ACKNOWLEDGEMENTS

The completion of this thesis was made possible through the help of many individuals. I would like to thank Doreen Osborne, of the Reading Training Center at Concordia University, for her help in obtaining many of the subjects for this study. I would also like to express my appreciation to Drs. Norm Segalowitz, Mike Corballis, and Nancy Taylor members of my examining committee, for their useful comments.

I am particularly indebted to my advisor, Dr. Mel Komoda, for his suggestions, criticisms, and encouragement, and his willingness to help at any time, with any aspect of the study. Working with him is a real pleasure.

I would also like to say thanks to a good friend, Michael Meaney, who gave me the original impetus to undertake such a task and gave me help and reassurance at many points along the way.

This research was supported by grants awarded by the National Research Council of Canada (Grant no. A0678) and la Formation de Chercheurs et D'action Concertée (DGES- FCAC 77 - 10). While conducting this study the author was supported by a scholarship from la Direction Générale de l'enseignement Supérieur du Québec.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

THE WORD SUPERIORITY EFFECT IN FLUENT AND LESS FLUENT READERS

The skill of reading is of extreme importance since an individual's achievement in many other academic areas is bound to his ability to read. For this reason, in the last several decades the area of reading has received a disproportionate amount of attention compared to other aspects of education (Gibson & Levin, 1975). However as E.B. Huey (1908), a pioneer in reading research, pointed out, reading is such a complex skill that a full understanding of the processes involved in reading would represent quite an achievement. As in 1908, a comprehensive model of reading has yet to be developed.

Despite the obvious complexity of the reading process, until recently most investigators have proposed relatively simple explanations of reading, such as: Reading is primarily a matter of discriminating the shapes of letters, reading involves the activating of conditioned meanings, or reading consists of translating letters into sounds (Kolers, 1970). For the most part, research on reading and learning to read has only dealt with two processes: The discrimination of letters or words as visual forms, and the translation of these forms into speech sounds. Together, these two processes were what psychologists and educators meant by reading.

These models were basically associationistic accounts of reading. They tended to view the reading process as consisting of discriminating the component letters of a word, putting together the sounds the letters make by some knowledge of phonics, and then producing the oral equivalent of the written word. Comprehension of a passage of text was thought to be accomplished by decoding each word in the text in the manner outlined above.

In these associationistic models learning to read was thought to merely involve learning the 'hook-ups' between letters and sounds, and then grafting this knowledge onto the child's existing ability to understand language. The processes involved in fluent and beginning reading were thought to be very similar, with the only difference being that the fluent reader's associations between letters and sounds are stronger.

Recent work in the area of human information processing as well as current investigations into the nature of the English orthography, however, suggests that it is improbable that fluent readers read in the manner proposed by these associationistic models. This work has, in turn, led to the development of alternative models of the reading process. Rather than being a passive process, as suggested by the associationistic models of reading, the current models of reading suggest that reading is an active process. That is, the reader does not simply receive new knowledge, but rather utilizes any existing knowledge he has to extract meaning from the text during the reading process. This thesis investigates the relative contribution of one type of knowledge, that of knowledge of orthographic redundancy, which may be actively utilized by the reader in the reading process. The working hypothesis for this thesis will be developed by first citing some of the work that has inspired current characterizations of the reading process and then briefly describing some current models of reading and some common assumptions made by these models as to the nature of the processes involved in fluent reading.

One of the basic assumptions of associationistic models of reading is that reading is a letter by letter process in which letters must first be converted into speech sounds before meaning can be derived (Goodman, 1968). This assumption is questionable on two accounts: (1) Studies in the area of human information processing have shown that fluent readers read much too quickly for reading to be a letter by letter process which is mediated by implicit speech, and (2) investigations into the nature of the English orthography have shown that correspondences between letters and sounds in English are too complex for readers to be able to efficiently recognize words on the basis of letter-sound correspondences.

In relation to the first point, current research has shown that fluent readers read much too quickly to be identifying in succession the letters or words on the page, and that, fluent readers need not in fact, process every letter or phoneme of the material they are reading into a full perceptual representation in order to abstract meaning. As early as 1965, Neisser & Beller, and Neisser & Stoper, for example, found that subjects could scan words in a list at less than 200 msec per word in order to determine whether or not the word belonged to a target class. Neisser argued that these rates are too quick for subjects to have been identifying letters one by one and then identifying the word by putting together the component letters, since naming a single letter requires over 100 msec (Neisser, 1967, p.108). More recent work by Mc Conkie and Rayner (1975) and Rayner & Mc Conkie (1976) tends to support this point.

More direct evidence for the notion that fluent readers need not process every letter of the material they are reading into a full perceptual representation in order to derive meaning is given by a study by Smith (1969). In this study words and their component single letter were projected on a screen at below contrast threshold. The contrast level was gradually increased until the subject indicated that he could identify the word or letter. The contrast level at which single letters could be identified alone was compared to identification of the same letter in the context of a word. Words were found to be identified under conditions in which their component letters could not be identified. In fact, Holmes (1971) has taken this study to indicate that words can be identifed with half the featural information that would be necessary for individual letter identification provided that the features sampled are taken from different locations within the configuration.

Hence there is evidence to suggest that fluent readers read too quickly to be utilizing a letter by letter strategy in which letters are converted into speech sounds. Also, it seems that readers need not even process every letter or phoneme of the material they are reading into a full perceptual representation in order to abstract meaning. As will be elaborated later, these findings have led several researchers to suggest that readers may in fact sample the visual data in reading rather than process every element of the text.

In relation to the second point, critics of associationistic models of reading have been quick to point out the 'chaotic' nature of the English orthography. Since no one-to-one correspondence exists between written and spoken English, the orthography is thought to be too irregular and unreliable for a reader to be able to reliably recognize words. Hall (1961), for example, documents the capricious nature of English spelling by listing the many spellings that sounds may have. Miller (1965) suggests that, in order to apply phonics rules, words would often have to be read from right to left since the manner in which a letter will be pronounced often depends upon which letters follow. The letters HO... for example, can be pronounced in eleven different ways depending upon whether they are followed by T, OT, OK, RIZON, USE, PE, NEY, IST, UR, NEST. Another problem is cited as being that acoustically identical utterances are often spelled differently, and acoustically different utterances are often spelled the same (e.g. hare-hair, and house-house). Some such as Pitman (1961) have gone as far as to suggest that the English alphabet should be modified so as to be more phonemic for the purpose of teaching reading!

It appears, however, that there are two separate aspects vis-a-vis English orthography which are often confused (Gibson & Levin, 1975). The first is the orthographic rule system or the legal letter sequences. The second is the correspondence between these written sequences and the spoken language. The work briefly described below will show that while the correspondence between written sequences and spoken language may be too complex for reading to take place in the manner proposed by associationistic models, the two systems are related in complex, though not chaotic ways, and orthographic rules govern what sequences of letters may be put together to form words.

Earlier claims of the chaotic nature of the English orthography had assumed that regularity in spelling involved a one-to-one correspondence between letters and sounds. Recent investigations of the orthography, however, have indicated that the controlling rules and principles of the system lie deeper in the language than in the surface phonology (Chomsky, 1970; Francis, 1958; Venezky, 1967). This has led linguists to claim that English spelling is regular without being phonetic.

Francis (1958), for instance, was one of the first to point out that English orthography uses a complicated system of markers to compensate for deficienceies in grapheme-phoneme correspondence. Markers are letters or letter sequences, which although having no sound equivalent themselves, indicate the phonemic reference of other letters in their environment. For example, the final E in the word MATE indicates the long vowel sound of the letter A as opposed to the short vowel sound in the word MAT.

Venezky (1967) analyzed 20,000 words in a further attempt to extract correspondences between spelling and sound in English. He demonstrated that written English, though rooted in a phonemic base, is influenced by both morphemic and phonemic factors. Venezky noted, as did Francis, the tendency of English orthography to preserve the spelling of the base word despite variation in sound (eg. SIGN, SIGNAL, and SIGNATURE). He also described the morphemic markers for noun plurals, past tense, and the possessive, the spellings of which also remain constant despite phonemic variation.

According to Venezky, spelling-sound relationships can not be described simply in terms of single letters but must also be described in terms of letter combinations which act as a single unit (e.g. TH and SH). Venezky refers to these combinations of letters as relational units. In addition to the relational units there are markers. The function of markers is to indicate the correspondence of other relational units, as Francis suggested, or to preserve a graphotactical pattern. For example, in the word LOVE, the letter E is added to preserve a pattern which does not permit final V's. Markers also serve to preserve morphological patterns, for example, in the word MOUSE the final E indicates that the S is not a plural or third person singular. When the orthography is analyzed in this manner, there are over 300 spelling-to-sound correspondence rules and 52 major spelling units in the English language.

Chomsky (1970) has further elaborated on the tendency of English orthography to preserve the spelling of a word despite variations in sound. She points out that in English, words are not related according to sound but rather to meaning. The orthography is regular in the sense that it corresponds to an underlying abstract level of representation rather than surface phonetic form. Thus, the spellings of compounds and derivatives (words derived from the base form) are based on morphemic considerations. Each morpheme is spelled in a uniform manner even though it may be pronounced in several ways. For example, the base form MEDIC remains the same in the words MEDICINE, MEDICAL, and MEDICINAL, yet it has three different pronunciations. In this manner the orthography captures the underlying sameness that exists at the level of meaning and reflects regularities that exist at a deeper level, making the extraction of meaning and efficient reading easier.

These studies seem to have important implications for models of the reading process. They highlight the complex, although not irregular, relationship between spelling and sound in English suggesting that since the rules of correspondence are conditional (eg. the letter C corresponds to the sound /s/ when it occurs before E,I,Y plus a consonant as in CITY, and in most other positions it corresponds to /k/), a simple associational model of reading may not be the best to entertain.

At the same time, these studies illustrate that although letter-sound correspondences in English are complex, the orthography is not completely irregular. Rather, orthographic rules govern what sequences of letters may be put together to form words and a complex system of markers helps to preserve graphotactical and morphological patterns. These orthographic rules take into account the sequence of vowels and consonants and the position in the word occupied by the letter or letter cluster. For example, orthographic rules dictate that in English the letter Q must always be followed by the letter U, and that the cluster KM can not occur unless it crosses a morpheme boundary as in the word MILKMAID.

As a result of these orthographic rules which govern the sequences of letters which can validly form words, there is a considerable degree of redundancy in the English language. Miller, Bruner, and Postman (1954) have defined redundancy in the following manner: "When missing or ambiguous portions of a stimulus pattern can be supplied correctly by S on the basis of context alone, the missing portions carry little or no information. This fact is referred to as the redundancy of the language. If a language is highly redundant, the relative information per symbol is much lower than it would be if successive symbols in a message could be chosen independently. The extent to which the context limits the range of possible continuations and makes the next choice depend upon the choices of the preceeding symbols is the extent to which the language is redundant and the information per symbol is reduced" (p.131).

Massaro (1975) illustrates the notions of between letter (orthographic), between word (syntactic), and within meaning (semantic) redundancies with the following example: "Suppose the reader encounters the following sentence: 'With the bases loaded the boy hit the l_ll over the fence'. Assume that the reader completely resolved all of the letters in the sentence except for the two underlined positions. Accordingly, it is necessary to identify the two missing letters in the four letter word. Partial visual information defines a vertical line at the first letter position and no feature information is registered for the second position. The one visual feature in the first position eliminates all vowel alternatives for that position, exemplifying the use of visual information. Having determined that the first and last two letters are consonants, orthographic constraints (orthographic redundancy) dictate that the second letter is a vowel. At this point many possible four letter words remain, for example, tell, tall, ball, bull, hill, fill. Syntactic information given by the surrounding words (syntactic redundancy) eliminates all of the alternatives except nouns. Finally, the meaning of the other words in the sentence also provide contextual information (semantic redundancy). It would make no sense to say 'The boy hit the bull over the fence' therfore ball is the only remaining alternative " (p.243).

There is a considerable amount of evidence which shows that redundancy is fairly high in the English language. Garner (1962, p.245), has pointed out that there have been two general methods for estimating the amount of redundancy in printed English. One method is based on a guessing-game technique while the other is a multivariate analysis of the terms involved in predicting letters at various positions in sequences. According to Garner both of these methods lead to estimates of approximately 50 per cent redundancy in English with intraword constraints or orthographic redundancy being higher than those operating across words. This evidence has led several researchers to hypothesize that readers may utilize this redundancy to supplement visual information in reading.

