they concluded that the error rate on the vowels was related to the number of orthographic representations of each vowel.

It is also interesting to note that Shankweiler and Liberman reported that the error patterns for oral repetition of words showed some striking differences from the reading patterns reported above. Errors in the initial and final position were equally distributed while vowels accounted for fewer errors than the consonants.

The 1972 Shankweiler and Liberman findings supported the conclusion that visual preception problems are not a primary cause of reading failure. Problems with decoding consonants were attributed to phonemic segmentation while problems decoding vowels were attributed to their orthographic complexity. Factors which might affect the validity of some of their conclusions include the selection of many atypical words for the word list as well as the failure of the authors to explore the possibility that orthographic complexity might be involved in decoding consonants as well as vowels.

In summary, the consensus of research on segmentation skill is that it is related to early (first grade) reading. The research, however, is correlational in nature and there is some question as to the importance of segmentation skill beyond the very beginning of first grade and to its relative importance when considered along with other factors such as the complexity of letter-sound correspondences within words. Data relative to these concerns will be presented later in the review.

Vellutino is another researcher who has conducted research designed to identify the nature of the verbal deficits which might play a role in reading failure. Vellutino, Harding, Phillips and Steger (1975) examined fourth, fifth and sixth-grade subjects of middle and upper-middle class SES who were assigned to a poor reader group (two or more years below grade level) or a normal reader group. Subjects for both groups had either a verbal or performance IQ score of 90 or above. They found that poor readers did not have trouble with visual-visual association and transfer tasks while they did have problems with visual-verbal tasks. The authors concluded that children with specific reading disability do not have difficulty abstracting and generalizing invariant components of words because of a basic dysfunction in categorical processing but, rather, that they have a specific problem with visual-verbal association.

Vellutino and Scanlon (1979) reported the results of a series of experiments designed to shed further light on the verbal deficits of poor readers. Their work will be considered in detail because they accept an hypothesis which would seem to conflict with the previous research findings of Vellutino and his associates on the role of visual-verbal association in reading failure.

Their work was an ambitious study designed to provide both correlational and experimental evidence to evaluate the relative merits of the following hypotheses:

> "...poor readers' difficulties in code acquisition [learning to decode words] are attributable to dysfunction in verbal recall, presumably associated with basic deficiency in phonetic coding [remembering sounds] and structural analysis [phonetic segmentation]."
>
> "...difficulties in code acquisition...arise because of specific impairment in associating visual and verbal information."
>
> The problems described in hypotheses one and two "occur because of acquired processing strategies that minimize the tendency to code information phonetically."
>
> (Vellutino and Scanlon, 1979 p. 27).

The average and poor second and sixth graders were pretested on a measure of phonetic segmentation ability and divided into three treatment and two control groups, with good and poor readers roughly matched for intelligence using the Slosson Intelligence Test (1963). The treatment groups were subjected to a 20 to 30-minute training session for five or six days that focused on phonetic segmentation and/or response acquisition. Then all the subjects participated in short response acquisition, alphabetic training and alphabetic transfer tasks of one session each. In the response acquisition training the subjects were to learn six nonsense syllables such as "gov" and "zab." The subjects heard the word, then counted forward to a specified number and then they had to repeat the word.

In the alphabetic mapping task the same six syllables were paired with symbols made up of three graphemes (such as 7 for "g"), with invariant one-to-one correspondences between the graphemes and the individual phonemes in the syllables. Finally, an alternate form of the phonetic segmentation test was administered as a posttest to all subjects.

Vellutino and Scanlon reported that the first of the three hypotheses was the most viable because poor readers did worse on auditory memory for nonsense syllables and continued to do worse when the syllables were paired with pictures. That is, the authors concluded that auditory memory for sounds and not difficulty in learning visual-verbal associations was the primary problem associated with reading failure. They also reported that the poor readers' low scores on the measure of phonetic segmentation indicated that difficulties in code acquisition may be due to deficiencies in segmentation ability. Finally, they reported that the segmentation training was successful in improving the scores of all readers including the poor readers on the posttest; however, since the poor readers' performance did not improve to the level of the normal readers, they concluded that the learning and memory deficits are not easily remediated and thus constitute a basic deficiency.

A number of problems with the data analysis and the conceptualization and design of the study call the above conclusions into question. The first problem is that a portion of the data analysis (based upon comparison of a significant double interaction and a non-significant triple interaction) erroneously concludes that the five-day training in segmentation analysis increased segmentation ability in both normal and poor readers. The analysis technique of comparing the double and triple interactions does not address the question of whether or not specific treatment-control comparisons are significantly different. Inspection of their table 2A suggests that the comparison of the posttest means of the average readers in the phonemic segmentation, response acquisition treatment group and the response acquisition treatment group (41.07 - 32.4 yielding a difference of 8.7) was probably responsible for the significant double interaction; it is likely that the absence of a three-way interaction was due to the lack of statistical power resulting from only 15 subjects per cell.[1]

Thus, it was not correct to conclude that segmentation training helped the poor as well as the normal readers. The poor reader groups receiving segmentation training had posttest means of 28.73 and 29.07 while a control group of poor readers had a mean of 28.33. These differences between treatment groups and one of the control groups of

1 In a telephone conversation in January, 1984, Professor Vellutino indicated that the conclusion that phonemic segmentation training helped the poor as well as the normal readers was made in haste before the AERA conference. In a verson of the same paper, which is currently being prepared for publication, the authors will not conclude that the segmentation training helped the poor readers.

.4 and .74 can not be considered significant in light of the fact that random pretreatment differences among the groups ranged as high as 2.2. The poor readers did not profit from segmentation training.

A second problem is that the measure of segmentation ability might not have been optimal. The first part, which asks students to make same - different judgments on minimally contrasted words, employed a procedure similar to a procedure considered invalid by Wallach, Wallach, Dozier and Kaplan (1977) and criticized by Samuels (1973). This task includes difficult instructions and requires a knowledge of the same - different concept. Thus the task probably measures much more than segmentation ability.

Third, the rationale of why segmentation training should improve response acquisition was not adequately developed. A detailed description of the phonetic segmentation training obviously could not be provided; however, it would seem from the description offered that it concentrated on awareness that syllables and words could be broken down into phoneme segments and it did not concentrate on training letter-sound relationships. Assuming that phonetic segmentation awareness and ability is a prerequisite for learning alphabetic mapping, it does not follow that segmentation training in itself should improve memory for the sound-symbol correspondences used in the task. After subjects understood and mastered the principles of phonemic segmentation they would then need training on the sound-symbol correspondences used in the task.

Fourth, and most basically, it does not seem likely that the design of the experiment succeeded in isolating "pure" auditory memory for sounds from the ability to integrate or associate visual and verbal information, and from other variables. To the extent that the good readers, when presented with the sound, "gov," were able to provide for themselves an image of the symbols, g o v, it is possible that the symbols could have facilitated their recall of the sound. Therefore, it might not be justified to conclude that visual-verbal association ability is not a primary cause of reading failure. The experimental procedure was, in this author's opinion, not successful in separating and isolating the effects of pure auditory memory from visual-verbal association (mapping sounds to symbols).

It would have been possible to test the assumption that previously learned associations between phonemes and graphemes were available to facilitate learning. If, after the interpolated counting task the good readers were able to write the letters, "gov," for example, after hearing the sound, "gov," then it could be assumed that the grapheme-phoneme correspondences were available and might have played a role in their memory.

The poor readers, on the other hand, who might not have had previously-learned associations between letters and sounds, would not have had them available to help them code, discriminate and remember the sounds. The very fact that they had to count between hearing and repeating the sounds prevented them from using verbal rehearsal and in addition, presented them with the task of doing two things at the same time--counting and remembering the sounds--which might have caused them difficulty. Indeed, the process of counting might have been more difficult for the poor readers. It might have been harder for them to count, i.e., it required more concentration, which might have been responsible for reducing their scores. Another way to assess whether or not visual-verbal integration played a role in this task or similar tasks would be to test the number of letter-sound correspondences known to the subject, as well as the speed and automaticity with which the associations were available.

A fifth problem with the experimental procedure is that many subjects in the treatment group labeled response acquisition did not learn the responses to criterion because training was terminated after fifteen trials. After the free recall and picture-syllable tests were administered to test the effects of the response acquisition and segmentation training (and the results documented the fact that many subjects in the response acquisition group had not learned the responses), the subjects should have been trained to criterion on the responses before being exposed to the crucial code acquisition and transfer task. The subjects who did not know the responses would continue to be penalized on this new task, and thus differences which might have existed between the treatment groups could have been masked.

The conclusion in the Vellutino and Scanlon (1979) experiment that reading failure results from deficiencies in auditory memory for sounds in the absence of visual symbols is, in fact, in conflict with the previous research findings of Vellutino and his coworkers which supported the notion that reading failure was related to problems with visual-verbal association, namely, learning letter-sound correspondences. It is the present author's contention that faulty design and data analysis techniques led to the rejection of the hypothesis that visual-verbal association skills are important both in remembering sounds and learning letter-sound correspondences. In fact, the assumption that the auditory memory for sound task did not involve the use of visual associations is contradicted by experimental evidence offered by Ehri and Wilce (1979) that beginning readers can and do employ visual symbols (letters) in remembering sounds even if they are not provided by the experimenter.

Ehri and Wilce (1979) reported a series of four experiments which like Vellutino's work is concerned with identifying the processes which are operative in beginning reading and examining the degree to which these processes are in place in good and poor readers. They examined how first and second-graders store speech sounds in memory and the role orthography plays as a representational system. Their basic task employs a limited set of consonant-vowel-consonant (CVC) nonsense syllables which must be given as responses in a paired associate task to squiggles, the initial letter of the CVC syllable and numbers. The role of the mnemonic value of orthography was investigated by providing in various ways (e.g. visually, orally) the spellings (or in one case, misspellings) of the syllables as study aides.

Although beginning readers are able to remember and orally reproduce a large number of words, Ehri and Wilce's results indicated that beginning readers have a poor memory for meaningless speech sounds at the level of the phoneme or syllable. Using first and second-grade students for subjects, which were selected without prior knowledge of their reading ability or intelligence, they found that correct spellings provided a powerful mnemonic for remembering the responses and that readers can supply their own spellings if not provided. They also reported that the unsuccessful sound learners (the poor readers) were able to master segmentation of syllables of three but not four phonemes:

"The majority of mistakes on the phonemic segmentation task occurred on words or sounds containing four phonemes (i.e. dulp, brin, milk, horn, kest, grass). Even poor readers were successful on units with three or fewer phonemes" (Ehri and Wilce, 1979, p. 33).

Also of interest, is the information provided on the testing of phoneme-grapheme correspondences in the CVC spelling production and the CVC sounding out tasks. In both cases the good readers are at the ceiling of the tasks with attenuated standard deviations while the poor readers, in terms of the total number of items on the tasks, are 48% and 53% below the performance of the good readers. Poor beginning readers simply have not mastered phoneme-grapheme correspondences.

To summarize, the work of Ehri and Wilce is important to the present review because it suggests, contrary to the assumption underlying the Vellutino and Scanlon (1979) experimental design, that memory for the phonemes of the letters in the alphabet can not be isolated from the visual images of their spellings. Also important are data that indicate that the basic process of phonemic segmentation is not difficult for poor readers but that poor readers do fail when they have to segment more complex words or syllables. Finally, their data on subjects' spelling and sounding out words indicates that poor readers have not mastered letter-sound correspondences even though they can name the letters of the alphabet. It is to be noted that there is a difference between the visual-verbal associations of letters and their names, on one hand, and letters and their sounds, on the other hand. The former is actually a one-to-one correspondence system in which individual correspondences are actually associations between a visual symbol and a syllable. For example, the name for the letter "B" is actually a syllable which can be written as, "be." The latter is a complex correspondence system in which individual correspondences are associations between visual symbols and meaningless abstractions, phonemes. Thus, it would seem that poor readers have problems with the more abstract and complex relationships between letters and their sounds, not between letters and their names.

Firth (1972) is another researcher who has examined many "verbal" factors as causes of reading failure. His work differs from the work of other researchers examined so far in this chapter in that he examined a large number of variables as possible causes of reading failure.

As part of his doctoral dissertation, he conducted a comprehensive correlational survey of the ways in which average and "bad" (his term) readers differ. Based upon his conclusion that reading and intelligence are essentially independent, Firth developed a unique methodology in which he sought out subjects to fill all four quadrants of the matrix, presented in Figure 1.

By making comparisons across the bottom row of this matrix (which is labeled "total"), he was able to answer the general question of how "bad" and average readers differ. Analysis of the first two rows of the matrix answered the specific questions of how "bad" and average readers of low intelligence differ, and how "bad" and average readers of average intelligence differ. Unfortunately, he does not address the questions: how "bad" readers of low and average intelligence differ, and most importantly, how average readers of average intelligence differ from "bad" readers of low intelligence.

As noted above, Firth's work is important for this section of the review because of his examination of a large number of skills and tasks which might play a role in reading acquisition and reading failure. For example, under the heading of "auditory analysis" Firth studied phonetic segmentation ability which is the central theme of the work of

		Reading	
		Bad	Average
Intelligence	Low		
	Average		
	Total		

Figure 1

Matrix representing Firth (1972) reader group comparisons

Liberman and her co-workers. Paired associate tasks similar to those used by Vellutino and Scanlon (1979) were administered as were tasks involving visual discrimination. Auditory discrimination and blending were tested using the Wepman and the Roswell-Chall tests. Simple alphabetic tasks relevant to the work of Ehri as well as Vellutino were also included. Thus the unique value of this research is that it contains a comprehensive battery of many of the skills that other researchers have hypothesized are relevant to beginning reading. The fact that they were all administered to the same sample of subjects provides a rare opportunity to ascertain the relative importance of these various skills.

Based upon this comprehensive investigation Firth reached the following conclusions. First, the skill which most clearly distinguishes the average from the "bad" readers was the subjects' ability to pronounce nonsense words, which Firth labels a phonics skill since none of the words were ever seen or practiced by the subjects. However, Firth cautions that phonics should not be considered important in its limited sense since subjects' ability to associate single letters with sounds (Neale Letter Sound Test) was not highly related to reading achievement. There was considerable overlap between "bad" and average readers on this test. However, tests involving more complicated phonics skills were good predictors of reading achievement.

Firth reports that the second best predictor was the auditory analysis test (phonemic segmentation). The Roswell Chall test was also a good predictor. Finally, skill in visually recognizing high-approximation letter sequences, i.e., sequences of letters which closely approximate the sequences of letters in actual words, also differentiated average and "bad" readers. Since there was an interaction between high and low-approximation letter strings Firth reasoned that phonics ability also played a role in this task since the high approximation strings were pronounceable.

These two conclusions support the conclusions reached earlier in this chapter on the importance of phonemic segmentation, and the learning and using of letter-sound correspondences. Phonemic segmentation is important, but not as important as the ability to use knowledge of complex letter-sound relationships to do well on the nonsense word test.

To return to Firth's work, he also addressed the question of whether or not the results were different when average and "bad" readers of low intelligence are considered separately from average and "bad" readers of average intelligence. The answer to this question was negative since on all of the best predictors the same relationships obtain across the two reader groups of both low and average intelligence.

A final point to be made about these results concerns an informal analysis conducted by the present author of Firth's data looking at differences between average readers of average intelligence versus "bad" readers of low intelligence. Although this comparison was ignored by Firth, it, nevertheless, provides an alternate conceptual (methodological) approach to the general question of how average and "bad" readers differ, which does not give equal weight, for example, to the statistically rare subjects who are average readers but who received a low intelligence score when forming the general group of average readers.

Re-examination of Firth's data comparing just low intelligence, "bad" readers to the average intelligence, average readers suggested that other variables might be important. The following list presented in Table 3 details variables for which there were at least two-thirds of a standard deviation difference and for which, based upon examination of cell means, standard deviations and F ratios of analyzed differences, there might have been a significant F ratio resulting had the comparison been analyzed.

When the results are analyzed this way (using a methodology which does not control for intelligence) a new set of variables emerges which might differentiate good and poor readers. Vocabulary, for example, might be considered as a factor involved in reading failure as are other skills related to verbal intelligence such as guessing words from context and memory for sentences. The relationship between vocabulary knowledge and reading achievement will be dealt with later in the review.

To summarize, Firth's work is important because of the range of skills and processes he examined. Although his work indicated that phonemic segmentation is important to reading failure, the nonsense word test, which involves a high degree of knowledge of orthographic relationships, is assigned a role of greater importance. Also, informal reanalysis of his data, without controlling for intelligence, suggests that verbal ability skills such as vocabulary and using context also might be important.

Summary

In this chapter the work of Liberman, Shankweiler and their associates, Vellutino and his associates, Ehri and Wilce, and Firth was reviewed and critiqued. A number of conclusions can be drawn.

It seems likely, based upon the work of Liberman et al. (1974), Helfgott (1976), Shankweiler and Liberman (1972), Firth (1972) and Ehri and Wilce (1977) that phonemic segmentation is a significant correlate of early, or first grade, reading achievement.

Table 3

Comparisons Between the Low Intelligence "Bad" Reader Group and the Average Intelligence Average Reader Group Expressed as a Numerical Difference of Cell Means and as a Percent of the Overall Standard Deviation.

Variable name	Numerical Difference	Percent of S.D.
Watts Vocabulary Test	6.8	1.1
Guessing words from context	6.3	.8
Memory for sentences	3.7	.9
Neale Letter Sound Test	3.8	.9

Also, it seems clear that average and poor readers have problems with visual-verbal associations, not at the syllable level since poor readers can name the letters of the alphabet, but at the phoneme level where the reader must learn complicated associations between letters and letter units, and individual sounds which are actually abstractions. Data in support of this position can be found in Vellutino et al.(1976), Ehri and Wilce (1979), Shankweiler and Liberman (1972) and Firth (1972).

Finally, returning to phonemic segmentation, there is indication that the skill is important only in the reading of words of at least four segments (Ehri and Wilce, 1977), that other factors, namely the complex letter-sound correspondences and vocabularly, might be more important factors in reading failure (Firth, 1972).

Consequently, in the next chapter of the review the nature of letter-sound correspondences will be examined more closely to attempt to understand the relationship between the complexity of letter-sound associations and reading failure.

CHAPTER 4

Orthographic Complexity

The review of the literature has, so far, detailed the history of the determinants of reading failure as they shifted from perceptual factors to verbal factors including skill with segmentation, and most recently, the skills of remembering and using complex letter-sound correspondences. This chapter will describe the work of a number of researchers in order to understand better the complex nature of letter-sound relationships in English orthography and to ascertain how that complexity relates to reading failure. A number of issues will be addressed:

1) Are the correspondences between letters and sounds in English orthography rule-governed or are they predominantly irregular, haphazard and erratic?

2) What evidence is there that the differing complexity of letter-sound correspondences in various languages is related to reading failure?

3) What attempts have been made to quantify the nature of the complexity of letter-sound relationships in order to study more carefully the relationship between letter-sound complexity and reading failure?

To address the first question, both the work of Hanna and his associates and the work of Venezky will be considered. Hanna and his associates have offered data that indicates that letter-sound relationships in English are fairly regular. A student of Hanna, (Moore, 1951) in an unpublished doctoral dissertation in which he examined 3,000 words, concluded that there is a consistent relationship between letters and phonemes for 80% of the phonemes in our language.

In 1966, Hanna, Hanna, Hodges and Rudorf, taking advantage of newly available computer technology, conducted a detailed analysis of the letter-sound correspondences in 17,000 American-English words.

Hanna et al concluded:

> While the overall average consistency of one graphic option representing a given phoneme without consideration of any other phonological factors was 73 percent, by considering the factor of position in a syllable, the predictability of graphemic options increased to the average of some 79 percent. Finally, when the factor of stress was added to the factor of position, the predictability was increased to slightly over 84 percent.
>
> Phase I, then, seems to have demonstrated satisfactorily the basic hypothesis that American English is primarily an alphabetical language. (Hanna et al., 1966, page 109.)

Venezky (1970) has also made a significant contribution in establishing that letter-sound correspondences are neither haphazard nor erratic. Venezky (1970) has presented a detailed description of English orthography in which he proposed a series of rules governing letter-sound correspondences. The treatise begins with an historical discussion of English orthography which details how Anglo-Saxon, Anglo Norman, Latin and French words and spellings were incorporated by scribes, and later, grammarians to form our present system. In the body of the work Venezky proposed rules for deriving sounds from English letters and he noted the frequency of those correspondences. Venezky's work differs methodologically from Hanna et al. (1966) in that letters and letter clusters are assigned to sounds on the basis of their position in the morpheme not their position in the syllable. Rules for consonants, vowels and fricative alternations are listed.

For example, Venezky reported that the consonant, "b," occurs 95 percent of the time in initial and medial positions with the final "b" being very rare. In initial and final clusters "b" occurs chiefly with "r" and "l." Based upon his 20,000 word sample Venezky concluded that "b" is silent only in a few words (such as "debt," "doubt" and "subtle") while in all other cases "b" always corresponds to the sound, /b/. The pronounciation of the "b" at the end of words is altered from silent to sounded with the formation of certain derivitives (e.g., bomb, bombard).

