THE CONTRIBUTION OF ORTHOGRAPHIC REDUNDANCY TO SECOND LANGUAGE READING PROBLEMS

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ABSTRACT

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A problem often experienced by proficient bilinguals with equivalent comprehension skills for written and oral materials is that the second language is read more slowly than the native language. It was hypothesized that this differential reading rate partly reflects the bilingual's inferior ability to capitalize on the orthographic redundancies of the second compared to the native language. Subjects in the study were native English speaking bilinguals with balanced listening and reading comprehension skills in English and French but who exhibited significantly slower reading rates in French. Their ability to utilize knowledge of the orthographic redundancies in English and French was examined with a test of the word superiority effect (Reicher paradigm). A word superiority effect was found for all subjects when the target letters appeared in the context of English words but not when they appeared in the context of French words. This finding indicates that these otherwise proficient bilinguals made less use of orthographic redundancy in French than in English. The results are discussed in terms of their implications for our understanding of both monolinguals' native language reading and bilinguals' second language reading.

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THE CONTRIBUTION OF ORTHOGRAPHIC REDUNDANCY TO SECOND LANGUAGE READING PROBLEMS

Large multiethnic and multilingual communities often place individuals in academic and business situations requiring the use of a second language. Consequently, for many bilinguals achievement in these areas is bound to their ability to effectively read materials printed in their second language. Several studies however, have demonstrated that while bilinguals have a mastery of the second language's vocabulary and syntax and experience no difficulties with spoken materials, they nevertheless read more slowly in their second language than in their first. The difficulty encountered by otherwise proficient bilinguals reading in a second language suggests that the second language reading process is inefficient in some respect. Despite its obvious implications, very little research has been concerned with investigating the sources of second language reading difficulty.

The problem however, can be examined in terms of current models of the first language reading process. In these models, the skilled first language reader is thought to actively utilize his knowledge of the language's orthographic, syntactic and semantic redundancies to supplement the visual information of the printed text. In addition to providing valuable insights into the complex skills involved in reading, these models suggest ways in which skilled and less skilled readers may differ. The skilled reader may capitalize on his linguistic knowledge and in doing so, merely needs to sample the printed material in order to abstract its meaning. The less skilled reader may be less able to fully utilize the language redundancies and hence, needs to rely more heavily on the visual information.

The research contained in this thesis is developed with respect to the current models of reading and is concerned primarily with the extent to which orthographic redundancy is utilized in first and second language reading. It is hypothesized that the inability to make full use of the second language's orthographic redundancy is partly responsible for the reading problems encountered by otherwise proficient bilinguals.

Second Language Reading

Studies concerned with comparisons between first and second language reading, have consistently reported slower reading speed and lower comprehension when bilinguals read in their second language (Daitchman, Note 1; Lambert, Havelka & Gardner, 1959; Kellaghan & Macnamara, 1967; Macnamara, 1965). In the case of novice second language readers, the deficits in speed and in comprehension could obviously reflect an inadequate command of the language. Such a simplistic explanation however, is not applicable when the readers are proficient bilinguals. A number of studies (Daitchman, Note 1; Kellaghan & Macnamara, 1967; Macnamara, 1965) have demonstrated that proficient bilinguals have a mastery of the second language's syntax, idiom and vocabulary. Yet, despite their knowledge, proficient bilinguals have been found to be less efficient when reading in their second than in their native language.

The difficulty encountered in second language reading has been documented by Macnamara (1965) in a series of studies with sixth-grade native speakers of English who had received their formal education in Irish. The children were given problems that required a relatively complex reasoning process but that were constructed using familiar vocabulary, in each of the two languages. To ensure that the vocabulary, as well as the syntactic structure of the problems were clearly understood, a set of simple problems containing each component of the complex problems were given to the children. Only the results of subjects who correctly answered all of the simple problems were analyzed. It was found that children performed significantly better when the complex problems were formulated in the native language than in the second. The inferior performance of subjects in the second language could not, however, be attributed to their insufficient knowledge of the language's vocabulary and syntax since they understood each component of the problems.

In a subsequent study, Kellaghan and Macnamara (1967) asked a similar group of children to read aloud and in succession, English and Irish versions of three problems that were comparable to those employed in the study previously outlined. It was found that although the problems contained the same number of words in each language, the children took significantly more time to read the second language versions than to read the native language ones. Moreover, the children's reading speed increased from the first to the third time of reading. This improvement in speed was greater when reading the second language than when reading the first. The studies by Macnamara (1965) and by Kellaghan and Macnamara (1967) indicate that bilingual children experience more difficulty in processing information written in the second language than similar information written in the first.

More recently, Daitchman (Note 1) has shown that adult bilinguals are also less efficient when reading in their second language than in their first and that this difficulty need not necessarily be attributed to the bilinguals' inadequate grasp of the language. He investigated whether proficient bilinguals achieve different levels of comprehension when reading or listening to passages of comparable difficulty in the two languages. The subjects were required to read or to listen to texts presented in either their native or their second language. Comprehension was assessed by a set of multiple choice questions that followed each text presentation. In the listening condition, subjects heard recorded versions of the texts read by native speakers. The rates of presentation of the aural materials were nearly identical for first and second languages. In the reading condition, the first and second language texts were projected on a screen one line at the time, at a rate corresponding to each subject's first language reading rate. The results revealed no difference in comprehension between first and second language in the listening condition. In contrast, in the reading condition, a significant difference in comprehension between languages was observed. It was found that bilinguals had inferior comprehension when forced to read the second language materials at a rate equivalent to that of their first language. The poorer comprehension in second language reading could not however, be attributed to the bilinguals' inadequate knowledge of the second language's vocabulary and syntax since they understood the spoken materials equally well in both languages.

These studies clearly show that bilingual children (Macnamara, 1965; Kellaghan & Macnamara, 1967) and adults (Daitchman, Note 1) read more slowly and less efficiently in the second language than in the native language. Moreover, these studies suggest that at least in the case of balanced bilinguals some factors other than an insufficient command of the second language are responsible for the difficulty encountered while reading.

Other investigators have attempted to investigate the nature of the second language reading problems by comparing the eye movements of native and non-native readers of English. Tullius (1971) initially proposed that second language readers were slower because they made more eye fixations and more regressions per line than native readers. When testing this proposition, Tullius found contrary to his expectations, that non-native readers of English did not fixate more often, nor did they regress more often than did native readers. Instead, non-native readers differed from native readers in that they made significantly longer fixations while reading. Similar results have been reported by Oller and Tullius (1973). In their study, the eye movements of non-native readers of English were recorded while reading texts which they comprehended at the level of 70 percent or more. It was shown that despite similar levels of comprehension, non-native readers of English required significantly longer fixations than did the native readers.

The results obtained by Tullius (1971) and by Oller and Tullius (1973) suggest that the deficiencies observed by Kellaghan and Macnamara (1967) and by Daitchamn (Note 1) in second language reading could have stemmed from the subjects having to make longer fixations while reading the second language than the first. Since it has been proposed (Shebilske, 1975) that the duration of fixation reflects information processing time, the results of the above studies imply that the second language reader requires more time than the first language reader to process the same amount of printed information.

Unfortunately, very little else can be said at this time about the source of second language reading inefficiency. Some insights into the problem can be gained however, from research on first language reading, to which we shall now turn.

First Language Reading

Traditionally, the processes involved in reading were thought to consist of first, the discrimination and identification of the visually presented linguistic symbols and second, the translation of these symbols into spoken language (Bloomfield, 1942; Fries, 1963; Gough, 1972; Venezsky, 1967). In general, this view of reading implied that word identification was achieved by sequentially processing the letters of a word and converting them into their oral equivalent by some knowledge of the phonic rules governing the spoken language. The meaning of a word was subsequently derived by analyzing these sounds, using language strategies similar to those employed in analyzing speech.

There are however, several counter arguments to the notion that skilled reading involves the sequential decoding of printed letters into sounds. The work of linguists (Chomsky, 1970; Francis, 1958; Venezsky, 1967) has shown that although English orthography is systematic and rooted in a phonemic base, there is not a one-to-one correspondence between the alphabetical symbols and the phonemes of the language. Instead, the orthography reflects the deeper underlying structure and not the surface level sound structure of the language (Chomsky, 1970). This complex relationship between the written symbols and the deeper meaning suggests that it is unlikely that skilled readers always identify words by mapping individual letters into sounds, and then into meaning.

In addition, it has been pointed out (Goodman, 1968; Holmes, 1971; Smith, 1971; 1973) that this view of the reading process is based on the erroneous assumption that identification of individual letters is a necessary preliminary to word identification and that identification of a word is a prerequisite for the abstraction of meaning. In support of these criticisms, research in the area of human information processing has demonstrated that skilled readers read at a rate that is incompatible with the serial processing of letters and words into full perceptual representations from which meaning is derived.

Several investigators (Neisser & Beller, 1965; Neisser & Stoper, 1965; Pierce & Karlin, 1957) have shown that words are identified and their meaning abstracted in less time than would be required if identification proceeded in a letter to sound and in a letter by letter fashion. In these studies, subjects identified words in lists at rates varying from 200 msec to 350 msec each. Neisser (1967) has convincingly argued that since naming a single letter may take over 100 msec, it is unlikely that a word can be identified by the serial processing of every one of its letters or phonemes.

More direct evidence that skilled readers are capable of extracting the meaning of a word without first processing each letter is the finding that words can be identified even when their component letters are not easily discriminable. Kolers and Katzman (1966) have reported that when letters which spelled a word were presented individually in slow succession (250 msec each), all of the component letters were identified better than the word they spelled. In contrast, when the same letters were presented in rapid succession (125 msec each), words were identified better than their component letters. Furthermore, Smith (1969) has shown that tachistoscopically projected letters presented in the context of a word were recognized at a lower contrast level than when the same letters were presented in isolation.

Taken as a whole, these studies demonstrate that skilled readers read too quickly to be identifying a word by sequentially spelling out the sounds corresponding to every one of its component letters and abstracting its meaning by sounding out the word. Moreover, it appears that skilled readers are capable of identifying a word with less visual information than that required to identify each of its letters.

These findings have led several theorists (Goodman, 1968; Hockberg, 1970; Massaro, 1975; Ryan & Semmel, 1969; Smith, 1971) to conceptualize reading as one type of linguistic performance in which a reader utilizes his linguistic knowledge during the actual perception of printed materials. Typically, proponents of this view de-emphasize the importance of the purely visual information and stress the importance of non-visual contextual information in reading. The non-visual information is derived from the reader's knowledge of the regularities of spelling (orthography), of structure (syntax) and of meaning (semantics) that characterize the written language. Accordingly, three types of contextual information are available to the reader: 1) orthographic redundancies or intra-word constraints provided by the rules of spelling; 2) syntactic redundancies provided by the preceding words in a sentence and by the rules of syntax; and 3) semantic redundancies provided by the meaning of the preceding words as well as topic of the passage. By imposing constraints on the possible sequences of letters or words that can be combined to form meaningful units in a particular context, each type of redundancy facilitates the reader's task.

The concepts of orthographic, syntactic and semantic redundancies are illustrated by Massaro (1975) in the following example: "Suppose a reader encounters the following sentence: 'With the bases loaded, the boy hit the _ _LL over the fence.' Assume that the reader completely resolved all the letters in the sentence except for the two underlined positions. Accordingly, it is necessary to identify the two missing letters in a four letter word. Partial visual information defines a vertical line as the first letter position, and no feature information is registered for the second position. 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 alternatives still remain, e.g., tell, tall, ball, bull, nill, 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 provides contextual information (semantic redundancy). It would also not make sense to say The boy hit the bull over the fence. Therefore, BALL is the only remaining alternative." (Massaro, 1975, p. 243)

Massaro's illustration suggests that a reader is capable of using contextual constraints to supplement missing visual information. This notion is in agreement with that held by several theorists who have described reading as either a psycholinguistic guessing game (Goodman, 1969), a sampling process

(Hockberg, 1970; Smith, 1971), a constructive process (Ryan & Semmel, 1969) or a dynamic process (Massaro, 1975). In general, these contemporary theories or reading view the reader as being actively involved in integrating his knowledge of the orthographic, syntactic and semantic redundancies of the written language to reconstruct the printed message. By capitalizing on his knowledge of these constraints, a reader merely needs to selectively sample the visual information in order to abstract the meaning expressed in the passages of a text.

In the following section, the model of reading proposed by Massaro (1975) will be elaborated upon, since it is characteristic of the more contemporary models. Moreover, Massaro's model delineates each of the processing stages by which a reader decodes the stimulus into a meaningful percept.

Massaro's Model of Reading

In the reading model proposed by Massaro (1975), the reader dynamically draws upon his linguistic competence during the encoding stages of the reading process. As may be seen in Figure 1, the model specifies each of the processing stages and suggests how these processes may be integrated in the total activity of reading.

