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Word Identification Processes for Children and Adults: The Role Syllables and Phonemic Recoding

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WORD IDENTIFICATION PROCESSES FOR CHILDREN AND ADULTS: THE ROLE OF SYLLABLES AND PHONEMIC RECODING

by

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VITA

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INTRODUCTION

The cognitive processes involved in the act of reading have long concerned the experimental psychologist. One fact which has emerged from the research in this area is that reading is best considered as an intricate combination of perceptual, linguistic, and memorial skills. The present work is concerned with one set of these skills; namely, the perceptual processes involved in the identification of words. It will be assumed that perceptual processes involve both the extraction of information from sensorily-present letter strings as well as the interpretation of this information so that a letter string may be unambiguously identified as representing some semantic category. This assumption is based on the observation that nearly all models of letter and word identification view the perceptual process as including an extraction stage in which visual features (i.e., lines, curves etc.) are detected by the visual system and an interpretation stage in which the extracted information is assigned to some category stored in memory (cf. Smith & Spoehr, 1974).

Initially, a review of experimental findings dealing with the visual processing of printed English will be undertaken. Of particular interest will be the debate surrounding the nature of the basic perceptual unit involved in word identification. While some researchers have maintained that the letter is the basic perceptual unit (e.g., Massaro, 1973), others have suggested that higher-order perceptual units such as syllables may play an important role in the visual identification of words.

Following the literature review, two general models of word identification processes will be described. Both of these models suggest the existence of higher-order perceptual units but, nonetheless, represent rather divergent points-of-view regarding the manner in which words are identified.

The present experimental work attempts to assess which of the two positions is the more likely explanation of the perceptual aspects of the reading process. In so doing, a double-edged approach is taken towards an understanding of word identification processes. On the one hand, the perception of words is studied under conditions where the temporal parameters of presentations are varied, the frequency or familiarity of the stimulus items is varied, and finally, the orthographic structure of the stimulus words is varied according to the number of syllabic units. These latter two manipulations, in particular, delve critically into the role of higher-order perceptual units in word identification. In addition, the perceptual analysis of words is investigated in situations where the subjects' own experience with the reading process is taken into account. This last strategy will entail the use of varied populations of readers. To serve this purpose, grade school as well as college students have been enlisted as experimental participants. It is hoped that the present research will clarify potential interactions between subject and stimulus characteristics which are important for a true understanding of word identification processes.

Word Identification Processes

As long ago as 1885, Cattell suggested that fluent reading does not involve a letter-by-letter analysis of words. His assertion was

based on a number of interesting phenomena indicating that words were more perceptible than random arrangements of letters or even single letters presented in isolation. One finding, for example, indicated that more letters could be reported following a brief visual display if they made up a word than if they simply constituted an unrelated string. Other findings indicated that a word could be identified in its entirety faster than one could verify that a particular letter was contained in the word and also, that words could be identified at lower visual thresholds than single letters. At the time of Cattell's investigations, however, such findings could only be explained by statements such as "the meaning literally seems to leap out of the word and individual letters never reach consciousness" (Huey, 1908, p. 113). One fact which did seem to emerge from Cattell's early work was that familiarity or past experience with the visual configurations constituting words was an important determinant of their perceptibility or, at least, a determinant of their reportability. Hence, the basic question was raised as to how familiarity affects word identification.

Later research, focusing on the role of familiarity in the visual processing of written material, indicated that sequential redundancy found in English orthography could facilitate verbal inferences drawn from visual information. Miller, Bruner, and Postman (1954), for example, maintained that given only partial identification of a word, the remainder could be predicted on the basis of regularities in English spelling patterns. In this sense, familiarity with orthographic structure simply promotes efficient guessing; it does not actually affect the perceptual processes of word identification. This position was subsequently

formulated into the "Fragment Theory" of word identification (Newbigging, 1961) and was suggested as an explanation for many of Cattell's early discoveries as well as the observation that common words have a lower visual threshold than rare words.

A recent wave of experimentation in visual information processing, however, has mounted evidence suggesting that familiarity can also influence the actual perception of a word. Reicher (1969), for example, tachistoscopically presented subjects with either a word, an unrelated string of letters, or a single letter, followed immediately by a visual mask intended to degrade the image of the stimulus (cf. Kahneman, 1968). During the test trial a probe-recognition technique was employed in which two alternative letters were presented adjacent to one of the letter positions while the other positions were identical to the original stimulus. Therefore, if the stimulus word was CAP, the letters P and T would be presented above and below the empty third position during the test trial. In the case of a single letter stimulus, there would only be one test position available. The subject's task in these probe-recognition experiments was to decide which of the two alternative letters had been in the actual stimulus display.

Both Reicher (1969) and Wheeler (1970) discovered that the accuracy of letter identification was superior when the tested letters were presented within a word. Because both alternatives in the recognition task formed a word, the possibility of verbal inferences was assumed to have been eliminated in the case of word stimuli. This phenomenon has been called the "Word Superiority Effect". Wheeler (1970) interpreted this finding, that the identification of a letter presented in a word

is actually better than the identification of a letter presented alone, as implying that the analysis of a letter in a word is not independent at a perceptual level from the other letters making up the word. Therefore, word identification does not seem to involve an independent analysis of letters but rather some larger perceptual unit.

A number of subsequent studies have replicated the "Word Superiority Effect" (Johnston & McCelland, 1973; Smith & Haviland, 1972) while others have elaborated on other facets of the Reicher (1969) study (Aderman & Smith, 1971; Manelis, 1974; Spoehr & Smith, 1975). For example, Reicher (1969) had also discovered that the presentation of pronounceable pseudowords (e.g., MIRP) resulted in superior letter recognition as compared to the presentation of individual letters but somewhat poorer performance as compared to words. Aderman and Smith (1971) as well as Spoehr and Smith (1975) extended this finding by demonstrating that pronounceable pseudowords were also superior to unpronounceable letter strings (e.g., PMRI) in the probe-recognition task. Manelis (1974) confirmed this difference in performance between pronounceable and unpronounceable nonwords and demonstrated that single letters and unpronounceable letter strings result in similar levels of performance.