This conceptualization of the nature of the English orthography along with studies showing that readers need not read on a letter by letter basis, has led several researchers (eg. Goodman, 1968; Hochberg,1970; Massaro, 1975; Smith, 1971) to propose models of reading in which the reader is thought to sample the visual data and capitalize on the redundancy of the English language as an aid in fluent reading. According to these models, in beginning reading letter recognition and letter sounding are important processes. Fluent reading, however, does not merely involve the conversion of letters into speech sounds. Rather, the fluent reader is thought to be involved in an active process in which he selectively samples the visual data and combines this information with his knowledge of semantic, syntactic, and within word orthographic constraints to construct hypotheses as to the meaning of larger units. The reader must then utilize his knowledge of language, his past experience, and his existing concepts in order to decode written language. Four such models of reading which tend to characterize current conceptualizations of the reading process are briefly described below.

Goodman's "Psycholinguistic Guessing Game" Model of Reading

Goodman (1968) was one of the first workers in the area of reading to refute the idea that reading is a letter by letter or word by word process and to propose a model in which reading is considered as a sampling process or in his terms a "Psycholinguistic Guessing Game". In Goodman's model beginning readers must acquire special skills which are of little use once efficient reading develops. As shown in Figure 1 the processes involved in beginning reading are thought to be very similar to those proffered by associationistic models of reading. That is, the beginning reader must discriminate the letters of a word and then put together the sounds the letters make in order to produce an

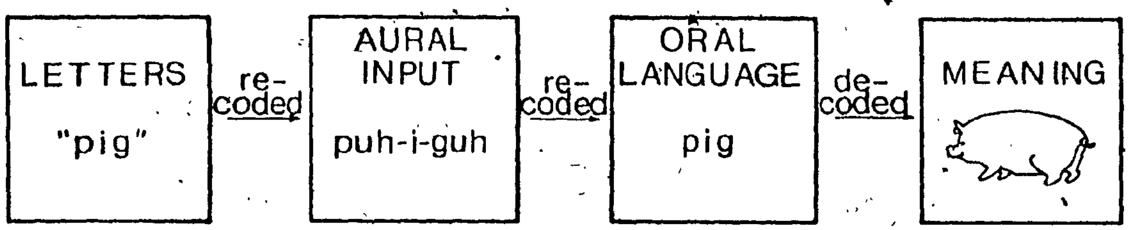

Figure 1. The sequence of events thought to be involved in beginning reading in Goodman's model.

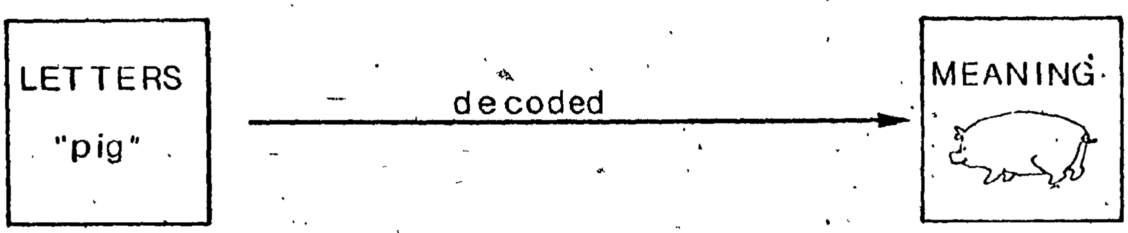

Figure 2. The sequence of events thought to be involved in fluent reading in Goodman's model.

aural representation of the written word. The reader must then go beyond this intial recoding which results in aural input which is not language, adding further aural input to create a reasonable approximation of oral language. The reader can then decode this oral language as he would oral language input in listening.

Eventually, recoding and decoding become simultaneous so that as shown in Figure 2, the fluent reader decodes meaning directly from graphic input. The speed of reading is then not limited to the speed of talking since the reader perceives whole phrases in an instant. Reading becomes a rapid series of guesses so that the less visual information the fluent reader is required to use, the more rapid and efficient his reading. Efficient reading is thought to result from the skill of selecting the fewest cues necessary to produce correct guesses.

In this model readers are thought to use two types of information in order to produce guesses and derive meaning: (1) cue systems within words consisting of letter-sound relationships, spelling pattern-phonemic relationships, and word-shape word-name relationships, and (2) cue systems in the flow of language or the reader's knowledge of the structure of the language. There are also thought to be cue systems from within the reader such as the recoding strategies he knows, his past language experience, and his general conceptual background. The fluent reader uses these cue systems simultaneously and to such an extent that only minimal graphic cues are needed for reading.

There have been many criticisms of Goodman's model. Gibson and Levin (1975) for example, have pointed out that the model is quite vague and leaves several questions unanswered, such as: On what basis does the reader make his predictions? What unit does he predict? How does he check his predictions? How does he know where to look? and What constitutes a confirmation and what happens if he has guessed wrong? Nonetheless, Goodman's model has set the stage for models of reading in which the reader is thought to sample visual data and actively use his knowledge of language in the reading process. As will be seen from the brief descriptions of several models to follow, in this manner it characterizes many of the current models of reading.

Hochberg's Model

Hochberg (1970) has constructed a model of reading in which he attempted to answer one of the questions left unanswered by Goodman's model - Where do the eyes move next after a prediction? According to Hochberg the task of the beginning reader is very difficult in that he must learn to execute small sequential eye movements which are very different from those required in normal vision. The advanced reader, however, overcomes this problem by learning to sample a page of text so that he does not need as many short glances. The advanced reader fixates on important cues and decides where the next important cue is located so that he can move his eyes there. In doing this the reader is aided by what Hochberg calls peripheral search guidance and cognitive search guidance. In peripheral search guidance low acuity information picked up in the periphery suggests to the reader where to move his eyes next to pick up potentially interesting information. In cognitive search guidance, previous information provides the reader with hypotheses about where to look next.

Hochberg does not really specify how the reader locates important cues. He does, however, suggest several types of information which may be used by these guidance systems. In relation to peripheral search guidance, Hochberg points out, for example, that since the first letter of a word contains much information about the identity of the word, that the peripheral search guidance system could place fixations at or near letters that follow blank spaces. In order to test this hypothesis Hochberg, Levin, and Frail (1966) measured reading rate in second and fourth graders when the blank spaces between words were filled with X's. The reading speed of slow readers was not affected by this manipulation of the text, while fast readers showed marked deficits in reading speed. Another example given by Hochberg is that short words such as ON, TO, IN, often need not be read since they can be inferred from the context. He suggests that readers may detect upcoming short words in peripheral vision and decide whether or not to look at them.

Hochberg suggests that one type of information utilized by the cognitive search guidance system is redundancy in the text. He points out that in order for sampling to be effective there must be some degree of redundancy in the text. The reader, in turn, must have some knowledge of within word and within sentence redundancy since in order to use the cognitive search guidance system he must be able to fill in the spaces between the points he samples.

In this model, as in other current characterizations of the reading process, the skilled reader is thought to have learned guessing techniques, to utilize redundancy in the text, to read for meaning, and not to be concerned with the specific stimulus pattern that confronts his eyes but rather with what information it gives him about what he is reading and where to look next. The main task of the skilled reader is then seen as one of extracting information from an array of redundant symbols.

Smith's Model

Smith has proposed a model of reading in which the reader's knowledge of the rules and constraints of language also play a large role. In his model reading is thought not to be primarily a visual process but rather to involve two types of information: (1) visual information from the printed page, and (2) non-visual information or what the reader knows about language - the statistical information about the probabilities of sequences of letters and words.

Since in this model reading is not primarily a visual process, the amount of visual information the reader picks up in a glance is thought not to be as important as the amount of non-visual inoformation that he picks up which can lessen his dependency on visual information in deriving meaning.

In Smith's model the raw material of reading consists of distinctive features or elements of the visual configuration of letters and words. Features are considered to be distinctive when they result in the reduction of the number of alternative letters or words that a visual configuration could be. Identification of letters and words is thought to be similar to a process of categorization where a category is a unique cognitive grouping to which a visual configuration can be allocated together with a name. Feature lists specify the features that a configuration must have in order to be allocated to a particular category. Words are not thought to be identified on a letter by letter basis, but rather combinations of features are discriminated simultaneously in different areas of the configuration and integrated for identification of the whole. In this manner features are extracted from individual letters but a word can be identified before all of the component letters are recognized. Smith (1971) gives the following example to illustrate this notion: Suppose that for some two-letter word a subset of features has been extracted from each letter. Assume that enough information was obtained from the feature tests to narrow the alternatives to A and E for the first letter, and T and F for the second. The visual information thus reduces the possibilities to four two-letter configurations, ET, EF, AF, and AT. Of these, only the last configuration is a word so that the reader can accurately identify it as such (p. 135).

Smith's model is basically a non-mediated model of reading since he postulates that the skilled reader can go directly from visual features to meaning. Word recognition is not mediated by letter recognition. Rather, each word is represented in long term memory by a criterial set of features specifying that particular category. Readers are thought to use their knowledge of the sequential dependencies among letters in English to establish word feature lists rather than letter feature lists, since word feature lists are more economical in that they require fewer feature tests for the identification of the word than would be required if the word were identified on a letter by letter basis. The reader must also use syntactic and semantic redundancy to establish criterial lists of visual features that uniquely identify meaning, since meaning feature lists are more economical than word feature lists. In this manner readers can automatically derive meaning on the basis of finding a category concept with a criterial set of features which match the visual features of the phrase being read. This manner of reading is termed "immediate word identification" in Smith's model.

In the early stages of reading, however, the reader often does not have feature word lists that permit allocation of a visual configuration to a named word category. The processes involved in the early stages of reading are thought to be similar to the associationistic account of reading. Smith terms this method of reading as "mediated word identification". In order to become a skilled reader, the beginning reader must take advantage of orthographic redundancy in establishing criterial sets of features for words, and syntactic and semantic redundancy in order to establish meaning feature lists.

Massaro's Model

Massaro (1975) has proposed a model of reading in which the reader dynamically utilizes his knowledge of language in the encoding stages of reading. His model looks at reading in the context of human information processing theory and thus attempts to delineate each of the processing stages between the presentation of the graphic stimulus and the reader's abstraction of meaning.

Figure 3 shows the sequence of events thought to be involved in the reading process. Feature detection first transmits the visual features on the page into preperceptual visual storage in the form of a preperceptual visual image. The primary recognition process then transforms these features into letter units held in synthesized visual memory. The primary recognition process operates