In the first stage of reading, the retinal image obtained during an eye fixation on the printed page is trans-

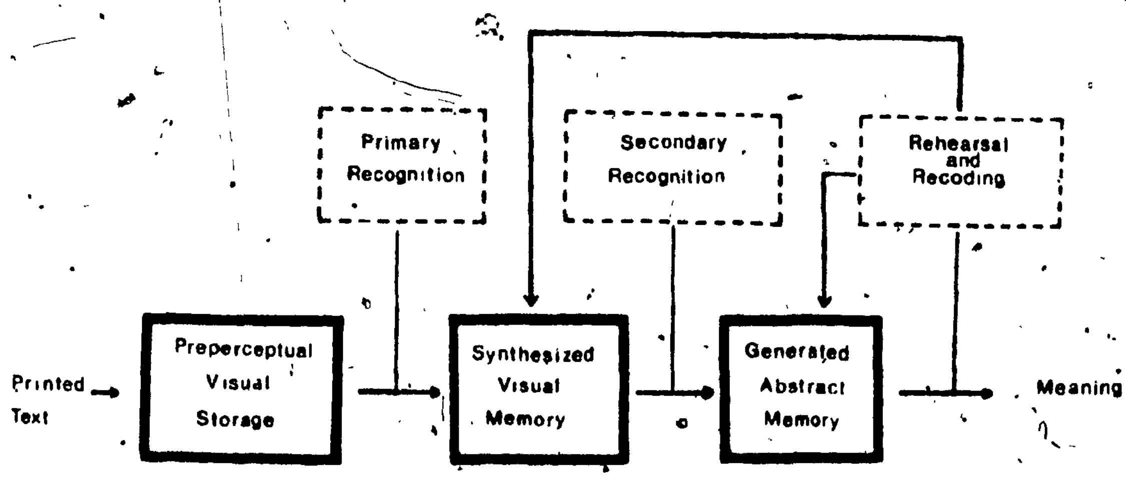

Figure 1: A schematic representation of the primary and secondary recognition processes and of rehearsal and recoding operations in Massaro's model of reading. The boxes enclosed by solid lines represent storages and those enclosed by broken lines represent processes. The arrows typify the flow of information. (Adapted from Massaro, 1975)

duced by the visual receptor system and is then taken up by a "feature detection process". This process is assumed to transmit the visual features of the printed letter into a "preperceptual visual storage". The features are considered to be purely visual in that there is a one-to-one relationship between the stimulus properties of the letters and the information held in preperceptual storage. This initial stage of the reading process is considered to be passive and thus, sharply contrasts with later stages in which there is not a one-to-one correspondence between the input and the output.

Once the set of visual features are in the perceptual storage, the "primary recognition process" transforms these features into letter or word units by utilizing information held in the reader's long term memory. This information consists of the lists of features defining each letter of the alphabet and of the rules of orthography governing the language. The primary recognition process operates in parallel on a number of letters. The number of letters that can be processed at the same time, is dependent upon the acuity of the retina, and on the contribution of lateral masking of the adjacent letters. The primary recognition process has access to both the visual features held in preperceptual storage and the information stored in long term memory. From the visual features read out of the preperceptual storage, the primary recognition process is able to define a set of possible candidate letters for each letter position of a word. By combining this information with that stored in long term memory, the primary recognition process selects from the set of candidate letters, the letter that not only has similar visual features but that is also highly probable given the orthographic structure of the language. Hence, the primary recognition process is active, since a reader utilizes both visual and non-visual information to narrow down the alternatives at each letter position in a word.

Once the letters have been identified by the primary recognition process, the sequence of letters are then transmitted in parallel to the "synthesized visual memory". The synthesized visual memory serves to maintain the letter sequences while the "secondary recognition process" transforms the sequence into a meaningful word. The secondary recognition process abstracts the meaning of a word by relating the letter sequence to a word in the long-term memory lexicon. All words contained within the long-term memory lexicon are coded perceptually and conceptually. Accordingly, the meaning derived from the secondary recognition process results from a matching of the letter string to a word in the lexicon memory which is most likely to occur in a particular context.

In addition, Massaro (1975) postulated the existence of a feedback system from a generated abstract memory to the synthesized visual memory that can modify the secondary recognition process. This feedback system consists of recoding and rehearsing operations. Via this feedback system, the reader's conceptual expectations held in the general abstract memory can serve to alter materials in the synthesized visual memory and thus affect the secondary recognition process.

Within Massaro's model the reader's knowledge of orthographic, syntactic and semantic constraints are actively utilized during the primary and the secondary recognition processes in word identification and extraction of meaning. Thus, these redundancies serve to supplement the purely visual information. This implies that at least for the competent reader, the contextual information plays an important role in the reading process. In the following section, a number of studies that substantiate this inference will be reviewed.

Studies Investigating the Role of Redundancy in Reading

Orthographic Redundancy. The manner in which letters may be combined to form letter clusters or words is generally governed by certain orthographic rules. In English for example, orthographic rules dictate that the letter Q must always be followed by the letter U, whereas the clusters KM cannot occur unless it crosses a morpheme boundaries such as in the word MILKMAID (Gibson & Levin, 1975). Adult readers appear to have some knowledge of these intra-word constraints since they can predict successive letters of a word with better than chance accuracy (Gardner, 1962).

As early as 1954, Miller, Bruner and Postman showed that readers were sensitive to the predictability of letter sequences. In their study, subjects were tachistoscopically presented with strings of eight letters and asked to report all letters. The strings varied in the extent to which they approximated the statistical structure of English orthography. For example, stimuli representing a zero, first, second and fourth order of approximations to the English orthography were OZHGPMPMTU, UTYEHUOLD, THERASES and VERNALIT, respectively. The results revealed that as the letter strings approached the regular orthography, more letters were identified correctly. Miller et al. (1954) concluded that a familiar context facilitates recognition since a reader can apply his knowledge of the spelling rules to reduce the number of possible letter alternatives that can be expected to occur. However, there may be an alternative explanation for these results. As the letter string approaches regular orthography, it also becomes more pronounceable; hence, perhaps pronounceability of a string rather than orthographic redundancy, facilitates recognition.

Gibson and her associates (Gibson, Pick, Osser & Hammond, 1962; Gibson, Bishop, Schiff & Smith, 1964; Gibson, Shurcliff & Yonas, 1970) conducted several studies which purported to demonstrate that the pronounceability of spelling patterns plays a role in reading. In the first study (Gibson et al. 1962), the perception of tachistoscopically presented pronounceable non-words was compared to that of unpronounceable non-words. The pronounceable non-words obeyed the rules of English orthography such that they were constructed by placing a typical English initial or final consonant cluster at the beginning or the end of the letter strings, respectively. The unpronounceable non-words were prepared by inverting the initial and final consonant clusters of the corresponding pronounceable non-words. For example, some of the corresponding pronounceable and unpronounceable non-words were SLAND and NDASL, and GLURCK and CKURGL, respectively. Subjects correctly reported approximately 20 percent more of the pronounceable than the unpronounceable non-words. This finding was interpreted by Gibson et al. as indicating that the perceptual unit in word perception was the pronounceable spelling pattern.

This interpretation however, can be questioned on two methodological points. First, subjects were required to report in writing all of the letter strings. If one considers the possibility that pronounceable non-words could be rehearsed with greater ease in short-term memory than unpronounceable ones, the advantage of pronounceability could reflect differences in retention rather than differences in perception. Second, it has been argued (Anisfeld, 1964; Massaro, 1975) that the non-words' pronounceability was confounded with the orthographic constraints of the English language. Anisfeld for instance, has pointed out that the letters forming the pronounceable non-words had higher sequential probability of occurrence in English orthography, as calculated by Underwood and Schulz (1960) summed bigram or trigram frequency tables. Consequently, since the pronounceable non-words contained letter sequences that did not violate the rules of English orthography and hence were highly predictable, perhaps orthographic redundancy rather than pronounceability could have aided the perception of pronounceable non-words.

In light of such criticisms, Gibson et al. (1970) conducted a study in which deaf and hearing subjects were presented with the same non-words as those used in the study previously outlined. They reasoned that if pronounceability is an important factor in word perception, then deaf subjects would not show the usual pronounceable advantage effect, since they obviously had no previous experience with pronounceability. It was found that the deaf subjects made more errors on both pronounceable and unpronounceable non-words than the hearing subjects. However, the differences between the number of errors made on pronounceable and unpronounceable non-words were equivalent for the deaf and the hearing subjects. Gibson et al. concluded that since the deaf subjects also benefited from the pronounceability of non-words, pronounceability was not the crucial factor in word perception.

Instead, they suggested that pronounceability is an indirect measure of orthographic word structure and that the readers' knowledge of orthographic redundancy facilitated the perception of non-words.

Given that within-word redundancy appears to play a role in the reading process, several investigators have attempted to systematically assess the reader's utilization of specific types of orthographic redundancies. The majority of these studies have been concerned with the contribution of sequential redundancy or the knowledge of the constraints that characterize valid spelling patterns.

Herrmann and McLaughlin (1973) have provided some evidence to substantiate the notion that the predictability of a letter string as determined by the rules of orthography, facilitates the identification of letters. In his study, three types of letter strings were used: four-letter words, non-words with the same transitional probabilities as the words and non-words with low transitional probabilities. The transitional probabilities were measured according to bigram frequencies previously tabulated by Underwood and Schultz (1960). Subjects were tachistoscopically presented with a matrix containing four stimuli and asked to identify which of two given target letters appeared in the display. Performance accuracy on words and non-words of the same transitional probability was equivalent and superior to performance accuracy on low transitional probability non-words. The results of this study indicate that sequential constraints operate to aid letter identification independently of meaning.

Smith (1969) and Lott and Smith (1970) have also been concerned with the utilization of sequential redundancy in the reading process. In their studies, either words, non-words or their single component letters were tachistoscopically presented at an intensity well below visual recognition threshold. The intensity level was gradually raised until the subjects correctly identified one or more of the letters. The increment in intensity needed for the recognition of a letter was interpreted as reflecting the amount of visual information required for correct identification. The difference between the increment in intensity necessary to identify a letter presented alone as compared to the same letter presented in either words or non-words was termed a mean gain.

In the study by Smith (1969) the intensity level at which adult readers could identify letters presented alone was compared to that needed for identification of the same letters appearing in high or low sequentially redundant words and non-words. Sequential redundancy was estimated from Baddeley, Conrad and Thompson's (1960) tables of digram frequencies for written English. The results showed that letters embedded in words and high redundant non-words were recognized at lower intensity levels than those embedded in low redundant non-words or in isolation. Smith interpreted this mean gain as evidence that the readers had knowledge of sequential dependencies among letters and were able to use the information provided by other parts of the multi-letter configuration to identify letters in redundant contexts.

Lott and Smith (1970) replicated Smith (1969)'s finding with primary school children and adults. They reported that all children appeared to use their knowledge of sequential redundancy. Interestingly, this ability increased up to the fourth grade at which point the children had the competence of adult readers.

Another approach to investigate the contribution of a reader's knowledge of sequential redundancy to reading has involved comparing the performance of skilled and less skilled readers in a visual search task. In these studies, subjects searched for a target letter through a list of words and non-words tachistoscopically displayed, and the search time was recorded. On some trials (catch trials) the target letter was not presented in the display; these trials provided an estimate of the time necessary for a subject to reach his decision about the absence of the letter. The catch trials assessed the amount of visual information that subjects could attend to, as well as their ability to utilize distinctive features of letters. The word and non-word trials served to differentiate between the subjects' ability to supplement visual information with non-visual redundant information.

Krueger, Keen and Rublevitch (1974, Experiment 1) compared the performance of adults and fourth-grade children on the visual search task. They reported that adult readers searched the lists twice as fast as fourth-grade readers, and better fourth-grade readers searched faster than poorer fourth-grade readers. Since the adults and the better fourth-grade readers showed a superior visual search skill, they would also be expected to be superior in utilizing sequential redundancy provided by word contexts. The reduction in the amount of time required to search through word lists however, was equivalent for adults and children and equal for the better and poorer readers.

In a subsequent experiment Krueger et al. (1974, Experiment 2) correlated the adult readers' ability to exploit the words structure in letter search with reading skills. They found that the better readers tended to take more advantage of sequential redundancy of words to reduce search time than the poorer readers. Krueger et al. did not provide any explanation for the discrepancy between the results of this experiment and those of their first.

Recently however, Mason (1975) has argued that the search time advantage in word trials over non-word trials observed in the Krueger et al. studies cannot be explained in terms of the readers' utilization of sequential dependencies between letters. She pointed out that in the visual search paradigm, the decision as to whether or not the target letter is contained in a display, is reached on the basis of purely visual information. She proposed that the better performance on word over non-word trials was due to the readers' knowledge of spatial redundancy or the correlation between the visual features of letters, and their spatial position in a letter string.

Mason (1975, Experiment 2) tested her hypothesis by comparing the performance of poor and good sixth-grade readers on the Krueger paradigm in which the stimuli comprising the search lists varied in spatial frequency redundancy. The stimuli were generated using Mazner and Tresselt (1965) single letter frequency counts for six letter English words. These counts specify the frequency of occurrence any one letter has in a particular position in a given string length. The spatial redundancy of each stimulus was calculated by summing the spatial frequency of each letter contained in the string. In this manner, three types of stimulus were prepared: 1) six letter words in which the letters did not sum to the maximum spatial frequency possible; 2) non-words containing the same letters as the words but in which the letters were arranged so that the summed spatial frequency was the maximum possible; and 3) non-words with the lowest spatial frequency possible. Mason found that the performance of poor readers was equivalent to that of good readers in low spatially redundant non-word displays. Similarly to readers in the Krueger et al. (1974) experiment however, good readers searched the lists containing highly spatially redundant non-words more rapidly than lists where the same letters formed common words. Mason concluded that spatial redundancy of the six letter strings rather than familiarity was responsible for the decrease in search time.