As an example of what might be termed a more complex set of rules, consider those proposed for the letter, "c." Venezky reported that "c" occurs mostly in the initial and medial positions with occurrences in final positions accounted for by borrowed words such as "arc," "talc" and "shellac." The "c" has the /CH/ sound in two words, "cello" and "concerto." The "c" is silent in three words (e.g., indict). The "c" before the letters "i," "y," "e" (and in facade) has the sound of /S/. In all other positions the "c" takes the sound, /K/. Venezky does not account for the 38 occurrences identified by Hanna et al. when "c" takes the /SH/ sound in words such as "ocean," "ancient," and "deficient."

In the chapter on fricative alternations Venezky discussed among other things, palatization. This is the process which can account for many of the so-called "irregular" spelling-to-sound correspondences. Consider the words, "credulous" and "credulity." In the former the "u" is palatalized; the "u" in the latter is not. Venezky offers the following rule: when "d," "t," "s," "x," or "z" is followed by an unstressed vowel the consonant is palatalized. For example, in the word "cordial" the "i" takes a /J/ sound. The exceptions to this rule are the words: "sure," "sugar," "mature" and "produce" (the noun). The only problem with applying this rule in the situation in which the reader is decoding a word is that the reader has to know which syllable is stressed in order to properly apply the rule.

Unfortunately, if one doesn't know how to read a word it is unlikely that one will know which syllable is stressed.

Venezky begins the chapter on vowel sound correspondences by noting that on a single letter basis vowels exhibit no regularity since "o" corresponds to 17 different sounds, "a" to 10, "e" to 9 and the combined group to 48.

> When the morphemic structure and consonant environment of the words in which these units appear are analyzed, however, a single major pattern emerges, from which regular subpatterns can be derived. Exceptions still remain, large numbers of them in some cases, but the underlying pattern is so dominating that the exceptions, which were once the rule, become mere oddities, begging for historical justification. (Venezky, 1970, p. 101).

Venezky divides the vowels into two groups: primary and secondary. The primary units consist of a single vowel and single vowels followed by a silent "e." The secondary units consist of vowel combinations. The primary vowel patterns are divided into "free" and "checked" alternates corresponding to "long" and "short" vowels respectively. Venezky then offers this rule which predicts whether a single vowel will be "free" or "checked."

> In monomorphemic words a primary spelling unit corresponds to its free alternate when it is followed by (1) a functionally simple consonant unit followed by l or r, and then another vowel unit (including final e). It corresponds to its checked alternate in the remaining cases, i.e., when followed by (1) a functionally compound consonant unit, e.g., x, dg, (2) a cluster of consonant units, e.g., -nm, lth or, (3) a word-final consonant unit or units. (Venezky, 1970, pp. 102-103).

Venezky provides examples of these correspondences that are reproduced in Table 4.

Still under the section of primary vowel patterns Venezky goes on to describe two major subpatterns: final "e" and geminate consonants including lists of irregular final "e" patterns. He also covers

Table 4

Rules for Free and Checked Alternates taken from Venezky, 1970.

Spelling	Free Alternate		Checked Alternate		
	1	2	1	2	3
a	canine	ladle	badge	saddle	sat
e	median	zebra	exit	antenna	ebb
i	pilot	microbe	chicken	epistle	hitch
o	vogue	noble	pocket	cognate	sod
u	dubious	lucre	luxury	supper	rug

morphophonemic alternations (e.g., angel, angelic; athlete, athletic) and the effect of "r," "l," "w" and "gh" on vowels in specified environments. Finally, Venezky goes on to explain the secondary vowel pattern correspondences for the vowels "ai"/"ay"/, "au"/"aw," "ea," "ee," "ei"/"ey," "eu"/"ew," "ie," "oa," "oi"/"oy," "oo," "ou"/"ow" and "ui."

In the conclusion section of the book Venezky remarks that the spelling of the base form of a word tends to be phonemic, whereby position, environment and overt markers allow the same symbol to perform several different functions, and whereby several symbols represent the same sound. The spelling of compounds and derivatives tends to be morphemic: the established graphemic form of the base is retained as much as possible, regardless of the phonemic alternations involved. For reading instruction Venezky suggests that words be grouped into:

transfer words	-	having predictable patterns
association words	-	having unpredictable, but frequently occurring patterns
isolated words	-	words which should be taught as whole words to inhibit transfer.

Thus, Venezky (1970) presents a persuasive arguement that spelling to sound correspondences are not wildly irregular. His work is important to this review in that it clearly defines rules governing letter-sound correspondences and his work provides part of a foundation upon which to develop a procedure to specify the complexity of letter-sound relationships within words.

It should be noted that Venezky in no way claims that the rules he has proposed have a psychological reality in a reader's decoding of words, that is, that the reader is either consciously or unconsciously aware of the rules and uses them in decoding words. However, the very fact that a relatively small number of rules can account for large numbers of seemingly irregular words, indicates that it might be possible for the reader to build up expectancies of letter-sound correspondences given certain orthographic and morphemic constraints. Such expectations would allow competent readers to decode unfamiliar words, as well as nonsense words, which are strings of letters which conform to the basic orthographic rules. Venezky's work clearly demonstrates that the relationships between letters and sounds are not haphazard; rather, they are rule-governed but complex.

To conclude, the work of Hanna et al. (1966) and Venezky (1970) clearly establishes that letter-sound correspondences are fairly regular and rule-governed. The relationships are complex, not haphazard.

The second question asked at the beginning of this chapter concerned the relationship between complexity and reading failure. A seemingly fruitful area for testing hypotheses concerning the relationship between the complexity of letter-sound relationships and reading failure is the study of children learning to read languages which differ in their complexity of letter-sound correspondences. Both linguists and reading researchers have classified various written alphabetic languages according to the complexity of their letter-sound correspondences. Finnish, for example, is often cited as a language with regular one-to-one letter-sound correspondences; (see Kyostio, 1980 and van Heuven, 1980). On the other hand, English is characterized by complex letter-sound relationships.

There are obviously severe methodological problems inherent in the task of collecting cross-cultural data on letter-sound complexity and reading failure. However, a number of researchers have attempted such studies. Kyostio (1980) has presented information on the Finnish language. It has only 13 consonants and 8 vowels. The additional consonants: "b," "c," "f," "g," "x" and "z" only appear in a limited number of foreign loan words. There are no silent letters and a particular sound is always represented by the same letter. However, there are complex aspects of the language: there are 16 dipthongs, the ratio of consonants to vowels is higher than in English, i.e., Finnish has 96 vowels for every 100 consonants, the duration of vowels and consonants (which are represented by doubling letters) has a greater importance than in English and the verbs are inflected. For example, the various forms of the verb, "come," are written as: "tule," "tulee," "tulle" and "tullee;" while the forms of the verb, "blow" are written as "tuulle," "tuulee," "tuullee" and "tullee." Finally, Finnish words have more syllables than their English counterparts. Thus, although based upon Kyostio's analysis it seems correct to conclude that letter-sound relationships in Finnish are less complex than those in English, it must also be stated that Finnish does have a number of complex elements.

Kyostio then provides data on reading failure in both the United States and Finland which indicates that the percentage of reading problems in the United States is twice that of Finland. Kyostio concludes that Finnish children do not have problems with the mechanical (decoding) aspects of reading, but do have trouble later with comprehension and other higher level skills.

Another line of research which sheds light on the relationship of letter-sound complexity to reading failure concerns attempts of reading researchers to devise curricula which minimize the complex demands of the reading task. For example, Gleitman and Rozin (1973 and 1977) and Rozin and Gleitman (1977) have devised a syllabary which allows beginning readers to decode symbols corresponding to syllables avoiding learning alphabetic relationships. These authors began their theoretical justification with reference to the historical development of written language in which the writing system employing the alphabetic principle developed last and only once. To teach children to read they developed a syllabary in which pictures, numbers and letters represent the sounds of syllables. They report great success in teaching inner-city children to "read" using this system. It was hoped that in mastering the syllabary principles students would gain insight into written language which would help them master alphabetic relationships. However, the students encountered difficulty when presented with the alphabet with its more complex letter-sound relationships and the authors candidly reported that the process of teaching children to read by beginning with the syllabary produced results which were no more successful than other approaches used with inner-city children.

The final question posed at the beginning of this chapter concerned efforts of researchers to quantify the complexity of letter-sound correspondences to study its relationship to reading failure. The final section of this chapter will review the attempts of Shankweiler and Liberman, and Guthrie and Seifert to quantify the nature of letter-sound relationships.

As noted in the previous chapter of this review Shankweiler and Liberman (1972) hypothesized that the complexity of the relationships between the vowel sounds and letters was a good predictor of reading errors involving vowels. They ranked the vowel sounds according to the number of letter-sound alternatives with the vowel sounds of the letter "i," having the fewest alternatives in their list and the vowel sounds of the letter, "u," having the most alternatives. In the list of words used, the vowel sounds of the letter, "i," are always represented by the letter, "i," while the vowel sounds of the letter, "u," are represented by "u," "o," "oo," "ou," "oe," "ew," and "ui." They concluded that the error rate on the vowels was related to the number of orthographic representations of each vowel.

There are a number of limitations to their approach:

1) They decide upon two different hypotheses to explain problems reading vowels versus problems reading consonants: problems with consonants were attributed to poor segmentation ability while problems with vowels were attributed to the number of letter options for sounds.

2) Their approach to specifying letter-sound complexity is limited to just the correct reading of the vowels, not to the whole word.

3) Their difficulty index is based upon grouping by sound (the long and short sounds of the letter "u" are represented by seven different letters or letter combinations) and not grouping by letter (counting the number of sounds the letter "u" can represent). Since the task under study is reading and not spelling, it would seem to be more appropriate to make the groupings based upon the different sounds corresponding to each letter.

4) The values for the letter-sound options are based solely on the letter-sound correspondences in the list of 204 words, which was criticized by the present author as being atypical because the words were selected to equalize the occurrence of initial and final consonant clusters.

For these reasons the present author concluded that the work of Shankweiler and Liberman (1972) does not offer an optimal procedure for specifying the complex letter-sound relationships in words in order to better understand reading failure.

Guthrie and Seifert (1977) have conducted a more detailed investigation into the relationship between the complexity of letter-sound correspondences and reading achievement. Citing the work of Gibson and Levin (1975) and Venezky (1976) they started with the assertion that learning to identify words in English is a rule-learning process in which children search for invariant features and patterns. Guthrie and Seifert suggested that letter-sound correspondences that are governed by simple rules are detected and abstracted before correspondences governed by more complex rules.

Guthrie and Seifert hypothesized that the checked alternates of vowels (the short vowel sounds in cat, pin, cot and cut) have a less complex relationship to sounds than the following three categories of letter-sound correspondences: free alternates (long vowels such as pine and cute), secondary vowel patterns (such as bait and bread) and consonant influenced vowels (such as wild and post). To test this hypothesis Guthrie and Seifert tested 65 normal (their label) and 41 older poor readers three separate times over the course of the school year. The normal and older poor readers were roughly matched for reading achievement with the result that the poor readers were, on average, three years older than the normal readers and scored six points lower on the Peabody Picture Vocabulary Test. Thus, the subjects were not matched for intelligence. The dependent variable was scores on the Kennedy Institute Phonics Test (KIPT) which required children to say the names of letters and give their sounds, and to read: consonant vowel combinations, short vowel words, long vowel words, nonsense words and special rule words.

Gutman scale analyses of the data revealed five independent scales on the KIPT ordered from easy to difficult as follows: consonant vowel combinations, short vowel words, long vowel words, special rule words and nonsense words. Additional analyses in which the pretest was used as a covariate and which were conducted using various groupings of subjects, indicated that consonant vowel combinations and short vowel words are learned before long vowel and special rule words. The researchers then examined whether the differences in the acquisition of these skills were due to the complexity of the rules or to the time or to the sequence of introduction of the skills in the curriculum. They reported analyses of the curriculum of the normal readers which revealed that the long and short vowels were taught in tandem (e.g. cut and cute together). Thus, based upon instructional sequence one would suppose that the long and short vowel words would have been learned at the same time. Since this was not the case Guthrie and Seifert concluded that words governed by simple letter-sound correspondence rules are learned before words governed by more complex rules, since performance on the checked alternates (subjects read 65 percent correctly) was higher than on free alternates (33 percent correct), secondary major correspondences (39 percent correct) and consonant influenced vowels (36 percent correct).

However, in the discussion section of the article, the authors cited the work of Venezky and Johnson (1973) which suggested that instruction did affect acquisition of vowel patterns of varying complexity and as a result, Guthrie and Seifert adopted the position that instruction and complexity probably interact.

To touch further on the issue of instruction which Guthrie and Seifert assigned a secondary role, their data presented on the frequency of occurrence of various vowel patterns in the curriculum and on the percent of correct readings of each of those patterns have been combined by the present author and are presented in Table 5.

Examination of the data in this way gives rise to another interpretation of the results which was not mentioned by Guthrie and Seifert. It would seem to be equally valid to conclude that the checked alternates were learned to a greater degree because their occurrence in the first-grade textual materials is almost four times more frequent than that of the other three vowel patterns.

Guthrie and Seifert's approach to the complexity of letter-sound correspondences requires closer scrutiny. Their definition of complexity is based upon the set of rules of letter-sound correspondences identified by Venezky (1967). Based on these rules Guthrie and Seifert asserted that the graphemic environments of one-syllable short vowel words are simpler than those of long-vowel words and that the correspondences between letters and sounds for long-vowel words require both more rules and more complex rules. In support of this position they cited Shankweiler's and Liberman's (1972) work which examined the relationship between the number of errors made on vowels and the number of grapheme representations for those vowel sounds. However, the Shankweiler and Liberman research would seem to be only analogous to Guthrie's and Seifert's research. The former deals with the number of

Table 5

<u>Frequency of Occurrence of Vowel Patterns in First Grade Readers and Correct Reading of Those Patterns</u>, taken from Guthrie and Seifert (1977).

	Percent of Occurrence in the First Grade Reader	Percent of Words Correct During Testing
Checked Alternates	31%	65%
Free Alternates	8%	33%
Secondary vowels (major)	6%	39%
Consonant Influenced Vowels	3%	36%
Other rules and multi-syllable words	62%	-

letter-sound alternatives, the latter with the number and complexity of rules.

For a more detailed understanding of the Guthrie and Seifert definition of complexity it is necessary to inspect the various subtests of the KIPT since the groups of words contained in each subtest actually operationalize the definition. Guthrie and Seifert have grouped the words in the long-vowel and short-vowel subtests based upon the vowel sound, regardless of the letter which represents the sound. So for example, the short vowel word list contains such words as "log," "snap," "sip," "gum," and "fed." However, because the list contains any word with the short vowel sound words such as "young" and "bread" are also included, even though the short vowel sounds in these words are represented by a two vowel unit. It would seem that the letter-sound relationships in words such as "young" are governed by more complex rules than the letter-sound relationships in words such as "fed." Indeed, it seem curious that if one is interested in the task of decoding letters into sounds, words should be grouped into lists by the sounds the letters represent rather than by the letters themselves. The reader does (or might) not know the sound until after s/he has successfully decoded the word. It seems to the present author that the words should be grouped according to the number of possible sounds which could be associated with the letters in a particular word.

Similar comments can be made about the long vowel list that contains words such as "heap," "rude" and "green," words with vowel patterns which typically correspond to long vowel sounds. However, the list also contains words such as "great" and "bolt," which represent certainly less frequent and probably more complex letter-sound correspondences.

Interestingly, Guthrie and Seifert's most difficult list of words, which they term 'special rule words,' is not grouped according to the letter sounds.

To summarize, Guthrie and Seifert (1977) have presented evidence which suggests that the complexity of letter-sound correspondences is an important factor related to difficulty in decoding words. However, based upon the criticism described above, it would seem that the operational definition of complexity could be improved by relating complexity not to sounds but to letter-sound correspondence alternatives.

This chapter on complexity has included studies relevant to the three questions posed at the beginning of the chapter. The work of Hanna, his students and associates, and the work of Venezky make it clear that letter-sound correspondences in American English are not irregular or haphazard; they are rule-governed and complex. The work of cross-cultural researchers, as well as the work of Rozin and Gleitman suggest that the complexity of letter-sound correspondences might be related to reading failure. Finally, attempts of Shankweiler and Liberman, and Guthrie and Seifert to quantify the complexity of letter-sound correspondences were discussed and criticized.

CHAPTER 5

Discussion of Top-Down Processes and Selection of a Model of Reading

In developing a model of reading and, thereby, specifying possible causes of reading failure some researchers have made a distinction between "top-down" and "bottom-up" processes. Models which emphasize the "bottom-up" approach (e.g., Gough, 1972) assume that the initial perception and recognition of letters and words proceeds relatively independently of higher cognitive processes. Researchers who hold the "top-down" view (e.g., Goodman, 1973) maintain that the decoding of individual letters is governed by information from semantic and syntactic sources and is relatively independent of perceptual processes.

An analogous distinction between types of reading theories was offered by Smith (1979). He classifies "bottom-up" theories as "outside-in" theories in which reading is conceived as the processing of letters, and then words, in a hierarchial series of decisions which bring information into the brain. "Top-down" theories are referred to as "inside-out" theories in which reading is conceived as an active, centrally directed and motivated process involving generation and choosing of likely hypotheses with use of visual information only when necessary to resolve uncertainty. Prior knowledge reduces the number of alternatives the reader needs to consider.

However, these distinctions between types of models and theories probably have been overstated and the distinctions probably have little heuristic value. If we ignore these labels and re-examine the reading process with the knowledge that poor readers actually do not misperceive letters and words (the perceptual deficit hypothesis of reading failure was rejected), then attention must be turned to skills and knowledge sources which the reader brings to or learns in the reading situation. Such skills or knowledge sources previously discussed in the review include the ability to perceive the individual phonemic segments which comprise the syllable and the increasing knowledge of complex letter-sound correspondences.

Some insights offered by "top-down" and "inside-out" theorists on the nature of the reading process will now be considered as possible causes of reading failure. To begin with, a paper by Rumelhart (1977) will be considered since he specifies various sources of knowledge which come into play during reading.

Rumelhart (1977) begins his article by discussing examples of two information-processing models of the reading process: Gough (1972) and LaBerge and Samuels (1974). He criticizes the form of both models because they work from the bottom up, progressing from the apprehension of features and letters, words, etc. and they allow only a particular level of processing to affect the next highest level. There is no provision for the interaction of information from various levels to affect processing at one particular level particularly a lower level.

Rumelhart then goes on to cite a series of experimental results which call into question the assumption that information from "higher" levels of processing does not affect processing at lower levels. Among other things, he cites the fact that the perception of a single letter is facilitated by the provision of surrounding letters (Reicher, 1969) and he cites an experiment carried out in his laboratory by Stevens (undated). In this experiment letter strings were presented to subjects for short durations, using a tachistoscope. The letter strings contained both legal and illegal letter clusters in various word positions. The term legal meant the letter cluster occurs in English; illegal clusters do not occur. Stevens found that the predominant errors made by his adult subjects were to change illegal into legal clusters illustrating that orthographic knowledge of typical letter sequences actually affects the perception of individual letters. Thus, Rumelhart proposed that a model of reading must allow for the interaction of information from the visual stimulus and from other knowledge sources at every level of the process.

Rumelhart also pointed out how semantic and syntactic information affect processing of words and then he offered his own interactive model of the reading process in which alternative hypotheses with accompanying probabilities are developed at the feature, letter, letter cluster, word, syntactic and semantic levels and that information interacting at all or some of these levels can produce a decision at any one level (e.g., the feature or letter level) before processing at every level is complete.

The advantage of the Rumelhart model is that it allows for the flow of information in both "top-down" and "bottom-up" directions. It can easily account for the positing and evaluation of hypotheses at the word and phrase level in absence of complete processing at the feature, letter and letter cluster levels as suggested by "top-down" theorists. It can also account for a strict "bottom-up" approach in which letter and letter cluster information is transferred directly into meaning or transferred into meaning through the mediation of phonological coding, although it would seem that the "bottom-up" approach would suffer without help from such "top-down" information as the generation of various word hypotheses. It should also be noted that the model can be slightly revised to include phonemic segmentation skill and previously learned letter-sound correspondences at the letter and letter cluster levels.

The importance of Rumelhart's model to the present review is the specification of the importance of knowledge sources which are involved in the reading process. If these knowledge sources do play a significant role in the reading process, then they must be investigated to ascertain their role in reading failure. Of particular interest in this connection is Rumelhart's inclusion of word knowledge in the model. As a consequence, it would seem that the ability to have available and to generate words as hypotheses for strings of letters is an important factor in the process of decoding words and in beginning reading failure. As previously noted, Firth (1972) presented data which was interpreted by the present author to suggest that vocabulary was related to reading failure. Recently, Graves has studied the question in detail.

Graves (1980) conducted a study of students' vocabulary skills in relation to reading achievement, grade level and the difficulty of six word lists. The subjects were middle-class students in the fourth and sixth grades who were divided into three groups of low, middle and high reading achievement based upon teacher rankings. Unfortunately, as the author points out, the "low" group had an average reading percentile of only 40 and only 10 of the 144 subjects scored below the 25th percentile of the SRA Reading Test.