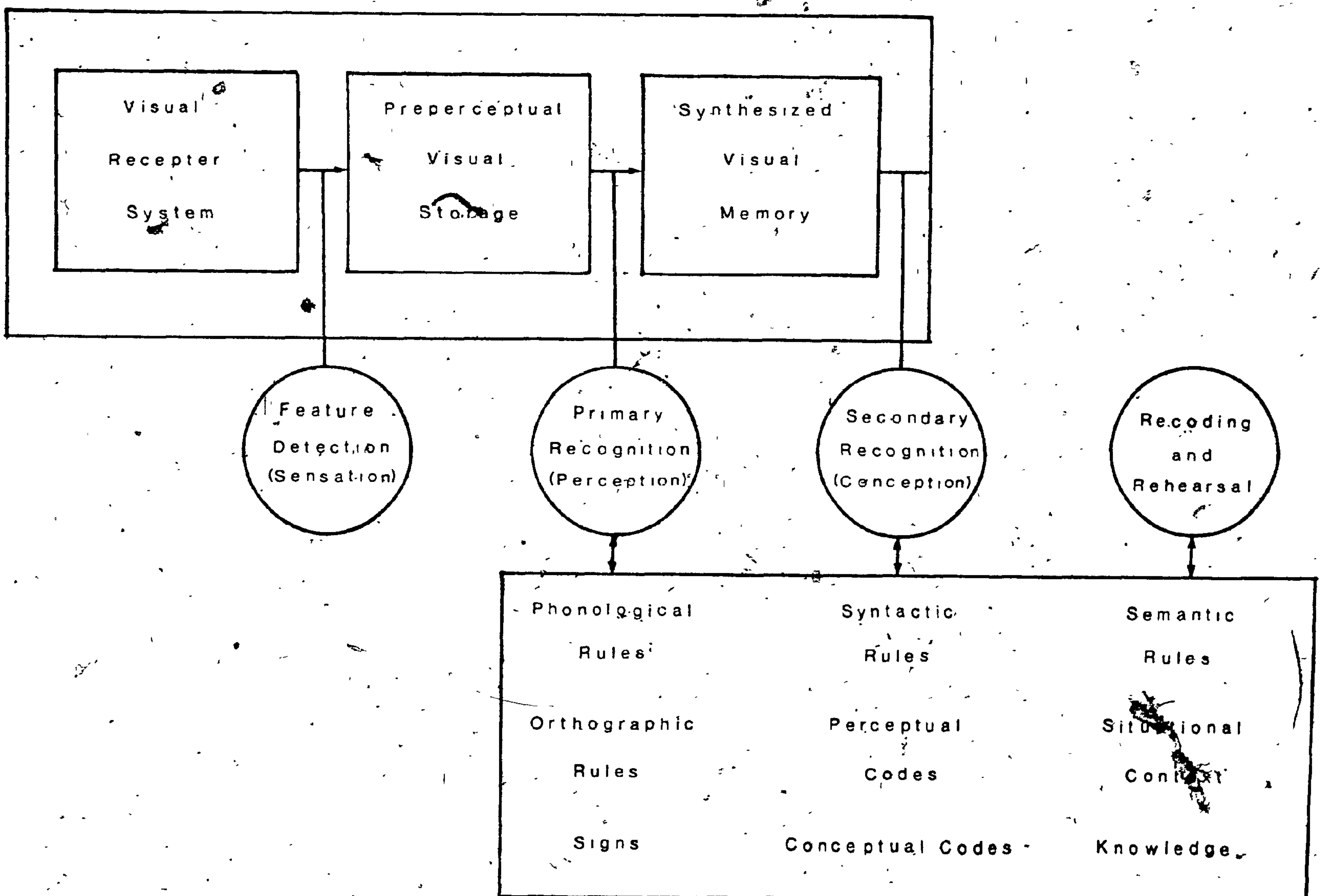

Figure 3. Flow diagram of the temporal course of visual information processing in Massaro's model.

simultaneously in parallel on a number of letters. The range of letters depends upon the acuity of the retina and the contribution of lateral masking. The primary recognition process has access to the rules of the orthography. Both the visual features read out of preperceptual storage and the constraints of the orthography contribute to primary recognition such that the visual features define a candidate set of letters at each letter position and at the same time the reader uses his knowledge of valid letter sequences to narrow down the alternatives at each letter position.

This string of letters and spaces is then transformed into preperceptual visual images in synthesized visual memory so that the page appears stable rather than 'jerky' as a result of the saccadic eye movements.

The secondary recognition process then transforms this visual information into meaning on the basis of visual information and syntactic and semantic expectancies. The perception of the sequence of letters takes the secondary recognition process to the location of the word in memory and this contains the perceptual and conceptual properties of the word.

In summary, although these models have been briefly described, and are by no means a comprehensive selection of current models of reading, they tend to characterize contemporary conceptualizations of the reading process. These models vary greatly in their sophistication and their approach. Goodman and Smith, for example, approach reading from a psycholinguistic view, while Massaro looks at reading in the context of human information theory in an attempt to delineate each step involved in the reading process from the presentation of the graphic stimulus to the abstraction of meaning. Hochberg emphasizes the role of eye movements in reading in his model. These models are similar, however, in that they all suggest that the fluent reader samples the visual data and in doing so capitalizes on the redundancy of the English language as an aid in fluent reading.

Studies Investigating the Role of Redundancy in Reading

Syntactic Redundancy: There is evidence to suggest that readers may utilize the redundancy available in a passage of text in order to supplement visual information in reading. At the level of syntactic redundancy Kolers (1970) has investigated the extent to which the reader's knowledge of the permissible combinations of words into phrases and sentences plays a role in the reading process. In his study subjects were asked to read aloud geometric transformations of a text in which letters were inverted or the text was rotated 180 degrees and a mirror image was printed. When the subject's oral reading errors were analyzed it was found that in 3/4 of the errors the word which was substituted was of the same part of speech as the printed word. That is, nouns tended to be substituted for nouns, verbs for other verbs, and so on. When the substituted word was not of the same part of speech, it nonetheless had syntactic similarity to the printed word. In another study (Kolers, 1966), bilinguals were asked to read aloud mixed passages of English and French. It was found that many of the errors made by the subjects tended to make the material more grammatically correct. The phrase 'made resound the earth', for example, was read by subjects as 'made the earth resound'.

In a similar study, Weber (1970) looked at first grader's use of grammatical context in reading. She found that 87 to 92 per cent of the oral reading errors made by beginning readers were grammatically acceptable to the preceding context. Less skilled readers were not found to differ from more skilled readers in respect to the use of grammatical constraints for the identification of words in a string. However, having made errors that did not fit into the context, only skilled readers corrected themselves. These findings taken with those of Kolers (1968, 1970), suggest that readers do have knowledge of syntactic redundancy and that they are sensitive to the grammatical category of the words they are reading. The stage at which such redundancy may play a role in the reading process is not specified, however.

Semantic Redundancy: Several investigators have also looked at the role of semantic redundancy or the contribution of contextual meaning to the interpretation of a letter string in reading. In many of these studies, as in studies investigating the utilization of syntactic redundancy, oral reading errors are analyzed to determine if they are semantically consistent with the preceding context. Basically these studies have found that readers tend to substitute words of similar meaning or consistent with the preceding context. For example, in the Kolers (1970) study outlined above, it was found that 90 per cent of the substitution errors were semantically consistent with the preceding text.

Other investigators have looked at the joint contribution of syntactic and semantic redundancy to the reading process. In these studies, word identification in conditions where syntactic and semantic information is available, is compared to situations in which the contribution of syntactic and semantic redundancy is absent.

Goodman (1965) compared the number of oral reading errors made by first, second, and third grade children when asked to read words in a list and when asked to read the same words in the context of a passage. He found that the children were able to read more words in the context of a passage than in a list and that this ability increased with grade level. Pierce and Karlin (1957) found meaningful material to be read twice as quickly as unrelated sequences, while Tulving and Gold (1963) found lower tachistoscopic recognition thresholds for words presented in the context of a meaningful sequence than words presented in an irrelevent context or no context. Hence, it seems that readers use syntactic and semantic information given by words already read to predict those that follow.

Orthographic Redundancy: There is also some research which has attempted to determine the contribution of the reader's knowledge of intraword constraints or orthographic redundancy to the reading process. While earlier studies tended to concentrate on sequential redundancy or the succesive order of letters within a string, more recent studies have looked at other kinds of intraword constraints, such as spatial frequency redundancy or how often any one letter occurs in a particualr position in a given string length, which may also be operative in the reading process. A variety of paradigms have been devised which purport to measure the utilization of intraword constraints and these are described below.

Krueger, Keen, and Rublevich (1974) have used a task in which a single (target) letter is centered above a column of five six-letter words, or non-words. The subject's task is to search down the columns for the target letter shown at the top and his search time is recorded. On some trials (catch trials) the target letter is not present in the display, in which case the time taken for the subject to reach the decision that the letter is not in the display is recorded.

In one study (Krueger, Keen, & Rubelvich, 1974, Experiment 1) adults and fourth grade children scanned through words and non-words for target letters. Adults were found to search twice as quickly as fourth graders.

In the fourth grade group, better readers searched faster than poorer readers. However, reduction in time of search through words as compared to non-words was as great for children as for adults, and for poor readers as for good readers. According to Krueger et al. this finding indicated that older subjects and better readers showed no superiority in their ability to utilize their knowledge of sequential constraints in the English language in order to reduce search time.

In a second study (Krueger, Keen, & Rublevich, 1974, Experiment 2), the same authors further investigated the relationship between the ability to utilize orthographic structure to speed letter search and reading ability. In this experiment the correlations between reading comprehension measures in adults and the reduction in search time for words vs non-words were significantly positive. That is, better readers tended to take more advantage of the familiar context of words in reducing search time, indicating that the ability to utilize sequential dependencies among the letters in a word may be important in the reading process. No explanation was given by the authors for the discrepancy between the findings of this study and their first experimemt.

Mason (1975), however, has argued that it is not the reader's knowledge of sequential dependencies among letters that is measured in the visual search paradigm and thus responsible for the better performance on word trials over non-word trials in Krueger's study. Mason pointed out that no information could be gained about what provides the facilitation on words as compared to non-words in Krueger's study since the distinction is made purely on the descriptive level and has no explanatory value. She hypothesized that it is spatial redundancy, or the degree of correlation between visual features and their spatial locations in multiletter configurations, that is used by subjects to augment visual feature information in the identification of letters, rather than sequential redundancy.

In order to test the hypothesis that spatial frequency may account for Krueger's finding of better performance on word over non-word trials, good and poor readers were tested in the Krueger paradigm with stimuli in which the spatial frequency cue was manipulated (Mason, 1975, Experiment 2). The stimuli were constructed using the Mayzner and Tresselt (1965) table of single letter frequency counts for various word-length and letter-position combinations in order to obtain the frequency with which each letter appears in a specific spatial location in six-letter words. To quantify spatial frequency redundancy, the frequency of letters over each six-letter item was summed. The three stimulus categories constructed consisted of words having a medium summed spatial frequency, the letters of the same words arranged to form non-words having summed spatial frequencies higher than their corresponding words, and the letters of the same words arranged to form non-words having summed spatial frequencies lower than that of their corresponding words. As in the Krueger study no differences were found between good and poor readers on the low spatially redundant items where only visual features could be used. However, good readers were faster on high spatially redundant non-words than the same letters arranged to form common words. This indicates that the factor contributing to the good readers' faster search time on words over non-words seems to be spatial redundancy rather than familiarity. Poor readers did not make use of the spatial redundancy cue. In another experiment, good readers were found to be faster than poor readers only when the target letters were in spatially redundant locations in the string. Again, this finding was taken as support for the hypothesis that the utilization of spatial redundancy is operative in the visual search paradigm.

Mason reasoned that the strategy of employing good and poor reader groups would allow her to assess process differences that may shed light on the complex component skills involved in reading. Since good readers were found to use the spatial redundancy cue in the visual search paradigm while poor readers did not, she argued that the ability to use spatial redundancy is important in the reading process. Although Mason's studies indicate that spatial frequency redundancy is indeed an important factor in the visual search paradigm, the role of sequential redundancy in the reading process still has not been precluded. Since Mason constructed her stimuli specifically so as to test the spatial frequency redundancy hypothesis, no information could be gained about the validity of the sequential redundancy hypothesis.

Mason further argued that while it "makes sense" to speak of sequential redundancy being operative in other paradigms, such as tachistoscopic forced choice masking paradigms in which only partial visual information can be extracted, it "doesn't make sense" in the visual search paradigm to suggest that the subject identifies the context and then guesses at the letter. She chose the visual search paradigm because "it is a better analogue to the reading process (since) reading does not normally occur under conditions where only partial visual feature extraction is available" (Mason, 1975, p. 151). However, Neisser (1964) has presented some evidence which suggests that when the visual search paradigm is used with well practiced subjects as in the Mason study, the task may be very different from that involved in normal reading. In Neisser's study, subjects reported that they did not see non-target letters when searching for a target letter and, moreover, could not visually distinguish words that had appeared on the list from those that had not. These results led Neisser to suggest that, in the visual search paradigm, non-target letters may only be processed to a moderate extent and then discarded from further consideration.

Moreover, current characterizations of the reading process suggest that reading does not involve a letter by letter recognition process, but rather that the reader samples the visual data and therefore obtains partial visual information (see section on models of reading above). Presumably then, the tachistoscopic presentation of stimuli would be a reasonable analogue to the reading process in that the presentation simulates the momentary fixations that occur between saccades in normal reading.

Smith (1969), and Lott and Smith (1970) have partially addressed the question of the role of sequential redundancy in reading. Smith has used a procedure in which words and their component single letters were presented on a projection screen at below contrast threshold. The contrast level was increased until the subject correctly reported the letter or word. The relative intensity of the stimulus when a letter or word was correctly identified was taken to be an indicator of the amount of stimulus information required to make the identification. The difference between the contrast level at which any one subject identified a letter alone and the same letter in the context of a word was then calculated.