In a subsequent experiment, Mason (1975, Experiment 4) manipulated the spatial redundancy of the target letters themselves in the two types of non-word lists. The results showed that good readers were faster than poor readers when the location of the target letter within the string was spatially redundant. Mason interpreted these findings as indicating that good and poor readers differed in their ability to utilize spatial redundancy but not in their ability to utilize the distinctive visual features of letters. Moreover, she argued that the better readers applied their knowledge of spatial redundancy available in words to supplement distinctive feature information. Thus, Mason concluded that knowledge of spatial redundancy aided the identification of individual letters in the visual search paradigm.

It should be noted however, that in Mason's experiments the possibility that sequential redundancy plays a role in reading was not eliminated since her stimuli were constructed to explicitly test the contribution of spatial redundancy. Hence, Mason's conclusion that spatial redundancy is the relevant factor contributing to letter identification was somewhat premature.

With respect to the visual search paradigm, it should be pointed out that some confounding variables may not permit an accurate assessment of the contribution of orthographic redundancy to the reading process. In this paradigm, the target letter and its position are known by the subjects before the search is begun. Consequently, the subjects may rely on strategies other than the use of orthographic redundancy to identify the target letters. Neisser (1967) has reported that in some cases, subjects do not notice non-target letters, nor can they visually distinguish between words that composed the list from those that did not. This suggests that in a visual search, the readers might not have actively processed the words, and perhaps orthographic redundancy might not be fully utilized.

Recently, there has been a study which systematically examined the contribution of orthographic redundancy as an aid to letter identification. Waters (Note 3) compared the performance of fluent and less fluent readers on the Reicher paradigm (1969). Subjects were tachistoscopically presented with an equal number of four letter words, anagrams of the same words and single-letters embedded in visual noise masks. The words were chosen such that each could be changed by one letter (the critical letter) to form a new word, i.e., SHIP/SLIP. The critical letter and the alternative letter (which could make another word) were the two possible responses in an accompanying forced-choice display. In one condition (precue), the forced-choice displays were presented before the target stimuli; in the other condition (postcue), the forced-choice displays followed the stimuli. On all trials, the subjects' task was to report which of the two letters contained in the forced-choice display had occurred in the same position in the stimulus. Waters (Note 3) reported that in the precue condition where the contribution of orthographic redundancy was minimized, less fluent readers were as accurate as fluent readers in identifying letters presented in either words, anagrams or visual noise masks. In the post-cue condition however, where orthographic redundancy facilitates letter identification, fluent readers were more accurate than less fluent readers in identifying letters appearing in word contexts. The results were taken as evidence that fluent readers are better able than less fluent readers at utilizing their knowledge of orthographic redundancy as an aid to letter identification. The use of the Reicher paradigm to investigate the contribution of orthographic redundancy in reading will be elaborated upon in a subsequent section.

Taken as a whole, the above studies suggest that readers are sensitive to the predictability of letters contained in strings. Furthermore, the readers appear to utilize their knowledge of orthographic redundancy to facilitate letter identification in tachistoscopically projected displays; although the specific type of orthographic redundancy is yet to be determined. In addition, Waters' (Note 3) findings add strong support to Massaro's (1975) notion that orthographic redundancy is utilized by the reader during the encoding stage of the reading process.

Syntactic Redundancy. There is evidence to suggest that the reader's knowledge of the permissible combination of words into phrases and sentences contributes to the reading process. A number of investigators have documented that native language readers are capable of utilizing the rules of syntax to reduce uncertainty in reading. Kolers (1970) has examined the extent to which a reader is sensitive to the grammatical category of words. In his study, subjects were required to read aloud geometrically transformed texts in which letters were inverted or the texts were rotated in three dimensional space and mirror images were printed. The analysis of the oral reading errors revealed that for the majority, the errors consisted of the substitution of some other English word for that which was printed. In approximately 75 percent of these errors, the substituting word preserved that same part of speech as the misread word. For example, subjects tended to replace misread nouns, verbs and prepositions by other nouns, verbs and prepositions, respectively. Moreover, when the substitutions were of a different part of speech, the replacing words tended to maintain the correct grammatical structure of the sentence. In this manner, nouns were more likely to be replaced by adjectives than by pronouns or verbs. Kolers further reported that subjects more frequently corrected errors that were grammatically inconsistent with the full sentence than those that were not.

In a similar study, Kolers (1966) asked French-English bilinguals to read aloud mixed French-English passages as well as comparable passages in either of the two languages. For example, one of the mixed language passages was:

> "Son cheval, suivi by two hounds, en marchant d'un pas égal, made resound the earth. Drops of ice se collaient à son cloak. A wind strong soufflait. Un côté of the horizon s'éclairait; et, in the whiteness of le crépuscule, he saw des lapins sautillant au edge of their burrows." (p. 359)

These bilingual passages contained several distortions of the usual French and English syntax. Nevertheless, when reading aloud, subjects tended to rectify the disordered syntax so as to make the passage more grammatically acceptable. For instance, the phrase "made resound the earth" was read aloud as "made the earth resound".

Using a comparable procedure, Weber (1970) investigated whether beginning readers were aware of the grammatical constraints provided by a sentence context, and whether they utilized this source of redundancy. In her study, the reading errors, as well as spontaneous self-corrections made by first-grade readers were analyzed. The error analysis revealed that for both skilled and less skilled beginning readers, approximately 90 percent of the errors consisted of the substitutions of words by other words which were grammatically consistent with the preceding words in the sentence. Moreover, Weber reported that the better readers generally corrected errors that upset the grammatical structure of the sentence while they ignored those which were grammatically acceptable to the full sentence. In contrast, the less skilled readers tended to correct both grammatically acceptable and unacceptable errors equally often.

Together, these studies indicate that both children (Weber, 1970) and adult readers (Kolers, 1966; 1970) do have some knowledge of the syntactic rules of the language and that they are sensitive to the grammatical categories of the words being read.

Semantic Redundancy. Several investigators have been concerned with the contribution of semantic redundancy to the reading process. In general, their studies have shown that a meaningful context facilitates both the identification and the interpretation of a sequence of letters or words. As in studies investigating the role of syntactic redundancy, one approach to examine the contribution of semantic redundancy in reading has been to analyze the substitution errors made by beginning and advanced readers. In the studies previously outlined, Kolers (1970) and Weber (1970) reported that the readers tended to substitute misread words by others that have a similar meaning or that preserved the meaning already derived. In Kolers' study for instance, approximately 90 percent of the words substituted were semantically consistent with the preceding passage of the text. Another investigator, (Goodman, 1965) compared the numbers of errors made by first, second and third grade children while reading aloud words in lists and in meaningful passages. The results revealed that the children made fewer errors when reading words in the context of a passage than when the same words were contained in a list.

The influence of a meaningful context on the reading process has also been investigated in tachistoscopic experiments. In these studies, the approach has been to compare the amount of visual information needed to identify a word presented under conditions in which the amount of syntactic and semantic information was varied. Tulving and Gold (1963) compared tachistoscopic recognition thresholds for words presented in either a meaningful context, an irrelevant context or no context. The length of each context was systematically varied so as to contain either 0, 1, 2, 4 or 8 words. In all trials, the target word consisted of the last word appearing in the context. It was found that words presented in a meaningful context were identified at a lower tachistoscopic threshold than when the same words were presented in either an irrelevant context or no context. Furthermore, as the length of the meaningful context increased, the recognition threshold for words decreased. Tulving and Gold suggested that a larger meaningful context facilitated the identification of a word by reducing the range of possible alternatives that the reader can expect in that particular context. This conclusion was further supported by the results of a subsequent study (Morton, 1964) demonstrating that the recognition threshold for a word was decreased when the word was highly predictable from the previous context.

In summary, the results of the Tulving and Gold (1963) and Morton (1964) studies indicate that less visual information is required for correct identification when meaningful contextual information is available. In addition, the errors analysis studies (Goodman, 1965; Kolers, 1970; Weber, 1970) suggest that readers are capable of utilizing the semantic redundancy of the passages in a text to facilitate reading. Thus, it appears that native language readers capitalize on the information provided by the meaning of the preceding words in the sentence to anticipate those that follow. It should be noted however, that these studies do not separate the differential contributions of semantic and syntactic redundancies since in all cases, the meaningful sequences of words being read contained both types of cues.

The studies reviewed in this section demonstrate that orthographic, syntactic and semantic contextual information plays a significant role in reading. The results of these studies add strong support to contemporary conceptualizations of the reading process (Goodman, 1969; Hochberg, 1970; Massaro, 1975; Ryan & Semmel, 1969; Smith, 1971). As previously mentioned, these theorists have described fluent reading as an active process in which the reader utilizes his knowledge of the redundancies that characterize the English language, to supplement the partial visual information of a printed page. An implication of this view is that by capitalizing on the language's orthographic, syntactic and semantic constraints, a reader can identify and abstract the meaning of a word with less visual information.

The Contribution of Redundancy to Second Language Reading

In addition to providing insights into the complex processes involved in first language reading, current models of reading can shed light on the sources of some second language reading problems. Given that the knowledge of redundancies serves to facilitate the reading process, the difficulties encountered in second language reading may reflect some efficiencies in the reader's ability to make full use of the second language redundancies. Consequently, the second language reader may rely more on the printed visual information and less on the non-visual or contextual information.

Compared to first language reading, very little reserarch has been concerned with the processes involved in second language reading. The results of a few studies (Cziko, Note 2; Hatch, Polin & Part, 1974; Macnamara, 1967; Macnamara, Feltin, Hew & Klein, 1968) however, suggest that bilinguals are less efficient at utilizing the syntactic and semantic redundancies of the second language.

Macnamara (1967) investigated the relative contribution of syntactic redundancies to first and second language reading. He compared the amount of time needed by English-Irish bilinguals to read anomalous or random passages in either languages. The anomalous passages were constructed such that they closely approximated English or Irish syntax but lacked meaning. For example, one anomalous passage was: "road in the country was insane, especially in dreary rooms where they have books...". A typical passage where the words appeared randomly was "house reins women bought scream especially much said cake love...". MacNamara reasoned that since the anomalous passages were somewhat predictable, they would be more easily read than random passages. The results showed that when presented with first language passages, subjects took less time to read the anomalous than the random ones. In contrast, when the passages were in the second language, no difference in reading time between anomalous and random passages was observed. Hence, it appears that the second language readers were less efficient in their ability to use their knowledge of Irish syntax to aid reading.

Hatch et al. (1974) investigated the contribution of syntactic redundancy to second language reading problems. In their study, native and non-native readers of English were asked to cross out as quickly as possible, a letter at each of its appearances in a text. It was found, that the non-native readers were more accurate than the native readers at this task. An analysis of the subjects' response patterns revealed that native readers crossed out letters appearing in content words, i.e., noun, verb, adjective and adverb, but not in function words, i.e., article, conjunction and preposition. Non-native readers however, tended to cross out letters appearing in content and function words equally often. The performance pattern of native readers was interpreted as indirect evidence that they relied more on their knowledge of English syntax than on the purely visual information while reading. Since the texts also contained semantic cues, a more probable explanation is that both syntactic and semantic redundancies contributed to a greater extent to first language than to second language reading.

More recently, Cziko (Note 2), using a modified cloze procedure (Oller, 1975), reported that only bilinguals who are highly proficient in their second language effectively utilized semantic redundancies to facilitate the reading process.

It appears then, that bilinguals do not utilize the syntactic and semantic redundancies of the second language to the same extent as those of the first language when reading. The inability to make full use of the second language's redundancies may be partly responsible for the difficulties encountered in second language reading.

The research contained in this thesis was designed to further investigate the source of the problems encountered by proficient bilinguals who read in a second language. In particular, it was decided to examine whether first and second language readers would differ in the extent to which they utilize the orthographic redundancy of each language during the process of word recognition.

METHOD OF INVESTIGATION

Three methodological considerations arose in designing this study. The first consisted of selecting an experimental paradigm which would provide an adequate test of the readers' utilization of orthographic redundancy and would allow for comparisons between first and second language. The second consisted of establishing whether orthographic redundancy is utilized in a language (i.e. French) other than English, since to date all research in this area has been performed in English. The third concerned the best procedure to select bilingual subjects who would have an adequate knowledge of the second language's vocabulary. The resolution of each of these methodological considerations will be discussed below.

Experimental Paradigm

The paradigm chosen to investigate the contribution of orthographic redundancy in first and second language reading was similar to that employed by Reicher (1969) in his study of the processes involved in word recognition. Reicher was the first of several investigators (Johnston & McClelland, 1973; Massaro, 1973; Mezrich, 1973; Smith & Haviland, 1972; Thompson & Massaro, 1973; Wheeler, 1970) to report a phenomenon which has since been labeled the letter-in-context effect or the word superiority effect.

The word superiority effect refers to the finding that under tachistoscopic conditions, a letter is more accurately identified when it appears in the context of a word than when it appears in the context of unrelated letter strings or alone.