Among other things, Graves tested students' knowledge of the meaning of words (vocabulary) in two ways: orally, in which the experimenter read both the stimulus word and the answer alternatives, and also by requiring the subject to read the stimulus word without assistance although the experimenter still read the answer alternatives. Individual students did not read and listen to the same stimulus words in the two conditions although the same words were used in a counter-balanced design for both conditions.

Graves' results with older and predominantly good readers indicated that there was little difference whether or not the experimenter read the target word: that is, knowing the meaning of the words and not the process of decoding was responsible for success on the task. Graves also reported that the vocabularies of the good and poor readers differed in size "quite a bit;" although he did not report the mean scores for the two groups. Finally, Graves reported that the lists of different difficulty (constructed based upon the Harris and Jacobson (1972) and the Dale and O'Rourke (1976) lists) were good predictors of whether or not students would know the meanings of the words, however, the data were apparently not subjected to correlational analysis.

The importance of Graves' work to the present review is that it suggests that reading failure might be related to vocabulary skills, that is, a student's knowledge of words and word meanings might play a role in a student's success in reading words.

To summarize the discussion in this section on "top-down" theories and Rumelhart's interactive model of reading, it was concluded that the distinctions between "top-down" and "bottom-up" processes have perhaps been overemphasized. However, Rumelhart's suggestion of an interactive model of the reading process would seem to hold much promise since it would seem that a comprehensive model of beginning reading and, thus, an explanation of reading failure would have to provide for input from various knowledge sources and their interaction. The most powerful argument in support of a model such as Rumelhart's comes from the significant research findings offered by separate groups of researchers studying various skills in isolation which can be included together in a single model. For example, phonemic segmentation, the complexity of letter-sound correspondences and vocabulary have all been separately established as being important. What is needed is a determination of the relative importance of these skills as they interact in a comprehensive model.

CHAPTER 6

Methodological Issues

As discussed in the first and second chapters of this review, there is a considerable body of evidence which indicates that perceptual deficits are not a major cause of beginning reading failure. The present chapter will deal with important methodological implications of the rejection of the perceptual deficit hypothesis.

In the past, since reading problems were thought to be basically perceptual in nature, since samples of good and poor readers differed in their intellectual ability and since intelligence was not thought to be highly correlated with perceptual ability, it made sense to seek to remove the effect of intelligence from studies on reading so that differences found between good and poor readers could not be attributed to already known differences in intelligence. Thus, much of the research on reading failure controlled for intelligence by using matched subject designs or covariance to remove the effect of intelligence.

However, given the assumptions of current research on reading failure, namely, that verbal not perceptual factors predominate, and since the verbal factors under study are measured with tasks very similar to, and in some cases, identical with tasks included on intelligence tests, then it might no longer make sense to control for intelligence. In so doing, a researcher might be inadvertently removing factors from consideration which should be studied.

Problems with using matched sample designs have been identified (Campbell and Stanley, 1963) and are generally well known in the field of educational psychology. In the area of research on reading failure this problem has also received attention. Reed (1970) demonstrated that different patterns of results for good and poor readers on various variables could be obtained based upon the selection of the intelligence variable upon which subjects were matched. Samuels (1973) also noted the inappropriateness of matching subjects for intelligence while studying reading failure. However, recently, Valtin (1978-79) has provided new data and a comprehensive discussion of this issue.

Valtin (1978-79), a researcher working in Germany, provided a summary of her research as well as data relating to methodological considerations which are relevant to this review. Concerning her own research (e.g., Valtin, 1970), she found in studying dyslexic children that failures in reading and writing were not connected to disturbances of visual perception as measured by the Benton and other visual tests. Further, she found no indication of disturbed spatial abilities and no relationship between scores on the Harris Test of Lateral Dominance and reading and spelling ability. However, Valtin did find that even though dyslexics and normals were matched for intelligence and father's profession, further interviewing revealed that dyslexia was correlated with limited education of the mother, large number of children in the home, birth order, crowded living conditions and the lack of interest in reading on the part of the parents.

Although these data were gathered in Germany, they were similar to data collected by Vellutino and others working in the United States at the same time, although neither group of researchers cited the other. The methodology which was employed by Valtin in her early research reflected the assumption that intelligence and social status needed to be controlled because normal and dyslexic samples tended to differ in these characteristics. She reports that the I.Q. of poor readers

(readers more than one standard deviation below the mean in reading achievement) is around 95 whereas average and good readers have mean I.Q.'s somewhere around 110 to 115. The average I.Q. of matched dyslexic and control groups generally falls around 105.

Valtin presented the following figure taken from Anastasi (1966, p. 204) to illustrate the characteristics of a matched I.Q. sample of good and poor readers. It can be seem that the matched pairs tend to consist of the "better" dyslexic readers and the "poorer" normal readers and neither sample is truly representative of the population it should represent.

Valtin also pointed out another problem with the matching procedure which resulted from attempts to explain and understand results based upon the matching for intelligence procedure. She found (Valtin, 1970) that dyslexic children were, surprisingly, actually faster in Thurstone's test of Perceptual Speed than the group of good readers. Perplexing results as these led Valtin to the work of Reed (1970) who explored problems with using samples matched for intelligence on a full scale intelligence score, using it as if intelligence were a unitary trait. The research of Reed (1970), replicated in Germany by Valtin (1978) using a different intelligence measure, revealed a number of problems which result from the fact that reading achievement is more closely related to verbal scores rather than performance scores. Thus, if full scale I.Q. is used, it is possible to identify 30 percent more subjects than if verbal I.Q. is used in the matching procedure. Also, if full scale I.Q. is used to match subjects, poor readers of average intelligence typically have elevated performance scores which "compensate" for relatively low verbal scores. This explains the surprising results of

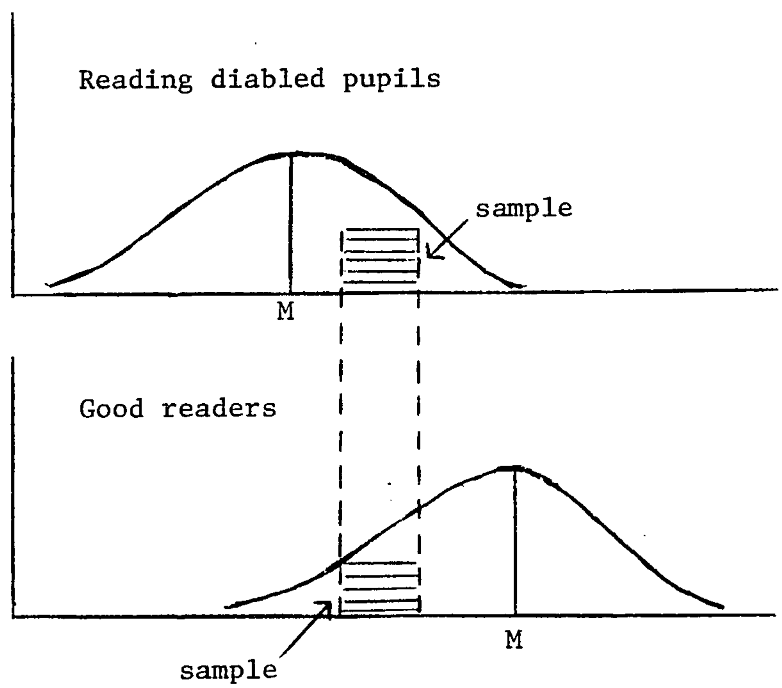

Figure 2

Matched samples from dissimilar populations. (Adapted from Anastasi, 1966, p. 204).

Valtin (1970), Oehrle (1975 and Kemmier (1967). Because the poor reader group with average intelligence has low verbal and high performance scores these types of subjects do better on the tests which correlate highly with performance I.Q. Thurstone's perceptual speed test is very similar to the performance I.Q. subtests and thus Valtin's dyslexics were actually able to score higher than the average readers, an artifact of subject selection by matching using full scale intelligence. Reed (1970) actually contends that most "deficits" in poor readers are artifacts of the matched pair design.

The work of Valtin and the work of Reed clearly demonstrates the problems involved in matching for intelligence, that samples are not representative and the results vary as a function of the intelligence measure chosen to match subjects or to use as a covariate. Further demonstration of these problems can be found by critical examination of data presented by Firth (1972). His methodological approach is consistent with most previous methodology which de-emphasized the role of intelligence.

Firth's procedures were specifically designed to control for differences in intelligence. This was accomplished by asking teachers of eight-year-old students (who were either in the end of the second grade or beginning of the third grade) to name students who were either having marked difficulty in learning to read or who were average readers. The Wechsler Intelligence Scale for Children (WISC) was administered (minus the vocabulary and object assembly subtests deleted to save time) to find students with a marked discrepancy between measures of their "reading" and "intelligence." To facilitate this research the psychologists would stop administering the WISC whenever it became apparent that a discrepancy would not be found--a procedure which could be criticized because it made the testers unnecessarily aware of the type of subjects for whom they were looking. When a hard-to-find subject with a discrepancy between ability and reading was found, a subject without such a discrepancy was chosen as a matched pair. A group of six-year-old students was also chosen without regard to their intelligence.

The fact that the typical "bad" reader does not have average intelligence and that most good readers do not have low intelligence is illustrated by the problems which arose in finding subjects for the contrasting quadrants. Furthermore, Firth is aware and discusses the fact that groups "matched" for intelligence actually differ quite dramatically in their pattern of verbal and performance scores which are combined to form the full scale (total) intelligence score. The full scale score (minus the vocabulary and object assembly tests) of the groups of "bad" and average readers both having average intelligence are 97.4 and 101.4 respectively. It is noted that the "bad" reader group's intelligence score is 4 points lower than that of the average readers even though they are considered "matched." Combining the above information taken from Firth's Table 4.1 (p. 90) and data from Table 5.36 (pp. 144-145), Table 6 was formed to illustrate the pattern of differences among the various groups. Examination of Table 6 reveals that the largest discrepancy between performance and verbal I.Q. is in the group of low intelligence "bad" readers. There is a 14 point difference with this group actually having a performance I.Q. in the average range. There is a similar verbal performance difference for the "bad" readers of average intelligence. The average intelligence score

Table 6

Pattern of Intelligence Scores for "Bad" and Average Readers Constructed from data presented by Firth (1972).

		Reading	
		"Bad"	Average
Low intelligence	Full	80.4	79.6
	Verbal/Performance	77.1/91.2	80.8/86.4
Average intelligence	Full	97.4	101.4
	Verbal/Perforance	93.4/103.0	98.8/103.7

of 97.4 is achieved for the "bad" readers by identifying a group of children with relatively high performance scores (103.0 on average) and relatively low verbal scores (93.4 on average)--a difference of almost ten I.Q. points.

In spite of these differences Firth considered these groups of subjects "matched" and he proceeded with his analyses. As Valtin (1978-79) and Reed (1970) pointed out, a sample so constructed results in the comparison of an atypical group of poor readers with an atypical group of average readers.

Firth was aware, however, that his methodology produced results different from what would have been expected had intelligence not been controlled. For example, Firth concludes that "bad" and average readers matched for intelligence do not differ in their ability to guess words in context. His Table 5.9 (p. 107) is included here as Table 7. However, the unanalyzed difference between low I.Q. "bad" readers and average I.Q. average readers of 6.3 approaches the magnitude of a full standard deviation and probably would have been found significant had it been analyzed. In fact, Firth cites a study by McLeod (1965) which reported such a significant difference and he criticizes it precisely because it did not control for intelligence.

It appears that the methodology chosen directly affects the decision to accept or reject the null hypothesis. Thus, data reported by Firth (1972), reanalyzed by the present author, illustrates the concerns expressed by Reed (1970), Samuels (1973) and Valtin (1978-79) that the application of the matching for intelligence methodology might actually determine the results of the experiment.

Table 7

Comparison of "Bad" and Average Readers of Low and Average Intelligence on Guessing Words in Context (taken from Firth (1962)

	"Bad" Readers		Average Readers		F Ratio
Group	Mean	S.D.	Mean	S.D.	
Low I.Q.	30.3	6.6	28.6	7.4	.74
Average I.Q.	34.3	8.0	36.6	5.5	.11
Total	32.4	7.6	32.3	7.7	.00

Overall Mean 32.3

Overall S.D. 7.6

To summarize, the work of Reed (1970), Samuels (1973), Valtin (1978-79) and Firth (1972) suggests that given the rejection of the perceptual deficit hypothesis and the subsequent examination of "verbal" factors as causes of reading failure, it might be inappropriate to use a methodology which controls for intelligence.

CHAPTER 7

Statement of the Problem

The review of the literature has identified various characteristics of persons and various characteristics of words which might play a causal role in beginning reading failure. The person characteristics identified include: phonemic segmentation ability, knowledge of complex letter-sound relationships, knowledge of vocabulary meanings, instruction and cognitive ability. The word characteristics identified include the complexity of letter-sound relationships in words, the semantic difficulty of words and instruction. The primary purpose of the research to be presented here is to examine, in a single data set, the relationship between these person and word characteristics and students' failure to read words. Based upon the studies reviewed specific predictions regarding each of these variables were made. The word, "person" or "task" is included in parentheses after each hypothesis to indicate whether it refers to a characteristic of the person or to a characteristic of the task of reading words.

Research has determined the importance of phonemic segmentation skills in the beginning reading process, however, there is some doubt concerning the importance of these skills after the very beginning phases of the process of learning to read. To be specific, research presented by Liberman and her associates (e.g., Liberman et al., 1974), Helfgott (1976), and Fox and Routh (1976) suggests that phonemic segmentation skill is related to reading failure at the kindergarten and first-grade levels. Also, Vellutino (1979) had advised practitioners to teach phonemic segmentation and awareness, and

Williams (1980) has already introduced a program designed to remediate reading problems in disadvantaged and learning disabled students based on a rationale that problems with segmentation skill impede progress in reading.

However, data presented by Firth (1972), Ehri and Wilce (1979) and Guthrie and Seifert (1977) suggest that phonemic segmentation might not be the most important variable or that it loses its predictive power after the first grade. If mastery of phonemic segmentation is only a minor stumbling block to reading acquisition then the approaches taken by Williams and Vellutino should not be recommended.

Hypotheses 1. Phonemic segmentation skill interacts with grade level as a predictor of reading achievement:

a) Phonemic segmentation is not related to reaching achievement in the third-grade sample of subjects. (Person)

b) All average readers and most poor readers will have mastered segmentation skill by third grade. (Person)

Other research suggests that failure in beginning reading might be related to the increasing complexity of the reading task, that is, to the complexity and difficulty of the letter-sound relationships in English orthography. For example, Shankweiler and Liberman (1972) concluded that error rates for pronouncing vowels were related to the possible sound alternatives for each vowel. Ehri and Wilce (1979) reported that poor readers could master the segmentation task with three phonemes, but not with four. They also reported that the poor readers could learn letter names, i.e., associations between a letter symbol and a syllable, but not letter-sound correspondences, more abstract (complex) associations between letter symbols and phonemes with the possibility of a number of sound alternatives for a single letter symbol. Firth (1972) has reported data on poor readers indicating that they can learn the relationships between some letters and sounds, but can not read nonsense words which require utilization of complicated rules to translate the letters into sounds.

Other evidence for the relationship between reading failure and the complexity of the reading task comes from cross-cultural research, the examination of attempts to improve reading acquisition by initially reducing complexity and from a limited number of researchers who have dealt directly with relationships between reading failure and complexity. For example, Kyostio (1980) has presented data which indicate that reading failure in the early grades is related to the complexity of the letter-sound relationships in a language. Gleitman and Rozin (1973) have presented data on the ease with which children can be taught to "read" using a syllabary.

Guthrie and Seifert (1977) have directly addressed the question and have concluded that the complexity of letter-sound relationships is related to reading failure; however, their approach to the operationalizing of complexity was criticized in the present review and could be improved. Furthermore, the relationship between complexity and instruction needs further explication. Guthrie and Seifert hedge on the issue, whereas Venezky and Johnson (1973) concluded that instruction (meaning when and to what degree a skill is taught) influences learning. Reinterpretation of Guthrie and Seifert's data by the present author suggested that instruction (represented by grade level in this study) and complexity interact.

Hypothesis 2a) The orthographic difficulty variable (constructed to quantify the complexity of letter-sound relationships in words) is a significant predictor of the number of errors made on those words by average, poor and very poor readers in second and third grade. (Task)

Hypothesis 2b) Orthographic difficulty interacts with the grade level at which words are typically included in Basal Readers as a predictor of error rates on words.

Hypothesis 2c) Subjects' knowledge of complex letter-sound relationships (as measured by performance on the nonsense word test) is a significant predictor of error rates on words. (Person)

As noted above, the work of Guthrie and Seifert (1977), and the work of Venezky and Johnson (1973) suggest that instruction might be an important variable to study in relation to failure in beginning reading. This conclusion is supported also by the work of Calfee (1980) who found that beginning readers learn what they are taught.

Hypothesis 3a) The grade level at which words are typically taught in basal readers is a significant predictor of error rates on words. (Task)

Hypothesis 3b) The grade level of students is a significant predictor of students' performance on the word reading task. (Person)

Rummelhart's (1977) interactive model of reading suggests that processes other than letter based associations, "top-down" processes, influence the perception/reading of words. The work of Graves (1980) suggests that knowledge of vocabulary is a "top-down" process which might be related to reading failure. However, his experimental design did not provide for individual subjects to read and be tested on the meaning of the same words.

Hypothesis 4a) The semantic difficulty of the words in the word list is a significant predictor of reading error rates for the same words. (Task)

Hypothesis 4b) The number of words for which the subjects know the meaning is a significant predictor of the number of errors made by the subjects reading the same words. (Person)

Finally, a review of the methodology used to study reading failure indicated that the relationship between intelligence and reading achievement has received little attention. The research of Valtin (1978-79), Reed (1970) and Firth (1972) suggests that intelligence and reading achievement are related and that the procedure of controlling for intelligence alters the results of an experiment, possibly obscuring the importance of variables interrelated with intelligence. Consequently, the present experiment will not control for intelligence or use a matched sample design.

Hypothesis 5 Cognitive ability (represented by a score on the Cognitive Abilities Test) is significantly related to subjects' ability to read words. (Person)

CHAPTER 8

Method

The reasons that students have problems learning how to read were explored by studying the relationships between variables representing characteristics of subjects and reading achievement, and the relationships between variables representing characteristics of the reading task (that is, characteristics of words) and reading achievement. A major aspect of this research study involved the development of a method to quantify the complexity of letter-sound correspondences. A description of the development of the orthographic difficulty variable follows, which is in turn followed by a description of the other variables used in this study.

Orthographic Difficulty

A relationship between two sets of elements can be simple or complex. Consider possible relationships between a hypothetical set of letters and a set of sounds. Assume that the column of symbols in figure 3 are letters and that the numbers, 1, 2, and 3, represent sounds of a language, either at the phoneme or syllable level, then a correspondence system can be constructed in which each one of the letters represents one and only one sound and that sound is represented by one and only one symbol. That is, there is an invariant one-to-one relationship between the letters and the sounds. This would certainly constitute the most <u>non-complex</u> orthographic system imaginable.

A slightly more complex arrangement would be to use a sequence of two letters to represent a blend of two sounds. This is slightly more complex because the reader must recognize the two letters as forming a

letters		sounds
	-	1
	-	2
	-	3

<u>Figure 3</u>

Example of a letter-sound correspondence system unit; however, it is still not very complex because it deals with a cluster of two one-to-one correspondences.

The system can be made more complex by adding various elements. For example, a letter could be used as a marker, that is, a letter would not correspond to a sound but would help to establish the sound of another letter. To return to English orthography, in the word "hope," the last "e" is not sounded; it indicates that a previous letter, the "o," will take the long vowel sound. Another element which could be added would be to have one letter represent different sounds. In English the most frequent examples of this instance are the vowels and the letter "y." The "a" takes different sounds in the words, "hat" and "what," for example.

Another element which could make a correspondence system more complex would be to have two letters which typically represent separate sounds combined in a unit to represent a third, entirely different sound which is not a blend or a combination of the two original sounds. In English, the letter combination, "ch", is an example of a unit which represents a sound which is not a blend of the two component letters.

Next, the system would be made more complex by introducing letter units which stand for the sound of only one of the two letters. For example, the letters "oa" in the word "boat" represent only the /o/ sound. Similarly, a letter or a group of letters can be included in a word, but can represent no sound. For example, the letters "gh" in "fight" are not sounded.

Finally, letter units can be given alternative sounds. The letters "ea" can take on many different sounds. Consider the words, "great," "learn," "hear," and "bear."

The above discussion indicates the complexity of letter-sound correspondences in English orthography, however, it is not immediately obvious how that complexity can be quantified. Previous attemps critiqued in the review of the literature section included Guthrie's work which grouped words by the sounds the letters represented (long versus short vowel words, for example) and the work of Liberman et al. based solely on the number of letter alternatives for vowel sounds.