Using this paradigm, Smith (1969) compared the contrast level at which subjects identifed single letters and the same letters in the context of high and low sequentially redundant words and non-words. Sequential redundancy was measured according to a table of digram frequencies for written English (Baddeley, Conrad, & Thompson, 1960). Letters were more easily identified in the context of words and high redundancy non-words than low redundancy non-words. Smith therefore argued that in this procedure the subject's gain in identifying letters in the context of a word over letters alone, indicated the extent to which the reader had acquired implicit knowledge of dependencies within words and was able to use information from other parts of the structure to identify letters in words.

Lott and Smith (1970) used this procedure with children in grades one through four and adults. Using simple three letter words, they found that implicit knowledge of dependencies within words was apparent in grade one readers and increased up to grade four where there were no differences between grade four readers and adult readers. They concluded that knowledge of sequential constraints develops early in reading.

This study is suggestive of the idea that the reader's utilization of intraword constraints may play a role in the reading process. As noted in the description of the different models of reading, however, Massaro argues that orthographic redundancy is actively utilized by the reader during the time of perceptual synthesis so that alternatives are eliminated during the time of letter recognition. Thus, the results of the Lott and Smith study may not be directly applicable to the normal reading process, since the results could be due to a simple guessing strategy that is applied after the perceptual experience rather than due to the utilization of redundancy during the encoding stage in the reading process. In order to determine whether orthographic redundancy can facilitate letter identification during the time of perceptual synthesis itself, a procedure which eliminates guessing strategies that occur after perceptual synthesis would have to be used.

METHOD OF INVESTIGATION

This study was designed to further investigate the relative contribution of the reader's utilization of non-visual information, particularly orthographic redundancy, to the reading process. More specifically, the question as to whether fluent and less fluent readers would differ in the utilization of orthographic redundancy during the perceptual process of word recognition itself was investigated as a means of assessing process differences that may shed light on the complex skills involved in the reading process.

Two major methodological considerations arose in designing this study: (1) which experimental paradigm would most adequately test the reader's utilization of orthographic redundancy, and (2) what would be the best method of defining the fluent and less fluent reader groups. The rationale for using the particular paradigm chosen for this study and the method of defining the fluent and less fluent reader groups will be discussed below.

Experimental Paradigm: In investigating this problem the paradigm employed was similar to that used by Reicher (1969) to investigate the phenomenon variously referred to as the word superiority effect, the word advantage effect, or the letter in context effect. Basically, the label 'word superiority' refers to the fact that when single letter and word stimuli are presented tachistoscopically so that only partial visual information can be extracted, a letter is more accurately identified when it appears in the context of a word, than when it appears alone. The paradigm, first employed by Reicher (1969) uses a two alternative forced choice technique. For example, the stimulus SHIP is presented very briefly, a visual noise mask follows, and the viewer is then given two alternatives H or K for the second letter position. Identification of the letter H (critical letter) in the context of the word SHIP is compared to the corresponding single letter trial in which H alone is presented as the stimulus with H and K as alternatives, and the results indicate that H is more accurately perceived in the context of SHIP than when it is presented alone. This paradigm eliminates guessing strategies that occur after perceptual synthesis since both alternatives form a word.

Originally Reicher, using this paradigm, had claimed that the word advantage effect was not due to the viewer's utilization of orthographic redundancy. He argued that since both alternatives in the forced-choice procedure form a word, that the contribution of redundancy had been eliminated in this paradigm. The assumption of this argument was that redundancy is a decision effect which is operative when the viewer must decide between the two alternatives. Reicher hypothesized that the word advantage effect was due to the fact that words or clusters of letters are the basic perceptual unit in reading and are, therefore, processed more efficiently.

Subsequent to Reicher's study a number of investigators attempted to determine the factors which may be operating in the paradigm to produce the word superiority effect. Wheeler (1970) investigated several methodological factors which he thought may have been accounting for the effect with the Reicher paradigm. He proposed several different hypotheses to account for the word superiority effect. Wheeler noted that in the Reicher paradigm word stimuli were centered with respect to the fixation point, whereas the position of letter stimuli varied, therefore, it may have taken longer for the subject to locate the single letter stimuli in the visual field. Also, Reicher's paradigm did not take into account that if a subject sees some of the letters of a word but not the critical letter he may be more likely to choose the alternative which forms the more frequent word. Similarly, recognition may have been easier for some word pairs (eg. CARE-CAKE) than others (eg. TAME-TAMP), since the words occur more frequently in the English language. Finally, Wheeler proposed that there may be some properties of words which cause the pattern recognition mechanism to focus on the aspect which most distinguishes it from other words and these aspects are most likely to be in those letter positions for which there are alternative letters that can be switched to form new words (ie. the critical letter). All of Wheeler's hypotheses were rejected on the basis of his experimental results.

Johnston and Mc Clelland (1973) employed the Reicher paradigm and made a number of additional methodological improvements in order to rule out the possibility that methodological factors accounted for the differences on word trials compared to single letter trials. In this study (1) word and letter trials were blocked so that subjects could use the best strategy in each condition rather than adopting one set for both conditions, (2) the subject viewed the alternative choices outside of the tachistoscope well after the offset of the stimulus so that onset of the alternatives would not interfere with processing of the stimulus, (3) word alternatives were given on word trials and letter alternatives on letter trials since in the Reicher paradigm the subjects may not have known which of several partially processed letters was the one being tested, and (4) a single letter condition in which the letter was surrounded by masks was included since in the single letter condition the letter may have been difficult to locate in the visual field. Again, a sizeable word superiority effect was found, ruling out the possibility that these methodological factors may have accounted for the effect in the Reicher paradigm.

More recent evidence (eg. Thompson & Massaro, 1973), however, has suggested that redundancy is not a decision effect in the Reicher paradigm. Rather it has been argued that redundancy is operative at the recognition stage of visual information processing, and that the word superiority effect is in fact due to the reader's utilization of orthographic redundancy.

Thompson and Massaro (1973, Experiment 1, Post-cue condition) have claimed that redundancy is not adequately controlled in the Reicher paradigm. They conducted an experiment in which the Reicher paradigm was employed and the visual similarity of the two alternatives was manipulated such that on half the trials the two alternatives were highly visually similar (eg. P and R), and on the other half the two alternatives were distinct (eg. R and M). They argued that if redundancy is operative at the level of deciding between the two alternatives in the Reicher paradigm, then the subject must hold off the decision about what is in preperceptual visual storage until the alternatives are presented, and in this case the similarity of the critical letter to the alternative would have a large effect on both letter and word trials. If, however, redundancy is operative at the recognition stage of visual information processing, then the similarity of the alternatives should have no effect. Similarity of the alternatives was found to have no effect. This led Thompson and Massaro to suggest that the viewer may synthesize the visual stimulus before the two response alternatives are presented, and that orthographic redundancy may still be operative in the Reicher paradigm.

Thompson and Massaro (1973, Experiment 2, Pre-cue condition) then conducted a second experiment in which orthographic redundancy was thought to be adequately controlled. In this study, subjects were told all of the response alternatives before the test presentation and therefore before perceptual synthesis. In this task there were only four alternatives, two similar and two distinct, and the alternatives always occurred in the center of a three letter word. Since the subjects knew what the valid alternatives were before the stimulus presentation, and the position the critical letter would occupy in the word or single letter presentation, words should have no advantage over letters due to redundancy because redundant information from the word context would not contribute anything by way of narrowing admissible response alternatives. In this experiment no word superiority effect was found and similarity had a large effect for both single letter and word trials.

These studies led Thompson and Massaro to conclude that the word superiority effect in the post-cue condition could be accounted for by the fact that letters in words or valid spelling patterns have an advantage in that the viewer can apply what he knows about the orthography of the language as a clue to the identity of a letter. In short tachistoscopic presentations the number of features that can be extracted is limited. When the letter strings consist of valid spelling patterns or words, however, the viewer can use his knowledge of orthographic redundancy at the recognition stage of processing to improve performance. For example, in the illustration given above, suppose on a given trial the viewer has extracted the following feature information S⊦IP . Using the partial feature information available for the critical letter he might narrow down the alternatives for the second letter to B,E, F, H, R, or P. If he assumes that the four letters must spell a word, he can use this knowledge to correctly synthesize the letter H since the letters B, E, F, R, and are invalid in the context of S IP. In the letter alone case the subject may have the same featural information (ie. ⊦) to narrow down the alternatives to B,E,F, H, R, or P. The subject, however, is equally likely to synthesize any one of these letters since no other constraints are present (Massaro, 1975).

Baron and Thurston (1973) have conducted a series of seven experiments which add strong support to Thompson and Massaro's contention that the word superiority effect is due to the viewer's utilization of redundancy on word trials. In these studies, Baron and Thurston attempted to determine what type of knowledge the viewer had learned about words which may play a role in the word superiority paradigm. They investigated the contribution of the following types of information: (1) frequency of words as visual units, (2) meaning of words, (3) pronounceability, and (4) conformity of words to rules of English orthography. The first experiment compared the performance of subjects on words, pronounceable non-words, and un-pronounceable non-word stimuli. Since an equivalent word superiority effect was found for words and pronounceable non-words the role of meaning and familiarity was ruled out. The superiority of pronounceable stimuli compared to non-pronounceable was then investigated.

Since the superiority of pronounceable stimuli was maintained on two letter as well as four letter stimuli it was concluded that this advantage was not due to a memory limitation with unpronounceable stimuli. Also, since the effect was not diminished when the two possible words sounded exactly alike, an explanation of the effect in terms of additional acoustic information for pronounceable items was ruled out. In a final experiment, the performance of chemists on a task in which legal and illegal chemical formulas were the stimuli was investigated since chemical formulas are visually similar to English, have well defined rules of spelling, and are not pronounceable in the same way as English words. Unfortunately, reaction time to saying whether two formulas were the same or different was measured rather than tachistoscopic recognition, with the assumption being that whatever processes may account for quicker reaction time for regular formulas are also those that account for the word superiority effect. Quicker reaction times were found for legal formulas than illegal formulas suggesting that spelling regularities regardless of pronounceability account for the superiority effect.

These studies all seem to suggest that the word superiority effect can be accounted for by the fact that subjects are able to utilize their knowledge of orthographic redundancy on word trials. Also, it seems that orthographic redundancy facilitates letter recognition during the time of perceptual synthesis itself. Moreover, the results obtained from the Reicher paradigm are thought to be directly applicable to normal reading situations (Massaro,1975) since the tachistoscopic presentation of the stimuli simulates the momentary fixations that occur between saccades in normal reading.

For these reasons, the paradigm employed in this study was similar to that of Reicher. The major differences between the paradigm employed in this study and that of Reicher were that a pre-cue condition in which the alternatives were presented visually before each trial was included and single letters were presented in the context of masking symbols so as to control for lateral masking (Bouma,1970). As in the Reicher paradigm the critical durations for subjects were first established so that all subjects were performing at approximately 70 per cent accuracy on single letter trials. The accuracy of subjects in identifying single letters in the context of words, and non-words or anagrams of the same words,was then compared to the baseline conditon of single letters, with greater accuracy in identifying letters in the context of words as compared to single letters indicating a word superiority effect. The anagram trials were included since they constituted displays with the same visual features as on word trials but without the contribution of orthographic redundancy.

It was predicted that if the reader's utilization of orthographic redundancy plays an important role in the reading process, as suggested by current models of reading, then fluent and less fluent readers should differ on a task in which the utilization of orthographic redundancy has been shown to aid performance. The two groups, however, should not differ on the same task when the contribution of orthographic redundancy has been minimized. Since the contribution of orthographic redundancy as an aid to letter recognition has been shown to be minimized in the pre-cue condition, differences between fluent and less fluent readers should be small. That is, neither fluent nor less fluent readers should show a gain on recognizing letters in the context of words over recognizing the same letters in the context of anagrams or visual noise masks. In the post-cue condition, however, the ability to utilize orthographic redundancy has been shown to aid letter identification on word trials, hence, less fluent readers should show less gain in the word condition compared to the single letter or anagram condition than fluent readers.