The paradigm used by Reicher employed a forced-choice procedure that was assumed to preclude the possibility that a word context would facilitate performance by enabling the subject to utilize his knowledge of orthographic redundancy. In this paradigm, the subject is first presented with a brief display containing either a word, an anagram or a single letter. The target stimulus is immediately followed by a visual mask that covers the area previously occupied by the stimulus. The visual mask is presented simultaneously with two choice letters, the critical letter which had already appeared in the target stimulus and the alternative letter which could form a new word if inserted in the same position. The subject's task is to identify which of these two letters was contained in the target stimulus. For example in word trials, if the stimulus is DOVE the two alternative letters for the first position would be D and M. The subject's performance is analyzed by comparing the number of errors made on word trials, to those made on either anagram or single-letter trials containing the same critical letter. Typically, the results show that letters appearing in a word context are identified more accurately than when the same letters are presented in an anagram context or in isolation. Reicher interpreted the word superiority effect as indicating that words or clusters of letters are the basic perceptual units in reading.

Several investigators (Johnston & McClelland, 1973; Massaro, 1973; Thompson & Massaro, 1973; Wheeler, 1970) have replicated Reicher's (1969) finding and have shown that the word superiority effect can not be attributed to some methodological artifacts operating in the paradigm itself. Wheeler (1970) proposed five alternative explanations which could have produced the word superiority effect in Reicher's study. First, since the forced-choice alternative display immediately followed the target stimulus, the former might have interfered more with the recognition of a single-letter stimulus than with that of a word stimulus. Second, since the word stimuli were centered with regards to the fixation point, the position of single-letter stimuli had to vary. Consequently, more time might have been required for the subject to isolate the single-letter stimuli in the visual field. Third, the subjects might have a tendency to focus on some properties of the word which distinguishes it most from other words. These properties are most likely to be found in those letter positions where a new letter can be inserted to form a new word. Fourth, if the critical letter had not been identified in the word stimulus, when presented with the two letter forced-choice display, the subject might select the letter that forms the more frequent word when combined with those letters he has already recognized. Finally, recognition of certain words might be facilitated by their more frequent occurrence in the language. When Wheeler (1970) tested these hypotheses using appropriate controls with the Reicher paradigm, he found that none could account for the superior perception of a letter embedded in a word as compared to in isolation.

The robustness of the word superiority effect has further been documented by Johnston & McClelland (1973). They employed the Reicher paradigm under conditions that would rule out other possible artifactual interpretations of the word superiority effect. In their study, several methodological improvements were made so as to provide an adequate comparison between word and single letter perception. First, word and letter trials were blocked, thus allowing the subject to adopt an optimal recognition strategy under each condition rather than to possibly maintain a "word set" for both conditions. Second, the forced-choice displays contained word alternatives on word trials and letter alternatives on letter trials. For example, when the stimulus word was COIN and the first letter position was being tested, the choice alternatives were <u>C</u>OIN and <u>J</u>OIN. In the corresponding single-letter stimulus, the letter C was presented alone with C and J being offered as alternatives. This procedure ensured that the subjects would know which among several letters in the stimulus was the one being tested. Third, since a letter presented in isolation may be relatively difficult to locate in the visual field, an additional single-letter condition was included. In this condition, the noise character, # occupied the three remaining positions. For example, the embedded single-letter stimulus corresponding to the word COIN was C### with the same alternatives as in the word and the letter alone trials. Fourth, in order to control for the possibility that the onset of the forced-choice display might be interfering with the processing of the stimulus, the alternatives were always presented outside of the tachistoscope and well after the offset of the stimulus. Finally, a condition in which the position of the letter being tested was given prior to the single-letter trials but not to the word trials was included. By eliminating uncertainty as to the position being tested only in single-letter trials, this procedure introduced a bias in favor of letter stimuli. Although Johnston and McClelland (1973) used an experimental design that controlled these biases which could have accounted for the word superiority effect, the results showed that a letter contained in a word was identified more easily than a letter presented either in isolation or embedded in masking symbols. Hence, the studies of Wheeler (1970) and of Johnston and McClelland (1973) provide considerable evidence against the possibility that some methodological artifact operated in the Reicher paradigm to produce the word superiority effect.

Initially, Reicher (1969) claimed that the word superiority effect could not be attributed to the viewer's utilization of orthographic redundancy. An assumption that is implicit in this claim is that the knowledge of orthographic constraints facilitates word identification by simply restricting the number of possible response alternatives. Hence, according to Reicher, redundancy is a decision effect that is operative only when the subject has to guess which of the two letter alternatives had appeared in the word stimulus. Consequently, Reicher (1969) argued that his paradigm eliminates the contribution of orthographic redundancy since the two letters in the forced-choice display could equally well complete a word.

More recently however, Massaro (1973), as well as Thompson and Massaro (1973) have provided compelling evidence that redundancy does not play its role in the decision stage in the Reicher paradigm. The results of their studies have shown that a viewer can identify the critical letter appearing in a word without first considering the letter alternatives contained in the forced-choice display. Hence, they have suggested that in the Reicher paradigm, redundant information is processed during the primary recognition stage and that the viewer's utilization of orthographic redundancy is responsible for the word superiority effect.

Thompson and Massaro (1973, Experiment I) demonstrated that the redundancy is used at the recognition stage rather than at the decision stage, in the following manner. They manipulated the visual similarity (similar or distinct) of the letter alternatives presented after both single-letter and word stimuli in the Reicher paradigm. For example, when the word stimulus was EAST, the visually similar alternatives for the first position were E and F, whereas the visually distinct alternatives were E and C. They reasoned that if redundancy simply helps the subject to arrive at a decision when forced to select between two alternatives, then he would need to postpone his decision about what is being held in perceptual storage until the alternatives are presented. In this case, the similarity of the alternative letter to the target letter would considerably influence performance on both single-letter and word trials. In contrast, if redundant information is processed during the actual recognition stage, then the similarity of the two alternatives would have no effect on performance. Again, it was found that letters embedded in words were identified better than those presented alone, and that the similarity of the alternatives did not affect performance. Consequently, Thompson and Massaro (1973) concluded that redundancy operates at the recognition stage of information processing and not at the response selection stage as implicitly assumed by Reicher

(1969). Hence, since the visual information of both single-letter and word displays is synthesized prior to the presentation of the alternatives, orthographic redundancy most likely accounts for the word advantage effect observed in the Reicher paradigm.

Thompson and Massaro (1973, Experiment II) subsequently designed a second experiment intended to provide a more adequate control for redundancy. In this study, the subjects were given all of the response alternatives and informed as to the position of the critical letter prior to the start of the experimental session and thus prior to perceptual synthesis. The response set was restricted to four alternatives, two of which were visually similar, and the other two visually distinct. It was argued that since the subjects knew the alternatives as well as the location that the critical letter would occupy in the word stimulus, they would change their strategy and perhaps look for visual features only in the location specified. Therefore, letters appearing in words would not be more accurately identified than those appearing alone, since the effects due to the redundant information provided by a word context would be eliminated. It was found that this precueing procedure transformed the word superiority effect into a letter advantage effect. Moreover, the similarity of the alternative to the critical letter, was shown to affect performance. In both single-letter and word trials, subjects tended to select the alternative most similar to the critical letter. Shortly thereafter, Massaro (1973) using a precueing procedure in the Reicher paradigm, reported results which were consistent with those obtained by Thompson and Massaro (1973).

In summary, the studies by Massaro (1973), as well as Thompson and Massaro (1973) have shown, using the Reicher paradigm, that when the two letter alternatives are displayed after the stimulus presentation (postcue condition) performance on word trials is more accurate than that on single-letter trials. Conversely, when the alternatives precede the stimulus presentation (precue condition) the word superiority effect disappears. These investigators have proposed that the word advantage effect in the postcue condition reflect the fact that redundant information is available and that it operates to facilitate performance in word contexts. Accordingly, knowledge of orthographic redundancy helps the subject to limit the number of possible alternatives for each letter position in a word. Hence, less visual information is required in order to correctly identify a letter presented in a word than a letter presented alone.

The cited evidence suggests that the word superiority effect observed in the Reicher paradigm results from the viewer's use of orthographic redundancy. Furthermore, it appears that non-visual redundant information aids letter identification during the primary recognition process itself (Thompson & Massaro, 1973). Since it has been shown (Daitchman, Note 1; Kellaghan & Macnamara, 1967; Macnamara, 1965; Tullius, 1971; Oller & Tullius, 1973) that second language readers require more time than first language readers to process the same amount of printed information, it is suggested that the second language readers may be less able to capitalize on the redundant information of a word context. The Reicher paradigm thus seems to provide an appropriate way to examine the hypothesis that readers use orthographic redundancy differentially in first and second language readings.

In designing this study the following methodological modifications of the Reicher paradigm were made. First, in order to provide a fairer comparison between word and anagram trials and between word and single-letter trials, all single-letter stimuli were embedded in visual noise masks to control for lateral masking (Bouma, 1970). Second, a precue condition was included in which the two letter alternatives were visually displayed prior to each target stimulus presentation. Third, since this study was concerned with comparing the subjects' performance across languages, an attempt was made to equate the word stimuli in terms of their frequency of occurrence and in their summed transitional probabilities in each of the two languages.

As in Reicher's study, anagrams of the word stimuli were included since they contain the same visual information as the words but lack the non-visual redundant information of orthography.

As in most studies using the Reicher paradigm, the target stimulus duration required for each subject to perform at 70 percent accuracy on single-letter trials, was first determined. Once established, the stimulus exposures remained constant throughout the experimental session. The subject was presented with an equal number of words, anagrams of the same words and single letters embedded in visual masking symbols. Performance on single-letter trials then served as a baseline from which to compare the subject's accuracy in identifying letters presented in word or anagram contexts.

It has been proposed in this thesis that bilinguals are less efficient in utilizing orthographic redundancy when reading in their second language than in their first. This inefficiency should appear in a task where the use of orthographic redundancy facilitates performance. For instance, if bilingual readers differ in the extent to which they capitalize on non-visual redundant information of their second language as compared to their first, these differences should emerge in the postcue condition. Bilinguals reading in their first language should identify letters appearing in words more accurately than those appearing in either anagram or visual noise mask contexts. If bilingual readers are less efficient at utilizing the orthographic redundancies of the second language, then there should be little or no advantage for the recognition of letters presented in words over the recognition of those presented in anagrams or masking symbols. In addition, there should be no difference between the performance of both language groups on anagrams or single-letters, since neither provide redundant contextual information. In contrast, since the precue condition minimizes the contribution of orthographic redundancy, both first and second language readers should perform equally well when identifying target letters appearing in words, anagrams and visual noise masks.

The Word Superiority Effect in French

The second methodological consideration concerned the fact that to date studies demonstrating that a reader utilizes the redundant information of a word context have been conducted with native readers of English. Although it seems likely that native readers of French would also benefit from using redundancy, the possibility remained that perhaps some inherent characteristic of the French language might restrict the extent to which redundancy contributes to the process of letter identification.

If this were the case, poorer performance in the recognition of letters presented in the context of French words (the second language for all subjects) as compared to English words, could be attributed to this artifact rather than to the second language readers' inability to make full use of the language's redundancies. Therefore, a pilot study was conducted in order to ensure that francophones do utilize the orthographic redundancy provided by a word context as an aid to letter identification.

Five francophones participated in this study and served in both the postcue and the precue conditions. The procedure was identical to that of the main experiment with the exception that only French stimuli were presented. The results were analyzed by comparing the number of errors made by each subject on word, anagram and single-letter trials in each of the two conditions. The mean error scores on the precue condition were 17.60, 19.80 and 16.40 for words, anagrams and single-letter trials, respectively. In the postcue condition, the means error scores for words, anagrams and single-letter were 5.20, 16.60 and 19.60, respectively. The mean and standard deviation of the number of errors made on each type of stimulus materials and in both conditions are presented in Appendix A. The results of the analyses of variance are given in Appendix B. It was found that when the contribution of redundancy is minimized, as in the precue condition, francophones performed equally well when identifying letters appearing in word, anagram or visual noise masks contexts. In contrast, in the postcue condition where the redundancy of a word context has been shown to aid letter identification, a significant word superiority effect was obtained. These results provide evidence that the French language contains intra-word redundancy. Moreover, it appears that francophones apply their knowledge of these redundancies to facilitate letter identification.

The existence of a word superiority effect in French parallels that found in the English language. Therefore, it is possible to compare the relative contribution of the knowledge of orthographic redundancy to skilled reading in both languages i.e. French and English. In making such a comparison, one must ensure that the bilingual has an adequate knowledge of the second language vocabulary.

Definition of Proficient Bilinguals

The first phase of this study involved the selection of subjects who were generally equally proficient in both their native (English) and their second language (French). For this purpose, 20 native speakers of English with French as a second language were contacted to participate in the study. All prospective subjects reported themselves to be fluent bilinguals who experienced no difficulties in comprehending spoken or written material in their second language. The selection procedure consisted of assessing each subject's listening and reading proficiency, in their first and second language, using texts followed by multiple choice questions. A detailed description of the procedure employed and of the criteria to be met by each subject are presented in the following section.

METHOD

Listening and Reading Comprehension Tests

All texts and accompanying multiple choice questions used in the listening and reading comprehension tests, originated from Educational Laboratories, Don Mills, Ontario. The English texts were taken from series HG-10/19/22/23 and from series IJ-6/9/16/20, with an average length of 1547 words. The French texts were obtained from series GH-4/8/9/25 and IJ-6/19/20/24, with an average length of 1341 words.

Each test was presented either aurally, via headphones, or visually, in the form of typed pages. For the purpose of aural presentation, all texts were recorded on magnetic tape by a native speaker. The English and French texts were read at an average rate of 209 and 200 words per minute, respectively. The length and rate of presentation for each text are given in Appendix C. In the visual presentation, the subjects were requested to read the texts at a rate that would optimize their comprehension. The length of time required to read each text was recorded.