Because pronounceable pseudowords, in a number of cases, produce advantages similar to those observed for actual words, the more general term "Familiarity Effects" as opposed to the term "Word Superiority Effect" will be used in discussing the findings of the probe-recognition experiments. This term is taken from Kreuger (1975) who has recently reviewed many of the studies presently under discussion. "Familiarity"

is intended to refer to experience with the regularities in English spelling patterns within a word which makes them pronounceable.

Despite the striking findings in the probe-recognition experments, the specific locus of the "Familiarity Effects" in word identification has remained rather ambiguous. The many attempts tp resolve the role of familiarity in visual information processing quickly centered around two theoretical issues. The first is concerned with the dichotomy drawn between parallel versus serial modes of perceptually processing the letters making up a word. The parallel position suggests that words are analyzed and interpreted as whole units with no intermediate identification of letters. That is, visual features are extracted from all letters simultaneously and the extracted information is matched with categories representing entire words which are stored in memory. Alternatively, the serial position maintains that feature information is sequentially extracted from individual characters and matched with letter categories in memory in, presumably, a left to right order. The second and very closely related theoretical issue deals with the role of acoustic recoding in word identification processes. A parallel processing position usually implies that acoustic recoding is unnecessary and that words are identified (i.e., meaning is assigned) solely on the basis of visual information. The serial position, however, necessitates that identified letters be translated into some sound representation so that meaning may be assigned through a unitary acoustic coding of the word. The "Familiarity Effects" discovered in the probe-recognition experiments will now be discussed in more depth keeping in mind these two theoretical controversies.

On the one hand, the strong superiority of words over isolated letters and unrelated strings, and the moderate superiority of words over pronounceable pseudowords (Reicher, 1969; Smith & Haviland, 1971; Wheeler, 1970) seems to suggest that there is something peculiar to a string of letters making up a word which enhances its perceptibility. Smith and Haviland have hypothesized that the letters in a word are "unitized" during perceptual processing into an impregnable visual configuration which elucidates perception of the stimulus as a whole. As a result, individual letters can be more easily reported in the probe-recognition task.

Recent studies by Travers (1973, 1975) have provided some evidence for the parallel processing of a word in a paradigm other than probe-recognition. In these experiments, strings of letters were sequentially presented in either a single spatial position (i.e., on top of one another) or is a spatial array as letters would normally be positioned in a word. The letter strings constituted either words or random letter arrangements. The subjects' task was to report as many letters as possible in the stimulus displays. The results of both studies indicated that stimulus words suffered more than random letter strings from forced serial processing. Travers' studies also indicated that forward and backward masking conditions (cf. Kahneman, 1968) more seriously impaired the subjects' reports for words than random letters when the strings were spatially arrayed. Apparently, it is important that an opportunity to process the word as a whole is made available.

In yet another paradigm, Johnson (1975) has supported a parallel position of word identification. In this reaction time study, the sub-

jects were tachistoscopically shown a series of stimulus words. The task in one condition, was to indicate whether the display item was a specific target word, while in a second condition, the task was to indicate whether the stimulus display contained an instance of a specific target letter. Results indicated that a word could be identified as a word faster than a letter could be detected in a stimulus display. Johnson (1975) argued that if letters are first individually identified before being integrated into a word "unit", the results should have been exactly the opposite of those discovered.

Other findings, however, in the probe-recognition experiments are at odds with the "whole-word" position discussed above. For example, the superiority of pronounceable pseudowords over unrelated strings of letters indicates that the perceptual enhancement is not solely due to the "wordness" of letter strings but also involves a more general component, the pronounceability of the stimulus items. It may also be noted that some investigators have failed to obtain the word-pseudoword difference found in the Reicher (1969) and Wheeler (1970) experiments (Baron & Thurstone, 1973; Manelis, 1974).

The potential role of a general property such as pronounceability in the production of "Familiarity Effects" raises another possible explanation for the processes of word identification. The different levels of letter identification for pronounceable and unpronounceable items in probe-recognition may not be due to the extraction or interpretation of featural information derived from letter strings but rather to an additional stage of processing which is involved in the identification of words. This stage would be the situation described above

where individual letters are identified and then translated into an acoustic representation. In the probe-recognition experiments, this stage would result in a single representation of a pronounceable letter string which is easily maintained in memory during the interval between stimulus presentation and the onset of the response alternatives. Unrelated letter strings could not be unitarily represented in an acoustic fashion during the interval and, therefore, memory limitations not enhanced perceptibility could account for the differences observed between pronounceable and unpronounceable letter strings with the probe-recognition technique. At least one study (Mezerich, 1973) strongly suggests this possibility. This interpretation of "Familiarity Effects" does not, therefore, rule out a letter-by-letter analysis of words. In fact, the basic train of events; serial identification of letters, acoustic recoding, and assignment of meaning, is postulated by two general theories of word identification during reading (Gough, 1972; Rubenstein, Garfield, & Millikan, 1972).

A number of observations, however, argue against this interpretation as a general explanation of word identification processes. First, it is not clear why a difference between pronounceable pseudowords and single letters should be found in the probe-recognition studies (Reicher, 1969; Wheeler, 1970) if pronounceability produces the situation just described. Certainly, a single letter can be represented in an auditory fashion just as easily as a pseudoword. Baron and Thurstone (1973) also demonstrated superior letter recognition with the probe-recognition technique for pronounceable versus unpronounceable bigrams (e.g. AD or XD). Again, it appears unlikely that two letters would

exceed the subjects' short-term memory limitations.

Second, the subjective notion of pronounceability is confounded with the orthographic structure of a letter string. In order for a string of letters to be pronounceable, it must necessarily be consistent with the orthographic or spelling rules of the English language. These rules specify which possible combinations of letters may occur in English words. They are vastly complex, taking into account positional and sequential (i.e., what letters have gone before) information and probably can not be verbalized by even the most skilled reader.