In the present study, letter-sound complexity will be quantified using the progression from simple to complex correspondences outlined above. To summarize, the above discussion identified the following correspondences:

1 letter . . . . to 1 sound

2 letter blend . . . . to 2 sound blend

1 letter . . . . to no sound

1 letter . . . . to no sound with the letter used as a marker

1 letter . . . . to 2 or more sound alternatives

2 letter unit. . . . . to 1 sound (of the two letters)

2 letters. . . . . to no sound

2 letter unit. . . . . to a new sound

2 letter unit. . . . . to 2 or more sound alternatives

Two general rules are proposed to specify the degree of complexity of the letter-sound correspondences:

(1) The more sound options for a letter or a letter unit, the more complex the correspondence

(2) The more letters or elements which combine to form the letter symbol, the more complex the correspondence

As an example of the first rule consider the following correspondences:

l	-	/L/	e.g.	log
y	{	/E/	e.g.	happy
		$/I_3/$	e.g.	dysfunction
		/Y/	e.g.	young
		/I/	e.g.	cry

The "l" always corresponds to the /L/ sound when the letter is sounded. However, "y" can take any one of a number of sounds. The relationship between "y" and its sounds is considered more complex than the relationship between "l" and its sound.

As an example of the second rule consider the following correspondences:

l	-	/L/	e.g.	log
ch		/CH/	e.g.	church
a_e		/A/	e.g.	hate
oa		/O/	e.g.	boat

In this example, the "ch," and "a_e" and "oa" symbols are considered more complex since in each case the correspondence with the sound is based upon not a single letter but a unit composed of two letters which must be perceived as a unit.

According to the first rule, in general, vowels should represent more complex orthographic relationships than consonants since vowels have many more sound options, and consonants are more invariant. According to the second rule, all two or more letter units should be considered more complex than single letters because they first must be perceived as a unit before they are related to a sound which is not a blend of the sounds of the component letters.

The logic advanced, however, does not offer guidance in deciding which of the situations as represented by the two rules is more complex: is it more complex for two letters to combine into a unit and represent a new sound or is it more complex to have three or more different sounds represented by a single letter? Any attempt to categorize one of the two situations as more complex would be arbitrary. Therefore both types of correspondences will be given identical complexity ratings. However, since each correspondence in a word will be rated separately and the ratings totaled, a word with two such correspondences will be considered more complex than a word with just one such correspondence.

So far in this section of the chapter, the author has outlined a system and a rationale for classifying orthographic relationships as simple or complex. Further specification of orthographic relationships seems to be necessary. As noted above, the letter "y" can correspond to four sounds, which constitutes a complex situation. Is the relationship between "y" and any one of the sound alternatives more complex than the others? The answer is negative since each of the four correspondences combine to produce the complex orthographic relationship. However, the individual correspondences do differ in their frequency of occurrence in English orthography, so perhaps the frequency of letter-sound correspondence is germane to the task of quantifying orthographic relationships with a view to studying children's problems in learning to read.

As an example, three of the possible sound correspondences of the letter "c" are considered:

c	-	/K/	e.g.	cat
c	-	/S/	e.g.	center
c	-	/CH/	e.g.	cello

The work of Hanna et al. (1966) makes it possible to quantify the frequency of these occurrences. The c - /K/ correspondence is most common with 3,452 occurrences in English orthography. The c - /S/ correspondence is less common with 1,067 occurrences and the c - /CH/ correspondence is very rare with only two such correspondences. Thus, it seems possible that knowledge of the frequency of the various sound alternatives for a letter can be used to further specify the nature of orthographic relationships.

Therefore, to the variable complexity will be added the variable frequency of occurrences of letter-sound correspondence alternatives to form an index of orthographic difficulty.

To summarize, the orthographic difficulty of a word is considered to be a function of the following elements:

(1) The complexity of the letter-sound correspondences:

one letter to one sound option	-	simple
one letter unit to multiple sound options	-	complex
unit of two or more letters to one sound option	-	complex
unit of two or more letters to multiple sound options	-	complex

(2) The frequency of occurrences of sound options for letters in English orthography.

(3) The number of complex letter-sound relationships within a word since the values of each letter-sound correspondence are added to form the orthographic difficulty index.

Given these general principals, the specific rules listed in Table 8 are proposed for specifying the orthographic difficulty of any word in the English language.

Examples of how the rules are applied are presented in Table 9. For each word the orthographic difficulty value is listed below the individual letter or letter unit. The right-hand column lists the total orthographic difficulty rating for the entire word. The rules described were used to assign orthographic difficulty values to the random sample of 120 words used in the study. The orthographic difficulty values of individual words ranged from 0.0 to 5.0.

Thus, the orthographic difficulty variable describes a characteristic of words and represents aspects of the complexity of the reading task, i.e., the complexity of letter-sound correspondences and the frequency of occurrence of those correspondences.

Definition of other variables used in the study

(1) Reading achievement was represented by two variables. It was represented by a score from a standardized reading comprehension test expressed as a grade equivalent score. This was used solely for the purpose of dividing students into average, poor, and very poor reader groups. Reading achievement was also represented by a score based upon the number of words read correctly on a list of randomly

Table 8

Rules for Assigning Orthographic Difficulty Values

Rule	Value	Examples
1. Single vowel correspondences:		
vowel corresponding to its own short sound	0	cat
vowel corresponding to its own long sound or another of its short sounds	1/2	me or father
vowel corresponding to the short or long sound of another vowel or a new sound	1	many or kilo
the vowel y corresponding to the /E/ sound	1	happy
the vowel y corresponding to the /I/ or $/I_3/$ sound	1 1/2	cry or myth
2. Vowel unit correspondences:		
vowel unit correspondence is frequent (100 or more) and corresponds to a sound of one of the letters which is its own long sound, its own short sound or another of its short sounds	1	beat, head or wood
vowel unit correspondence is infrequent (99 or less) and corresponds to a sound of one of the letters which is its own long sound, its own short sound or another of its short sounds	1 1/2	toe, edge or heart
vowel unit corresponds to a new sound or the sound of another letter	2	out or rein
three vowel unit	2	ease

Table 8 (continued)

Rules for Assigning Orthographic Difficulty Values

Rule	Value	Examples
2. Vowel unit correspondences (continued):		
two vowel unit corresponding to two vowel sounds	2	dial
3. Syllable boundaries:		
first syllable boundary in a word	1/2	
second syllable boundary	1/4	
4. Single consonant correspondences:		
consonant corresponding to its own sound or a frequent (1,000 or more) correspondence to a sound of a different letter	0	cat or center
two consonant blend	1/4	stop
three consonant blend	1/2	string
silent consonant	1	bomb
consonant corresponding to a new sound or an infrequent (999 or less) correspondence to the sound of a different letter	1	ocean or gem
consonant corresponding to two sounds	2	exact

Table 8 (continued)

Rules for Assigning Orthographic Difficulty Values

Rule	Value	Examples
5. Consonant unit correspondences:		
consonant unit corresponding to the sound of one of its letters; or a frequent (100 or more) correspondence to the sound of another letter or a new sound	1	talk, phone or thing
infrequent (99 or less) correspondence of a new sound or the sound of another letter	1 1/2	chef or rough
two identical letters with one sound	0	less
silent consonant unit	1 1/2	fight

Table 9

Orthographic Difficulty Ratings for Selected Words

Words/Individual Values			Orthographic Difficulty Rating
h	a	t	
0	0	0	0
f	ee	t	
0	1	0	1
cr	y		
1/4	1 1/2		1 3/4
sh	ow		
1	2		3

selected first, second, third and fourth-grade words. This served as the major dependent variable and it was chosen for the following reasons:

a) This study examined beginning reading and is primarily concerned with decoding.

b) The relationship between a score on a word list test and reading achievement is clear and direct. The relationship between a score on a standardized test and reading achievement is much less clear and less direct. Standardized test scores represent normative comparisons and because of the multiple choice format a correct answer can be due to knowledge or guessing. A wrong answer could result from a clerical error in marking the answer sheet, inability to decode words, inability to understand the meaning of words, misunderstanding the question, etc. thus the score on the word list test is more directly related to the subject's ability to read individual words.

c) Standardized reading tests have particular problems with the measurement of poor readers because of the way they are constructed to focus on a particular grade level and because of their multiple choice format. Kilian (1978) compared the achievement test scores of second graders in a New York City school with their scores on a word list test taken five months after the standardized test. On the achievement test, no second grader scored below the chance mean, a grade equivalent of 1.2, (equivalent to answering correctly 18 of 74 items on the test) even though many students were working below first-grade level and some were even total nonreaders as revealed by their scores on the word list test.

d) The psychometric properties of a word list test can compare favorably with standardized tests. Kilian (1978) reported high test-retest reliability and a .83 correlation with a standardized achievement test.

(2) Vocabulary, as a person variable, refers to a subject's knowledge of the words used in the study; as a task variable, it refers to the semantic difficulty of the words, that is, the number of errors made by the subjects on each word. A student was considered to "know" a word if the student could give a meaning or if the student could demonstrate that she/he knew a meaning of the word by using it in a sentence.

Because of the amount of time it took to test each student to determine if he/she knew the meaning of the words, not every student was tested on the meaning of every word. A vocabulary score was obtained for only 80 of the sample of 120 words. The 80 words were alternately assigned to one of two lists. Individual subjects were alternately assigned to be asked the meanings of one of the two lists of 40 words. Therefore, the vocabulary error score for each word represents the number of errors made by half of the subjects on the individual words. The vocabulary error score for each subject represents the number of errors individual subjects made on 40 words, ten from each grade level sample of words.

(3) The subjects' ability to deal with the complexity of letter-sound relationships within words was measured by the nonsense word test.

(4) It was not possible, given the limitations of the present study, to observe the content of instruction for the students in the

study. As a substitute for a direct measure of instruction, an assumption was made that the grade level of subjects and the grade placement of words in basal readers reflected instruction. The rationale for this assumption is reported below and data which offer support for it are reported in the Results and Discussion chapter.

Grade level is used as both a person characteristic and a word characteristic. As a person characteristic it is represented by the subjects' grade placement. It is assumed that students in grade two have had less instruction than students in grade three.

As a word characteristic grade level refers to the placement of words in basal reading series in books designed for particular grade levels. Basal readers have adopted an approach to teach reading in which new words are first introduced, then practiced in stories and exercises and then reviewed from time to time. Harris and Jacobson (1972) have examined the most common basal readers and have constructed a list indicating the grade level at which most basal readers introduce words. Based upon this information it is possible to determine which words are most likely to have been taught. For example, it is likely that all of the second and third grade students who were subjects in this study were "taught" the first-grade words; it is also likely that students will not have received instruction on the fourth-grade words, although it is possible that students might have encountered individual fourth grade words in their readings.

(5) Phonemic segmentation (also referred to in the literature as phonetic segmentation) is used as a person variable. It refers to a subject's ability to demonstrate the number of individual phonemes which make up a word. Subjects' segmentation skills were determined with the

procedure used by Liberman et al. (1974) in which students indicate the number of sounds in a word or a word part by tapping with a pencil. Three separate dependent variables were used to represent subjects' phonemic segmentation skill: number of errors to criterion, number of trials to criterion and total errors.

(6) It was not possible to obtain intelligence scores from an individually administered comprehensive battery intelligence test. As a substitute, cognitive ability represented by the Standard Age Score on the Cognitive Ability Test (Thorndike and Hager, 1978) was used as a person variable. Data reported in the Results and Discussion chapter do not support the assumption that the Cognitive Abilities Test was a good substitute for an individually administered intelligence test.

Design

The purpose of the study was to examine the correlates of performance on a word reading task. To accomplish this, both characteristics of the subjects and characteristics of the words were examined to determine which would covary with reading performance. A schematic representation of the variables identified in the hypotheses which might relate to reading performance is presented in Figure 4. The variables on the top portion of the figure represent characteristics of subjects; the variables on the lower portion represent characteristics of words.

The characteristics of subjects which might relate to reading failure were examined using the following statistical model:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + e$$

where

Y = the number of errors each subject made in reading the sample of 120 words taken from first, second, third and fourth grade levels.

B_0 = a constant

X_1 = grade level - a categorical variable coded 1 if in grade three, zero otherwise.

X_2 = phonemic segmentation score - the number of trials to criterion of six consecutive correct trials.

X_3 = phonemic segmentation score - the number of errors made before reaching the criterion of six consecutive correct trials.

X_4 = phonemic segmentation score - the number of errors made on the total of 42 items on the segmentation task.

X_5 = vocabulary: knowledge of words - the number of errors made by subjects on a sample of 40 words of the 120 words used in the study.

X_6 = complexity of letter-sound relationships - the number of errors made in reading the 30 nonsense words.

B_1 through B_6 = regression weights

e = error term

The characterististics of words which might relate to reading failure were examined using the following statistical model:

$$W = B_0 + B_1Z_1 + B_2Z_2 + B_3Z_3 + B_4Z_4 + B_5Z_5 + B_6Z_6 + B_7Z_7 + e$$

where

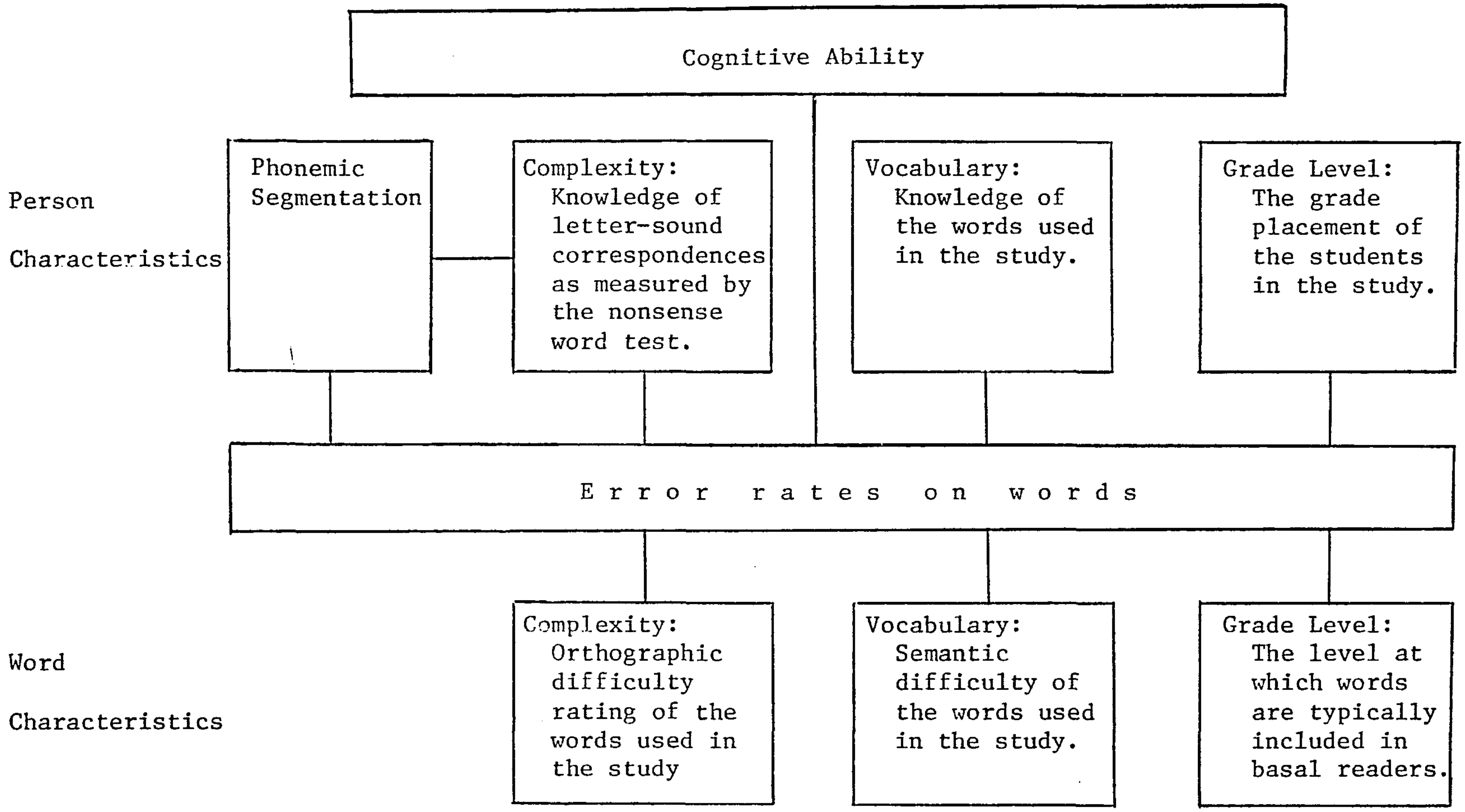

Figure 4

Illustration of the Variables Identified as Possible Causes of Beginning Reading Failure.

W = number of errors made by the subjects reading each individual word of the sample of 120 words.

B_0 = a constant

Z_1, Z_2, Z_3 = grade level - three categorical variables representing a word's inclusion in one of the four groups of words; first, second, third or fourth grade words.

Z_4 = orthographic difficulty - the ratings assigned to each individual word in the sample of 120 words.

Z_5 = number of letters in each word in the sample.

Z_6 = Thorndike Lorge rating for each word in the sample.

Z_7 = vocabulary (the semantic difficulty of words) - the number of errors made by a random sample of half the subjects on each of 80 of the sample of 120 words.

e = error term

B_1 through B_6 = regression weights

Subjects

The subjects were selected from three elementary schools in a city school district in Westchester County. The school district contains a range of socioeconomic levels and has a racial/ethnic distribution as follows: 33 percent Black, 13 percent Hispanic, 2 percent Oriental and American Indian and 52 percent other.

Permission letters were sent to the parents of 123 students in the second and third grade, all of whom were reading at or below grade level as determined by their Spring, 1982 reading scores on the Iowa Tests of Basic Skills. In two of the three schools the permission letters were signed by the researcher; in the third school the permission letters were signed by both the researcher and the principal. The letters were given to the students for them to take home and give to their parents. The 57 students (46.3 percent of the potential sample) who returned the signed permission slips indicating parental permission to participate were included as subjects in the study. The permission letters are included in the appendix.

Table 10 presents a frequency distribution of the national percentile rankings of those second and third-grade students who were given permission letters and a corresponding frequency distribution of those second and third-grade students who actually participated as subjects in the study.

The percentile rankings in Table 10 are grouped into three levels of achievement: percentile rankings from 1 to 23 are grouped together (stanines 1, 2 and 3), percentile rankings 24 to 39 are grouped together (stanine 4) and percentile rankings 40 to 50 are grouped together (stanine 5). As Table 10 indicates, the actual sample of subjects includes a representation of subjects from each grouping of percentile rankings, with the better readers being slightly over represented and the poorer readers being slightly under represented. For example, the actual sample contained five subjects at the second grade level with percentile rankings of 1 to 23. If the actual sample of subjects had exactly matched the potential sample, there would have been eight instead of five students in this category. It should also be noted that four of the third graders and three of the second graders had been left back. They were an average of one year older than their classmates and they had received an additional year of instruction.

Table 10

Frequency Distributions of National Percentile Rankings (on the Iowa Tests of Basic Skills Reading Subtest) for Potential and Actual Subject Samples.

National Percentile Rankings	Very poor readers						Poor readers				Average readers			
	0-3	4-7	8-11	12-15	16-19	20-23	24-27	28-31	32-35	36-39	40-43	44-47	48-50	Total
Second Grade														
Potential sample (letters sent)	2	1	2	6	5	2	6	0	7	16	0	8	10	65
	18 or 27.7%						29 or 44.6%				18 or 27.7%			
Actual sample	0	1	1	0	2	1	3	0	3	8	0	4	6	29
	5 or 17.2%						14 or 48.3%				10 or 34.4%			44.6%
Third Grade														
Potential sample (letters sent)	2	3	2	4	3	3	3	5	9	2	4	3	15	58
	17 or 29.3%						19 or 32.8%				22 or 37.9%			
Actual sample	2	0	0	2	2	0	1	2	5	0	3	2	9	28
	6 or 21.4%						8 or 28.6%				14 or 50.0%			48.3%

Difference: actual - potential percent	Very poor readers	Poor readers	Average readers
Second grade	-10.5	3.7	6.7
Third grade	- 7.9	-4.2	12.1

There were also differences between the sample and the district population in terms of racial/ethnic classification. The population and sample distribution are presented in Table 11. The Black and Hispanic students are over represented in the sample by 10 percent while the nonminority students are under represented by 8 percent. The sample did not include representation of the Oriental and Native American students which comprise 2 percent of the student population.

Procedure

The children who composed the sample were second and third-grade students of average and below-average reading achievement. Their teachers had prepared them previously by telling them they would take part in a reading study. The children were each called from their classrooms in turn. They were tested individually, in a quiet room, without interruption. The children sat in a chair next to a desk or table as did the tester.

First, the tester introduced herself and said hello to the child by name. Then she said, "I am trying to find out more about how children learn to read. Thank you for helping. I have some lists of words for you to read; then we're going to play a tapping game and then you're going to tell me what some of the words mean. Let's start." Then the tester gave the child the first list of words and the child read them. If a child was having difficulty reading a word, the tester said, "What is that word?", and pointed to it. If the child could not read the word, the tester said, "Please go on to the next word."