Each participant was tested individually in two sessions of approximately 1.5 hour duration each, held on different days. At the beginning of the first session, the subjects were asked to guess the answers to multiple choice questions related to two English and two French texts that they had not been previously exposed to and never saw again. The subjects were told that the purpose of this task was to investigate the clarity of the questions. This procedure provided an estimate of the rate of correct guessing without prior knowledge of the text, for each set of multiple choice questions. In this manner, differences in comprehension scores resulting from the idiosyncrasies of the measuring instrument were controlled for.

Following the guessing task, the subjects were tested for listening (auditory) and reading (visual) proficiency in both their native and second language. Within each session, the subjects were alternately presented with three English and three French texts, in one modality (auditory or visual). Hence, over the two sessions, each subject was exposed to 12 texts in total, six auditorily and six visually. The order of presentation regarding the language and the modality was counterbalanced across subjects.

At the end of each auditory and visual text presentation, the subjects answered the multiple choice questions. Each English text was accompanied by 10 multiple choice questions, whereas the French texts had eight multiple choice questions each. The use of multiple choice format permitted objective scoring of answers. Answers to these questions also provided an overall measure of listening and reading profidiency which made possible comparisons between the two languages.

In order to be included in this study, each subject had to satisfy the following criteria: 1) their listening and reading comprehension scores in both English and French had to be at least 70%; 2) the difference in scores between the two languages in both listening and reading had to be less than 10%.

Subjects

In all, eight females and four males satisfied the above criteria and were included in the study. All subjects acquired their second language skills in the context of their daily life, i.e., home, work, neighborhood, rather than solely in school settings. The scores for each subject on the comprehension tests are given in Appendix D. Subjects were paid $3.00 an hour to participate in the study. All subjects had normal or corrected to normal vision, as assessed by the Keystone School Vision Screening Test.

Materials and Apparatus

A three channel slide projection tachistoscope controlled by a Coulbourn logic system was used to present the stimulus materials. Brief presentations of stimuli were achieved by three Lafayette tachistoscopic shutters (Model 43016) each attached to a slide projector (Ektagraphic Model Af 2). All stimuli contained black figures and were projected on a white homogeneously illuminated background.

The experimental stimuli consisted of one English and one French set. In each set there were three types of display: four letter words, anagrams of the words and letters with the ampersand symbol as noise character.

Word Stimuli: The word stimuli in each language set consisted of 60 monosyllabic four letter words chosen such that each of the words could be changed by one letter (the critical letter) to form a new word. The critical letter came equally often from each of the four possible positions in the four letter words. Hence, in each language set there were 15 words at each letter position. The critical letter and an alternative letter which could form a new word if inserted into the critical position,were the two possible responses in the accompanying forced-choice display. For example, the two possible responses for the English word HALL were L and F, with L being the critical letter. Similarly, for the French word SOIR, the two possible responses were R and N, with R being the critical letter. In each language set,all pairs of words were chosen so that they differed very little in their mean frequency of usage in their respective language. The words formed by the critical and alternative letters had mean frequencies of occurrence in English of 56.4 and 58.6, respectively; while in the French set, their frequencies of occurrence in French were equal to 55.8 and 61.46, respectively. The frequency of occurrence of the English words were determined from Thorndike-Lorge (1944) word frequency count and the French words estimates were taken from Beaudot (Note 4). In addition, the words in each of the two language sets had approximately equal summed transitional probability, as calculated from Underwood and Schulz (1960) and Beaudot (Note 5) summed bigrams frequency tables.

Anagram Stimuli: For each word stimulus in each of the two languages, one corresponding anagram stimulus was prepared. The anagram, a nonsense letter string, was generated by keeping the critical letter in the same position as in the word, while rearranging the order of the other letters. For example, the anagram for the word HALL was LAHL, with L and F being the response alternatives offered, as in the word condition. When constructing each anagram an attempt was made to minimize the summed transitional probability of the four letter combination.

Single-Letter Stimuli: A single-letter stimulus corresponding to each word of the two language sets was also included. The single-letter stimulus contained the same critical letter which occupied the same position as in the word. Since the letter was presented singly, the remaining three positions were filled with ampersands in order to control for lateral masking (Bouma, 1970). Ampersand symbols were selected since they have been found to be considerably more effective as pattern mask than characters such as # sign (Estes, 1973). Hence, the single-letter presentation corresponding to the word HALL consisted of the display &&&L, with L being the critical letter and F being the alternative letter.

Forced-Choice Display: In all, each language set contained 60 four letter words, 60 corresponding anagrams and 60 corresponding single-letter stimuli. Each stimulus was accompanied by a forced-choice display containing the critical and the alternative letters. One of the letters was located above and the other below the position of the target letter to be identified in the corresponding stimulus display; the other three positions were indicated by underscores. Within each position tested and within each stimulus type, i.e., word, anagram and letter, the critical and the alternative letters appeared equally often above and below the target letter position in the stimulus display.

All stimuli contained in the English set are found in Appendix E and those of the French set are given in Appendix F.

Practice Stimuli: In addition to the experimental stimuli, one set of practice stimuli for each cue condition was constructed. Each set contained 80 single-letter stimuli with corresponding critical and alternative letters. In both sets, each letter of the alphabet was used approximately the same number of times. The incorrect alternatives were chosen randomly. The practice sets served to familiarize the subject with tachistoscopic displays and to assess the appropriate stimulus exposure for that subject.

A fixation point consisting of a small black dot was projected on the center of the stimulus field before each trial. All experimental and practice stimuli contained black uppercase letters. The height and width of the letters subtended visual angles of approximately 0.7° and 0.5° respectively, at a viewing distance of 101.3 cm. At this distance, each four letter stimulus subtended a visual angle of approximately 3.6°. The visual noise mask consisted of a rectangle filled with crossing diagonal lines, and extended approximately 0.6° above and below each stimulus and to its left and right boundaries.

Design

The subjects participated in two cue conditions in each of the two languages (precue and postcue in English and precue and postcue in French). Half of the subjects served in the precue condition in either English or French first and the remaining subjects served in the postcue condition in either English or French first. Within each of these four conditions, the subjects were exposed to words, anagrams and letters. In all, each subject contributed 60 observations to each combinations of variables: Cue conditions (pre- or post-), Language conditions (English or French) and Type of Stimulus Material (word, anagram and letter).

Procedure

The subjects were seated in a lighted room at a table facing the stimulus field of the tachistoscope. The subjects were individually tested over four sessions of the experiment, each held on different days and lasting approximately one hour. The subjects were first introduced with the sequence of tachistoscopic events of the experimental condition for the session. They were then familiarized with the displays by receiving eight practice trials, in which they had to identify the critical letters of single-letter stimuli exposed for 200 msec. The subjects were instructed that (a) the task was difficult and would require full attention on all trials; (b) before each trial the subject should look at the fixation point corresponding to the center of the area where the critical letter might appear; (c) the position of the critical letter in the stimulus display could be determined from the position of the two letters offered as alternatives in the accompanying forced-choice display; (d) only one of the two letters could occur among the four possible positions in the stimulus display; (e) the critical letter would appear equally often in the upper and lower position in the forced-choice display; (f) one of the two letters had to be verbally reported on each trial, even if guessing was required. The instructions given to the subjects are found in Appendix G.

Pretesting: As previously mentioned, the design of the experiment demands that on the single-letter condition, all subjects reported approximately 70 percent of the critical letters correctly. Therefore, following the brief practice, each experimental session began by a pretest in which the target stimulus duration required for each subject to perform at 70 percent accuracy on single-letter condition was determined. For this purpose, practice single-letter stimuli and accompanying forced-choice displays were presented in a sequence corresponding to that of the subsequent experimental condition. Thus, when pretesting in the precue condition, the forced-choice display preceded the stimulus display, while in the postcue pretesting, the forced-choice display followed the stimulus display. The target duration was determined by using a modified method-of-limits procedure, always beginning with an ascending sequence. Once established, the target stimulus duration remained constant throughout the session for that subject. It should be noted that since single-letter stimuli were employed to determine the target durations, they should not differ for the French and the English conditions. The ranges of durations over all subjects were 60 to 88 msec for the precue condition and 50 to 90 msec for the postcue condition. The target stimulus durations for each subject are shown in Appendix H.

Precue Condition: In the precue condition, each trial was sequenced in the following way: the fixation point was first displayed on the center of the white illuminated field for 1500 msec. The fixation point was immediately followed by the two letters forced-choice display. The forced-choice display was exposed for 1000 msec, and was immediately followed by the stimulus. The stimulus remained in view for the duration established during pretesting. Upon the offset of the stimulus, the visual noise mask was exposed for

1000 msec. The subjects' task was to report aloud, which of the two letters contained in the display that preceded the stimulus had occurred in the same position, in the stimulus. The sequence of tachistoscopic events comprising each trial in the precue condition is illustrated in Figure 2.

Postcue Condition: In the postcue condition, the fixation point was first shown for 1500 msec and was immediately followed by the stimulus. The latter was exposed for the duration determined in pretesting. The stimulus was immediately followed by the visual noise mask covering the area which the stimulus had just occupied. The visual noise mask and the forced-choice display were presented simultaneously and were exposed for 1000 msec. The subject's task was to verbally report which of the two letters presented above and below the mask had occurred in the same position in the preceding stimulus. Figure 3 illustrates the sequence of events comprising each trial of the postcue condition.

In both languages of the precue and postcue conditions the type of stimulus, i.e., word, anagram and single-letter, were presented in a random order. In each condition, the intertrial interval was two seconds, in which the subject's verbal response was recorded.

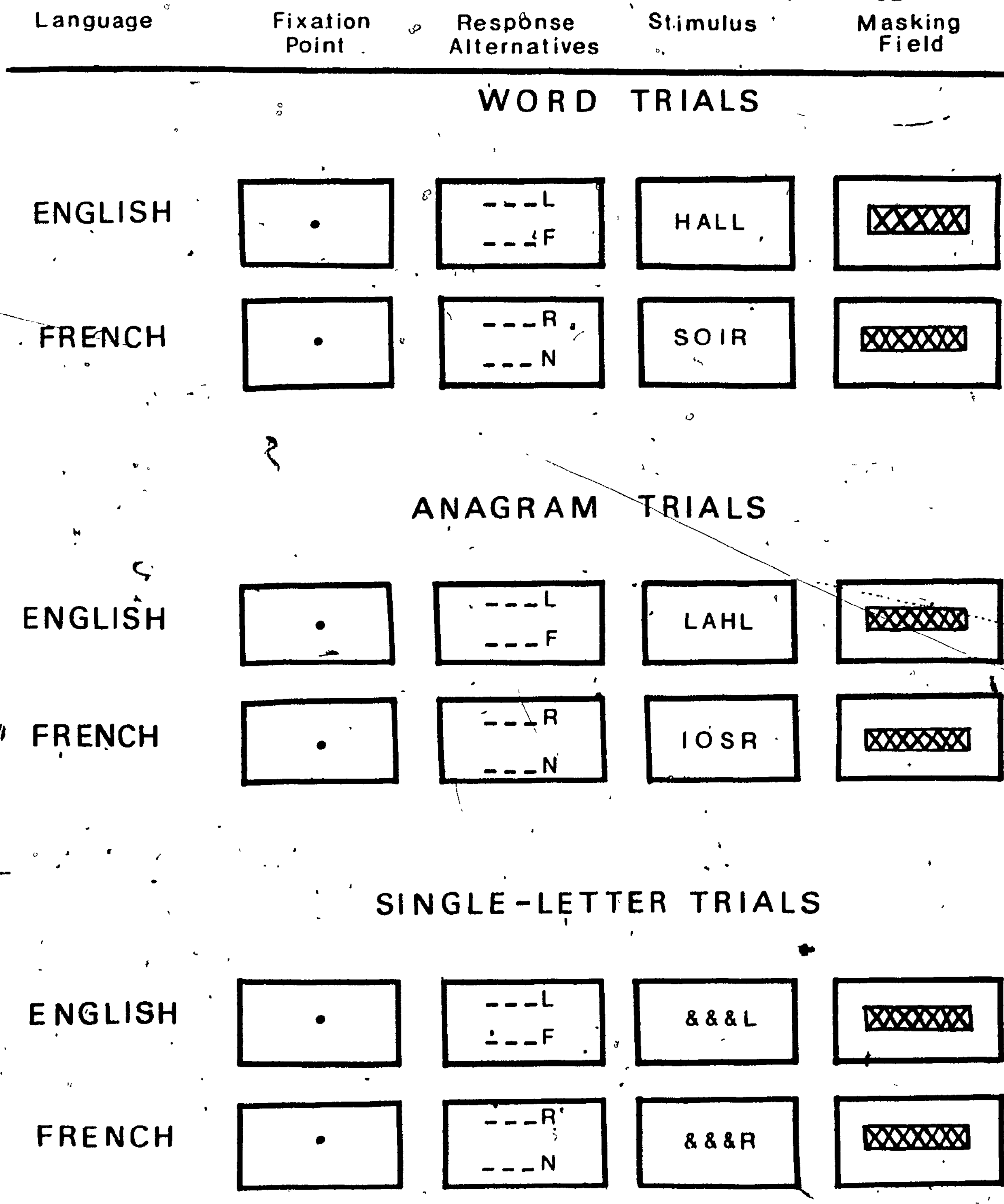

Figure 2: Sequence of tachistoscopic events in both languages of the precue condition.