Nonetheless, many letter combinations are quite common in certain positions of a word (i.e., ch, th, ck, ing, etc.) and the skilled reader may come to treat these combinations as single perceptual units during the reading process. Wheeler (1970), for example, proposed that words are broken down into chunks of "n" letters which make up common spelling patterns (SPs). The letters composing a unit are processed in a parallel fashion but the units themselves are processed in a serial order. Wheeler's proposal, however, does not deal directly with the role of acoustic recoding in word identification but rather focuses on the idea that knowledge of orthographic structure might be actively involved in the perception of written material.

Aderman and Smith (1971) have demonstrated a situation which illustrates Wheeler's position. In their experiment, subjects were tachistoscopically presented with either letter strings consistent with English spelling patterns (SP items) or strings which consisted of random arrangements of unrelated letters (UL items). One group of subjects was given a set for SP items while a second group was led to expect the

UL items. On subsequent critical trials, where either expected or unexpected items were presented, an advantage in probe-recognition was found for SP items only when they were expected. Apparently, the use of orthographic information regarding SPs was used only under conditions where it would be expected to prove beneficial. Therefore, the role of orthographic structure in the enhancement of tachistoscopic reports appears to involve an active perceptual strategy which may be employed by the knowledgeable reader; it does not seem to be a means for simply facilitating an inevitable auditory recoding of visual information.

The notion of higher-order perceptual units, however, is not new to the probe-recognition experiments. Gibson, Pick, Osser, and Hammond (1962), concerned with the development of reading ability, suggested that clusters of letters or SPs which have an invariant mapping to sound form perceptual units in reading. By detecting the correspondences between graphic clusters and phonemic representations, Gibson et al. (1962) demonstrated that pronounceable pseudowords which followed the rules of English orthography (i.e., contained SPs) could be more easily reported than unpronounceable strings by adults. This same basic finding was extended by Gibson, Osser, and Pick (1963) to the tachistoscopic identification of words, nonwords, and random letter strings by 1rst and 3rd grade children. It should be noted that the distinction between the two types of items was not as pronounced for these young subjects and to a certain extent was limited to performance with very short letter strings.

Gibson's position depends upon the relationship between graphemic representations of SPs and their phonemic or sound correspondences.

It is extremely useful in that developmental considerations are given as to how the skilled reader comes to treat SPs as single perceptual units; this is a consideration which has not been discussed in recent investigations using the probe-recognition technique. Gibson, however, remains unclear as to the specific role of SPs in the identification of words by skilled readers. In a fairly recent summary of her research, it is not specifically stated whether SPs influence the actual perceptual analysis of graphemes or the ability to recode identified letters more efficiently into auditory representations (Gibson, 1970).

However, the findings of Gibson, Shurcliff, and Yonas (1970) that congenitally deaf individuals also perform better with pronounceable pseudowords seem to indicate that Gibson intends the SP to function as a visual unit rather than as a unit of acoustic recoding in that the deaf possess no phonemic representation of language although the existence of a motor speech code is still a possibility. The assumption might then follow that knowledge of orthographic structure can be stored in purely visual-spatial terms, at least, for the deaf.

Other evidence that purely visual-spatial information of this sort can be employed during the process of reading by individuals other than the congenitally deaf may be taken from the experiments conducted with clinical patients who have surgically had the commissural pathways between the hemispheres of their brains severed. Sperry (1970). for example, presented these split-brain individuals with printed words in such a way that the stimulation reached only the right or left hemisphere. When words reached only the right hemisphere (speech functions are usually located in the left hemisphere), the individuals were able

to haptically retrieve the object named by the word from a group of objects but they were unable to verbally produce the object nor were they able to recognize the name of the object when spoken. This finding suggests that the semantic content of the word was identified using visual information with little evidence of acoustic recoding.

The Baron and Thurstone (1973) study, employing a normal reading population, has further illustrated a distinction between pronounceability per se and orthography or the conformity of words to regularities of English spelling. Experiment IV of their investigation was intended to discover whether the sound of a word once coded could aid a subject in a tachistoscopic recognition task. For this purpose, three groups of stimuli were constructed. The first consisted of pairs of homophonic words, pronounced alike but spelled differently (e.g. FORE and FOUR). After each tachistoscopic presentation, the subject was asked to indicate which member of the pair had occurred. These homophonic pairs were compared to a control set of pairs where the two words were pronounced differently but differed in exactly the same letters as the homophones (e.g. SORE and SOUR) and to a control set of pairs which were unpronounceable but again differed in the same letters as the homophones (e.g. FCRE and FCUR).

If the sound of a string in some way aids discrimination, it would be predicted that the homophones would be poorer in performance than the non-homophonic word pairs and the same as the unprouncеable items. Baron and Thurstone's results, however, indicated no significant difference between the homophonic and non-homophonic pairs while both of these types were clearly superior to the unpronounceable pairs of

of letter strings. As Baron and Thurstone point out, these findings rule out the sound of the word as an aid to discriminating response alternatives but do not preclude the possibility that the simple act of forming an acoustic code from a visual one helps to extract information from the visual presentation.

At this point, it will be wise to discuss a number of studies (e.g. Bjork & Estes, 1973; Massaro, 1973; thomson & Massaro, 1973) which have questioned the validity of the "Familiarity Effects" found in probe-recognition experiments. The basic argument of these investigators is that redundancy was not adequately controlled in the previous studies and therefore, the typical word advantage is due to inferential rather than perceptual processes. All of these investigators present data from experiments in which they believe redundancy has been properly controlled and show that the more accurate recognition of letters presented within words as compared to single letters and unrelated strings is eliminated. Massaro (1973) has, therefore, argued that the letter is the basic unit of perception and that there is no evidence for higher order perceptual units.

In the Reicher (1969) study, for example, the inferential role of redundancy as a variable affecting response probabilities for word stimuli was supposedly controlled by presenting letters as response alternatives which in both cases would form a word. Thomson and Massaro (1973), however, argue that this control can only be considered adequate if it is assumed that the subject maintains extracted visual information in memory until the response alternatives are presented and then selects a response on the basis of the best match between extracted information

and the alternative letters. In some cases, it is pointed out that the extracted information may not allow an unambiguous identification of a given letter. Therefore, the argument is made that the similarity of the alternative letters should influence the level of response accuracy. For example, letters like D an O which share a curved feature should result in poorer performance than disimilar alternatives like D and K. Thomson and Massaro, however, found no effect for the similarity of alternatives on the accuracy of probe-recognition for word or single-letter stimuli.