After the child had finished the first list, the tester gave him/her the second list and asked him/her to continue reading. The length of time it took for a child to complete this task varied from a

Table 11

Racial/Ethnic Distribution of the Total District and of the Sample of Students Included in the Study

	Black	Hispanic	Oriental Native American	Other
Population	33	13	2	52
Sample	40	16	0	44

few minutes to 15 minutes depending on a child's familiarity with the words and how quickly s/he read.

After the child finished the list of 120 words, the tester gave him/her the list of nonsense words. The tester said, "These are not real words, but some sound like words. Please read them." Again, if a child stopped at a word, the tester would ask him/her to read the word, and if s/he could not, the tester said, "Please go on." This section usually took no longer than about five minutes.

Next, the phonemic segmentation task was administered exactly as described by Liberman et al. (1974). The tester began by saying, "Now I'm going to show you a tapping game. I'm going to say a word or a sound and I want you to tell me how many different sounds you hear. You will tell me by tapping the number of sounds with this (the tester showed them a wooden dowel). First, I'm going to show you how to do it, so please watch me." Then the tester proceeded with the training by presenting three sets of words or word parts. After saying a word with three sounds, such as "cat," for example, the tester said, "That word has three sounds, 'c,' 'a,' and 't,' and she tapped on the table with the dowel three times. The tester did this with every word or word part demonstrating how to listen for the sounds and how to tap. Then the tester asked the child to tap the number of sounds s/he heard, first reading the words or word parts consecutively, then mixing them up. If a child tapped correctly in both cases, the tester went on to the phonemic segmentation task. If a child tapped incorrectly during the training, the tester corrected him/her. She did not proceed to the task until the child tapped correctly on all of the training words and word parts. Once they proceeded to the task, the tester stopped and corrected the child if he/she tapped incorrectly and told the child the correct number of sounds. This training session and the phonemic segmentation task varied in length from five to twenty minutes depending, in large part, on how quickly the child learned to tap correctly during the training.

After the phonemic segmentation task, the tester went on to the vocabulary section. The tester gave the child either the "A" list or the "B" lists, alternating the lists with each successive child. The tester said, "This is a list of some of the words you read. Please tell me what each word means in your own words." The child was given the list of words to look at, but the tester read each word. If the child had difficulty explaining what a word meant, the tester said, "Can you use it in a sentence?" If the child could use the word in a sentence which demonstrated a meaning of the word, it was accepted as a correct answer. If the child said, "I don't know what it means," or "I don't know that word," the tester said, "O,K. we'll go on to the next word," and she read the next word on the list. The length of time for this section varied from five to twenty minutes.

When the child finished this last section, the tester thanked him/her for participating.

Materials

The list of words which served as the major dependent variable in this study was drawn from the Harris and Jacobson (1972) list of core vocabulary words. Based upon a computer analysis of the most frequently used basal reading series, Harris and Jacobson developed a list of words classified by the grade level at which they are typically taught in a majority of the series examined.

A random sample of 30 words was drawn from each list from the first to the fourth grades. This procedure was used so that the implications of the analysis might be applied to all words that are typically taught in basal readers. Table 12 includes a listing of the number of words in each list and the percent of each list which the random sample represents.

The 30 words constitute a sample which ranges from 14 percent of the first grade words to less than three percent of the fourth grade words. The list of words used in the study are included in the appendix.

The 30 nonsense words used in the study were drawn at random from a list of 100 four and five-letter words used by Firth (1972).

The stimuli for the segmentation task are those used by Liberman et al. (1974). Both the stimuli for the segmentation task and the nonsense words are included in the appendix.

Table 12

Descriptive Statistics for the Sample of 120 Words

Grade level of words	Number of words	Percent represented by the 30-word sample
1	211	.142
2	552	.054
3	881	.034
4	1196	.025

CHAPTER 9

Results and Discussion

I. Person Characteristics as Determinants of Beginning Reading Failure

The first part of the results section deals with analyses of characteristics of the subjects which relate to their ability to read words. The variables analyzed included: phonemic segmentation, vocabulary (students' knowledge of the meaning of words in the study), knowledge of complex letter-sound relationships (students' scores on the nonsense word test) and cognitive ability (a score on the Cognitive Ability Test).

The dependent variable for all analyses was the total number of errors made by each subject in reading the list of 120 words. On this variable the 57 subjects made an average of 34.81 errors with a standard deviation of 26.13.

Phonemic Segmentation Skill

As predicted in hypothesis 1a, contrary to the rationale underlying the recently instituted educational program of Williams (1980) and the recommendations of Vellutino (1979), skill in phonemic segmentation was not related to second and third-grade students' ability to read words. Table 13 presents the correlations between the dependent variable, the error rates on words, and the two segmentation measures employed in the Liberman et al. study (1974). A third measure (Error Total) was also employed by the present author with the hope that increasing the number of items contributing to the score and eliminating the criterion reference point would create a more reliable measure. Clearly, performance on the phonemic segmentation task is

Table 13

Means and Standard Deviations for the Three Phonemic Segmentation Measures; Correlations between the Three Phonemic Segmentation Measures and Errors Reading Words.

	Trials to criterion of 6 in a row	Errors to criterion	Error total (based on every item in task)
Second-grade subjects			
Mean	9.38	1.10	6.90
S.D.	2.98	1.08	2.69
Correlations with reading errors	.03	.23	.24
Third-grade subjects			
Mean	9.00	.82	6.93
S.D.	3.71	1.22	2.99
Correlations with reading errors	.01	.04	.01
All subjects			
Mean	9.19	.97	6.91
S.D.	3.34	1.15	2.82
Correlations with reading errors	.05	.20	.11

not related to subjects' ability to read words in the second-grade sample, the third-grade sample and the combined sample.

Thus, the data are considered to offer support for hypothesis 1a: phonemic segmentation skill is not related to third-grade subjects' ability to read words.

The errors to criterion variable and the total error variable were examined further to determine why segmentation skill was not related to the subjects' ability to read the sample of words used in the study. This further analysis was conducted to see if the lack of a relationship between the reading and the segmentation measures resulted from a situation in which all or most of the students had mastered the task. Figure 5 presents data on the number of students who made each possible error score on the task. For example, the three X's over the number one on the top left-hand corner of the figure indicate that three second-grade students who were very poor readers made one error on the segmentation task.

It is clear from Figure 5 that only two second-grade subjects and two third-grade subjects made more than two errors before reaching the criterion of six consecutive correct answers. These data seem to offer support for hypothesis 1b: all average readers in the third grade and most poor readers in the third grade have mastered phonemic segmentation. No average reader made more than one error on the task and only two students from the poor reader groups made more than one error. However, results from the analysis of the total error variable (the variable employed by the present author) would seem to contradict this conclusion.

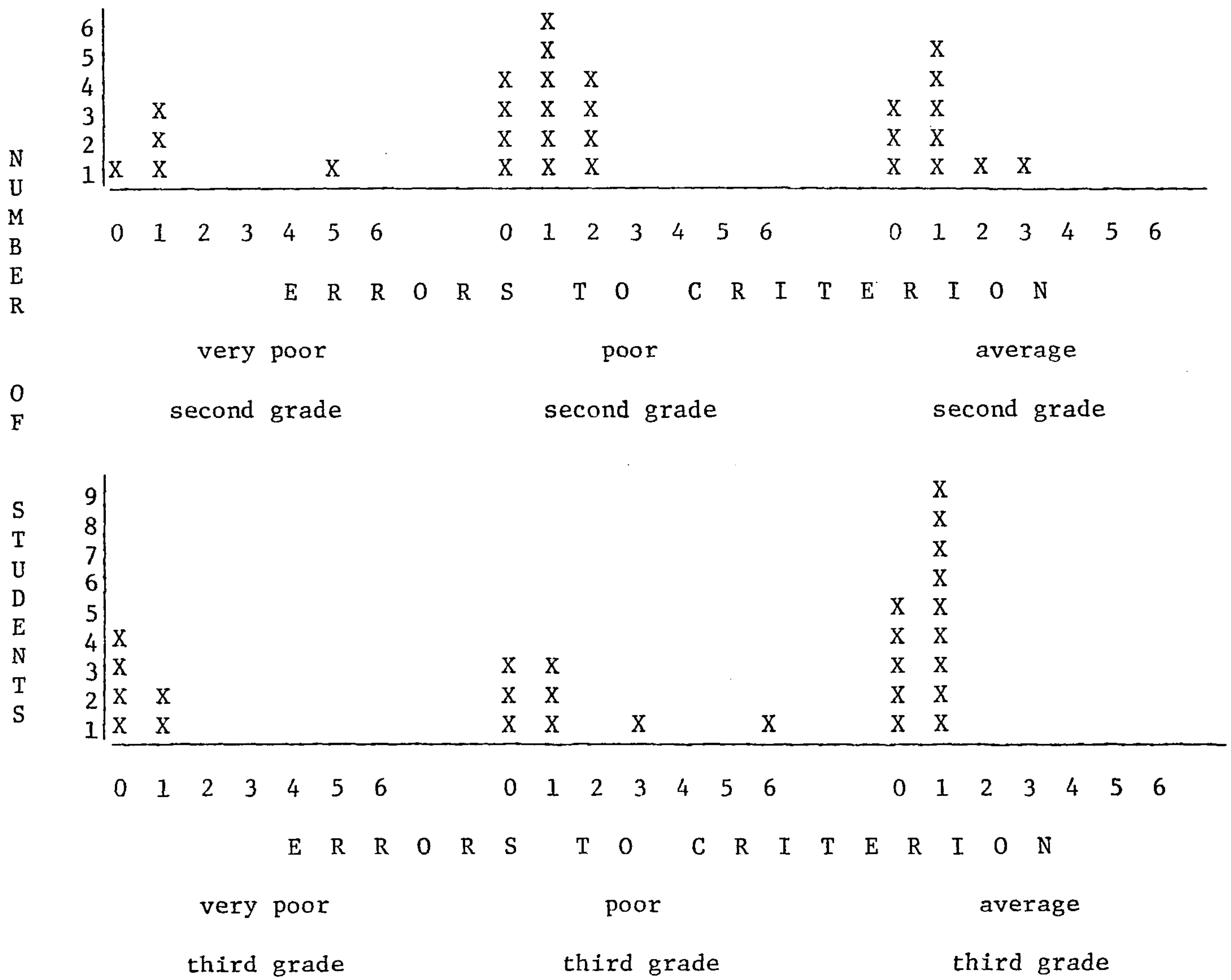

Figure 5
Number of students making each possible error score on the errors to criterion variable on the phonemic segmentation.

One would expect that if feedback were provided during the task and if subjects continued to answer items after reaching criterion, the subjects would make very few errors on the rest of the 42-item task since most made fewer than two errors before reaching criterion. Data on the number of errors made by students on the total segmentation task are presented in Figure 6.

If a mastery level is arbitrarily set at the 85 percent level (6 errors on the 42 item task) then it can be seen that 6 or 43 percent of the average third graders have not mastered the task and that 11 or 79 percent of the poor and very poor third-graders have not achieved mastery. This would call into question the conclusion that most third-grade students have mastered the task and would suggest instead that the criterion level of only six consecutive correct answers was inappropriate as a valid measure of skill on the task; the criterion for success on the task was set too low.

Thus, the further analysis of the segmentation measures did not support the notion, implicit in hypothesis 1b, that the subjects' mastery of the segmentation task precluded a significant relationship between that variable and performance on the reading task, because there is a large amount of variation in the total segmentation error variable. Performance on the segmentation task was simply not related to performance on the reading task.

Examination of the items on the segmentation task provides further evidence of the inappropriateness of the chosen criterion of six consecutive correct trials. The first six items do not contain a syllable with three phonemes. Students could reach the criterion without having to respond to a three phoneme syllable.

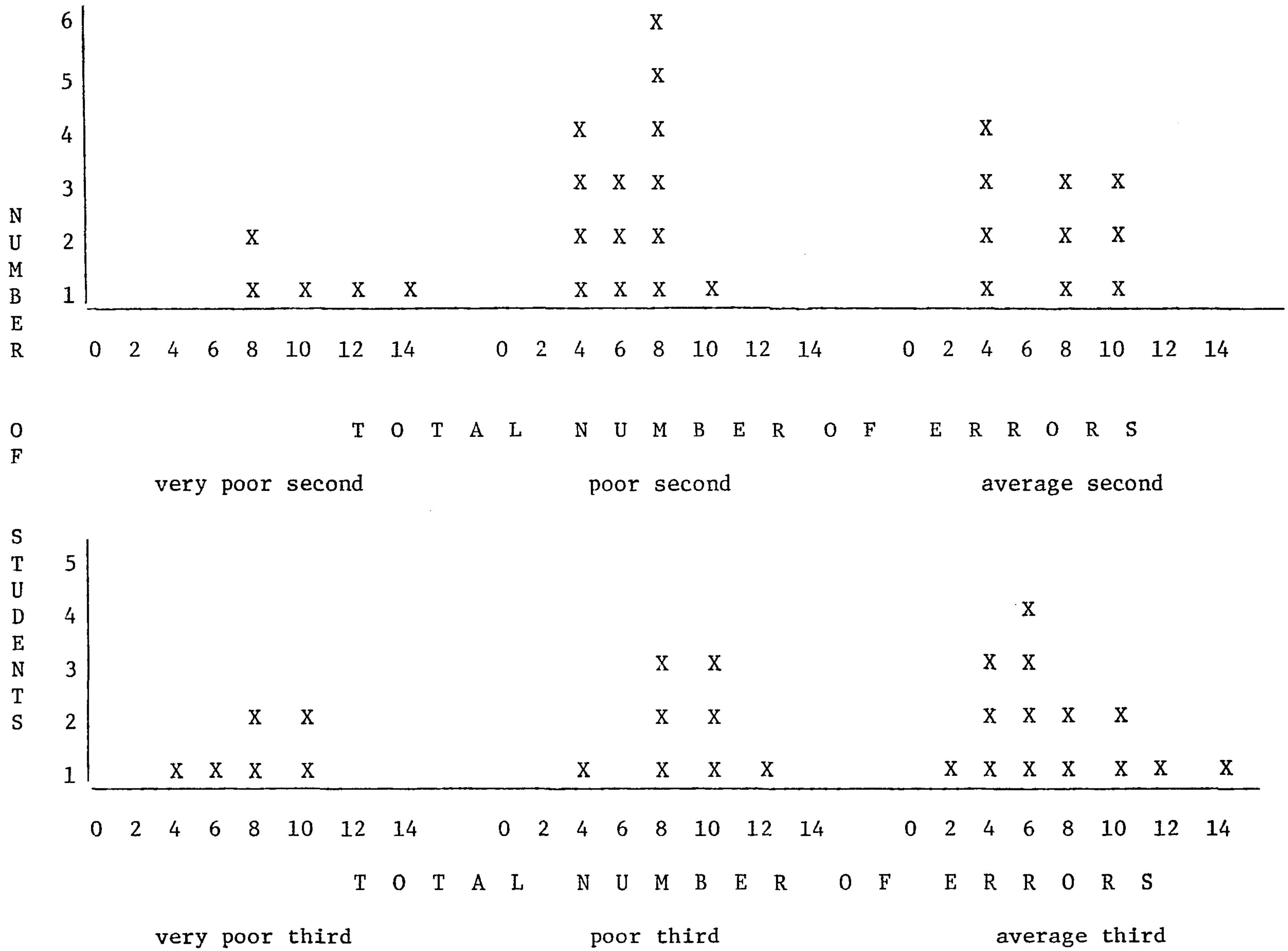

Figure 6
Number of students making 0 through 14 errors on the total segmentation task.

Given the fact that many students have not mastered the task, why is it that performance on this task is not related to the subjects' performance on the word lists? The explanation might lie in research conducted by Ehri and Wilce (1979) that was discussed in Chapter 5. It could be that third and fourth-graders, unlike preschool and kindergarten students, had readily available letter-sound associations in which the number of letters conflicts with the number of sounds: cough, for example, has three sounds and five letters. The conflict between the number of letters and sounds might have lowered some students' scores.

Furthermore, the isolation and definition of what a single sound or phoneme actually is does not seem, to the present author, to be clearcut. The dipthong, /oy/, as in "boy" is considered to have one phoneme; however, there is certainly sound variation in this dipthong and it could be construed as having two sounds.

To summarize, phonemic segmentation skill is not related to students' ability to read words. Hypothesis 1a was supported. Hypothesis 1b was not supported since many third graders have not mastered this task.

Grade level

Consistent with hypothesis 3b, in the analysis of the total sample of subjects, the grade level of a subject was a significant predictor of reading performance ($r = .62$; $F = 34.36$, significant at the .05 level). This result is important because it suggests that grade level or instruction is effective. The second graders were unable to read an average of 51 words while the third graders only missed an average of 19 words. However, of more importance to this study is the examination of variables which relate to reading performance within a group of subjects who presumably have had the same amount of instruction. Thus, analysis of the other independent variables which represent characteristics of subjects will be conducted separately for the second and third-grade samples of subjects.

Knowledge of complex letter-sound relationships (performance on the nonsense word task)

So far it has been established that segmentation skill does not relate to performance on the reading task, and the grade level of the subjects does. A major hypothesis of the present study was that one aspect of the complexity of the reading task, the complexity of the letter-sound correspondences in words represented by the index of orthographic difficulty, is a cause of difficulty in learning to decode words. If that is the case, then subjects who had internalized letter-sound correspondence rules which relate sets of phonemes to strings of printed letters should perform better on the word reading task than subjects who have not mastered difficult letter-sound relationships. That is, subjects' ability to read nonsense words is expected to be related to their performance on the word list.

On the thirty-item nonsense word test subjects made between 0 and 27 errors, with the second-grade subjects averaging 13.38 errors (standard deviation of 7.13) and the third-grade subjects averaging 7.71 errors (standard deviation of 6.29). The number of errors made on this task by individual subjects was used to predict the number of errors made by the same subjects on the word list. The results were analyzed separately for second and third-grade subjects and for all subjects combined.

Table 14 presents the means and standard deviations for the errors on the nonsense word test and the correlations associated with using the variable to predict the number of errors individual subjects made on the word list. For the second-grade sample of subjects, the nonsense word test is an excellent predictor of errors on the reading task, with a correlation of .87 accounting for 76 percent of the variance. For the third grade subjects, the nonsense word test is a very good predictor of errors on the reading task, with a correlation of .73 accounting for 53 percent of the variance.

The score on the nonsense word test is a powerful predictor of students' scores on the word list. In general, students who can read nonsense words can also read real words, and students who can't read nonsense words can't read real words either. Since the nonsense word test measures a subject's ability to employ the relationships between letters and sounds to decode the nonsense words, the results suggest that students' difficulty reading words stems from their poor ability to utilize letter-sound relationships to decode words.

These results support hypothesis 2c: subjects' knowledge of complex letter-sound relationships is a significant predictor of their error rates on the lists of words. Further, these results are consistent with the recent research and conclusions of a wide variety of researchers. Firth (1972) and Barron (1980) have presented similar findings. Chall (1967, 1979) has been a consistent advocate of the importance of decoding. Both Vellutino (1979) and Resnick and Weaver (1979), in reviewing a considerable volume of literature, have assigned decoding a critical role in beginning reading, and most recently, Stanovich (1980), in examining the merits of "top-down," "bottom-up"

Table 14

Means and Standard Deviations for the Nonsense Word Test; Correlations Associated with Using the Nonsense Word Test as a Predictor of Performance on the Reading Test

	Nonsense Errors		
	2nd grade subjects (N = 29)	3rd grade subjects (N = 28)	All subjects (N = 57)
Mean	13.38	7.71	10.60
Standard deviation	7.13	6.29	7.26
Correlations with reading errors	.87*	.73*	.82*

* significant at the .05 level

and interactive models of reading, has concluded that rapid context-free word recognition (decoding) is the process which most clearly distinguishes individual differences in reader competence.

Vocabulary (knowledge of the meanings of the words used in the reading task)

As described in hypothesis 3, vocabulary was also thought to be related to a subject's ability to read words. From the reading model suggested by Rumelhart (1977) it could be inferred that a subject is more likely to be able to read a particular word if that subject has knowledge of that word, that is, if a subject has that word available as a possible hypothesis for the word being read. It was predicted that subjects' scores on the vocabulary task are related to their scores on the reading task.

Subjects made between 0 and 18 errors on the 40 item vocabulary test, with the second graders averaging 7.2 errors and the third graders averaging 4.2 errors. The means, standard deviations and ranges for the vocabulary variable for the second, third grade and total sample of subjects are presented in Table 15, with the correlations describing the relationship between scores of subjects on the vocabulary task and scores on the reading task.

First, it should be noted that most students knew the majority of the 40 words which were used in the task with the second graders making 1.7 times the number of errors made by the third graders. As Table 15 indicates, the vocabulary error score was a significant predictor of the number of errors the subjects made reading the sample words in the second-grade sample and the total sample, but not in the third-grade sample.

Table 15

Means, Standard Deviations and Ranges for the Vocabulary Error Scores; Correlations Describing the Relationship Between Performance on the Vocabulary Task and Performance on the Reading Task.