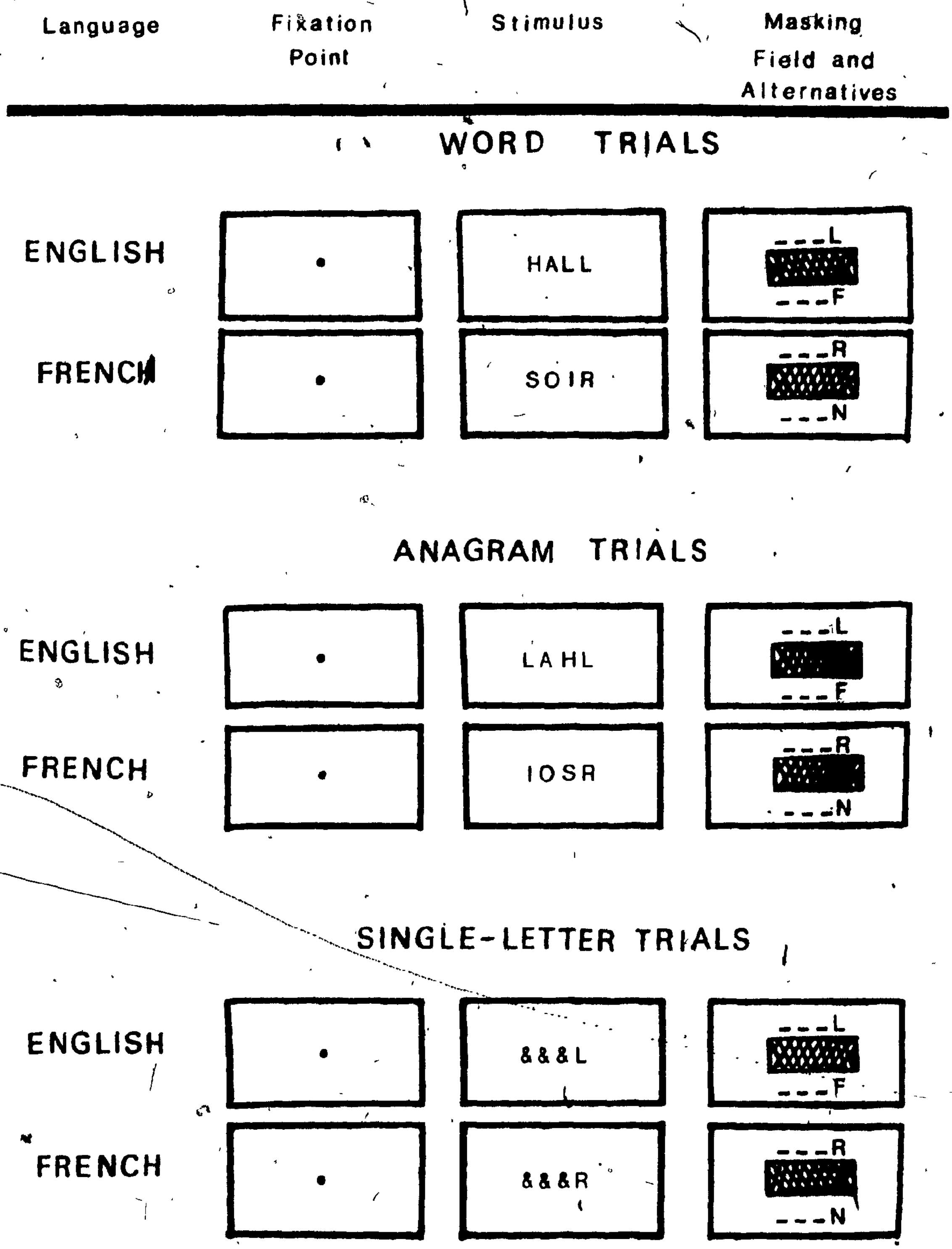

Figure 3: Sequence of tachistoscopic events in both languages of the postcue condition.

RESULTS AND DISCUSSION

Listening and Reading Comprehension Tests

The first set of data to be considered is the subjects' performance on the listening and reading comprehension tests used to select bilinguals with equivalent comprehension of their first and second languages. It will be recalled that subjects were pre-selected such that 1) their listening and reading comprehension in each of the two languages was at least 70 percent and 2) the differences in comprehension scores between the two languages when listening and reading was less than 10 percent. Each subject comprehension was assessed by computing the mean percentage of correct answers to the multiple choice questions accompanying the English and the French texts presented either aurally or visually. These scores were then averaged to obtain an overall estimate of the group comprehension when listening to and reading texts in each language. The mean and standard deviation of comprehension scores in each condition are found in Table 1.

As may be seen in Table 1, the subjects' performance on texts presented in each language and modality satisfied the previously established criterion. The difference in comprehension scores between aurally presented English and French texts was not significant, $t(11) = 0.49$, $p > .10$. Similarly, the comprehension scores for the visually presented texts did not

Table 1

Mean and Standard Deviation of Comprehension Scores in Each Condition

	Mode of Presentation			
	Aural		Visual	
English	M	81.94	M	81.18
	SD	6.27	SD	5.51
French	M	87.50	M	83.37
	SD	5.53	SD	7.32

Note: Maximum score = 100

differ between the two languages, $t(11) = 1.69$, $p > .10$. The rate of correct guessing of answers without prior exposure to the texts are given in Table 2. The result of a *t* test indicated that under these conditions, correct answering of the French questions was not easier than correct answering of the English ones, $t(11) = 0.16$, $p > .10$. These data clearly demonstrate that the subjects comprehended spoken and written materials in their second language as well as those in their first. Moreover, the similarity between the performance in the two languages cannot be attributed to the idiosyncrasies of the measuring instrument, since the correct guessing of answers without prior knowledge of the texts was the same in both languages.

Although reading comprehension in both languages was equivalent, there were differences in reading rates. An estimate of each subject's first and second language reading rate was obtained by calculating the number of words read per minute. The mean reading rate of each subject for the English and French texts are given in Appendix I. Table 3 shows the subjects' mean and standard deviation for first and second language reading. The analysis of reading rates revealed that second language reading was 33.30 percent slower than first language reading. A *t* test indicated such difference to be highly significant, $t(11) = 7.00$, $p < .001$.

The performance patterns of subjects in the reading and

Table 2

Mean and Standard Deviation of
Correct Answers on Guessing Task

Language		
English	M	31.61
	SD	7.84
French	M	31.17
	SD	7.54

Note: Maximum score = 100

Table 3

Mean and Standard Deviation of

First and Second Language Reading Rates

		Reading rates in words per minute
English texts	M	302.89
	SD	82.26
French texts	M	202.05
	SD	47.07

listening comprehension tests are similar to those of subjects in Daitchman's (Note 1) study. In his study, adult bilingual readers were exposed to text projected on a screen, one line at the time. The rate at which the passages were presented was the same for first and second language texts and was determined by assessing each subject's first language reading rate. He reported that given nearly identical rates of stimulus presentations, fluent bilinguals comprehended both languages equally well when listening, but nevertheless, had inferior second language comprehension when reading.

A similar second language reading deficit was observed in the present study. When the subjects were instructed to read each printed text at a rate that would optimize comprehension, the second language reader sacrificed speed in order to maximize comprehension.

The subjects' response patterns on the comprehension tests of the present study is congruent with the outcomes of several studies (Daitchman, Note 1; Kellaghan & Macnamara, 1967; Macnamara, 1965; Tullius, 1971; Oller & Tullius, 1973) that have compared first and second language reading skills. These studies clearly indicate that bilingual readers require more time to process information printed in their second language than the same amount of information printed in their first.

The additional length of time needed to read second language materials cannot however, be attributed to reader's inadequate knowledge of the second language's vocabulary and syntax. The subjects in the present experiment and in that of Daitchman (Note 1) were found to comprehend spoken materials equally well in both languages. Thus, a more likely interpretation of the slower rate of reading in the second language is that there exist certain inefficiencies in the reading process itself.

Given that the subjects in the present study have a deficit in second language reading that cannot be attributed to an insufficient knowledge of vocabulary or syntax; the results of primary interest are those concerned with the relative contribution of orthographic redundancy to the first and the second language reading processes. If bilingual readers are less efficient in capitalizing on the orthographic redundancy of the second language as compared to that of their native language, then three predictions can be made. First, in the postcue condition performance on word trials should be superior than that on either anagram or single-letter trials. Second, in the second language postcue condition performance on word trials should be inferior relative to that in first language. Third, there should be little or no difference between the performance accuracy on word, anagram and single-letter trials in either languages of the precue condition, since the contribution of orthographic redundancy is presumably minimized.

For the purpose of analysis, the number of errors made by each subject on word, anagram and single-letter trials in each cue and language conditions were computed. Figure 4 displays the overall performance pattern of subjects in each condition, and Table 4 presented the mean and standard deviation of error scores for each condition. The results of two t tests indicated that as expected, the critical target duration at which each subject performed at 70 percent accuracy in single-letter condition did not differ between the two languages of the precue condition, $t(11) = 1.31$, $p > .10$, nor between the two languages of the postcue condition, $t = (11) = 0.11$, $p > .10$. Hence, since it has been suggested (Estes, 1975; Estes, Bjork & Skaar, 1974; Thompson & Massaro, 1973) that subjects may use different strategies in the precue condition as compared to the postcue condition, the error scores were subjected to two separate analyses: one for the precue condition and the other, for the postcue condition.

Precue Condition

The number of errors made by each subject on word, anagram and single-letter trials in both languages of the precue condition are shown in Appendix J. These data were analyzed using a two-way analysis of variance for repeated measures, with factors being Language (English, French) and Type of Stimulus Material (word, anagram, letter). The results of the analysis yielded a main stimulus material ef-

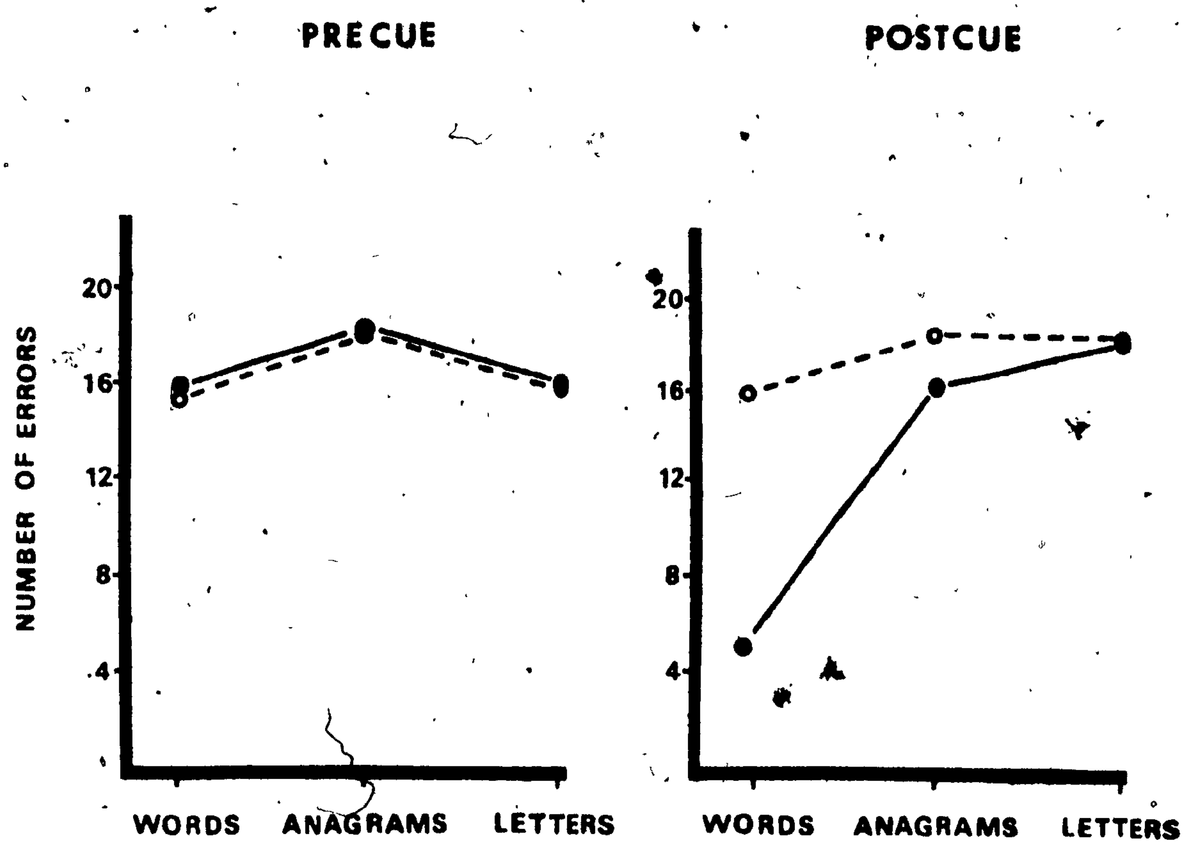

Figure 4: Mean number of errors made by subjects on the first and second language word, anagram and letter stimuli in the precue and postcue condition. The solid line and closed circles represent the first language and the broken line and open circles represent the second language.