It has instead been suggested that the subjects must, during or immediately following a stimulus display, "synthesize" a response based on the extracted visual information even if it is only partial in nature. When the alternatives are presented, the subject simply checks to see if the choices include the letter "synthesized" for that position. If the alternatives do not include the letter synthesized for that position, Thomson and Massaro (1973) suggest that the subject guesses at random thus explaining the failure to find an effect for similarity.

Given that the above situation is an accurate description of what the subject is actually doing, Thomson and Massaro (1973) then argue that redundancy is still operative in the case of word stimuli. During word presentations, redundancy will serve to reduce the number of possible interpretations of partially identified letters because in combination with other identified letters, the stimulus as a whole must be a word. In the case of single letter stimuli and unrelated strings where redundancy information is not available, the subject can not as conveniently restrict the number of potential letters in synthesizing a response because any letter which contains the features

which have been extracted must be considered a viable alternative. In sum, with word stimuli, the subject has a higher probability of synthesizing a correct response from partial information.

Thomson and Massaro (1973) as well as Bjork and Estes (1973) and Massaro (1973) have attempted to better control redundancy by informing the subject at the outset of their experiments what the response alternatives would be and testing only those alternative letters throughout the experiment by presenting them alone, in words, or in random letter strings. For example, a subject would be told that L and R are the possible responses and on every trial, one of the two must be selected. Only the type of display in which those alternatives appeared was varied. As already mentioned, the typical advantage for letters presented within words was eliminated under this experimental procedure.

While the findings of the investigations discussed above undoubtedly must be given serious consideration, the interpretations of this data are certainly not without question. This is particularly true of the assertion made by Massaro (1973) that the individual letter is always the basic perceptual unit in the processing of printed English.

To begin with, neither Thomson and Massaro (1973) or Massaro (1973) addresses the fact that pronounceable pseudowords also result in superior letter recognition as compared to single letters and unrelated strings. It is assumed that the same arguments concerning uncontrolled sources of redundancy would be made. However, it does not seem likely that a subject would be able to restrict alternatives for partially identified letters in pseudowords to the extent that Thomson and Massaro (1973) have suggested is the case with actual words. The rationale

behind this statement is that in the "synthesis" process postulated by Thomson and Massaro, the subject can not limit potential choices to letters which would complete a word but rather must consider any letter which would make a string pronounceable. It would seem that these requirements would entail many more possibilities.

The observation may also be made that in most probe-recognition experiments (e.g. Reicher, 1969), the subject does not know on any one trial whether the upcoming item will be pronounceable or unpronounceable. Therefore, the subject would not necessarily have any basis for synthesizing a response as a word or a pronounceable item when partial identification of a letter occurs.

Perhaps, the most important criticism which can be addressed to the Thomson and Massaro (1973), Massaro (1973), and Bjork and Estes (1973) studies deals with the nature of the experimental task. Remember that the subjects knew that a limited set of alternative letters would be tested on each trial. It seems highly probable that the subjects in these experiments might develop a set or strategy in which they are simply trying to detect features which would discriminate the specific alternatives and not process the stimulus as a whole. If such were the case, the generalizability of these studies to the process of identifying words during actual reading would be seriously questionable. While the ability to generalize any of the probe-recognition studies to actual reading may be questioned, at least, the Reicher type experiments give the subject a set to process the entire stimulus. This notion of set is particularly important when one considers the results of Aderman and Smith (1971) which seem to indicate that the

production of "Familiarity Effects" seems to depend upon an active perceptual strategy on the part of the subject.

This last point is also related to the definition of perception which Thomson and Massaro (1973) as well as Massaro (1973) seem to have adopted. In their discussion, they appear to view actual perception only in terms of the extraction of visual features whereas most workers in this area, as indicated in the introduction to the present paper, include an interpretation stage as part of perceptual processing in which the features are interpreted or identified. While it may be granted that linguistic properties of letter strings do not affect extraction, the notion of set does appear to suggest that such properties can influence the way in which extracted features are identified or interpreted.

As a final point, it should be noted that both the Thomson and Massaro (1973) and Massaro (1973) article actually focus attention on letter identification rather than word identification. Although Massaro has asserted that individual letter identification is a prerequisite to word identification, he has not discussed the nature of the combinational process which must then occur in order to integrate the individual letters into a unitary code so that semantic properties may be assigned to a letter string during actual reading.

Three potential interpretations of the role of familiarity in the identification of words may now be summarized. First, it may be suggested that words come to be treated as unique visual configurations. According to this interpretation, the identification of individual letters is somewhat irrelevant for the reader responds to the word as a

whole and is primarily trying to discriminate the word at hand from other possible words. Smith (1971) maintains that the visual information used to carry out this task is extracted from component letters but taken together this information representing the word, does not necessarily include all of the information that would be required to unambiguously identify a single letter. Smith's ideas will be more fully developed in a later section of this paper.

The evidence surrounding the "whole-word" position is both experimentally and conceptually incomplete in explaining the entire scope of "Familiarity Effects". On the positive side, the superiority of words over single letters in the Reicher (1969) and Wheeler (1970) studies seems to be taken into account. Also, the early findings of Cattell (1885) can be given a reasonable interpretation as well as the more recent work of Travers (1973, 1975) and Johnson (1975).

On the negative side, the fact that pronounceable pseudowords often result in superior performance when compared to unpronounceable items in probe-recognition experiments means that a property of a word other than the fact that it has meaning is involved in the production of "Familiarity Effect". This property can be embodied in pronounceable strings of letters having no particular meaning. This observation leads to a conceptual problem with the "whole-word" position. Little consideration is given to the means through which readers acquire the ability to treat words as whole visual configurations. It certainly seems to be acquired through experience because young readers very definitely use acoustic representations of words to mediate visual identification (cf. Chall, 1967). Additionally, the research of Massaro (1973) and that of Thomson and

Massaro (1973) provides a challenge to the "whole-word" position and must be given serious consideration.