	Vocabulary Errors		
	Second graders	Third graders	All subjects
Mean	7.21	4.18	5.72
Standard deviation	3.76	3.67	3.99
Range	1-18	0-18	0-18
Correlations with reading errors	.44*	.12	.47*

* significant at the .05 level

The above results were considered to offer only partial support for hypothesis 3b that the number of words for which the subject knows the meaning predicts the number of errors made reading the same list of words. The fact that vocabulary scores did not predict reading errors for the third-grade subjects might be due to the fact that the third-graders knew the meanings of almost all the words.

Cognitive Ability

Hypothesis 4a predicted that cognitive ability (represented by a score on the Cognitive Abilities Test, Thorndike and Hagen, 1978) would be related to the subject's ability to read words. The present data do not support this hypothesis. The correlations between the group-administered ability test and the errors on the word lists were -.31 for the second-grade sample and -.08 for the third-grade sample. These correlations were not significant at the .05 level. A possible explanation for the lower correlation in the third grade is that the ability test is given in the district from which the sample was drawn only in the second grade but not in the third grade. Thus, the second-grade correlation measured a concurrent relationship while the third-grade correlation was predictive, i.e., it measured the relationship between second-grade ability scores and reading performance in the third grade over a year later.

However, the fact that there were not significant relationships between the reading errors and the ability measure, certainly deserves further examination. At the second grade level the Cognitive Abilities Test is basically a measure of various concepts. For example, it measures relational concepts, such as: behind, hottest, middle-sized, and left hand; it also measures class inclusion concepts, such as determining that a rhinoceros does not belong in a set of animals that live in the sea; number concepts, such as: whole, equal, and total number; and vocabulary concepts, such as: insect, trunk, hedge, and boarding.

The reported relationships between the second-grade Cognitive Ability Test and various subtests of the Iowa Tests of Basic Skills (ITBS) are not particularly high. For example, the Cognitive Ability Test at the second-grade level correlates .61 with the word analysis subtest, .67 with the reading subtest and .50 with the spelling subtest. Corresponding correlations between the Cognitive Ability Test and the ITBS reading subtest for the present sample of subjects, which represents only the lower half of the normal range of reading achievement, were as follows: .39 for the second graders and .11 for the third graders. The correlation of -.31 between the Cognitive Ability Test Score and the word reading task used in this study is only eight points lower than the correlation between the Cognitive Ability Test Score and the ITBS reading subtest.

Thus, the lack of relationship between the Cognitive Ability Test Score and the reading errors on the word lists for the second and third sample is due, in part, to the restricted range of the sample. However, another likely reason for the low correlations is that performance on the tasks on the Cognitive Ability Test is probably not strongly related to subjects' ability to read words on a word list.

The apparent discrepancy between this finding and the findings of the literature reviewed in Chapter 6 is probably not real. The fact that Firth and Valtin found relationships between individually administered, timed, and comprehensive intelligence batteries (such as the WISC) and reading comprehension does not rule out the possibility that a group administered, untimed ability test that emphasizes vocabulary and language concepts is not related to second and third-grade students' ability to read words which is based on a sample of subjects drawn from only the bottom half of the continuum of reading achievement.

Indeed, the mixed findings for the vocabulary measure and the negative findings for the ability measure, although contrary to what was hypothesized are in fact compatible with each other. The results suggest that mastery of the decoding process (learning to read words) is not dependent upon knowledge of vocabulary or language concepts for average and poor second and third-grade readers.

Summary of Person Characteristics

A stepwise regression was conducted on the total sample of second and third grade subjects to summarize the relationships between the characteristics of subjects and difficulty reading the word list. The results of this analysis are reported in Table 16. The nonsense word variable correlates .82 with the reading task, accounting for 67 percent of the variance. The grade level variable adds 10 percent additional variance yielding a multiple correlation of .88. These results indicate that subjects who have mastered the complicated rules of letter-sound correspondences and subjects who have presumably received an additional year of instruction are the subjects who make few errors reading lists of words. Subjects' phonemic segmentation ability, their knowledge of vocabulary and their scores on the Cognitive Ability Test were not consistently related to their performance on the word list.

Table 16

Stepwise Regression of Subject Characteristics

	Multiple correlation	Increase in variance	Total variance	Change in R^2 F values
Nonsense score	.82	-	.67	112.92*
Grade level	.88	.10	.77	24.47*

* significant at the .05 level

II. Word Characteristics as Determinants of Beginning Reading Failure

The next part of the results section deals with characteristics of the reading task, that is, characteristics of words which might be related to reading failure in beginning reading. The variables examined include orthographic difficulty, the number of letters in a word, the Thorndike Lorge ratings, the semantic difficulty of words and the grade level at which words are typically taught. Since the orthographic difficulty variable was newly constructed, analysis of its reliability and construct validity will be presented first.

Reliability of the Index of Orthographic Difficulty

Interrater reliability was examined to determine the degree to which the rules for assigning the orthographic difficulty values to words were clear and explicit. The author, who developed the index, served as one rater; the other rater was trained using the words employed in the pilot test. The training consisted of three half-hour sessions with the researcher and an additional two hours of practice assigning values to words.

Interrater reliability was computed on the random sample of 120 words which served as the major dependent variable in the present study. The orthographic difficulty rating assigned by the two raters was exactly the same for 117 of the 120 words. The correlation coefficient was .99. Thus, the rules for assigning orthographic difficulty values are clear and explicit.

Construct Validity of the Orthographic Difficulty Variable

The orthographic difficulty ratings assigned to the individual words in the study ranged from 0 to 5.0, with the average orthographic difficulty value increasing slightly from a mean of 1.35 for the first-grade sample of words to a mean of 1.96 for the fourth-grade sample of words. The mean, standard deviation, and range for each group of words and for the total group are presented in Table 17.

The orthographic difficulty variable was constructed to quantify the varying degrees of complexity associated with the correspondences between letters and their sounds. If the orthographic difficulty measure is a valid measure of an aspect of the complexity of the process of reading words, then words with high orthographic difficulty ratings should be harder to read than words with low orthographic difficulty ratings.

To explore the construct validity of this new variable, the orthographic difficulty ratings for the lists of 30 words at the first, second, third and fourth-grade levels were used to predict the error rates for the words obtained by the 57 subjects reading the words. Further, the power of the orthographic difficulty variable to predict the error rates on the word list was compared to the predictive power of two other variables previously used to describe the difficulty of words. The variables examined were the number of letters in a word (often used as a predictor of word difficulty in readability formulae) and the Thorndike-Lorge Frequency Count of words. The relationship between the orthographic difficulty variable and the number of letters variable is crucial in the establishment of the construct validity of the orthographic difficulty variable and will therefore be described in detail.

As was described in the methods section, the number of letters in a word contributes to the orthographic difficulty rating of an individual word because the values assigned for individual letter-

Table 17

Mean, Standard Deviation, and Range of the Orthographic Difficulty Variable

Grade level assignment of words	Mean	Standard deviation	Range
Grade 1	1.35	.91	0 - 3.5
Grade 2	1.50	1.04	0 - 3.25
Grade 3	1.77	1.00	.25 - 4.0
Grade 4	1.96	1.09	0 - 5.0
All words	1.64	1.03	0 - 5.0

sound correspondences are added to form the orthographic difficulty rating for each word. Thus, the orthographic difficulty variable and the number of letters variable should be correlated, that is, it is expected that the orthographic difficulty variable and the number of letters variable will share a substantial amount of common variance. However, there should also be a substantial amount of unique variance, since it is hypothesized that letter-sound correspondences vary in their complexity and differentially affect the difficulty students have in reading individual words. This aspect of the relationship between the two variables is crucial to the construct validity of the orthographic difficulty variable. If some letter-sound correspondences are more complex and difficult than others and if the orthographic difficulty variable is adequately quantifying that difficulty then the orthographic difficulty variable should be a better predictor of error rates on words than the number of letters variable. If not, the rules used to identify differing levels of letter-sound complexity and difficulty can not be considered valid and the orthographic difficulty variable can not be considered a valid construct.

The correlation coefficients describing the relationship between the three independent variables, orthographic difficulty, number of letters per word and the Thorndike Lorge rating, and the dependent variable, the number of errors made by the subjects on each word, are presented in Table 18 for each grade level of words and for all words.

The correlations between the orthographic difficulty variable and the errors rates ranged from .35 in the first-grade sample of words to .71 in the second-grade sample of words. Orthographic difficulty was a significant predictor of error rates for the second, third and fourth

Table 18

Correlations Between the Word Characteristic Variables: Orthographic Difficulty, Number of Letters and Thorndike Lorge Rating and the Error Rates on First, Second, Third and Fourth Grade Words.

	Orthographic difficulty	Number of letters	Thorndike Lorge ratings
Errors on first grade words	.35	.22	-.09
Errors on second grade words	.71*	.38*	.21
Errors on third grade words	.57*	.51*	-.07
Errors on fourth grade words	.43*	.50*	-.37*
Errors on all words	.52*	.59*	.25

* significant predictor (at .05 level) of error rates on words.

grade samples of words (and it came close to being significant in the first-grade sample).

The correlations between the number of letters in a word and the errors made on the word ranged between .22 and .51, with significant correlations occurring in the second, third and fourth-grade samples of words.

The correlations between the Thorndike-Lorge ratings and the error rates on words ranged from -.37 and .21, with only the -.37 correlation for the fourth grade words reaching significance.

Comparison of the correlations for orthographic difficulty and the number of letters variable in each sample of words indicated that, with the exception of the fourth-grade words, the correlations between the orthographic difficulty variable and the error rates were higher than the correlations between the number of letters in a word and the error rates. To determine whether these correlations were significantly higher, a stepwise regression analysis was conducted to determine the contribution of the orthographic difficulty variable over and above the contribution of the number of letters variable. The results of this analysis are presented in Table 19.

The amounts of variance accounted for by the orthographic difficulty variable over and above the contributions of the number of letters variable ranged from 3 to 38 percent in the individual samples of words. However, the increase in variance reached significance only in the second grade sample of words.

Table 20 presents the other side of the coin, the amount of variance accounted for by the number of letters variable over and above the contribution of the orthographic difficulty variable. In the

Table 19

The Contribution of the Orthographic Difficulty Variable Over and Above the Contribution of the Number of Letters Variable in the Prediction of Error Rates on Words.

	Variance due to number of letters	Increase due to orthographic difficulty	Total variance	Change in R^2 F values (df 1,27)
First grade words	.047	.073	.120	2.23
Second grade words	.148	.382	.530	21.97*
Third grade words	.256	.082	.339	3.37
Fourth grade words	.252	.034	.286	1.28
All words	.343	.028	.371	5.18* (df 1,117)

* significant at the .05 level

Table 20

The Contribution of the Number of Letters Variable Over and Above the Contribution of the Orthographic Difficulty Variable in the Prediction of Error Rates on Words.

	Variance due to orthographic difficulty	Increase due to number of letters	Total variance	Change in R^2 F values (df 1,27)
First grade words	.120	.000	.120	0.00
Second grade words	.502	.028	.530	1.59
Third grade words	.326	.012	.339	.51
Fourth grade words	.181	.105	.286	3.95
All words	.265	.107	.371	19.83* (df 1,117)

* significant at the .05 level

individual sample of words the amounts of variance accounted for by the number of letters variable over and above the contribution of the orthographic difficulty variable ranged from 0 to 11 percent with none of the increases reaching significance, although the increase came close to significance for the fourth grade sample of words.

Table 21 presents the intercorrelations among the three variables representing characteristics of words. It should also be noted that the intercorrelations between orthographic difficulty and the number of letters variable were substantial, ranging from .54 to .76. The intercorrelations between orthographic difficulty and the Thorndike Lorge ratings were low or negative. These correlations ranged from -.06 to .23.

To summarize, a new variable, orthographic difficulty, was constructed to represent one aspect of the cognitive complexity of the reading task, namely, the difficulty involved in translating the printed symbols to the sounds of words. The results of the analysis of its construct validity are not clearcut. By itself the orthographic difficulty variable is a significant predictor of error rates on words typically taught in second, third and fourth grade. However, the analysis did not clearly establish the orthographic difficulty variable as a valid construct since in only one case (second grade words) does it account for a significant amount of variance over and above what is accounted for by the number of letters variable even though in three out of four cases the amount of variance accounted for is numerically higher and approaches the .05 level of significance.

Considering just the number-of-letters variable, it was a significant predictor of error rates on words in three of four cases:

Table 21

Intercorrelations of Orthographic Difficulty, Number of Letters and Thorndike Lorge Ratings.

	1	2	3
First grade words			
Orthographic difficulty	1.00	.62	-.06
Number of letters		1.00	.27
Thorndike Lorge ratings			1.00
Second grade words			
Orthographic difficulty	1.00	.71	.03
Number of letters		1.00	.09
Thorndike Lorge ratings			1.00
Third grade words			
Orthographic difficulty	1.00	.76	.23
Number of letters		1.00	.36
Thorndike Lorge ratings			1.00
Fourth grade words			
Orthographic difficulty	1.00	.54	.05
Number of letters		1.00	-.12
Thorndike Lorge ratings			1.00
All words			
Orthographic difficulty	1.00	.67	.17
Number of letters		1.00	.32
Thorndike Lorge ratings			1.00

the second, third and fourth-grade words. It represents another aspect of the complexity of the reading task. Additional letters represent increased information and a concurrent increase in the possibility of error in decoding words. Further, longer words can be considered more complex because of syllable boundaries.

Since both the orthographic difficulty variable and the number of letters variable represent various aspects of the complexity of the task of decoding words, and since the construct validity of the orthographic difficulty variable was not clearly established, it was decided to include the number of letters variable along with the orthographic difficulty variable to represent the complexity of the task of reading words in the analyses of characteristics of words. The issue of the construct validity of the orthographic difficulty variable will be addressed again later in this chapter and in the final chapter.

Orthographic Difficulty and Grade Level as predictors of performance on the word list.

To illustrate the relationship between the orthographic difficulty rating of individual words at various grade levels and the number of errors made on those words, the continuous variable, orthographic difficulty, was divided into three categories, roughly approximating a three-stanine grouping of 54 percent in the middle category and 23 percent in the two extreme categories. The categories were labeled: easy, average and difficult, with data presented for each category for words that are typically taught in basal readers in first grade, second grade, third grade and fourth grade. Inspection of the data in Table 22 makes it clear that both second and third-grade students made more

Table 22

Percent of Errors for First, Second, Third and Fourth Grade Words, for Three Categories of Orthographic Difficulty, for Second and Third Grade Subjects.

	Orthographic Difficulty			
	Easy	Average	Difficult	Total
Second grade subjects (N = 29)				
First grade words	08	17	41	19
Second grade words	22	35	53	36
Third grade words	29	49	71	53
Fourth grade words	51	57	78	63
Third grade subjects (N = 28)				
First grade words	03	03	04	03
Second grade words	03	08	13	08
Third grade words	11	18	34	21
Fourth grade words	23	23	40	29

errors on words with "difficult" letter-sound relationships, and they also made increasingly more errors on first, second, third and fourth-grade words.

Hypothesis 2a states that orthographic difficulty is a significant predictor of reading errors on the word list for second and third-grade subjects of average, poor and very poor reading ability. Table 23 presents the correlations relative to this hypothesis, along with the means and standard deviations for the errors on the words made by the various reader groups.

Table 23 makes it clear that orthographic difficulty is a good predictor of error rates on words when those words are read by average, poor or very poor second or third-grade readers. However, it is possible that a variable that covaries with orthographic difficulty is responsible for the relationship, so further analyses were undertaken.

As was mentioned earlier in this section, the orthographic difficulty ratings of words increase with the grade level of the words. On average, the words taught in the fourth grade have higher orthographic difficulty ratings than those of the third-grade words; the third-grade words have higher ratings than the second-grade words; etc. This raises the possibility that it was instruction or grade level and not orthographic difficulty which was primarily responsible for the significant relationship between orthographic difficulty and the number of errors made on the words.

Given the limited resources of the present study, it was not possible to observe and record over a period of two years the words to which the students were exposed during the course of their reading instruction. However, the Harris Jacobson (1972) categorization of

Table 23

Mean Number of Errors per Subject and Standard Deviations for the Error Rates on Words on the 120 Word Reading Task; Correlations Describing the Relationship Between the Orthographic Difficulty Variable and the Error Rates on the Words.

	Very poor	Poor	Average	Total
Second Graders				
Mean number of errors per subject word	.67	.45	.26	.42
Standard deviation	.30	.30	.25	.26
Correlation	.59*	.50*	.45*	.54*
Third Graders				
Mean number of errors per subject word	.26	.19	.09	.15
Standard deviation	.26	.23	.14	.18
Correlation	.42*	.39*	.35*	.42*

* significant at the .05 level

words according to the grade level at which the words are typically taught in basal readers might provide a variable which would reflect the students' instruction in the words used in the study. As hypothesis 3a predicts, the grade level at which words are taught is a significant predictor of error rates on the word list with a multiple correlation of .665 accounting for 44 percent of the variance ($F = 30.609$, $df = 3,116$). Further, there were large differences in the students' performance on the words typically taught at the four grade levels. The subjects missed 10 percent of the first grade words, 23 percent of the second grade words, 37 percent of the third grade words and 47 percent of the fourth grade words.

These results suggest that the students who served as subjects in this study have had much less exposure in their reading instruction to the fourth grade words than to the third-grade words, and less exposure to the third-grade words than to the second-grade words, etc. This implies that the grade level at which words are typically taught (as identified by the Harris Jacobson lists) is an acceptable variable to use as a substitute for the direct observation and recording of the content of reading instruction over a long period of time.

To return to the relationship between orthographic difficulty and instruction, since the orthographic difficulty rating of words increases with the grade level of the words, the question arises: does knowledge of the orthographic difficulty rating of individual words contribute significantly in predicting error rates for words over and above what can be predicted based upon the knowledge of when words are usually taught? A series of prediction equations were analyzed in which in each case the grade-level variable was entered first in the prediction equation. The results of the separate analyses for the various groups of average, poor and very poor second and third-grade readers are presented in Table 24.

Clearly, the orthographic difficulty variable, that is, the difficulty of the letter-sound relationships within individual words, is related to the error rates on the words, even after controlling for the grade level of the words, for the three groups of second-grade readers and for the three groups of third-grade readers. This must be considered as offering strong support for hypothesis 2a: the orthographic difficulty rating of words is a significant predictor of the number of errors made on those words by average, poor and very poor readers in second and third grade.

However, given the fact that the construct validity of the orthographic difficulty variable was not unambiguously established, further analysis was conducted to determine if the orthographic difficulty variable contributes variance over and above both the variable representing the grade level on which words are typically taught and the number of letters variable. The results of this analysis are reported in Table 25. For each of the second-grade reader groups and for the total second-grade group, orthographic difficulty contributed significant variance over and above the contribution of the other two variables in predicting error rates on words. For the third-grade reader groups, orthographic difficulty contributes significant variance over and above the contribution of the other variables for the very poor readers and the total third grade sample. Also, it came close to reaching significance in the poor reader group. Although the results are still not conclusive,

Table 24

Contribution of the Orthographic Difficulty Variable Over and Above the Contribution of the Grade Level Variable in the Prediction of Error Rates on Words for Average, Poor and Very Poor Second and Third Grade Readers.

	Variance due to the grade level of words	Increase due to orthographic difficulty	Total variance	Change in R^2 F values (df 1,116)
Second graders				
Very poor	.236	.251	.486	56.06*
Poor	.497	.119	.616	35.63*
Average	.341	.106	.448	22.09*
Total	.464	.160	.625	49.12*
Third graders				
Very poor	.375	.085	.459	18.00*
Poor	.293	.073	.365	13.18*
Average	.219	.065	.284	10.53*
Total	.333	.087	.420	17.22*

* significant at the .05 level

Table 25

Individual Stepwise Regression Analyses for Various Second and Third Grade Reader Groups.

	Variance due to the grade levels of words	Variance due to instruction and number of letters	Increase due to O.D.	Total variance	Change in R^2 from adding O.D. F values
Second grade readers					
Very poor	.236	.391	.103	.494	23.140*
Poor	.497	.592	.036	.628	10.99*
Average	.341	.414	.039	.453	8.09*
Total	.464	.580	.055	.635	17.27*
Third grade readers					
Very poor	.375	.450	.022	.472	4.65*
Poor	.293	.352	.021	.373	3.85
Average	.219	.271	.020	.291	3.14
Total	.333	.406	.025	.430	4.90*

O.D. - orthographic difficulty

* significant at the .05 level

they do contribute further support for the construct validity of the orthographic difficulty variable.

Hypothesis 2b concerned the interaction of instruction, the achievement level of subjects and orthographic difficulty as predictors of the error rates on words. Again, in this analysis, the grade level of the words was used as a substitute for the recording of the content of reading instruction over a period of time. This hypothesis was examined using a multivariate approach which explored the relationships among six dependent variables (error rates on words read by average, poor and very poor readers in second and third-grade) and the nine independent variables (four categorical variables representing the four grade levels of the words, orthographic difficulty, and the interaction terms). The six dependent measures represent repeated measures on the words selected for the study: the same list of words was read by the second and third-grade subjects, who were average, poor and very poor readers.