Definition of Fluent and Less Fluent Reader Groups: In order to assess the relative contribution of orthographic redundancy to the reading process, it was decided to use Mason's strategy of employing fluent and less fluent reader groups as a means of assessing process differences that may lead to an understanding of the component skills involved in reading. Since the models of reading in which orthographic redundancy is thought to play a role are models of skilled reading, as opposed to beginning reading or learning to read, it was necessary to use adults as subjects in this study. Since Mason's study, as most other investigations employing a fluent-less fluent reader group strategy, used children as subjects, one problem became how to best define the populations of fluent and less fluent readers using adult subjects.

Studies using children as subjects have traditionally used standardized reading tests as measures of reading fluency and designated children at or above grade level as good or fluent readers, and children scoring two or more years below their grade level as poor or less fluent readers. Although a plethora of reading tests exists for use with child populations, relatively few current tests have been designed for use with college level and adult populations. The standardized reading test used for purposes of group definition in this study was the Nelson Denny Reading Test-Form A (Nelson & Denny, 1960). The test consists of a 100 item multiple choice vocabulary test and a series of reading passages on which comprehension questions are asked. Both subtests are timed. Separate raw scores are computed for the comprehension and vocabulary tests. A reading rate raw score based on one minute of reading is also computed.

Alternate form reliabilities for reading rate and vocabulary are cited by the authors as being in the range of .92-.93 and for comprehension scores as .81. Since the comprehension test is a measure of both reading rate and comprehension in that since the test has a fixed time limit, the quicker the reader reads the more questions that can be answered, only comprehension scores were used in the designation of the reader groups. Also, since the purpose of the study was to investigate processes involved in reading rather than the clinical implications of non-fluent reading per se, raw scores rather than percentiles were used since the purpose of obtaining reading measures was to rank order the subjects in this study in terms of reading ability rather than to compare each subject with other readers at the same grade level.

METHOD

Material and Apparatus

A Ralph Gerbrands Model T 44 four channel tachistoscope was used to present the stimulus materials. A white adaptation field was present continuously except during presentation of stimulus materials. The adaptation field card, a visual noise mask, a practice set of sixty stimuli for each condition, as well as an experimental set of 180 stimuli for each condition were each printed on 4 x 6 inch (10.2 x 15.2 cm) white cards. The adaptation field card contained a black X in the center of the card surrounded by a 4.5 x 1.5 cm rectangle. The visual noise mask consisted of a 4.5 x 1.5 cm rectangle filled with crossing diagonal lines approximately 6 mm apart (See Figure 4). The letters, which were printed with black ink using a Staedtler .70mm technical pen and a Timesaver Lettering Guide No. 260-V, were capital letters and were 8 mm high and subtended a visual angle of 26' at a viewing distance of 76.2 cm.

Stimuli: The word stimuli consisted of 60 monosyllabic four letter words chosen such that each of the words could be changed by one letter (critical letter) to form a new word. The critical letter came from each of the four possible positions of the four letter words equally often so that there were 15 words at each letter position. The critical letter and the letter substituted to form a new word constituted the two alternatives in the forced choice procedure. For example, H and K were the two alternatives for

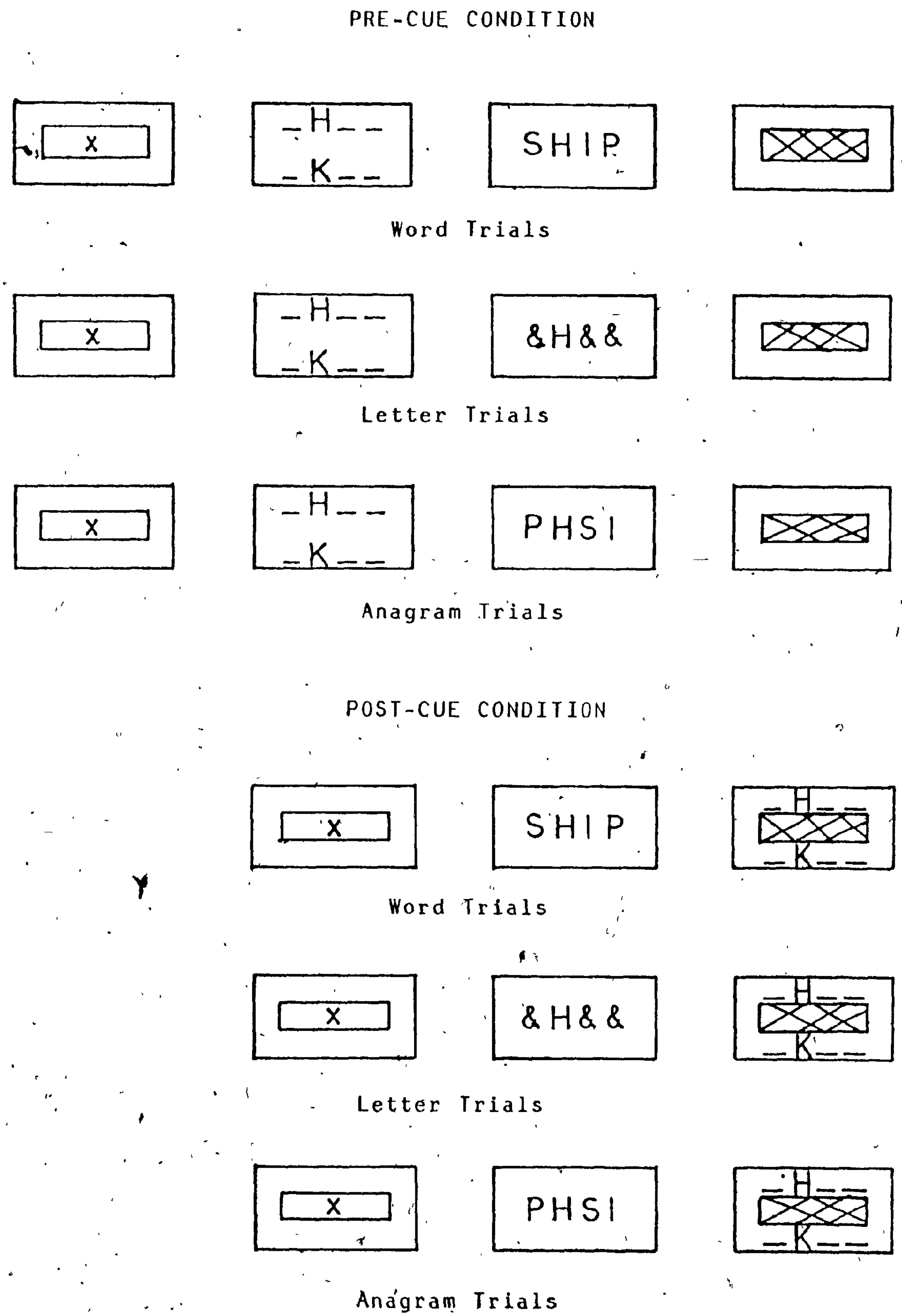

Figure 4. Examples of tachistoscopic displays in all stimulus conditions.

the word SHIP, with H being the critical letter.

The single letter stimuli were made by using the same critical letter in the same position as in the word sets. Since the letters were presented singly the other positions were filled with the symbol "&" in order to control for lateral masking (Bouma, 1970). For example, the single letter presentation corresponding to the word display SHIP consisted of the display &H&& with the alternatives being H and K.

The anagrams were constructed by using the same critical letter in the same position as in its corresponding word and then arranging the other letters of the word so as to form a random letter string. For example, PHSI, with the alternatives H and K, was the anagram corresponding to the word display SHIP. Appendix A presents all word, anagram, and single letter stimuli used in the experiment.

Procedure

The subjects (Ss) were tested using a repeated measures design over the two sessions of the experiment (pre- and post-cue). Half of the subjects in each reader group served in the pre-cue condition in the first session of the experiment and the post-cue in the second, and the other half in the reverse order. Each session lasted approximately two hours. Each subject contributed 60 observations to each combination of the major variables: cue condition (pre- or post-), type of stimulus material (words, letters, or anagrams), and the four different positions of the critical letter.

The instructions to the Ss emphasized (a) the way in which the position of the critical item in the stimulus display could be determined from the position of the underscores and alternatives on the card, (b) that before each trial S should look at the fixation point corresponding to the center of the area where the critical letter might appear, and (c) that one of the alternatives must be given on each trial. The instructions read to the subjects are found in Appendix B.

Pre-Testing: Since the design of the experiment demanded that all subjects perform at approximately 70 per cent accuracy on single letter stimuli, at the beginning of each session the experimenter pre-tested in order to determine the stimulus duration required for each subject to perform at 70 per cent accuracy on single letter trials. Since pilot testing had shown that the critical duration necessary for any one subject to perform at 70 per cent accuracy was not always the same for the pre-cue and post-cue conditions, and since the sessions were conducted on different days and any one subject's critical duration may vary from day to day, each subject's critical duration was determined separately for the pre-cue and post-cue conditions. The method for determining the critical duration was a modified method of limits procedure. The test items consisted of 60 single letter stimuli constructed similarly to those used in the corresponding condition of the experiment. That is, in determining the critical duration for the pre-cue condition alternatives were presented before the stimulus, while in the post-cue condition the alternatives followed the stimulus. The stimulus durations necessary for 70 per cent accuracy in the pre-cue condition were within the range of 10-110 msec for less fluent readers and 40-100 for fluent readers, and were in the range of 20-100 msec for less fluent readers and 50-110 msec for fluent readers in the post-cue condition. Appendix C shows the critical duration for each subject.

Pre-Cue: In the pre-cue condition on each experimental trial the fixation point was first displayed on a blank field. A ready signal from E preceded each trial informing S to initiate the trial by pressing a hand switch. The fixation point was then further displayed for 200 msec and was immediately followed by a card showing the two alternatives- one directly above and one directly below the position the critical letter would occupy in the stimulus to follow. Underscores filled the positions which would be occupied by other letters in the stimulus. The critical letter occurred equally often in the top and bottom positions. The alternatives were shown for 500 msec and were immediately followed by the stimulus. The visual noise mask followed the stimulus and was displayed for 500 msec. The S's task was to report aloud which of the two alternatives on the card preceding the stimulus had occurred in that position in the stimulus.

Post-Cue: In the post-cue condition Ss initiated the trial by pressing the hand switch. The fixation point was displayed for an additional 200 msec and this was immediately followed by the stimulus. The stimulus was followed by the visual noise mask which occupied the position which the stimulus had just occupied and lasted for 500 msec. The two response alternatives were displayed one directly above and one directly below the mask in the position of the critical letter. The critical letter occurred equally often in the top and bottom position. Underscores were also used to indicate the position the critical letter had occupied in the stimulus. The S's task was to report aloud which of the two alternatives had occurred in the stimulus display. Figure 4 shows examples of the visual displays in each condition.

In each condition the stimulus material was sorted into three blocks of trials with 60 stimulus items in each block. Each block contained a mixture of word, letter, and anagram stimuli. The stimuli were placed in random order in each block and in a different random order in each conditon. A short rest period followed each block of trials.

Subjects

The subjects in this experiment were 33 undergraduate students who were paid to participate in the study. The subjects were solicited from undergraduate courses in English and Psychology, and the Reading Training Center at Concordia University. Subjects obtained through the Reading Training Center had registered in but not as yet completed a reading training course.

Initially there were 15 subjects in the less fluent reader group and 18 subjects in the fluent reader group.

However, the pre-testing procedure did not result in an accurate estimate of the critical duration for some subjects. It was reasoned that since the task was too difficult for these subjects, in that they were performing at about chance level (p=.50) on single letter stimuli, they could not be expected to show a word superiority effect in either condition. Hence, subjects who were performing at chance level on single letter stimuli in the post-cue condition were eliminated from the study. Subjects whose critical durations were accurately established in the post-cue condition but not in the pre-cue condition were included in the study but their data was not included in the analysis of the pre-cue condition. This procedure was adopted so as to increase the sample size in the post-cue condition since an error analysis was performed for this condition and the increased sample size would increase the power of the tests. As a result of this procedure there were 13 subjects in each reader group in the post-cue condition. In the pre-cue condition there were 9 Ss in the less fluent reader group and 11 Ss in the fluent reader group.

All Ss were initially screened with the Nelson Denny Reading Test - Form A. Subjects whose raw comprehension score fell below 36, the median of the test, were designated as less fluent readers while those subjects whose scores fell above the median were designated as fluent readers. Raw comprehension scores for the less fluent readers ranged from

14 to 32, and for the fluent readers from 36 to 68, with the median of the total group being 34. All subjects were required to have English as their mother tongue and normal or corrected vision. Reading scores and demographic characteristics of the subjects are found in Appendix D.