Table 4

Means and Standard Deviations of
Error Scores in Each Condition

		Precue Condition		
		Words	Anagrams	Letters
English	M	16.17	18.08	15.75
	SD	2.76	4.72	2.99
French	M	15.25	18.00	15.75
	SD	3.74	3.33	2.53
		Postcue Condition		
English	M	5.67	16.17	18.08
	SD	3.98	5.65	2.27
French	M	15.83	18.33	17.75
	SD	6.45	4.73	2.09

fect, $F(2,66) = 3.65$, $p < .05$. Neither the language effect nor its interaction with stimulus material were significant. A summary of Anova is presented in Table 5.

As may be seen in Figure 4, the performance patterns of subjects in each of the two languages of the precue condition were comparable. The findings that the language factor did not yield a significant main effect, nor did it interact with the type of stimulus material are of interest. These findings indicate that when the contribution of orthographic redundancy is minimized, bilinguals perform equally well on stimulus materials presented in their native and their second language.

In order to determine the source of the significant effect of stimulus material, the mean number of errors made on each type of stimulus were collapsed across languages. The mean error scores on word, anagram, and single-letter trials were 15.71, 18.04 and 15.75, respectively. A visual inspection of these means immediately reveals that the subjects made approximately the same number of errors when identifying critical letters appearing in either word or ampersand contexts. More errors were made however, when the letters to be identified were presented in the context of anagrams.

The absence of a word superiority effect replicates the results of previous studies that have employed a precue condition in the Reicher paradigm (Bjork & Estes, 1973; Estes et al., 1974; Massaro, 1973; Thompson & Massaro, 1973, Experiment 2; Waters, Note 3). These investigators have pro-

Table 5

Precue Condition: Summary Table of Anova

Source	df	MS	F	Significance of F
Language	1	2.00	0.171	.681
Stimulus Material	2	42.792	3.652	.031
Language x Stimulus Material	2	1.542	.132	.877
Explained	5	18.133	1.548	.187
Residual	66	11.717		

posed that the elimination of the word superiority effect in the precue procedure is due to the fact that the two letter alternatives are given in advance of the stimulus presentation. Consequently, the subject does not need to utilize the redundant information provided by a word context to restrict the possible response alternatives.

The precue procedure has been shown to typically transform the word superiority effect into a letter advantage effect. The above investigators with the exception of Waters (Note 3) have consistently reported an advantage for the identification of target letters presented alone as compared to when the same letters appeared in either words or anagrams, with no difference in accuracy being observed between words and anagrams. This letter advantage effect has been attributed to the detrimental effects of lateral masking of the adjacent letters, within an anagram or a word (Townsend, Taylor & Brown, 1971).

In the present study and that of Waters (Note 3) however, the letter superiority effect was observed only when the subjects' performance on single-letter trials was contrasted to that on anagram trials. The difference between the identification accuracy of letters embedded in word or ampersand contexts was not significant. The inconsistency in results has been paralleled by a difference in the precueing procedure used. Subjects in Bjork and Estes (1973), Estes et al., (1973); Massaro (1973) as well as Thompson and Massaro (1973)'s studies were verbally informed of the letter alternatives prior to a series of trials, whereas in the present study and that of Waters (Note 3) the alternatives varied in each trial and were visually displayed prior to each stimulus presentation. These differences in methodology may perhaps be responsible for the discrepancy observed with respect to the subjects' performance on anagram trials.

Postcue Condition

As can be seen in Figure 4, the performance pattern of subjects in the postcue condition differed both, across languages and across type of stimulus materials. The number of errors made by each subject on word, anagram and letter trials in the two languages of the postcue condition are shown in Appendix K. As in the precue condition, these error scores were subjected to a two-way analysis of variance for repeated measures, with factors being Language (English, French) and Type of Stimulus Material (word, anagram, letter). The results of the analysis showed a significant main effect of language, $F(1,66) = 14.23$, $p < .001$, and a significant main effect of stimulus materials, $F(2,66) = 18.59$, $p < .001$. The interaction of language with the stimulus materials was also significant, $F(2,66) = 8.92$, $p < .001$. A summary of Anova is presented in Table 6.

A post-hoc Tukey analysis was conducted to determine whether a word superiority effect was present in each of

Table 6

Postcue Condition: Summary Table of Anova

Source	df	MS	F	Significance of F
Language	1	288.00	14.229	.001
Stimulus Material	2	376.222	18.588	.001
Language x Stimulus Material	2	180.500	8.918	.001
Explained	5	280.289	13.848	.001
Residual	66	20.240		

the two languages. The magnitude of the word superiority effect was calculated by comparing the mean number of errors made by subjects on word trials to those made on either anagram or single-letter trials. The results of the Tukey's analysis are presented in Table 7. The analysis revealed that in the native language condition, the differences between the number of errors made on letter and word trials and that between word and anagram trials were significant $p < .001$, whereas the difference between letter and anagram trials was not. Thus, when presented with native language stimuli, subjects made less errors when identifying a letter appearing in the context of a word than when the same letter was presented in either an anagram or an ampersand contexts. The post-hoc analysis further indicated that the word superiority effect did not occur in the second language condition. The number of errors made on single-letter trials did not differ from those made on either word or anagram trials. Thus, unlike in the native language condition, subjects were not more accurate in identifying letters presented in word contexts. Similarly to the native language condition however, the difference between errors made on single-letter and anagram trials was not significant.

The word superiority effect found in the first language condition is consistent with the results of previous studies in which the two letter alternatives were displayed after the stimulus presentation (Johnston & McClelland, 1973;

Table 7

Postcue: Analysis with Tukey Test Between Mean Number of Errors on Word, Letter and Anagram Trials in Each Language Condition

Comparisons	Mean Differences	Probability
English Condition		
Letters vs Anagrams	2.91	NS
Anagrams vs Words	11.50	$p < .001$
Letters vs Words	13.41	$p < .001$
French Condition		
Anagrams vs Letters	1.58	NS
Anagrams vs Words	3.50	NS
Letters vs Words	2.92	NS

Mezrich, 1973; Reicher, 1969; Thompson & Massaro, 1973, Experiment 1; Waters, Note 3; Wheeler, 1973). These investigators have reported that when letters are tachistoscopically presented, such that only partial visual information can be extracted, letters embedded in words are more accurately identified than those embedded in either anagrams or visual noise masks and those presented in isolation. Massaro (1973; 1975) as well as Thompson and Massaro (1973) have proposed that the word superiority effect reflects the fact that words contain redundant information whereas, irrelevant letter strings and single letters do not. Accordingly, performance on words is facilitated when a reader applies his knowledge of orthographic redundancy during the primary recognition process. This knowledge then allows him to narrow down the number of possible letter alternatives which could have occurred in the tested position of the word. Hence, less visual information is necessary to correctly identify a letter appearing in a word than one appearing in an irrelevant letter string or alone.

Despite the fact that redundant information was also available on word trials of the French postcue condition, no significant word superiority effect was found. The absence of a word superiority effect indicates that subjects were less efficient at utilizing their second language's orthographic redundancy to aid letter identification.

To recapitulate the following results add strong support to this contention. It was found that 1) where the contribution of orthographic redundancy was minimized, i.e. precue condition, the performance of subjects on word, anagram and single-letter trials did not differ between the two languages; 2) where orthographic redundancy should facilitate performance, i.e., postcue condition, and subjects were presented with anagrams containing the same visual information as the words but lacking the redundancy of the words, performance did not differ significantly across languages; 3) where in the same condition orthographic redundancy was provided by a word context subjects capitalized on this information to improve performance on English word trials but not on French word trials. Moreover, the absence of a word superiority effect in the second language postcue condition cannot be attributed to some inherent characteristic of the French language. The results of a pilot study showed that francophones identified letters presented in French word contexts more accurately than those appearing in either anagram or ampersand contexts. Together these findings provide evidence to suggest that bilinguals are less able to make full use of the orthographic redundancy of the second language to aid letter identification.

GENERAL DISCUSSION

This thesis dealt with a problem often encountered by proficient bilinguals. They read in the second language more slowly than in the first, despite being equally capable in both languages in written and oral comprehension and in spoken expression. In some respects then, bilinguals are like less skilled native language readers. They have fluent command of the language but nevertheless read the (second) language slowly. Current models of reading suggest that one of the ways in which skilled and less skilled readers differ is that skilled readers appear to be more efficient at capitalizing on the redundant information provided in a written text. More specifically, there is evidence that skilled readers can better utilize orthographic redundancy as an aid to identify letters in word contexts. It was hypothesized therefore, that the bilinguals' difficulty partly reflects an inability to effectively utilize the redundant information of the orthography in the second language.

The results of the experiment reported in this thesis, support this hypothesis. The significant word superiority effect in the first language of the postcue condition substantiates the notion that the first language reader capitalizes on his knowledge of the orthographic redundancy in the language to supplement the visual information (Goodman, 1969;

Hockberg, 1970; Massaro, 1975; Ryan & Semmel, 1969; Smith, 1971). The absence of a word superiority effect in the second language postcue condition indicates that the bilingual reader does not effectively utilize the language's orthographic redundancy as an aid to letter recognition. It does not seem likely that these results stem from the reader's insufficient knowledge of the vocabulary in the second language, since all subjects had balanced listening and reading comprehension skills in English and in French.

The hypothesis was further supported by the finding that in the precue condition, neither the main effect of language, nor its interaction with the type of stimulus were significant. This indicates that when the contribution of orthographic redundancy is minimized, bilinguals do not show a word superiority effect and perform equally well in their two languages.

The finding that orthographic redundancy is not effectively utilized by second language readers extends previous research concerned with second language reading problems. Other investigators (Cziko, Note 2; Hatch et al., 1974; Macnamara, 1967; Macnamara et al., 1967) have reported that bilingual readers do not take full advantage of the syntactic and semantic redundancies of their second language. The present study adds orthographic redundancy as a source of the difficulties encountered by second language readers.

It remains to be determined however, whether or not bilinguals are cognizant of the redundancies in the second language. For example, it is possible that bilinguals are aware of the redundancy patterns but are unable to utilize this knowledge effectively. Cziko (Note 2) pursuing this direction has reported that second language readers have some knowledge of syntactic redundancies but fail to demonstrate knowledge of semantic constraints. At the level of orthographic redundancy, the second language reader's knowledge could be assessed by using a variation of the present paradigm. For example, one could allow the second language reader more time to process the visual data, either by manipulating the target stimulus duration or the interval between the offset of the stimulus and the onset of the visual mask. With an adequate time available to process the stimulus, the bilingual may be able to fully use his knowledge of the redundancies of the second language.

Although second language reading research is still in its infancy, it should be pointed out this research could provide a better understanding of first language reading. Waters (Note 3) showed that less fluent native readers of English were less efficient in their ability to use orthographic redundancy as an aid to letter identification. In spite of the fact that studies comparing the performance of skilled and less skilled readers have been fruitful, these studies are dependent upon how well different groups of readers are matched on characteristics such as intelligence and general knowledge. If we assume that the second language reader is comparable to the less fluent first language reader, research with bilinguals permits the investigation of two types of reading skills while at the same time, controlling for individual differences. Using this approach, future research could further examine the degree to which orthographic, syntactic and semantic redundancies are differentially utilized by various types of readers.

In closing, the research contained in this thesis demonstrated that orthographic redundancy contributes differentially to first and second language reading processes. Otherwise proficient bilinguals are less effective at utilizing the orthographic redundancies of their second language as an aid to letter identification. This study adds to our knowledge of the complex skills involved in the reading process. Ultimately, a better understanding of the total activity of reading could lead to the design of instructional and remedial programs aimed at improving reading skills in general and second language reading skills in particular.

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Appendix A

Mean and Standard Deviation of Error Scores of Francophones in Each Condition

	Words	Anagrams	Single-letters
Precue condition			
<u>M</u>	17.60	19.80	16.40
<u>SD</u>	5.27	2.86	4.04
Postcue condition			
<u>M</u>	5.20	16.60	19.60
<u>SD</u>	1.30	4.16	2.19

Appendix B

Summary Table of Analysis of Variance
for Each Condition of Pilot Study

			Precue condition	
Source	df	MS	F	Significance of F
Stimulus Material	2	14.87	1.85	NS
Subjects	4	32.23	4.51	NS
Stimulus Material x Subjects	8	8.03		
			Postcue condition	
Source	df	MS	F	Significance of F
Stimulus Material	2	288.60	50.78	P<.0001
Subjects	4	12.43	23.21	NS
Stimulus Material x Subjects	8	5.68		

Appendix C

Length of Texts and Rate of Auditory Presentations of Each English and French Texts

Serial number	Total words	Duration (minutes)	Rate of presentation (words per minute)
	English selection		
HG-10	1536	7.00	219
HG-19	1566	7.03	223
HG-22	1602	7.42	216
HG-23	1494	7.25	206
IJ-6	1380	6.92	200
IJ-9	1548	7.50	206
IJ-16	1644	8.13	202
IJ-20	1602	8.00	200
	French selection		
GH-4	1008	4.75	212
GH-8	1266	6.00	211
GH-9	1176	7.87	150
GH-25	1374	8.78	156
IJ-6	1584	7.57	209
IJ-19	1494	6.83	219
IJ-20	1458	6.66	219
IJ-24	1368	6.33	216

Appendix D

Comprehension Scores of Subjects

	Auditory Presentations (% correct responses on 3 texts)		Visual Presentations (% correct responses on 3 texts)	
S	English	French	English	French
1	90.00	83.33	96.66	83.33
2	83.33	87.50	83.33	91.67
3	90.00	83.33	96.66	79.17
4	80.00	87.50	90.00	87.50
5	73.33	70.83	86.66	75.00
6	73.33	75.00	80.00	87.50
7	90.00	83.33	93.33	95.83
8	80.00	79.17	83.33	75.00
9	83.33	83.33	86.67	79.17
10	83.33	87.50	86.67	91.67
11	73.33	78.33	83.33	79.17
12	83.33	75.00	83.33	75.00

Appendix E

English Word, Anagram and Single-Letter Stimuli

First Letter Position	Word	Anagram	Letter	Alternatives
	BAIT	BTAI	B&&&	W--- B---
	BEAR	BRAE	B&&&	G--- B---
	CALF	CFLA	C&&&	C--- H---
	CARD	CDRA	C&&&	C--- H---
	CASH	CSAH	C&&&	R--- C---
	DAMP	DPMA	D&&&	R--- D---
	EVEN	EVNE	E&&&	E--- O---
	FAST	FTSA	F&&&	F--- C---
	JAIL	JLAI	J&&&	F--- J---
	KING	KGNI	K&&&	W--- K---
	KITE	KTEI	K&&&	K--- B---
	NICE	NCIE	N&&&	M--- N---
	RAKE	RKAE	R&&&	R--- B---
	REAL	RLAE	R&&&	R--- D---
	SLOW	SWLO	S&&&	S--- P---

Appendix E (cont.)