To illustrate the various strengths of the relationships among orthographic difficulty, and grade level of the words for the total sample, and the four reading groups, the results of 36 separate univariate analyses are reported in Table 26. This table illustrates the predictive strength of the orthographic difficulty variable, since in most cases, even with reader groups with as few as five subjects, there were significant relationships between the number of errors made on individual words and the orthographic difficulty ratings of those words. The most striking exception was the lack of a relationship between orthographic difficulty and the error rates on words for third graders reading first-grade words.

Table 26

Descriptive Statistics and Correlations for the Errors per Word Dependent Variable Derived from Various Groupings of Subjects Reading Words Taught in Grades One through Four.

	Second grade readers			All	Third grade readers			All	All
First grade	Very poor	Poor	Average	second	Very poor	Poor	Average	third	subjects
words	N = 5	N=14	N = 10	N = 29	N = 6	N=8	N = 14	N = 28	N = 57
Total errors	66	63	19	148	10	10	10	30	178
Errors per sub.	13.20	4.50	1.90	5.10	1.67	1.25	.71	1.07	3.12
Errors per sub. per word	.44	.15	.06	.17	.06	.04	.02	.04	.10
Standard deviation	.32	.13	.08	.12	.10	.08	.06	.05	.07
Correlation with O.D.	.43*	.30	.37*	.44*	.00	-.03	-.13	-.09	.35

* significant at the .05 level

Table 26 (continued)

Second grade words	Second grade readers: Very poor N = 5	Second grade readers: Poor N=14	Second grade readers: Average N = 10	All second N = 29	Third grade readers: Very poor N = 6	Third grade readers: Poor N=8	Third grade readers: Average N = 14	All third N = 28	All subjects N = 57
Total errors	100	153	59	312	31	26	10	67	379
Errors per sub.	20.00	10.93	5.90	10.76	5.17	3.25	.71	2.39	6.65
Errors per sub. per word	.67	.36	.20	.36	.17	.11	.02	.08	.22
Standard deviation	.25	.20	.19	.17	.20	.13	.05	.09	.13
Correlation with O.D.	.81*	.76*	.42*	.78*	.54*	.29*	.41*	.47*	.71*

* significant at the .05 level

Table 26 (continued)

Third grade words	Second grade readers: Very poor N = 5	Second grade readers: Poor N=14	Second grade readers: Average N = 10	All second N = 29	Third grade readers: Very poor N = 6	Third grade readers: Poor N=8	Third grade readers: Average N = 14	All third N = 28	All subjects N = 57
Total errors	115	245	104	464	62	61	56	179	643
Errors per sub.	23.00	17.50	10.40	16.00	10.33	7.63	4.00	7.39	11.28
Errors per sub. per word	.77	.58	.35	.53	.34	.25	.13	.21	.38
Standard deviation	.25	.23	.24	.21	.22	.23	.18	.18	.18
Correlation with O.D.	.52*	.63*	.46*	.62*	.50*	.42*	.32	.44*	.57*

* significant at the .05 level

Table 26 (continued)

Fourth grade words	Second grade readers: Very poor N = 5	Poor N=14	Average N = 10	All second N = 29	Third grade readers: Very poor N = 6	Poor N=8	Average N = 14	All third N = 28	All subjects N = 57
Total errors	122	290	135	547	83	88	71	242	789
Errors per sub.	24.40	20.71	13.50	18.86	13.83	11.00	5.07	8.64	13.84
Errors per sub. per word	.81	.69	.45	.63	.46	.37	.17	.29	.46
Standard deviation	.22	.27	.27	.24	.27	.29	.16	.20	.21
Correlation with O.D.	.59*	.29	.40*	.40*	.30	.34*	.43*	.42*	.43*

* significant at the .05 level

The first multivariate analysis combined the six dependent variables into one variable and indicated that orthographic difficulty does interact with the grade level of the words as a predictor of error rates on words ($F = 17.15$, $df = 3,111$, significant at the .05 level). The second multivariate analysis employed comparisons of the six dependent variables producing four new dependent variables and indicated that orthographic difficulty and the grade level of the words interact with the reading achievement levels of subjects as predictors of the word error rates; ($F = 79.77$, significant at the .05 level). That is, the strength of the orthographic difficulty variable varies across the different grade levels of the words and for groups of readers varying in their grade levels and achievement.

This offers support for hypothesis 2b, since orthographic difficulty was generally a good predictor of error rates on words, except for the third graders reading the first grade words. It is hoped that this result will serve to clarify the relationship between orthographic complexity and instruction which was discussed by Guthrie and Seifert (1977) and Venezky and Johnson (1973). The complexity of various items in a task determines which items will be learned first. However, extended instruction can be effective. After three years of exposure to first-grade words, the third graders had mastered those words; the fact that the words had been presumably taught and learned obscured the problems which subjects had with complex words while they were being learned.

To summarize, the orthographic difficulty of words is a characteristic of words which is a powerful predictor of problems students have in learning to read. Both poor and average readers have trouble reading orthographically difficult (complex) words.

So far in this section, it has been reported that both the grade level of words i.e., knowledge of when particular words are usually taught and orthographic difficulty are characteristics of words which are related to the probability that a particular word will be read correctly. The next part of this section explores the relationship between the semantic difficulty of words and error rates on those words.

Vocabulary (semantic difficulty)

As described in the Methods chapter, semantic difficulty ratings were obtained for only 20 of the sample of 30 words in each grade, for a total of 80 words. The relationship between vocabulary and reading performance was explored in this data set.

In general, most of the words were known by the subjects. Descriptive statistics for this variable are presented in Table 27. Inspection of the errors per subject column indicates that the subjects missed only one word or less out of 20 for the first and second-grade words, and that they missed only 3 of 20 third-grade words. As expected, they did poorest on the fourth-grade words, missing approximately 7 of the 20 words.

Hypothesis 3a predicted that the semantic difficulty of words in the word list is a significant predictor of the reading error rates for the same words. The data presented in Table 27 do not support this hypothesis. Although there is a significant relationship between the vocabulary and reading errors for the second-grade words, the reliability of this relationship must be questioned since it was

Table 27

Descriptive Statistics for the Vocabulary Measure; Correlations Describing the Relationship between Reading and Knowing a Meaning of Individual Words.

	Total errors	Errors per subject (28 subjects)	Errors per subject per word	Standard diviation	Correlation with reading errors
1st grade words (N = 20)	7	.25	.013	.03	.07
2nd grade words (N = 20)	32	1.14	.057	.08	.60*
3rd grade words (N = 20)	81	2.89	.145	.19	.30
4th grade words (N = 20)	206	7.36	.368	.33	-.01

* significant at the .05 level

based upon very few errors, and since a similar relationship was not found in the third and fourth-grade words where there is considerably more variance. Clearly, the most significant fact is that the second and third-grade subjects knew the meanings of almost all of the first, second and third-grade words. The results suggest that the semantic difficulty of the words typically taught in first through third grade cannot be a factor in the second and third-grade subjects' correct reading of those words simply because they are familiar with almost all of the words.

However, the lack of a relationship between semantic difficulty and reading errors was surprising in the fourth-grade sample of words because the subjects made a larger number of errors (an average of 7 errors on 20 words) and there was considerable variance. This does not offer support for Rumelhart's model as it applies to the reading of a single word, in that a subject's knowledge of a word, and therefore the availability of that word as one of a number of possible hypotheses for the word, was not a factor in the subject's correct reading of that word. It could be that the lack of a positive relationship found here is due to the small sample of words studied and to the small number of subjects who were asked the meaning of each word. However, given the fact that the correlation approached zero it seems unlikely that a more rigorous study would produce a different result. A more definitive statement will have to await further research.

It should also be noted, as a reminder, that the present study is dealing with beginning reading and only with the reading of single words. It is very possible that a similar study of mature readers would reveal a significant relationship between vocabulary and reading comprehension of text.

Summary of Word Characteristics

A stepwise regression was conducted to summarize the characteristics of words which relate to the likelihood that words will be read correctly by second and third-grade subjects. It was found that the semantic difficulty of words was not related, while the orthographic difficulty of words, the number of letters in a word, and the grade level at which words are typically taught were related.

The results presented in Table 28 indicate that the grade level variable was the best predictor of error rates for words, with a correlation of .66 accounting for 44 percent of the variance. Grade level, the number of letters in a word, and orthographic difficulty, together yield a multiple correlation of .77 accounting for 59 percent of the variance. It should also be noted that the orthographic difficulty variable contributes significant variance over and above the other two variables.

Table 28

Stepwise Regression of Word Characteristics

	Multiple correlation (cumulative)	Total variance (cumulative)	Increase in variance	Change in R^2 (df 1,116)
Grade level of words	.662	.439	-	30.21*
Letters	.738	.544	.105	26.59*
Orthographic difficulty	.768	.589	.045	12.52*

* significant at the .05 level

CHAPTER 10

Conclusions and Implications for Future Research

The previous chapter dealt separately with the characteristics of subjects and the characteristics of words which relate to beginning reading failure. The present chapter will consider the results of those separate analyses together to draw some conclusions about beginning reading failure. To facilitate this analysis, variables representing person and word characteristics as identified in the hypotheses are presented in Figure 7 along with the correlations representing the strength of the relationship between each variable and the dependent variable, error rates on words. As Figure 7 illustrates, the complexity, vocabulary and grade level variables were examined as both person and word characteristics. Phonemic segmentation and cognitive ability were studied as person variables only. A summary of the results pertaining to the analyses of each of the variables in the figure are presented in turn.

Phonemic segmentation

Consistent with what was hypothesized and contrary to the results and conclusions of Liberman, Shankweiler and Vellutino, the results reported support the conclusion that phonemic segmentation skill, which was measured using the same procedure used by Liberman et al. (1974), is not a major causal factor in second and third-grade students' failure to decode words.

Orthographic difficulty

Consistent with what was hypothesized for complexity as a person variable, the results indicate that subjects' ability to deal with the complexities of letter-sound relationships, as measured by the nonsense

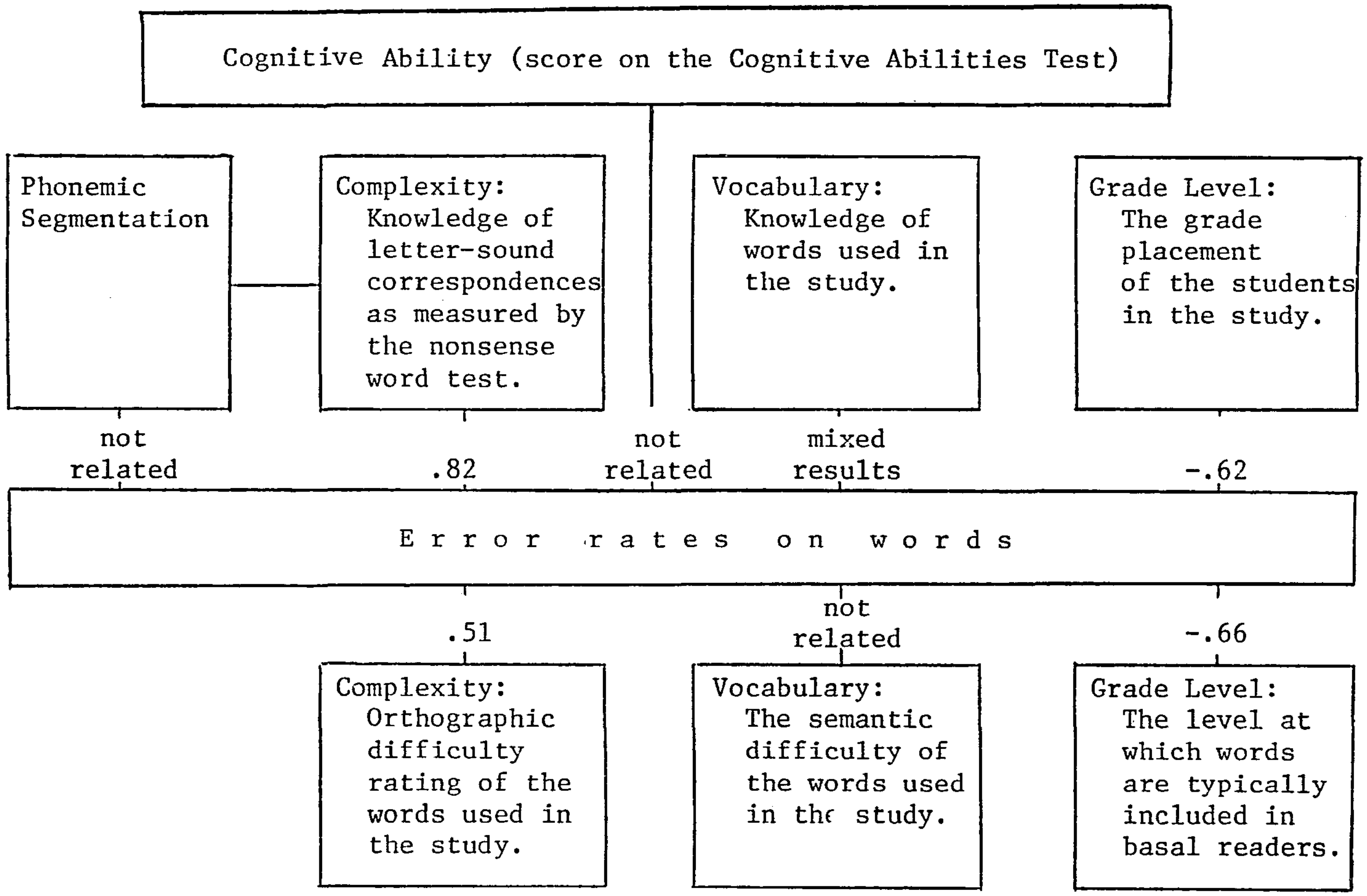

Figure 7

Relationship between the Variables Identified in the Hypotheses and Error Rates on the Word List.

word test, is related to their ability to read words. Also, consistent with what was hypothesized for complexity as a word characteristic, the results indicate that it is possible to rate words according to their complexity and use those ratings to predict which words on a list would be read correctly. The strength of this relationship is illustrated by the fact that the two task variables representing aspects of complexity, orthographic difficulty and the number of letters in words, account for 37 percent of the variance in the prediction of the error rates on words and by the fact that in the summary analysis the orthographic difficulty variable by itself contributes significant amounts of variance over and above what is accounted for by the grade level and number of letters variables.

Taken together, the analyses of the complexity variable as manifest in both person and word characteristics suggest that the complexity of the word reading task and the students' ability to deal with that complexity should be considered as possible factors in beginning reading failure. Subjects lacking in skills necessary to handle the complex aspects of letter-sound associations within words are, for the most part, also the same subjects who are having problems reading words; also words which have more complex letter-sound correspondences are, generally, harder for both poor and average-achieving students to read.

Grade Level

The grade level of the subjects was a significant predictor of the subjects' performance on the word reading task. As a word characteristic, knowledge of the grade level at which words are typically taught was a significant predictor of error rates on words.

The positive results for grade level as both a person and word characteristic suggest that instruction is an important variable in the process of learning to read and, thus, should be considered as a possible cause of reading failure. These results are consistent with the conclusions of Venezky and Johnson (1973) and Calfee (1981) that students learn what they are taught.

Vocabulary

Contrary to what was hypothesized, the combined examination of vocabularly as a person characteristic (students knowledge of the meaning of the words used in the study) and as a word characteristic (a rating of the semantic difficulty of the words used in the study) does not support the hypothesis that knowledge of a word is an aid to reading the word. This result suggests that "word knowledge" is not a skill that plays a major role in providing "top-down" information in the reading of words.

Cognitive ability

Contrary to what was hypothesized, subjects' ability to read words was not related to their cognitive ability, as measured by a score on the Cognitive Ability Test, a group administered, untimed test which emphasizes language and vocabulary concepts. Although unexpected, this result is consistent with the vocabulary results: it is likely that students' knowledge of words is unrelated to their ability to read words typically taught in first, second, third and fourth grade.

A summary of the results focusing on the variables which are related to reading failure is illustrated in Figure 8. The picture that emerges is one that emphasizes the importance of instruction in

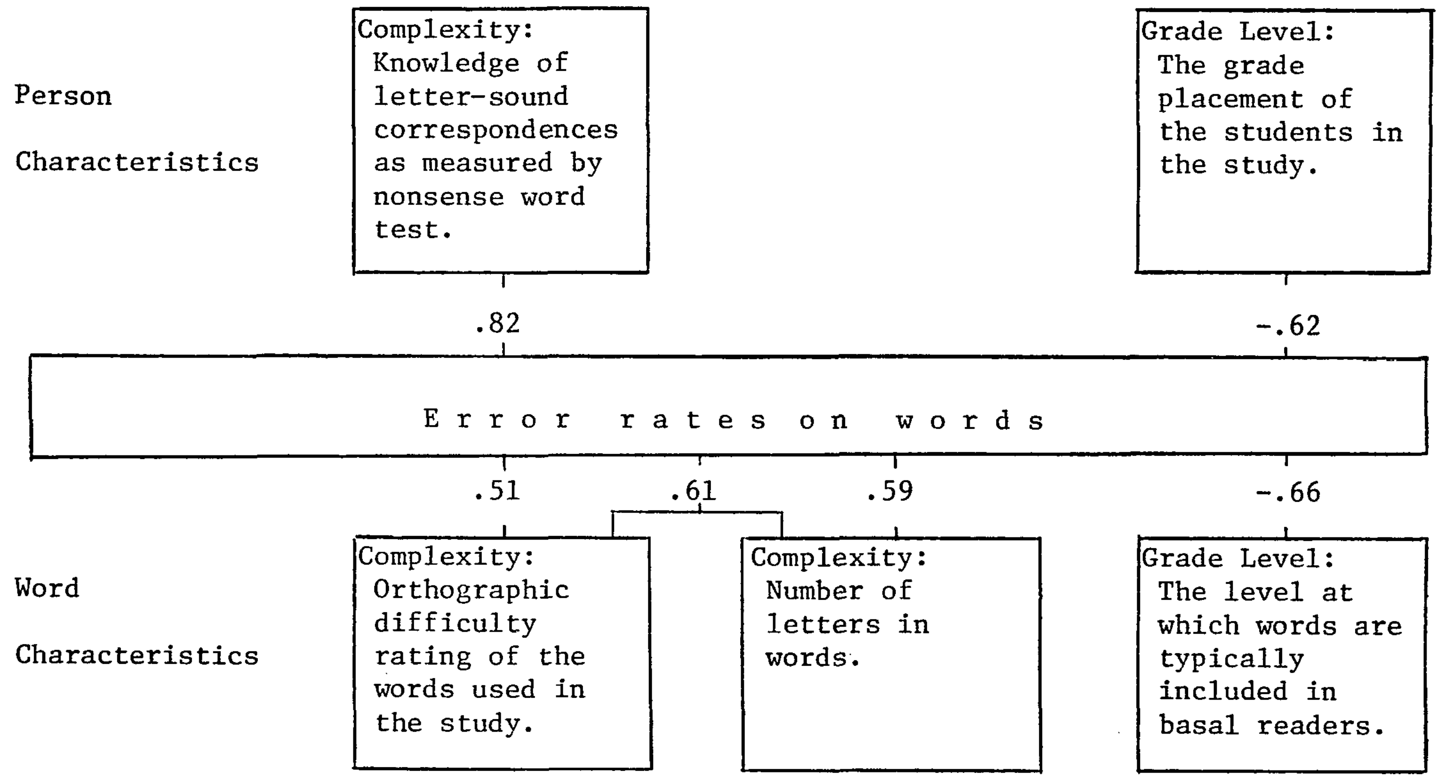

Figure 8

Illustration of Variables Related to Error Rates on the Word List fostering students' mastery of the reading task as that task increases in complexity.

As hypothesized, the results suggest that phonemic segmentation is not related and, therefore, it is no longer included. Vocabulary has also been removed. Contrary to what was hypothesized, the subject's knowledge of a word does not seem to facilitate the reading of words typically taught in grades one through four. This suggests that the demonstrated effect of "top-down" processes on the perception of words and letter sequences occurs, as far as beginning reading is concerned, below the level of the word: they operate at the letter and letter cluster level. Knowledge of complex letter-sound correspondences facilitates the perception of words while knowledge of word meanings does not.

Also missing from Figure 8 is the cognitive ability variable since, contrary to what was hypothesized, cognitive ability, as represented by a score on the Cognitive Ability Test, did not correlate with subjects' ability to read words. The interpretation favored here is that the particular measure chosen was not related because it emphasized language and vocabulary skills. However, this result does not rule out the possibility that other measures of intellectual ability might be related to subjects' ability to read words.

Causes of reading failure

The research described in the review of the literature section detailed a long history of variables which were considered and later rejected as possible causes of reading failure. Most of the variables considered and rejected represented basic psychological processing skills in which poor readers were thought to be deficient. These psychological process deficits included, most prominently, visual perception deficits, such as subjects' tendency to reverse and miss-perceive letters. They also included auditory discrimination deficits, visual-motor integration deficits and others.

The process of looking at readers of varying levels of proficiency and considering their performance reading words, which represent a measureable range of complexity, confirms the rejection of the basic psychological process deficit notions of beginning reading failure, including the rejection of the importance of the ability to perceive and count the individual phonemes in a syllable (phonemic segmentation). If these skills were not intact it is hard to explain how poor readers can read some words (words with simple letter-sound correspondences) and have problems reading other words.