RESULTS AND DISCUSSION

The contribution of the reader's utilization of orthographic redundancy to the reading process should be reflected by little difference between type of reader or type of stimulus material in the pre-cue condition, and a larger word superiority effect in the post-cue condition for fluent readers than less fluent readers. For the purpose of analysis error scores were computed for each subject in each condition. The magnitude of the word superiority effect was determined by comparing the number of errors made by subjects on word trials to anagram and single letter trials, with more errors on single letter or anagram trials reflecting a word superiority effect. The mean number of errors made on word, letter, and anagram trials by each reader group for both the pre-cue and post-cue conditions is presented in Table 1. Figure 5 shows the proportion of errors made by subjects on both the word and the anagram trials to single letter trials. Since the critical duration for each subject was determined separately for the pre-cue and post-cue conditions, and since the basis of the phenomenon may have been different in the two conditions, in that subjects may have utilized different strategies in each condition, two separate analyses were carried out.

Pre-Cue. As can be seen in Table 1, the pattern of results for both reader groups was very similar in the pre-cue condition. The error scores for each subject on each of the three levels of the stimulus material were analyzed using

TABLE 1

Mean Number of Errors on Word, Letter, and Anagram Trials by Fluent and Less Fluent Readers

Group		Stimulus Material	
	Words	Letters	Anagrams
	Pre- Cue Condition		
Fluent Readers			
M	13.18	11.54	15.09
SD	8.06	6.01	7.48
Less Fluent Readers			
M	13.77	12.33	15.88
SD	5.30	4.61	2.56
	Post-Cue Condition		
Fluent Readers			
M	3.61	16.53	11.23
SD	3.93	3.00	5.78
Less Fluent Readers			
M	10.46	15.92	15.38
SD	7.56	8.95	5.77

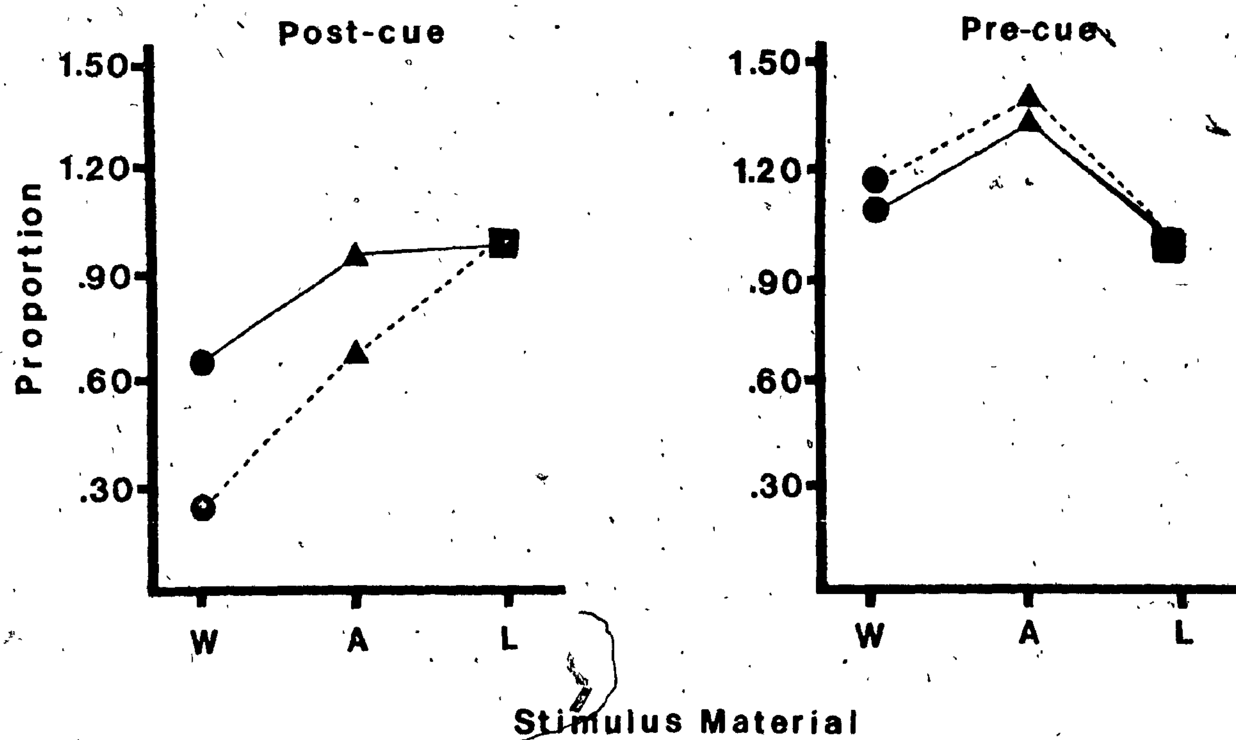

Figure 5. The proportion of errors of fluent (⋰) and less fluent (⁄) readers on word stimuli (•) and anagram stimuli (▲) using performance on the letter stimuli (■) as a baseline in the pre-cue and post-cue conditions

a Balanova program for a 2(Type of Reader) x 3(Type of Stimulus Material) mixed model design analysis of variance (ANOVA) for unequal N's. A summary table of the ANOVA is presented in Table 2. The main effect of stimulus material was significant. Neither the main effect of reader group nor the interaction between reader group and stimulus material were significant.

A Tukey (Myers, 1966) post-hoc test was used to determine the source of the significant effect of stimulus material. The mean number of errors made by all subjects on word, letter, and anagram trials were 13.4, 11.9, and 15.45 respectively. Differences between means exceeding the critical range at $p < .05$ were considered significant. The number of errors made on single letter trials were significantly less than those on anagrams $p < .05$. No other comparisons were significant.

The pre-cue condition employed in this study differed from those cited in the literature in that the two alternatives were presented visually before each trial, rather than the subject being told in advance of a series of trials of the pair of critical letters between which he would have to choose on each trial. Nonetheless, the finding of no difference between word and letter contexts, and word and anagram contexts, is consistent with these studies (Bjork & Estes,1973; Estes, Bjork, & Skaar, 1974; Massaro, 1973; Thompson & Massaro, 1973, Experiment 2). This finding of the absence a word superiority effect in studies using a pre-cue procedure, has been explained in the literature as a result of the fact that, when the target letter is identified for

TABLE 2

Pre-Cue Condition: Summary Table of ANOVA

Source	df	MS	F
Reader Group	1	7.85	.08
Subjects	18	98.44	
Stimulus Material	2	63.35	5.70*
Reader Group X Stimulus Material	2	.06	.01
Stimulus Material X Subjects	36	11.11	

*$p < .01$

the subject at the begining of a block of trials, redundant information from the word context has little to contribute by way of narrowing admissible response alternatives.

In addition, these studies have reported a letter superiority effect, in that errors on letter alone trials were less than on word trials. In this study, significantly fewer errors were made on letters than anagrams. However, the difference between words and letters was not large enough to reach significance, although the difference was in the right direction.

The absence of a main effect of reader group and a reader group X stimulus material interaction is consistent with the experimental hypothesis regarding the pre-cue condition. Thus, when the contribution of orthographic redundancy is minimized in the Reicher paradigm no differences between fluent and less fluent readers are found. This suggests that fluent and less fluent readers do not differ in their ability to utilize distinctive feature information in a tachistoscopic recognition task.

Post-Cue: As shown in Table 1 the pattern of scores across reader group and across type of stimulus material differed in the post-cue condition. As in the pre-cue condition, the error scores for each subject on each of the three levels of the stimulus material were analyzed using a Balanova program for a 2(Type of Reader) X 3(Type of Stimulus Material) mixed model design ANOVA. A summary of the ANOVA is presented in Table 3. The main effects of reader group

TABLE 3

Post-Cue Condition: Summary Table of ANOVA

Source	df	MS	F
Reader Group	1	233.65	4.35*
Subjects	24	53.68	
Stimulus Material	2	537.50	40.40***
Reader Group X Stimulus Material	2	92.81	6.54**
Stimulus Material X Subjects	48	14.19	

*$p < .05$

**$p < .01$

***$p < .001$

and stimulus material were found to be significant, as well as the interaction between reader group and stimulus material. Tukey post-hoc tests were used to determine whether the subjects in both reader groups showed a word superiority effect. Differences between the mean number of errors on word trials as compared to anagram trials were computed for each group. Differences between means exceeding the critical range at $p < .05$ were considered significant. Table 4 shows the results of the post-hoc analysis in the post-cue condition. For both groups, the number of errors made on single letter trials as compared to word trials, and anagram trials as compared to word trials were found to be significant. This superior performance of subjects in identifying a letter in the context of a word, as compared to in the context of an anagram or masking symbols, essentially replicates the findings of Reicher and others who have used this paradigm (Johnston & Mc Clelland, 1973; Reicher, 1969; Thompson & Massaro, 1973; Wheeler, 1970).

Further analysis of the post-hoc tests revealed that fluent readers showed an anagram superiority effect, in that letters were identified more easily in the context of an anagram than in the context of masking symbols $p < .01$, but that less fluent readers did not. This finding had not been predicted. Since the anagrams were essentially random letter strings it was thought that orthographic structure would have little to contribute as an aid in identifying single letters. It should be noted, however, that

TABLE 4

Post-Cue: Post-Hoc Analysis with Tukey Test Between Mean Number of Errors on Word, Letter, and Anagram Trials for Each Reader Group

Comparisons	Mean Difference	p
Less Fluent Readers		
Letters - Anagrams	15.92 - 15.38	NS
Anagrams - Words	15.38 - 10.46	<.05
Letters - Words	15.42 - 10.46	<.01
Fluent Readers		
Letters - Anagrams	16.53 - 11.23	<.01
Anagrams - Words	11.23 - 3.61	<.01
Letters - Words	16.53 - 3.61	<.01

TABLE 5

Post-Cue: Post-Hoc Analysis with Scheffé Test of Differences Between Mean Number of Errors on Word, Letter, and Anagram Trials for Fluent and Less Fluent Readers

Comparisons	Mean Difference	p
Fluent (Letters - Words) - Less Fluent (Letters - Words)	12.92 - 4.96	<.001
Fluent (Letters - Anagrams) - Less Fluent (Letters - Anagrams)	5.30 - .54	<.01
Fluent (Anagrams - Words) - Less Fluent (Anagrams - Words)	7.62 - 4.92	NS

orthographic structure was not completely eliminated in the anagrams. Since the design of the study demanded that the critical letter in the anagram occur in the same position as in its corresponding word, in order to provide a fairer comparison between letter and word trials, the arrangement of the letters of a word into a random letter string so as to form an anagram was constrained. In fact, as can be seen from Tables 6 and 7, although many of the characteristics of word and anagrams differed greatly, some such as spatial frequency total were similar for the two types of stimuli. Thus it seems that to the extent that fluent readers had broader knowledge about orthographic redundancy, they seemed to be using such knowledge with anagrams leading to an "anagram superiority effect".

Scheffé's multiple comparison method (Myers, 1966) was used to determine whether fluent readers showed a stronger word superiority effect than less fluent readers. The results of this analysis are presented in Table 5. The difference between the number of errors made on word trials as compared to single letter trials was significantly greater for fluent readers than less fluent readers. Thus, although both reader groups showed a word superiority effect, the results of the Scheffé analysis show that the word superiority effect of the fluent readers was significantly greater than that of less fluent readers. This result is consistent with the experimental hypothesis that fluent readers are better able to utilize the orthographic structure available in word stimuli as an aid in letter recognition than are less fluent readers.

The Scheffé analysis revealed, moreover, that the difference between the number of errors on anagram and single letter trials was also significantly greater for fluent than less fluent readers. It is possible, as suggested earlier, that fluent readers also capitalize on the redundancy in the anagrams as an aid in single letter identification.

Post-Cue Error Analysis: Since the results of the post-cue analysis showed that fluent readers had a larger word superiority effect than less fluent readers, suggesting that fluent readers were more efficient in utilizing orthographic information supplied from the context of a word as an aid in identifying single letters, an error analysis was attempted in order to determine which characteristics of the word stimuli or what type of orthographic information most aided fluent readers on word trials. Also, since fluent readers performed better on anagram stimuli than single letter stimuli, an error analysis was also performed on the anagram stimuli in order to further investigate the hypothesis presented above that the orthographic structure of the anagrams may have contributed to this finding.