The heavy emphasis on phoneme-grapheme correspondences in early reading instruction has inspired a second position regarding the role of familiarity in word identification. The primary assertions of this position are that the identification of visually presented words necessarily involves a preliminary identification of letters and that a translation or recoding process is necessary in order to convert the identified letters into an aural code so that meaning may be assigned. Perceptual analysis of words, according to Gough (1972), involves serial identification of letters with subsequent recoding to sound. It should be noted, however, that while Massaro (1973) also advocates the preliminary identification of letters in word processing, he does not specify that the process is necessarily a serial one. In either case, an interpretation of word identification which includes preliminary letter identification maintains that "Familiarity Effects" are not produced by actual perceptual processes but rather by memory limitations which operate when strings can not be translated into a single acoustic representation (Bjork & Estes, 1973) or by uncontrolled sources of redundancy in pronounceable items which allow for inference on the part of the subject.

While evidence is available indicating that some type of acoustic recoding does occur in some experimental situations (Rubenstein, Garfield, & Millikan, 1971), it is not conclusive in demonstrating the necessity of recoding during actual reading (cf. Brewer, 1972). The most serious problem facing theorists advocating a translation stage is the specifi-

cation of the exact nature of the acoustic code. Conrad (1972), for example, has pointed out that the formation of an actual phonetic code (i.e., covert speech) would make it physically impossible to attain fluent reading speeds of 500 words per minute.

A final position which may be taken in regards to Familiarity Effects may be viewed as a compromise of the two more extreme positions just described. Essentially, it is assumed that higher-order perceptual units are employed in analyzing words but that these higher-order units are not the entire word but rather a spelling pattern. The Gibson, Shurcliff, and Yonas (1970) study and the Baron and Thurstone (1973) study seem to indicate that experience with orthographic structure can enhance the perceptibility of letter strings which follow the regularities of English spelling apart from the influence of pronounceability. The position is consistent with most general findings that orthographically sound strings are more readily perceived than unpronounceable strings although the findings of Massaro (1973) and Thomson and Massaro (1973) are also at odds with the notion of higher-order perceptual units. Also, Gibson's developmental research (cf. Gibson, 1970) provides an explanation as to how higher-order perceptual units are formed.

Although this position involving higher-order units seems general enough to encompass most experimental results, it too is plagued by a number of difficulties. One problem is that various theorists stressing the importance of higher-order perceptual units differ to some extent regarding the specific mechanics of word identification and the exact locus of higher-order units in the overall process (cf. Smith & Spoehr, 1974). Most, however, see the role of these higher-order

perceptual units in an interpretation stage of perceptual processing in which extracted visual features are matched with stored categories of visual information. The differences alluded to above will be more fully discussed in a later section of this paper when two general models of word identification are described.

Perhaps, the foremost problem, however, arises in attempting to define the exact nature of a spelling pattern. Gibson, Pick, Osser, and Hammond (1962) primarily refer to SPs as common clusters which occur in set positions within a letter string. For example, the pseudo-word GLURK is an orthographically regular one; the consonant clusters GL and CK being acceptable in the initial and final positions of a word. However, the string CKURGL is not permissable because the consonant clusters CK and GL are not placed in the appropriate positions. Thus, orthographic regularity for Gibson et al. (1962) seems to be determined by both the commonality of letter clusters and the position in a word where these combinations usually occur.

Gibson, Shurcliff, and Yonas (1970), however, were not entirely sucessful in demonstrating that these properties of letters strings are accurate predictors of the perceptibility of the letter strings presented to the deaf and hearing subjects. When summed bigram and trigram frequency counts based on the Underwood and Schulz (1960) norms were correlated with report accuracy for individual stimulus items, there appeared to be little in the way of a predictive relationship. Bigram counts, taking into account positional information (Mayzner & Tresselt, 1965), were more accurate in predicting the items' perceptibility but substantial variance remained unaccountable. Positional

trigram counts (Mayzner, Tresselt, & Wolin, 1965) added nothing more in the way of predictive power and a simple rating of an item's pronounceability was far and away the most accurate predictor.

The developmental research of Gibson, Osser, and Pick (1963) is also somewhat puzzling in regards to the role of SPs in the identification of words. The Gibson et al. findings indicated that by the third grade children were already making efficient use of the structure found in pronounceable pseudowords during a tachistoscopic identification task. Using a less demanding visual comparison task, Rosinski and Wheeler (1972) found that even first grade children were aided by the presence of high frequency SPs in short letter strings and that by the third grade, children utilized SPs in longer strings as efficiently as adults. Both studies suggest that knowledge of or facility with SPs is not a sensitive measure for assessing the effects of familiarity on the visual processing of words for it does not vary considerably across different levels of reading ability. Yet, it seems apparent that children continue to develop their word identification skills beyond the third grade.

All of these observations clearly point out that the structure of words is more subtle than that described by any statistical norms of redundancy (i.e., bigram and trigram counts) and that all of the relevant dimensions along which orthographic information is structured are yet to be discovered.

The Syllable Effect

A recent experiment by Spoehr and Smith (1973) reports differences in the tachistoscopic report of one and two syllable words in both full

report and probe-recognition tasks. The phenomenon may be called the "syllable effect". This finding suggests that perceptual units of a more subtle nature than SPs are indeed formed and additionally point out a possible dimension along which familiarity with orthographic structure may be more profitably studied.

Basically, Spoehr and Smith (1973) have suggested that a syllable may serve as a unit of perceptual processing for visual information as appears to be the case for auditory information. In their experiments, subjects were tachistoscopically presented one and two syllable words matched in length, initial letter, and Thorndike-Lorge frequency count. For both full report and probe recognition tasks, subjects performed better with one syllable words. It was reasoned that one syllable words require the processing of one unit while two syllable words require the processing of two higher-order units.

Spoehr and Smith's (1973) rationale for these assumptions centers around the work of Hanson and Rodgers (1965) on the perceptual dividing or "parsing" of words into what they have called vocalic center groups (VCG's). Hanson and Rodgers maintained that English words possess considerable commonality regarding the location of vowels in a letter string. The formation of VCG's (i.e., the perceptual parsing process) follows a set of rules which are implicitly known by the skilled reader. These implicit rules may be likened to the implicit grammatical knowledge which a native speaker possesses concerning the formation of sentences in his language.