Given the knowledge provided by the present study as to the possibility of quantifying the complexity of the task of reading words, the answer to the question of why students are having problems in beginning reading is altered when the question is viewed from this new perspective. The present results suggest that problems in learning to read are a dual function of the increasing complexity of the reading task, that is, the complexity and frequency of occurrence of letter-sound correspondences and the number of letters in words, as well as the student's progress in mastering that complexity through instruction. The results suggest that students are having problems learning to read because they are having problems mastering a complex cognitive task.

However, the results do not provide a definite answer as to which of the two variables representing aspects of the complexity of words in this study is primarily responsible for students' problems in reading words. It could be that students' knowledge of letter-sound correspondences is incidental to their ability to derive meaning from print and that the number of letters in a word is the best predictor of the increasing complexity of the task. Alternate explanations are that the associations between words and their meanings are a amalgamation of visual, auditory and semantic elements as suggested by Ehri (1980) or that students' problems with mastery of the increasingly complex letter-sound correspondence system in English orthography are primarily responsible for their difficulties in reading words.

To speculate about the evidence presented here, the favored interpretation is that the complexity of letter-sound associations is of primary importance, considering the interrelationships between this variable and the number of letters in a word variable. This interpretation is favored because of the predictive power of the orthographic difficulty variable (as a word characteristic) over and above the grade level of words variable and the number of letters variable in the prediction of error rates on words in the summary analysis and because, as a person variable, the results clearly indicate that subjects' knowledge of letter-sound relationships (as measured by the nonsense word test) is a good predictor of subjects' ability to read words.

Implications for future research

From a methodological point of view, the present research has initiated a new approach through the use of the simultaneous analyses of variables as they are manifest in both the person and the task of reading words. The utility of this approach in the facilitation of hypothesis testing in an area such as reading which includes interrelated cognitive skills is illustrated by the following example.

The results indicated that vocabulary, as a person variable, (subjects' knowledge of the meaning of the words in the study), was a significant predictor of how second grade students performed on the word reading task, although the amount of variance accounted for by this variable was low and a similar relationship was not found for third grade students. However, such an analysis of vocabulary as a person variable alone provides a limited perspective since vocabulary knowledge correlates highly with general measures of intellectual ability and, possibly, many specific cognitive skills. It could very well be that anyone of a number of variables was responsible for the fact that knowledge of subjects' vocabulary skills allowed the prediction of subjects' performance on the word reading task. The methodological approach of simultaneously analyzing vocabulary as both a person and a word characteristic actually provides the opportunity of controlling for intellectual ability and all other person characteristics. If vocabulary is a significant factor in the process of correctly reading words, then words with high semantic difficulty should be harder to read than words with low semantic difficulty. Because the error rates for the semantic difficulty of words and the reading of words were generated by the responses of all subjects, the analysis of vocabulary as a word characteristic controls for intellectual ability and other person variables. Taken together, the task and person analyses of vocabulary provide a perspective and a conclusion which could not have been reached if vocabulary were examined as a person variable only.

A second contribution of the present research is the conceptualization of the process of reading words as a task which varies in difficulty according to the complexity and frequency of occurrence of letter-sound correspondences and the number of letters in a word. The identification of a continuum of complexity within the process of reading words calls into question as too simplistic much of the research on how poor and average readers differ in terms of various processing deficits. To return to the Vellutino and Scanlon (1979) experiment, which was described in detail in Chapter 3, the authors of that paper were not impressed with differences in the ability of poor and average readers to remember syllable-symbol associations. Instead, they were more impressed with the poor readers' inability to remember sounds. However, the task employed by Vellutino and Scanlon to test subjects' ability to associate sounds with symbols used a symbol-sound association system with invariant, one-to-one correspondences, an association system as non-complex as possible. Had Vellutino and Scanlon tested their poor and average readers on an association task which varied in its complexity, they might have been more impressed with differences between poor and average readers in this skill.

The crucial point is that the present results suggest that all words are not alike. Students' ability to handle the task of reading words as the words increase in complexity might be a critical variable to consider in attempting to answer the question of why some students are having problems learning to read.

By considering the problem of reading failure from both a person and a task perspective, a pattern of results emerges which suggests that future research should be directed to the question of why students are having problems decoding words. The research which most directly addresses this question is the Vellutino and Scanlon (1979) research paper. Although the present author criticized both the design and the conclusions of this study, nevertheless, the thrust of the paper is clearly aimed at what is, in the present author's opinion, a critical issue. There is a need to determine why students are having problems learning the associations of letters and sounds, but this question must be explored using letter-sound association tasks which vary in their complexity.

Finally, the present research has implications for the teaching of reading. If future research confirms the importance of decoding, instruction and the hypothesis that words vary in the complexity of their letter-sound correspondences, then curriculum development specialists would be presented with a challenge to improve beginning reading instruction. The present research offers no direct answers as to how instruction could be improved; however, given a knowledge of the revelant variables, it might be possible to design instruction so that students will be able to master complex letter-sound correspondences more quickly.

Conclusion

Resnick (1979), in summarizing the wide variety of both experimental and theoretical articles contained in a book entitled Theory and Practice of Early Reading, and in relating them to evaluation studies in field settings, concludes that learning to decode is of primary importance in beginning reading. Resnick is supported by Chall (1979), Vellutino (1979) and Stanovich (1980) who have reached similar conclusions. The present research contributes further support to this conclusion because it considered the relevant variables, in a single data set, as those variables were manifest in both persons and the task. The results suggest that a possible cause for beginning reading failure is that students are having difficulties learning to read words both because of the increasing complexity of this task and because of their problems mastering that complexity with reading instruction.

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Appendix

Words Randomly Drawn from the Harris Jacobson (1972)

Word Lists for Grades One through Four.

First grade words:

time	was	or
white	hop	which
dark	pocket	way
along	wish	came
be	maybe	duck
long	rocket	own
gave	story	friend
road	should	cut
food	leg	feet
cow	fat	any

Second grade words:

sweet	dinner	roll
near	fourth	trouble
elephant	sell	shout
wonder	eye	sled
stamp	land	fit
wonderful	cup	face
shape	woke	nail
star	smoke	greedy
evening	family	explore
mark	summer	blew

Words Randomly Drawn from the Harris Jacobson (1972)

Word Lists for Grades One through Four. (continued)

Third grade words:

sack	thrown	mention
weed	bridge	chief
hotel	invisible	slept
bread	knife	lightning
stuff	trail	upon
figure	touch	office
chuckle	draw	meant
arrow	aim	laughter
offer	warn	sail
hay	pour	tender

Fourth grade words:

phone	service	nobody
medical	chore	member
booth	kid	practical
instrument	ashore	weep
thrust	solid	relief
huddle	chart	paddle
provide	entire	kangaroo
argue	audience	mitten
receive	scornful	ridge
collar	jolly	fluff

Orthographic Difficulty Values

Key:	word	
	Hanna et al. phonetic spelling	
	orthographic difficulty values	total value

t	i	m	e		
T	I	M			
0	1	0			1.0

w	h	i	t	e	
HW		I	T		
1½		1	0		2.5

d	a	r	k	
D	A_5	R	K	
0	½	¼		.75

a	l	o	n	g	
SWA .	L	O_5	NG		
1 ½	0	½	1		3.0

b	e	
B	E	
0	½	.5

l	o	n	g	
L	O_5	NG		
0	½	1		1.5

Orthographic Difficulty Values (continued)

						Value
g	a	v	e			
G	A	V				
0	1	0				1.0
r	o	a	d			
R	O		D			
0	1		0			1.0
f	o	o	d			
F	O_6		D			
0	1		0			1.0
c	o	w				
K	OU					
0	2					2.0
w	a	s				
W	O_3	Z				
0	1	1				2.0
h	o	p				
H	O_3	P				
0	0	0				0.0
p	o	c	k	e	t	
P	O_3		K +	E_3	T	
0	0		1 ½	0	0	1.5

											Value
w		i		s		h					
W		I_3			SH						
0		0			1						1.0

											Value
m		a		y		b		e			
M			A		+	B		E			
0			1		½	0		½			2.0

											Value
r		o		c		k		e		t	
R		O_3			K		+	E_3		T	
0		0			1		½	0		0	1.5

											Value
s		t		o		r		y			
S		T		O	+	R		I_3			
	¼			½	½	0		1			2.25

											Value
s		h		o		u		l		d	
	SH					O_7				D	
	1					1½				1	3.5

											Value
l		e		g							
L		E_3		G							
0		0		0							0.0

											Value
f		a		t							
F		A_3		T							
0		0		0							0.0

Orthographic Difficulty Values (continued)

						Value
o	r					
O_2	R					
½	0					.5
w	h	i	c	h		
HW		I_3	CH			
1½		0	1			2.5
w	a	y				
W	A					
0	1					1.0
c	a	m	e			
K	A	M				
0	1	0				1.0
d	u	c	k			
D	U_3	K				
0	0	1				1.0
o	w	n				
O		N				
1		0				1.0
f	r	i	e	n	d	
F	R	E_3		N	D	
¼		1½		¼		2.0

Orthographic Difficulty Values (continued)

													Value
c		u		t									
K		U_3		T									
0		0		0									0.0
f		e		e		t							
F			E			T							
0			1			0							1.0
a		n		y									
E_3		N	+	I_3									
1		0	½	1									2.5
s		w		e		e		t					
S		W			E			T					
	¼				1			0					1.25
n		e		a		r							
N			E_2			R							
0			1½			0							1.5
e		l		e		p		h	a	n		t	
E_3		L	+	E	.		F		A_3	N		T	
0		0	½	½	¼		1		0		¼		2.5
w		o		n		d		e	r				
W		U_3		N	+	D		E_5	R				
0		1		0	½	0		½	0				2.0

							Value
s		t	a	m		p	
S		T	A_3	M		P	
	¼		0		¼		.5

											Value
w	o	n		d	e	r		f	u	l	
W	U_3	N	+	D	E_5	R	.	F	O_7	L	
0	1	0	½	0	½	0	¼	0	1	0	3.25

					Value
s	h	a	p	e	
SH		A	P		
1		1	0		2.0

					Value
s		t	a	r	
S		T	A_5	R	
	¼		½	0	.75

							Value
e	v	e	n	i	n	g	
E	V	+	N	I_3	NG		
1½	0	½	0	0	1		3.0

					Value
m	a	r		k	
M	A_5	R		K	
0	½		¼		.75

								Value
d	i	n		n		e	r	
D	I_3		N		+	E_5	R	
0	0		0		½	½	0	1.0

Orthographic Difficulty Values (continued)

						Value
f	o	u	r	t	h	
F	O		R	T_1		
0	1½		0	1		2.5
s	e	l	l			
S	E_3	L				
0	0	0				0.0
e	y	e				
	I					
	2					2.0
l	a	n	d			
L	A_3	N	D			
0	0	¼				.25
c	u	p				
K	U_3	P				
0	0	0				0.0
w	o	k	e			
W	O	K				
0	1	0				1.0
s	m	o	k	e		
S	M	O	K			
¼		1	0			1.25

							Value
f	a	m	i	l	y		
F	A_3	M + SWA	.	L	I_3		
0	0	0 ½ 1	¼	0	1		2.75
s	u	m	m	e	r		
S	U_3	M	+	E_5	R		
0	0	0	½	½	0		1.0
r	o	l	l				
R	O	L					
0	½	0					.5
t	r	o	u	b	l	e	
T	R	U_3		B	+	L	
¼		1½		0	½	1	3.25
s	h	o	u	t			
SH		OU		T			
1		2		0			3.0
s	l	e	d				
S	L	E_3	D				
¼		0	0				.25
f	i	t					
F	I_3	T					
0	0	0					0.0

Orthographic Difficulty Values (continued)

											Value
f		a		c		e					
F		A		S							
0		1		0							1.0
n		a		i		l					
N			A			L					
0			1			0					1.0
g		r		e		e	d		y		
G		R			E		D	+	I_3		
	¼				1		0	½	1		2.75
e		x		p		l	o		r	e	
E_3		KS	.	P		L	O		R		
0		0	½		¼		1		0		1.75
b		l		e		w					
B		L			0_6						
	¼				2						2.25
s		a		c		k					
S		A_3			K						
0		0			1						1.0
w		e		e		d					
W			E			D					
0			1			0					1.0

Orthographic Difficulty Values (continued)

													Value
h		o		t		e		l					
H		O	.	T		E_3		L					
0		½	½	0		0		0					1.0
b		r		e		a		d					
B		R			E_3			D					
	¼				1			0					1.25
s		t		u		f		f					
S		T		U_3			F						
	¼			0			0						.25
f		i		g		u		r		e			
F		I_3		G	+	U		R					
0		0		0	½	1		0					1.5
c		h		u		c		k		l		e	
	CH			U_3			K		+	L			
	1			0			1		½	1			3.5
a		r		r		o		w					
A_3			R		+		O						
0			0		½		1						1.5
o		f		f		e		r					
O_5			F		+	E_5		R					
½			0		½	½		0					1.5

Orthographic Difficulty Values (continued)

	Value
h a y	
H A	
0 1	1.0
t h r o w n	
T_1 R O N	
1 0 1 0	2.0
b r i d e	
B R I D	
¼ 1 0	1.25
i n v i s i b l e	
I_3 N . V I_3 Z + SWA . B L	
0 0 ½ 0 0 1 ¼ 1 0 0 1	3.75
k n i f e	
N I F	
1 1 0	2.0
t r a i l	
T R A L	
¼ 1 0	1.25
t o u c h	
T U_3 CH	
0 1½ 1	2.5

Orthographic Difficulty Values (continued)

												Value
d		r		a		w						
D		R			0_2							
	¼				2							2.25
a		i		m								
	A			M								
	1			0								1.0
w		a		r		n						
W		0_2		R		N						
0		1			½							1.25
p		o		u		r						
P			O			R						
0			1½			0						1.5
m		e		n		t		i		o	n	
M		E_3		N	+	SH			SWA		N	
0		0		0	½	1			2		0	3.5
c		h		i		e		f				
	CH				E			F				
	1				1½			0				2.5
s		l		e		p		t				
S		L		E_3		P		T				
	¼			0			¼					.5

Orthographic Difficulty Values (continued)

															Value
l		i		g		h		t		n	i	n		g	
L		I						T	+	N	I_3		NG		
0		½			1½			0	½	0	0		1		3.5
u		p		o		n									
SWA	.	P		O_3		N									
1	½	0		0		0									1.5
o		f		f		i		c		e					
O_5			F		+	I_3		S							
½			0		½	1		0							2.0
m		e		a		n		t							
M			E_3			N		T							
0			1				¼								1.25
l		a		u		g		h		t	e	r			
L			A_5				F		+	T	E_5	R			
0			1½				1½		½	0	½	0			4.0
s		a		i		l									
S			A			L									
0			1			0									1.0
t		e		n		d		e		r					
T		E_3		N	+	D		E_5		R					
0		0		0	½	0		½		0					1.0

Orthographic Difficulty Values (continued)

																			Value
p		h		o		n		e											
	F			O		N													
	1			1		0													2.0
m		e		d		i		c		a		l							
M		E_3		D	+	I_3	.	K		A_3		L							
0		0		0	½	0	¼	0		0		0							.75
b		o		o		t		h											
B			O_6				T1												
0			1				1												2.0
i		n		s		t		r		u		m		e		n		t	
I_3		N	+	S		T		R		O_7	.	M		SWA		N		T	
0		0	½			½				1	¼	0		1			¼		3.5
t		h		r		u		s		t									
	T_1			R		U_3		S		T									
	1			0		0			¼										1.25
h		u		d		d		l		e									
H		U_3			D		+		L										
0		0			0		½		1										1.5
p		r		o		v		i		d		e							
P		R		O	.	V		I		D									
	¼			½	½	0		1		0									2.25

Orthographic Difficulty Values (continued)

											Value
a		r		g		u		e			
A_5		R	+	G			U				
½		0	½	0			1½				2.5
r		e		c		e		i	v	e	
R		E	.	S			E		V		
0		½	½	0			2		0		3.0
c		o		l		l		a	r		
K		O_3			L		+	E_5	R		
0		0			0		½	1	0		1.5
s		e		r		v		i	c	e	
S		U_2		R	+	V		I_3	S		
0		1		0	½	0		1	0		2.5
c		h		o		r		e			
	CH			O		R					
	1			1		0					2.0
k		i		d							
K		I_3		D							
0		0		0							0.0
a		s		h		o		r	e		
SWA	.		SH			O		R			
1	½		1			1		0			3.5

															Value
s		o		l		i		d							
S		O_3		L	+	I_3		D							
0		0		0	½	0		0							.5
c		h		a		r		t							
	CH			A_5		R		T							
	1			½			¼								1.75
e		n		t		i		r		e					
E_3		N	.	T		I		R							
0		0	½	0		1		0							1.5
a		u		d		i		e		n		c		e	
	O_2		+	D		I_3	.	SWA		N		S			
	2		½	0		0	¼	2			½				5.0
s		c		o		r		n		f		u		l	
S		K		O_2		R		N	+	F		O_7		L	
	¼			½			¼		½	0		1		0	2.5
j		o		l		l		y							
J		O_3			L		+	I_3							
0		0			0		½	1							1.5
n		o		b		o		d		y					
N		O	+	B		O_3		D	.	I_3					
0		½	½	0		0		0	¼	1					2.25

Orthographic Difficulty Values (continued)

																	Value
m		e		m		b		e		r							
M		E_3		M	+	B		E_5		R							
0		0		0	½	0		½		0							1.0
p		r		a		c		t		i		c		a		l	
P		R		A_3		K	+	T		I_3	.	K		A_3		L	
	¼			0		0	½	0		0	¼	0		0		0	1.0
w		e		e		p											
W			E			P											
0			1			0											1.0
r		e		l		i		e		f							
R		E	.	L			E			F							
0		½	½	0			1½			0							2.5
p		a		d		d		l		e							
P		A_3			D		+		L								
0		0			0		½		1								1.5
k		a		n		g		a		r		o		o			
K		A_3		NG	–	G		SWA	.	R			O_6				
0		0		1	½	0		1	¼	0			1				3.75
m		i		t		t		e		n							
M		I_3			T		+		N								
0		0			0		½		1½								2.0

Orthographic Difficulty Values (continued)

					Value
r	i	d	g	e	
R	I_3	J			
0	1	1½			2.5
f	l	u	f	f	
F	L	U_3	F		
	¼	0	0		.25

Phoneme Segmentation Task

(Liberman et al., 1974)

1. is
2. bet
3. my
4. toy
5. bat
6. beet
7. soap
8. bit
9. his
10. pout
11. mine
12. caw
13. out
14. red
15. cough
16. cough
17. pot
18. boot
19. heat
20. he
21. hot
22. pa
23. mat
24. but
25. so
26. bite
27. up
28. bout
29. book
30. toys
31. cake
32. cool
33. bait
34. Ed
35. cup
36. at
37. book
38. book
39. lay
40. coo
41. boat
42. oy

Nonsense Words Randomly Selected from List Developed by Firth (1972)

pard	mand	antly
lind	entle	hing
leat	ling	sheam
estor	hund	ment
stine	whish	lant
elly	sher	clest
ting	trate	faind
blint	blist	nally
hance	ress	mante
stic	ness	grack

January 14, 1983

Dear Parents,

During the months of January and February a number of students at George Washington School will be given special reading tasks as part of a research study examining how children learn to read. The study is being conducted by Lawrence Kilian to satisfy the requirements for a doctoral dissertation at the Graduate Center of the City University of New York.

The students selected for the study will be asked to read; they will be tested on their word attack skills and their knowledge of vocabulary concepts. The reading tasks will be administered in school and will take approximately 30 minutes. The results will be made available to you and to your child's teacher if you so request.

Please indicate whether or not you want your child to participate in the research study by filling out and signing the slip below.

Sincerely,

Lawrence J. Kilian

Lawrence J. Kilian
Evaluation Associate
White Plains Public Schools

January 14, 1983

☐ I want my child, ______________________________,
to participate in the reading research study.

☐ Please send the results to me and my child's teacher.

☐ I do not want my child to participate in the reading research study.

Signature ______________________ Date ______________

January 14, 1983

Dear Parents,

During the months of January and February a number of students at Post Road School will be given special reading tasks as part of a research study examining how children learn to read. The study is being conducted by Lawrence Kilian to satisfy the requirements for a doctoral dissertation at the Graduate Center of the City University of New York.

The students selected for the study will be asked to read; they will be tested on their word attack skills and their knowledge of vocabulary concepts. The reading tasks will be administered in school and will take approximately 30 minutes. The results will be made available to you and your child's teacher if you so request.

Please indicate whether or not you want your child to participate in the research study by filling out and signing the slip below.

Sincerely,

Lawrence Kilian

Lawrence Kilian
Evaluation Associate

June Fleary

June Fleary
Principal

January 14, 1983

☐ I want my child, ______________________________,
to participate in the reading research study.

☐ Please send the results to me and my child's teacher.

☐ I do not want my child to participate in the reading research study.

Signature ______________________________ Date ____________________