Second Letter Position	Word	Anagram	Letter	Alternatives
	ACES	SCAE	&C&&	-C-- -P--
	BEND	DEBN	&E&&	-E-- -A--
	BURN	NUBR	&U&&	-A-- -U--
	DIVE	EIDV	&I&&	-O-- -I--
	FARE	RAEF	&A&&	-I-- -A--
	PUCK	KUPC	&U&&	-U-- -I--
	SHAG	AHGS	&H&&	-T-- -H--
	SLUG	GLSU	&L&&	-L-- -M--
	SKIP	PKSI	&K&&	-H-- -K--
	SPIN	SPNI	&P&&	-H-- -P--
	SWIM	IWMS	&W&&	-K-- -W--
	TAME	TAEM	&A&&	-A-- -I--
	TOIL	IOLT	&O&&	-O-- -I--
	WALL	LAWL	&A&&	-A-- -E--
	WHIT	IHWT	&H&&	-A-- -H--

Appendix E (cont.)

Third Letter Position	Word	Anagram	Letter	Alternatives
	BALE	EBLA	&&L&	--L- --N-
	BLOW	LWOB	&&O&	--O- --E-
	LACE	ELCA	&&C&	--N- --C-
	LOFT	LTFO	&&F&	--S- --F-
	MOLE	EMLO	&&L&	--L- --R-
	NONE	EONN	&&N&	--S- --N-
	PANE	EPNA	&&N&	--N- --C-
	PAST	TPSA	&&S&	--N- --S-
	REND	EDNR	&&N&	--A- --N-
	SHIP	SPIH	&&I&	--O- --I-
	SOON	SNOO	&&O&	--O- --W-
	TIME	EIMT	&&M&	--M- --L-
	TOOL	TLOO	&&O&	--O- --I-
	TRIM	TMIR	&&I&	--I- --A-
	VEIL	LEIV	&&I&	--A- --I-

Appendix E (cont.)

Fourth Letter Position	Word	Anagram	Letter	Alternatives
	BEAM	AEBM	&&&M	---M ---T
	DEAF	EADF	&&&F	---F ---R
	EASY	AESY	&&&Y	---Y ---T
	EVEN	EEVN	&&&N	---N ---R
	FEET	EEFT	&&&T	---T ---D
	FOOL	OOFL	&&&L	---T ---L
	GRIP	IGRP	&&&P	---M ---P
	HALL	LAHL	&&&L	---L ---F
	HEAP	AEHP	&&&P	---R ---P
	HERE	EHRE	&&&E	---D ---E
	POET	OEPT	&&&T	---M ---T
	RICE	RCIE	&&&E	---E ---H
	SLAP	LSAP	&&&P	---B ---P
	STAR	TASR	&&&R	---R ---Y
	TROT	OTRT	&&&T	---T ---D

Appendix F

French Word, Anagram and Single-Letter Stimuli

First Letter Position	Word	Anagram	Letter	Alternatives
	ARME	AMRE	A&&&	O--- A---
	CIEL	CLIE	C&&&	C--- M---
	COUP	CPUO	C&&&	L--- M---
	DOIT	DTOI	D&&&	D--- S---
	DORT	DTOR	D&&&	M--- D---
	DOUX	DXUO	D&&&	D--- R---
	FOIE	FEOI	F&&&	J--- F---
	LUIT	LTUI	L&&&	L--- N---
	MAGE	MGAE	M&&&	M--- N---
	POLI	PLOI	P&&&	J--- P---
	ROUE	RUOE	R&&&	J--- R---
	SAIS	SSIA	S&&&	T--- S---
	SANS	SSNA	S&&&	D--- S---
	SERA	SRAE	S&&&	S--- F---
	SOIR	SROI	S&&&	N--- S---

Appendix F (cont.)

Second Letter Position	Word	Anagram	Letter	Alternatives
	AILE	EIAL	&I&&	-L-- -I--
	CLOU	CLUO	&L&&	-H-- -L--
	DORE	EODR	&O&&	-O-- -U--
	FAIS	IASF	&A&&	-O-- -A--
	MAIS	IAMS	&A&&	-A-- -O--
	OTER	RTOE	&T&&	-T-- -S--
	PLIE	ELPI	&L&&	-L-- -R--
	PLIS	SLPI	&L&&	-R-- -L--
	PRIX	XRPI	&R&&	-A-- -R--
	SEIN	IESN	&E&&	-A-- -E--
	SOIS	SOSI	&O&&	-O-- -U--
	TAUX	UAXT	&A&&	-Q-- -A--
	VAUT	UAVT	&A&&	-A-- -E--
	VIES	EIVS	&I&&	-U-- -I--
	VOIS	SOVI	&O&&	-O-- -A--

Appendix F (cont.)

Third Letter Position	Word	Anagram	Letter	Alternatives
	AIME	EAML	&&M&	--M- --N-
	AIRE	EIRA	&&R&	--S- --R-
	ANGE	EAGN	&&G&	--G- --N-
	CIRE	ECRI	&&R&	--M- --R-
	CRUE	ERUC	&&U&	--U- --I-
	FAIT	ATIF	&&I&	--U- --I-
	GROS	RGOS	&&O&	--O- --I-
	JUPE	EJPU	&&P&	--R- --P-
	MIRE	EMRI	&&R&	--R- --S-
	PAIE	AEIP	&&I&	--I- --Y-
	RIRE	ERRI	&&R&	--V- --R-
	SOUS	SSUO	&&U&	--U- --N-
	VIDE	IEDV	&&D&	--T- --D-
	VIVE	EVVI	&&V&	--D- --V-
	VOLE	EVLO	&&L&	--L- --I-

Appendix F (cont.)

Fourth Letter Position	Word	Anagram	Letter	Alternatives
	AGIR	GAIR	&&&R	---R ---T
	BAIE	BIAE	&&&E	---N ---E
	CHER	CEHR	&&&R	---Z ---R
	CUIR	IUCR	&&&R	---T ---R
	DOIS	IODS	&&&S	---T ---S
	FAUT	UAFT	&&&T	---T ---X
	FOIE	FIOE	&&&E	---E ---S
	JOUR	UOJR	&&&R	---R ---E
	LIEN	IELN	&&&N	---N ---R
	PEUX	UEPX	&&&X	---X ---R
	ROUX	UORX	&&&X	---E ---X
	SOIR	IOSR	&&&R	---R ---N
	TOUX	UOTX	&&&X	---X ---T
	VOIR	IOVR	&&&R	---S ---R
	VOIX	IOVX	&&&X	---X ---T

Appendix G

Instructions to the Subjects

Postcue condition

You are participating in a study concerned with the perception of letters. For this purpose, brief displays containing black upper case letters will be presented to you on the screen of the tachistoscope you are now facing. Your head must be kept still throughout the experiment, thus you are requested to place your chin on the rest located in front of you. In this experiment, you will first be presented with a fixation point; as soon as it appears on the screen, fixate on it, since it is located in the center of the area where the next display will be shown. At the offset of the fixation point, you will be presented with a display containing a letter occupying one of these four adjacent positions. The remaining three positions will always be occupied by ampersand (&) characters. You must note both the letter and its position. The letter display will be immediately followed by a black grid that will cover the area it had just occupied. Above and below the grid you will see two letters, each occupying the same position as that occupied by the previously exposed letter; the other three positions will be indicated by underscores. Either the letter located above or the one located below the grid will have appeared in that same posi-

Appendix G (cont.)

tion in the single-letter display; the correct letter will appear equally often on the top and bottom position. Your task will be to report aloud, via this intercom, which of these two letters had appeared in that position in the previous display. You must always report one of the letters even if guessing is necessary.

For the first 8 trials all the displays will be presented at a reduced speed, however in the subsequent trials the target letters will be shown for very brief intervals. Each trial will require your full attention; it always will begin by a fixation point and end with a masking grid.

At the end of pretesting, the additional instructions were given to the subject: You will now be presented with four letter words (either French or English), four letter nonsense words and single letters with ampersand characters. Each type of target stimulus will be presented an equal number of times and in mixed order. Your task remains to identify which of the two alternative letters had appeared in that position in the previous display.

Precue condition

You are participating in a study concerned with the perception of letters. For this purpose, brief displays contain-

Appendix G (cont.)

ing black upper case letters will be presented to you on the screen of the tachistoscope you are now facing. Your head must be kept still throughout the experiment, thus you are requested to place your chin on the rest located in front of you. In this experiment, you will first be presented with a fixation point; as soon as it appears on the screen, fixate on it since it is located in the center of the area where the next display will be shown. At the offset of the fixation point you will be presented with a display containing two letters: one above and the other below the horizontal mid-line on the screen. Both letters will occupy either one of these four adjacent positions, the remaining three positions will be indicated by underscores. You must note both the two letters and their position. Either the letter located above or the one located below will appear in that same position in the next display. As you can see, this display will contain one of two letters; the remaining three positions will always be occupied by ampersand characters. The single-letter display will be followed by a black grid that will cover the area it had just occupied. Your task will be to report aloud, via this intercom, which of the two letters,contained in the display preceeding the stimulus,had appeared in that position in the stimulus. You must always report oneof the two letters

Appendix G (cont.)

even if guessing is necessary.

For the first 8 trials, all displays will be presented at a reduced speed, however in the subsequent trials, the target letter will be shown for very brief intervals. Each trial will require your full attention; it will always begin by a fixation point and end with a masking grid.

At the end of pretesting, the additional information was given to the subject: You will now be presented with four letter words (either French or English), four letter nonsense words and single letters with ampersand characters. Each type of target stimulus will be presented an equal number of times and in a mixed order. Your task remains to identify which of the two alternative letters had appeared in that position in the stimulus display.

Appendix H

Critical Target Stimulus Durations for Each Subject in Each Condition

	Precue condition		Postcue condition	
	English	French	English	French
Subjects				
1	70	75	70	65
2	85	70	70	80
3	68	63	90	85
4	65	65	90	75
5	60	50	50	55
6	75	80	70	70
7	77	75	70	74
8	65	60	78	80
9	65	60	90	85
10	68	60	55	72
11	75	80	80	75
12	85	88	80	80

Appendix I

Means Reading Rates for Each Subject
(number of words per minutes)

Subject	English texts	French texts
1	392.08	232.88
2	310.49	172.65
3	257.73	227.52
4	174.30	102.17
5	309.43	203.96
6	197.73	138.96
7	293.74	185.80
8	269.03	220.52
9	258.38	203.28
10	430.30	250.51
11	434.33	271.55
12	307.16	214.85

Appendix J

Error Scores of Each Subject in the Precue Condition

English (first language)

Subjects	Words	Anagrams	Letters
1	19	19	17
2	15	17	18
3	14	8	15
4	17	21	17
5	13	19	20
6	17	20	17
7	10	14	12
8	16	12	11
9	18	18	15
10	17	22	11
11	19	24	18
12	19	23	18

French (second language)

Subjects	Words	Anagrams	Letters
1	19	22	16
2	21	23	15
3	12	21	19
4	15	14	13
5	11	19	13

Appendix J (cont.)

Subjects	Words	Anagrams	Letters
6	17	16	19
7	13	17	12
8	13	12	15
9	19	21	19
10	9	17	16
11	15	18	18
12	17	16	14

Note: Maximum scores = 60

Appendix K

Error Scores of Each Subject in the Postcue Condition

English condition

Subjects	Words	Anagrams	Letters
1	11	20	21
2	3	7	21
3	1	7	17
4	2	13	15
5	5	16	19
6	3	17	17
7	3	17	17
8	9	21	19
9	4	20	16
10	10	20	17
11	4	11	16
12	13	25	22

French condition

Subjects	Words	Anagrams	Letters
1	19	24	19
2	23	19	18
3	9	17	20
4	8	16	16
5	20	20	16

Appendix K (cont.)

Subjects	Words	Anagrams	Letters
6	11	12	16
7	10	16	17
8	16	25	19
9	20	22	21
10	24	18	14
11	7	9	17
12	23	22	20

Note: Maximum scores = 60