The first step of the parsing process is the marking of vocalic elements which are not immediately followed by another vocalic element.

The consonants are then grouped with the vocalic elements; again following a set of implicit rules. Consider the word PAPER as an example. The vowels would first be marked. The initial consonant would then be grouped with the initial vowel and the final consonant with the final vowel. Most English words then follow a pattern in which the middle consonant is grouped with the second VCG. Hanson and Rodgers (1965) point out that for any pattern of vowels and consonants, there is a dominant rule for the parsing of letters into VCG's. Exceptions, of course, exist but they can be handled by secondary rules. It should be noted that the perceptual parsing rules proposed by Hanson and Rodgers follow the articulation patterns of words rather than their syllabication per se. In this sense, Spoehr and Smith (1973) have pointed out that the syllable effect is somewhat of a misnomer.

As should be obvious from the previous discussion, the parsing process is viewed as a theoretical operation occurring during the perceptual analysis of words. In fact, it is only one of a series of events that Spoehr and Smith (1973, 1975) have speculated upon in two sets of investigations. In a later section of the present paper, the function of syllabic structure and the parsing process will be brought into clearer focus as a general model of word identification based on Spoehr and Smith's research is described. For present purposes, suffice it to say that syllables or VCG's are viewed as preliminary visual units established for the eventual recoding of visual information into acoustic form. It is now important to consider some recent experiments which again stress the importance of acoustic recoding in the perception of letter strings.

A Phonemic Recoding Scheme

Spoehr and Smith (1975) begin by considering two specific proposals concerned with the nature of higher-order perceptual units. Both have already been treated in the present paper; the spelling pattern (SP) discussed by Gibson, Shurcliff, and Yonas (1970) and the vocalic center group (VCG) discussed in Spoehr and Smith's (1973) own previous research. The purpose of the first experiment in the 1975 paper was to determine which of these two perceptual units provided the superior explanation for the many effects of familiarity on the perception of letter strings.

During this experiment, the subjects were tachistoscopically presented with letter strings which were immediately followed by a visual mask. Testing was conducted via the probe-recognition technique used in the Reicher (1969) and Wheeler (1970) studies. Four types of letter strings were displayed; actual words such as BLAST, pronounceable pseudowords formed by changing the vowel in an actual word (BLOST), spelling pattern items constructed by dropping the vowel from a word (BLST), and finally, items were anagrams of the spelling pattern items (LSTB).

According to predictions generated from their earlier research, Spoehr and Smith (1975) predicted that the words and pronounceable items would result in superior perceptual performance as compared to the two other types because the parsing process could form an appropriate VCG which could then be efficiently translated into an acoustic representation. It was decided in the earlier paper that VCG's were important because syllabic constraints were crucial in directing the translation process. Spoehr and Smith (1975) further predicted that the spelling

pattern and unrelated items should produce similar performance levels because neither would allow the formation of a VCG which was assumed to be the important unit.

The results of this study indicated that the first prediction was borne out. The words and pronounceable items were superior to the two remaining item types. However, the second prediction was not confirmed. It was discovered that spelling pattern items enhanced the perceptibility of letters in the probe-recognition task when compared to the unrelated strings. Therefore, SPs per se do appear to play some role in the perception of letter strings.

In order to encompass these findings in their VCG model of word identification, Spoehr and Smith (1975) proposed that spelling patterns play a role in the translation stage. Spelling patterns are assumed to operate via what these researchers have called a phonemic recoding scheme. The mechanics are basically as follows. The parsing process prepares the visual information for translation by forming VCG's. The recoding scheme then takes over. Knowledge of SP patterns in the sense of phoneme-grapheme correspondences discussed by Gibson (1970) is important because they will specify the number of articulated sounds necessary to form an auditory representation.

Spoehr and Smith (1975) have illustrated the amount of phonemic recoding necessary for a particular letter string by way of tree diagrams. Consider one of the pronounceable items presented in the experiment under discussion, FRASH. The parsing process would establish a single VCG. The recoding process then breaks the syllabic unit down into one to two letter units which can then be assigned an acoustic representation.

FRASH would be recoded in the manner shown in Figure 1.

It is assumed that at each node generated by the recoding process, the subject checks to see if the unit generated there can be represented by a single phoneme through the application of phoneme-grapheme correspondences. If not, the unit is broken down still further until a one-to-one correspondence does exist between graphemes and phonemes. In the diagram shown in Figure 1, for example, FR could be broken down further while the spelling pattern SH could be represented by a single phonemic unit.

For the spelling pattern and the unrelated items, an additional problem is posed for the phonemic recoding scheme. In order to decompose a letter string of these types into smaller units of letters, a vowel must be present to signal the location of the first division. For these two types, however, none is present. Therefore, Spoehr and Smith (1975) assumed that subjects would insert a "pseudo" vocalic element in between those letter positions where an orthographically impossible combination of letters occurs. Consider the spelling pattern item FRSH. FR is an appropriate combination of letters but FRS is not and thus, the "pseudo" vowel is inserted between the R and S of this letter string. Figure 1 also provides examples of the amount of recoding necessary for the spelling pattern and unrelated items.