In order to carry out the error analysis, several of the characteristics of both word and anagram stimuli which may have been accounting for the better performance of subjects on word trials as compared to single letter trials, were first computed. Correlation coefficients between the characteristics of each stimulus item and the number of errors made by all subjects on that item were then computed. The rationale for this procedure was that if any one or more of these characterisitcs was the type of information being used by subjects as an aid in identifying letters, then a negative correlation should exist between that stimulus characteristic and errors. Moreover, if the larger word superiority effect of fluent readers could be accounted for by the fact that they were more efficient in utilizing certain types of orthographic information than less fluent readers, then the negative correlations between these characteristics and the errors for fluent readers should be greater than those for less fluent readers.

Four sets of correlations were carried out. Separate correlations were computed for fluent and less fluent reader groups in order to determine what type of information was better utilized by fluent readers so as to account for their stronger word superiority effect. Since both groups did show a word superiority effect, correlations were computed between the error scores for the group as a whole and the stimulus characteristics since this would increase the sample size and provide a stronger test. Finally, the difference between the number of errors made by fluent and less fluent readers on any one item was computed since this would provide a measure of how well that item discriminated between the groups, and these scores were correlated with the characteristics of that stimulus item.

According to Thompson and Massaro (1973), redundancy is operative at the level of perceptual synthesis of the stimulus and not at the level of choice between the two alternatives, hence the characteristics of the critical word and anagram stimuli, rather than the alternatives were used in calculating the correlations. The stimulus characteristics investigated in this study, as well as the manner in which they were computed were as follows:

1- Thorndike-Lorge Frequency- The frequency of occurrence of the word stimuli in the English Language was determined from the Thorndike-Lorge (1944) word frequency count.

2- Summed Transitional Total- Summed transitional totals for each word and anagram were computed as measure of the sequential dependencies among the letters in the word or anagram as a whole. These totals were obtained in the manner suggested by Mayzner and Tresselt (1962). The bigram frequency values, as given by Underwood and Schulz (1960), for the three sequential letter pairs in each word or anagram, were added to compute the total. For example, with the word SHIP the bigram frequency values for the letter pairs SH, HI, and IP, are 250, 448, and 36 respectively and yielded a summed bigram frequency total of 734 for the word.

3- Bigram Frequency Left, Bigram Frequency Right- The bigram frequency values for the bigram pair consisting of the critical letter and the letter preceding it, and the critical letter and the letter following it (bigram frequency left, bigram frequency right, respectively) were also obtained from the Underwood and Schulz bigram frequency tables. For example, in the word SHIP in which H is the critical letter the bigram frequencies for SH was 250 and for HI was 448. A comparison of the correlation between these measures and those in the previous category would help to determine whether the redundancy available in the bigram pairs containing the critical letter was sufficient or whether the sequential dependencies among the letters of the word as a whole served as an aid in single letter recognition.

4- Transitional Probability Left, Transitional Probability Right- The Underwood and Schulz tables only provide measures of the frequency of occurrence of bigram pairs and not the actual probability of one letter following another. In order to obtain a measure of the sequential probability of letters, bigram frequency left was divided by the total of all bigram pairs on the Underwood and Schulz tables beginning with the letter preceding the critical letter, while bigram freqeuncy right was divided by the total for all bigram pairs ending with the letter following the critical letter. For example, in the word SHIP in which H is the critical letter, the bigram pair SH was divided by the total for all bigram pairs beginning with the letter S in order to determine the probability of the letter S being followed by the letter H, while the bigram pair HI was divided by the total for all bigram pairs ending with the letter I in order to obtain the probability of the letter I being preceded by the letter H.

5- Summed Spatial Frequency Total- Summed spatial frequency totals were computed as a measure of spatial redundancy or the degree of correlation between visual features and their spatial locations within multiletter configurations as suggested by Mason (1975). The Mayzner and Tresselt (1965) table of single letter frequency counts, broken down to account for word length and letter position, was used to obtain spatial frequency redundancy totals for each word and anagram. To determine the summed spatial frequency of the word SHIP, for example, the frequency of occurrence of the letter S in position one of a four letter word, H in position two, I in position three, and P in position four were added together to come up with a total of 1209.

Table 6 presents a summary of the stimulus characteristics of the word stimuli used in this study, while Table 7 presents the characteristics of the anagram stimuli. A comparison of these two tables shows that while the measures of orthographic redundancy were much higher for the word stimuli than the anagram stimuli, the anagram stimuli were not really random letter strings since some of the measures of redundancy for anagrams were fairly high. Tables 8 and 9 show the inter-correlations among the stimulus characteristics of words and anagrams respectively. Many of the inter-correlations among the measures were high, but this was expected since the measures were not thought to be independent.

Kendall Tau (Siegel, 1960) correlation coefficients between the characteristics of each anagram and word stimulus item and the errors scores (for fluent readers, less fluent readers, the total group, and the difference between fluent and less fluent readers) on each item were then computed. Correlation coefficients at $p < .01$ were considered significant (Hays, 1963, pp. 487-489). The results of the analysis for word stimuli are presented in Table 10 and for anagram stimuli in Table 11. None of the correlations were significant.

There are several possible explanations for the lack of significant correlations between error scores and characteristics of the stimuli. Since it was hypothesized that

TABLE 6

Characteristics of 60 Word Stimuli

Characteristic	Critical Word	Alternative Word
Thorndike-Lorge Frequency		
M	52.3	58.9
SD	42.5	37.6
Summed Transitional Total		
M	1094.3	1164.4
SD	654.9	617.8
Summed Spatial Frequency Total		
M	1976.5	1969.0
SD	712.9	706.7
Bigram Frequency Left		
M	302.2	288.8
SD	249.3	250.6
Bigram Frequency Right		
M	292.8	336.0
SD	230.4	244.4
Transitional Probability Left		
M	.099	.081
SD	.078	.070
Transitional Probability Right		
M	.078	.082
SD	.067	.057

TABLE 7

Characteristics of 60 Anagram Stimuli

Characteristic		Critical Anagram	Alternative Anagram
Summed Transitional Total			
	M	335.5	379.4
	SD	204.8	231.1
Summed Spatial Frequency Total			
	M	1392.0	1415.7
	SD	732.9	699.5
Bigram Frequency Left			
	M	129.9	164.9
	SD	183.2	220.8
Bigram Frequency Right			
	M	79.2	103.9
	SD	101.8	118.7
Transitional Probability Left			
	M	.047	.050
	SD	.067	.061
Transitional Probability Right			
	M	.033	.047
	SD	.047	.074

TABLE 8

Kendall Tau Inter-correlations Among the

Stimulus Characteristics of Words

Characteristic	1	2	3	4	5	6	7
1. Thorndike-Lorge Frequency							
2. Summed Transitional Total	.16*						
3. Summed Spatial Frequency Total	-.03	.08					
4. Bigram Frequency Left	.11	.49***	.18*				
5. Bigram Frequency Right	.13	.35***	.26**	.32**			
6. Transitional Probability Left	.09	.50***	.14	.63***	.36**		
7. Transitional Probability Right	.06	.25**	.25**	.23*	.64***	.38**	
8. Critical Letter Frequency	.06	.21**	.36***	.37***	.35***	.38***	.42***

*$p < .05$

**$p < .01$

***$p < .001$

TABLE 9

Kendall Tau Inter-correlations Among the Stimulus Characteristics of Anagrams

Characteristic	1	2	3	4	5	6
1. Summed Transitional Total						
2. Summed Spatial Frequency Total	.18*					
3. Bigram Frequency Left	.35**	.20*				
4. Bigram Frequency Right	.20*	.04	-.09			
5. Transitional Probability Left	.41***	.21*	.73***	.08		
6. Transitional Probability Right	.09	.01	-.16	.68***	.13	
7. Critical Letter Frequency	.16	.30***	.22*	.03	.19*	.08

*$p < .05$

**$p < .01$

***$p < .001$

TABLE 10

Kendall Tau Correlations Between Stimulus Characteristics and Errors on Word Trials in Post-cue Condition

Errors	Characteristics						
	Thorndike-Lorge Freq.	Summed Transit. Total	Summed Spat. Freq. Total	Bigram Freq. Left	Bigram Freq. Right	Transit. Prob. Left	Transit. Prob. Right
Fluent Readers	-.01	.02	.07	.18	-.04	.21	.16
Less Fluent Readers	-.03	-.06	.02	.14	.10	.10	-.09
Total Group (Fluent & Less Fluent Readers)	.01	-.02	.04	.14	-.01	.13	.04
Difference Between Fluent & Less Fluent Readers	.02	-.03	0.00	.02	.04	-.05	.09

TABLE 11

Kendall Tau-Correlations Between Stimulus Characteristics and Errors on Anagram Trials in Post-cue Condition

Errors	Characteristics					
	Summed Transit. Total	Summed Spat. Freq. Total	Bigram Freq. Left	Bigram Freq. Right	Transit. Prob. Left	Transit. Prob. Right
Fluent Readers	.01	.05	-.04	.14	-.11	.01
Less Fluent Readers	.11	.08	.05	.16	.12	.08
Total Group (Fluent & Less Fluent Readers)	.01	.02	-.10	.11	-.10	.04
Difference Between Fluent & Less Fluent Readers	.09	-.04	-.04	.03	.04	.08

fluent readers were utilizing the orthographic redundancy available in word stimuli as an aid in letter identification it was predicted that a negative correlation would exist between errors and certain orthographic characteristics of the stimuli. However, since the fluent readers had a ceiling effect on words, in that they made very few errors, there may not have been enough variability in the error data for the correlations to be significant. Similarly, since the anagram stimuli were constructed so as to have little redundancy there may not have been sufficient variability in the characteristics of the stimuli for the correlations to be significant.

Another possibility is that the measures of orthographic redundancy utilized in the analysis do not adequately capture the nature of redundancy being used by the subjects. Gibson and Levin (1975) make a distinction between measures of "correlational redundancy" and "conditional redundancy". Correlational redundancy simply refers to the sequence or order of the letters in the word, while conditional redundancy takes into account the sequence of vowels and consonants and the position in the word occupied by the letter or letter cluster. According to Gibson and Levin, conditional redundancy plays a larger role in reading than does correlational redundancy. Of the measures used in this study, summed transitional total, bigram frequency right and left, and transitional probability left and right, are all measures of correlational redundancy. Mason's concept of spatial frequency redundancy takes into account the position individual letters occupy in a word but not the sequential probability of the letters in the word. It seems that adequate measures of conditional redundancies do not as yet exist for four letter words.

Finally, the logical possibility exists that orthographic redundancy does not account for the better performance of subjects on word trials in this paradigm. As noted previously, however, it seems to have been well established in the literature that this paradigm does in fact measure the reader's utilization of orthographic redundancy.

CONCLUSIONS

The finding of a significantly larger word superiority effect for fluent readers than less fluent readers in the post-cue condition provides evidence for the hypothesis that fluent readers are more efficient in their ability to utilize orthographic redundancy as an aid to letter identification. This hypothesis was further supported by the finding of little difference between reader groups or interaction between reader group and type of stimulus material in the pre-cue condition where the contribution of the strategy of utilizing orthographic information as an aid to letter identification is thought to be minimized. Together these two findings are consistent with current models of the reading process, such as those proposed by Goodman, Hochberg, Smith, and Massaro, in which the ability to sample visual data and capitalize on the redundancy available in printed material are thought to be important component skills in the process of fluent reading. Moreover, due to the nature of the paradigm employed in this study, it seems safe to say that readers actively utilize orthographic redundancy at the time of primary recognition or in the encoding stages of reading as suggested by Massaro.

Unfortunately the error analysis in this study failed to specify which characteristics of the word stimuli were being more efficiently utilized by fluent readers than less fluent readers in the post-cue condition. However, the finding of an anagram superiority effect for fluent readers but not for less fluent readers supports the prevalent notion in the literature that it is the orthographic structure of the word stimuli rather than meaning or familiarity which accounts for the word superiority effect with this paradigm and, thus, contributes to the differences found between fluent and less fluent readers. This finding of an anagram superiority effect along with the finding of no word superiority effect in the pre-cue condition also counters Reicher's rival hypothesis that the word superiority effect is due to the fact that the word is the perceptual unit in reading. If the word were indeed the perceptual unit, then a word superiority effect should also be found in the pre-cue condition, and subjects should not perform better on non-word stimuli such as anagrams.