Spoehr and Smith (1975) maintained that these differences in the amount of recoding accounted for the various levels of performance observed for the four item types in the probe-recognition experiment. They further demonstrated that recognition accuracy for the individual items in their experiment was strongly correlated with the amount of

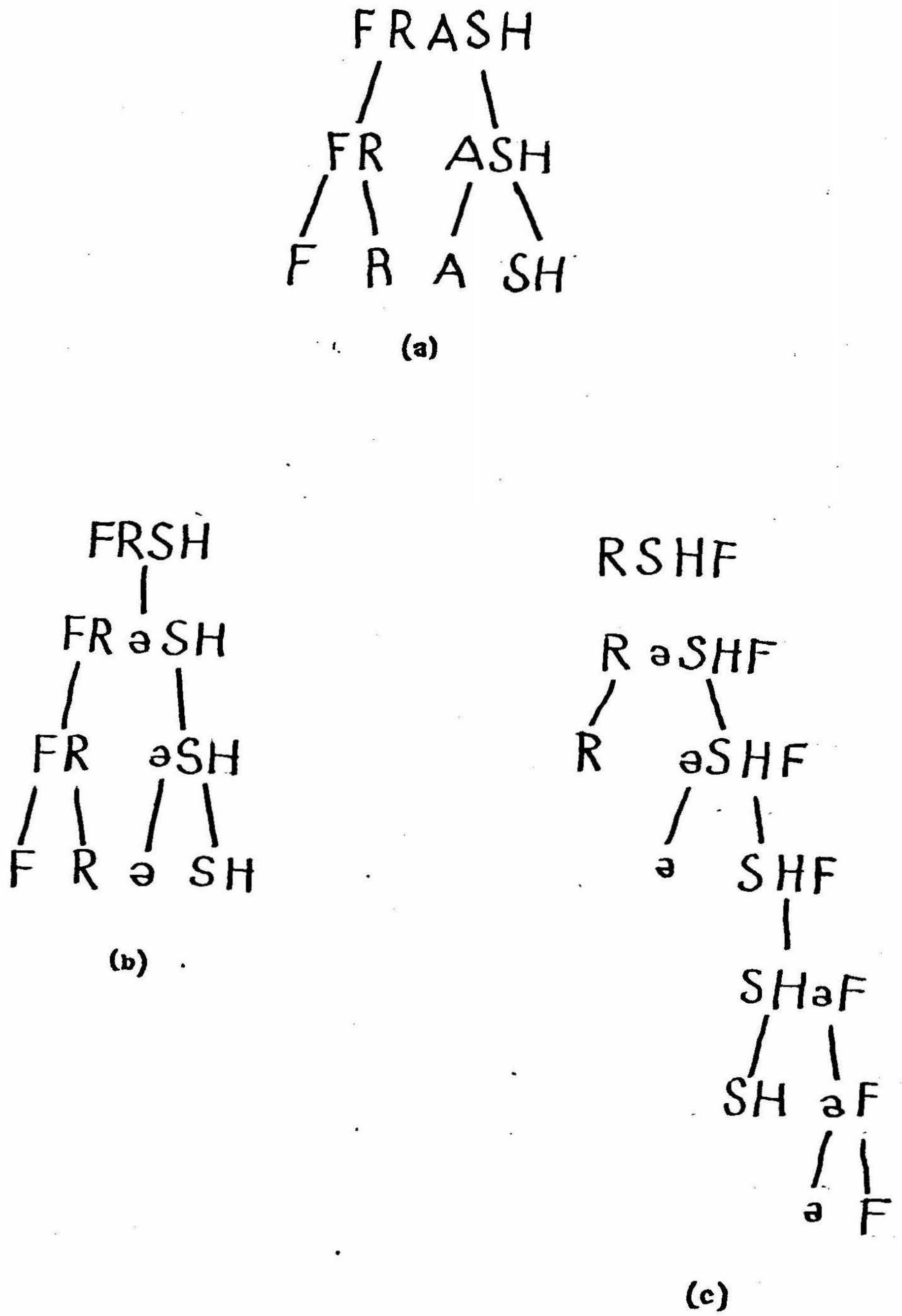

Fig. 1 Examples of tree diagrams generated by the Spoehr and Smith (1975) recoding scheme: (a) pronounceable item (b) spelling pattern item (c) unrelated letter string.

recoding required according to the translation scheme. Amount of re-coding was measured both in terms of the number of levels or the depth of the tree diagrams and in terms of the total number of nodes generated. The total number of nodes was the more accurate predictor of tachistoscopic accuracy, accounting for a significant 35% of the variance in tachistoscopic recognition.

A second study by Spoehr and Smith (1975), using slightly different item types, also resulted in tachistoscopic accuracy which was predicted under their phonemic recoding scheme. Generally, they proposed that this process of translating visual units (VCG's) into acoustic representations is a dominant if not necessary strategy in the perception of letter strings of all types; the efficiency of which is an important determinant of perceptual accuracy.

As a final point, Spoehr and Smith (1975) note that the recoding scheme alone can not account for their previous finding of a "syllable effect" in the perception of words. If the words PAINT and PAPER were not first parsed into VCG units, both would result in the same number of nodes and the recoding scheme described above would predict equal perceptibility for these words. The specific contributions of the VCG parsing process and the phonemic recoding scheme to the overall process of word identification will be considered in the next section of the paper.

TWO MODELS OF WORD IDENTIFICATION PROCESSES

In the following section, two general models of word identification processes will be described as they may occur during reading. The scope of these models ranges from that point in time where the visual system begins processing a word up until the point at which the letter string can be identified as representing some semantic category. Experimentally, the end product of the word identification process must be a written or verbal report. For both models, an attempt will be made to encompass the phenomena which have been previously considered and to discuss the potential role of higher-order perceptual units in the identification of words. Special attention will also be paid to the role of syllables and to the role of acoustic recoding in the visual processing of words.

The first model has been called the "VCG-Recoding" model. The name follows from the terminology of Spoehr and Smith (1973, 1975) and the model draws heavily from their experimental work. Certain contributions, however, have also been taken from the theory of word identification proposed by Gough (1972). The VCG-Recoding model is formulated in fairly rigorous information processing terms where specific stages regarding the state of input information are described and specific operations are detailed for transferring information from one state to another. It should be noted at the outset that the model as presently described, is nowhere explicitly detailed by Spoehr and Smith. The VCG-Recoding model should be viewed as an attempt to logically synthesize the different facets of Spoehr and Smith's (1973, 1975) program of

research into a complete description of word identification processes.

The second model to be described is a more lossely formulated feature-analytic view which emphasizes qualitative differences in word identification processes as the structure of the material and the reader's own knowledge of this structure varies. This model will be called the "Feature Redundancy" model and it is based largely on the work of F. Smith (1971) and Laberge and Samuels (1974).