Future research should attempt to more systematically determine what type of information is being more efficiently utilized by fluent readers than less fluent readers on word trials. This could be done by comparing the performance of fluent and less fluent readers in the Reicher paradigm on word and non-word stimuli constructed so as to specifically test the contribution of various types of orthographic redundancy. Rather than testing the contribution of simply one type of redundancy, as in the Mason study, a stronger design would be to compare the relative contribution of various types of orthographic redundandy to the reading process. A design in which the performance within and across reader groups on various lists of non-word and word stimuli constructed so as to test specific redundancy hypotheses is compared, would be one manner in which to achieve this. As noted previously, one problem in doing such research at the present time is the lack of measures which adequately capture the nature and degree of the redundancy in the stimuli. To date, most studies investigating the word superiority phenomenon have used only three and four letter words as stimuli. The phenomenon should be further invest-tigated with stimuli of varying word lengths in order to test the generalizability of the results and since more adequate measures of redundancy may be available for such stimuli. For example, the Mayzner and Tresselt Tables (1965) of trigram frequency counts which take into account word length and the position occupied by the trigram in the word could be used as measures of the spatial redundancy of clusters of letters in longer stimuli.

In closing it should be noted that these results should not be construed as suggesting that knowledge of orthographic redundancy is the sole variable contributing to fluent reading. The task employed in this study differs greatly from the normal reading process in that the contribution of syntactic and semantic redundancy are absent. It is still to be determined how much of a role orthographic redundancy plays in the reading process relative to other factors such as these other types of information which are utilized by the reader in the reading process. Other things being equal, however, it seems that the ability to utilize orthographic information does contribute to the reading process.

REFERENCES

Baddeley, A. D., Conrad, R., & Thompson, W.E. Letter structure of the English language. Nature, 1960, 186, 414-416.

Baron, J., & Thurston, I. An analysis of the word superiority effect. Cognitive Psychology, 1973, 4, 207-288.

Bjork, E.L., & Estes, W. K. Letter identification in relation to linguistic context and masking conditions. Memory & Cognition, 1973, 1, 217-223.

Bouma, H. Interaction effects in parafoveal letter recognition. Nature, 1970, 226, 177-178.

Chomsky, C. Reading, writing, and phonology. Harvard Educational Review, 1970, 40, 287-309.

Estes, W. K., Bjork, E. L., & Skaar, E. Detection of single letters and letters in words with changing versus unchanging mask characters. Bulletin of the Psychonomic Society, 1974, 3, 201-203.

Francis, W. N. The structure of American English. New York: Ronald Press, 1958.

Garner, W. R. Uncertainty and structure as psychological concepts. New York: John Wiley & Sons, 1962.

Gibson, E. J., & Levin, H. The psychology of reading. Cambridge, Mass.: MIT Press, 1975.

Goodman, K. S. A linguistic study of cues and miscues in reading. Elementary English, 1965, 42, 639-643.

Goodman, K. S. (ed.), The psycholinguistic nature of the reading process. Detroit: Wayne State University Press, 1968.

Gough, P. B. One second of reading. In J. F. Kavanagh & I. G. Mattingly (eds.), Language by ear and by eye. Cambridge, Mass.: MIT Press, 1972.

Hall, R. A. Sound and spelling in English. New York: 1961.

Hays, W. L. Statistics. New York: Holt, Rinehard, & Winston, 1963.

Hochberg, J. Components of literacy: Speculations and exploratory research. In H. Levin & J.P. Williams (eds.) Basic studies on reading. New York: Basic Books, 1970.

Hochberg, J., Levin, H., & Frail, C. Studies of oral reading; VII. How interword spaces effect reading. Cited in J. Hochberg, Components of literacy: Speculations and exploratory research. In H. Levin & J. P. Williams (eds.) Basic studies on reading. New York: Basic Books, 1970.

Holmes, D. L. The independence of letter, word, and meaning identification in reading. Reading Research Quarterly, 1971, 6(3), 394-415.

Huey, E. B. The psychology and pedagogy of reading. New York: Macmillan, 1908.

Johnston, J. C., & Mc Clelland, J.L. Visual factors in word perception. Perception and Psychophysics, 1973, 14, 365-370.

Kolers, P. A. Reading and talking bilingually. American Journal of Psychology, 1966, 79, 357-376.

Kolers, P. A. Three stages of reading. In H. Levin & J. P. Williams (eds.), Basic studies on reading. New York: 1970.

Kolers, P. A., & Katzman, M. T. Naming sequentially presented letters and words. Language and Speech, 1966, 9, 84-95.

Krueger, L. E., Keen, R. H., & Rublevich, B. Letter search through words and nonwords by adults and fourth grade children. Journal of Experimental Psychology, 1974, 102(5), 845-849.

Lott, D., & Smith, F. Knowledge of intraword redundancy by begining readers. Psychonomic Science, 1970, 19, 343-344.

Mc Conkie, G.W., & Rayner, K. The span of the effective stimulus during a fixation in reading. Perception and Psychophysics, 1975, 17(6), 578-586.

Mason, M. Reading ability and letter search time: Effects of orthographic structure defined by single letter positional frequency. Journal of Experimental Psychology, 1975, 104(2), 146-166.

Massaro, D. W. Perception of letters, words, and nonwords. Journal of Experimental Psychology, 1973, 100, 349-353.

Massaro, D. W. Primary and secondary recognition in reading. In D. W. Massaro (ed.), Understanding language: An information processing analysis of speech, perception, reading, and psycholinguistics. New York: Academic Press, 1975.

Mayzner, M., & Tresselt, M. Anagram solution times: A function of word transition probabilities. Journal of Experimental Psychology, 1962, 63, 510-513.

Mayzner, M. S., & Tresselt, M. E. Tables of single letter and digram frequency counts for various word-length and letter position combinations. Psychonomic Monograph Supplements, 1965, 1(2).

Miller, G. A. Some preliminaries to psycholinguistics. American Psychologist, 1965, 20, 15-20.

Miller, G.A., Bruner, J. S., & Postman, L. Familiarity of letter sequences and tachistoscopic identification. Journal of General Psychology, 1954, 50, 129-139.

Morton, J. The effects of context upon the visual duration thresholds for words. British Journal of Psychology, 1964, 55, 165-180.

Myers, J. L. Fundamentals of experimental design. Boston: Allyn & Bacon, 1966.

Neisser, U. Visual search. Scientific American, 1964, 210(6), 343-344.

Neisser, U. Cognitive psychology. New York: Appleton-Century-Crofts, 1967.

Neisser, U., & Beller, H. K. Searching through word lists. British Journal of Psychology, 1965, 56, 349-358.

Neisser, U. & Stoper, A. Redirecting the search process. British Journal of Psychology, 1965, 56, 359-368.

Nelson, M.J., & Denny, E.C. The Nelson-Denny reading test. Boston: Houghton Mifflin Co., 1960.

Pierce, J.R., & Karlin, J.E. Reading rates and the information rate of a human channel. Bell Systems Technical Journal, 1957, 36, 497-516.

Pitman, I. J., Learning to read: An experiment. Journal of the Royal Society of Arts, 1961, 109, 149-180.

Rayner, K., & Mc Conkie, G.W. What guides a reader's eye movements? Vision Research, 1976, 16, 829-837.

Reicher, G. Perceptual recognition as a function of meaningfulness of stimulus material. Journal of Experimental Psychology, 1969, 81, 275-280.

Siegel, S. Nonparametric statistics for the behavioral sciences. New York: Mc Graw Hill, 1960.

Smith, F. The use of featural dependencies across letters in the visual identification of words. Journal of Verbal Learning and Verbal Behavior, 1969, 8, 215-218.

Smith. F. Understanding reading - A psycholinguistic analysis of reading and learning to read. New York: Holt, Rinehart, & Winston, 1971.

Thompson, M.C., & Massaro, D.W. The role of visual information and redundancy in reading. Journal of Experimental Psychology, 1973, 98, 49-54.

Thorndike, E.L., & Lorge, I. The teacher's word book of 30,000 words. New York: Bureau of Publications, Teacher's College, Columbia University, 1944.

Tulving, E., & Gold, C. Stimulus information and contextual information as determinants of tachistoscopic recognition of words. Journal of Experimental Psychology, 1963, 66, 319-327.

Underwood, B.J., & Schulz, R.W. Meaningfulness and verbal learning. Philadelphia: Lippincott, 1960.

Venezky, R. L. English orthography: Its graphical structure and its relation to sound. Reading Research Quarterly, 1967, 2, 75-106.

Weber, R. M. First graders' use of grammatical context in reading. In H. Levin and J. P. Williams (eds.), Basic studies on reading. New York: Basic Books, 1970.

Wheeler, D. Processes in word recognition. Cognitive Psychology, 1970, 1, 59-85.

Fluent Readers

Subject	Pre-Cue	Post-Cue
14	40	110
15	50	70
16	80	80
17	70	80
18	100	80
19	95	60
20	60	60
21	75	85
22	100	80
23	65	50
24	75	75
25	80	85
26	60	90

APPENDIX D

READING SCORES AND DEMOGRAPHIC CHARACTERISTICS OF SUBJECTS

Less Fluent Readers

S	Age	Grade	Comp. Raw Score	Comp. %ile	Vocab. Raw Score	Vocab. %ile	Rate Raw Score	Rate %ile
-1	25	13	16	4	22	20	115	4
-2	20	15	28	5	64	88	338	69
+3	28	14	14	1	16	3	161	7
*-4	22	15	14	1	48	58	396	84
*-5	25	16	32	7	63	82	446	95
+6	32	16	18	1	40	25	359	78
+7	34	14	24	10	48	53	174	9
+8	29	16	24	3	71	91	174	6
-9	22	12	28	25	36	74	287	65
*-10	19	14	28	8	58	84	287	55
-11	24	12	22	12	36	74	140	8
+12	20	14	30	10	40	41	338	76
*-13	32	15	24	4	32	19	216	17

*Subjects whose data was not included in the analysis of the pre-cue condition.

+- Sex of Subject; Males (-), Females (+)

Fluent Readers

S	Age	Grade	Comp. Raw Score	Comp. %ile	Vocab. Raw Score	Vocab. %ile	Rate Raw Score	Rate %ile
+14	20	14	36	21	41	45	238	32
-15	25	15	38	21	80	98	371	79
*-16	22	14	40	30	50	70	349	79
-17	23	16	38	17	49	51	327	66
+18	24	15	66	97	71	95	407	86
-19	21	15	62	89	59	80	426	89
+20	26	14	52	65	73	96	563	98
*+21	22	15	58	80	48	58	359	76
+22	42	14	58	81	88	99	639	99
+23	29	15	66	89	83	99	~~396~~	84
+24	23	16	68	98	75	93	371	82
+25	26	15	56	74	63	86	359	76
+26	30	16	64	92	61	78	338	70

* Subjects whose data was not included in the analysis of the pre-cue condition.

+- Sex of Subject; Males (-), Females (+)

SUMMARY OF READING SCORES AND DEMOGRAPHIC CHARACTERISTICS

Fluent Readers	Age	Grade	Comp. Score	Vocab. Score	Rate Score
Pre-Cue					
Median	25	15	56	71	371
Range	20-42	14-16	30-68	41-88	238-639
Post-Cue					
Median	24	15	58	63	371
Range	20-42	14-16	30-68	41-88	238-269
Less Fluent Readers					
Pre-Cue					
Median	25	14	24	40	174
Range	20-34	12-16	14-30	16-71	115-359
Post-Cue					
Median	25	14	24	40	287
Range	19-34	12-16	14-32	16-71	115-446

APPENDIX E

RAW SCORES

Pre-Cue Condition

Less Fluent Readers

Subject	Words	Letters	Anagrams
1	11	14	13
2	9	8	15
3	12	7	15
6	15	13	14
7	25	22	19
8	6	11	15
9	14	14	16
11	15	7	17
12	17	15	19

Fluent Readers

Subject	Words	Letters	Anagrams
14	5	2	3
15	27	13	27
17	19	14	12
18	28	20	28
19	14	10	11
20	5	3	10
22	10	13	17
23	15	20	20
24	4	4	8
25	7	12	12
26	11	16	18