The VCG-Recoding Model

Four basic stages are included in this model; feature extraction, identification of letters, perceptual parsing of letters into VCG units, and phonemic recoding of VCG's into acoustic representations. For the most part, these stages are assumed to occur in sequential order with subsequent stages operating on the output of the preceding one. The stages will now be considered in order of occurrence.

When a word is confronted by a reader, the first step is for the visual system to extract featural information from the input. Featural information refers to a description of the input in terms of basic line segments, angles, and curves. The VCG-Recoding model assumes that the extraction process operates on the features making up the individual letters of a word. Therefore, a set of features is generated for each of the component letters (cf. Smith & Spoehr, 1974).

Both physiological and behavioral evidence suggests that the visual system is, in fact, sensitive to features of the type just described. On the one hand, Hubel and Wiesel (1962, 1963, 1965) have demonstrated that certain cells in the visual cortex of a cat are sensitive only to line segments in specific orientations while still other

cells are activated only by particular angles. Thus, physiological data seems to indicate that cortical cells function as detectors for very specific kinds of featural information.

Behavioral studies are also suggestive of the feature extraction process. Mayzner (1975) has demonstrated that incorrect reports of briefly presented letters are usually other letters which are very similar in geometry to the one actually presented. For example, "R" is very often confused with "P".

Returning to our description, the next stage in the VCG-Recoding model is an interpretive one in which the extracted feature sets are serially matched to individual letter categories. This stage, of course, assumes that the reader has had experience with alphabetic characters in order for these identifications to be made. It is assumed that a schematic description of the features representing each letter is stored in memory.

According to Smith and Spoehr (1974), the result of this matching or identification process is that the categorized information is held in a very brief sensory store. Sperling (1960) has described this sensory register as a rather literal copy of the presented information persisting in the nervous system. Neisser (1967) gave the name "icon" to the contents of the sensory store.

At this point, it will be wise to deal with a conceptual problem surrounding the letter identification stage. The "VCG-Recoding" model maintains that the process of categorizing extracted feature sets is a serial one. Therefore, the letters are identified in a sequential order; presumably left to right during reading. However, the manner in

which the term identification is used by Spoehr and Smith (1973) in discussing this stage does not mean that the letters are named at this point of processing. Rather, identification, in this context merely implies that the reader comes to "know" what the features represent and could therefore respond to them in some discriminative manner. It should be noted, however, that most researchers supporting a serial analysis of letters uses the term identification to mean that letters are read out of the icon (i.e., named) sequentially and it is only then that they are identified.

The third stage in the "VCG-Recoding" model is the perceptual parsing process described by Spoehr and Smith (1973) in which categorized strings of letters are segmented into vocalic center groups. This operation would supposedly represent a situation where letters can be discriminated although they have not yet been named. The parsing operation follows a set of implicit rules proposed by Hanson and Rodgers (1965). To reiterate, the vocalic elements of a word are first marked with the consonants subsequently grouped with the correct vocalic element according to the appropriate rule for the presented pattern of vowels and consonants. The parsing operation is operating on iconic information.

The final stage of word identification in the VCG-Recoding model is the phonemic recoding scheme. This process translates the visual VCG unit into an acoustic form. Spoehr and Smith (1975) point out that the type of recoding they intend is not a covert speech code but rather a program which can generate either overt or covert speech. Gough (1972) has suggested that visual information is transposed into

what he has called a systematic phonemic representation. According to Chomsky and Halle (1968), systematic phonemes are abstract entities that are related to the sounds of the language but stand at some temporal distance from the actual posting of speech commands.

Spoehr and Smith (1975) are not entirely clear with regards to the mechanics of the phonemic recoding scheme. The experimental work with which this proposed scheme was developed only considered the identification of single syllable words or pseudowords and unpronounceable letter strings which could not be formed into proper syllabic units. Therefore, the manner in which the translation process operates on a word containing two or more VCG's is not specifically detailed. However, in discussing the relationship between perceptual parsing and phonemic recoding, Spoehr and Smith (1975) indicate that the recoding scheme operates independently and sequentially on VCG units in order that the phonemic constraints within the entire word may be properly specified. This means that the translation of one unit is completed before the translation of a second unit begins. For present purposes, it will be assumed that the recoding of syllabic units is a strictly serial process with the translation of two units requiring more time than the translation of one. This assumption is necessary in order that the "syllable effect" be considered as a general phenomenon in word identification under tachistoscopic conditions. Spoehr and Smith (1975), as mentioned, do not believe that the phonemic recoding scheme alone accounts for the "syllable effect". However, it should lastly be pointed out that the Spoehr and Smith (1975) study also indicates that the amount of recoding (i.e., the number of nodes generated) within a single VCG influences the tachistoscopic

accuracy. Therefore, the recoding process is not parallel within a single unit but logically it appears that the time to move from unit to unit is at least as important as the time necessary to complete the recoding of a single VCG.

In summary, the VCG-Recoding model of word identification describes four operations, feature extraction, letter identification, perceptual parsing, and phonemic recoding. It assumes that this sequence of operations is the general means by which all letter strings are identified (i.e., words, pseudowords, unrelated letters). Also, the VCG-Recoding model specifies that perceptual accuracy is determined by the likelihood that all of the stages of processing can be efficiently completed. Difficulty in completing any of the stages can produce anomolies in the identification of words or other types of letter strings.

The Feature Redundancy Model

The "Feature Redundancy" model begins with the basic premise that words not letters are being identified during the process of reading. Therefore, any operation which is concerned with the analysis and identification of individual letters is considered to be somewhat irrelevant to the actual processes of word identification.

F. Smith (1971) assumes that the first step in word identification is the extraction of visual features similar in nature to those described in the VCG-Recoding model. However, Smith maintains that the extraction process occurs in a parallel fashion and that the generated set of features is not simply matched against individual letter categories but rather is matched against stored featural sets repre-

senting entire words whenever possible.

The notion of feature redundancy which is important for this model means that the visual features extracted from a word tend to occur in familiar patterns and relationships across the entire word. The idea is very much like the redundancy and predictability of letters in a word but is referring to purely visual information. Actually, it should become clear that the Feature Redundancy model maintains that featural redundancy is the reason behind the "familiarity effects" which have been discovered in many experiments. The crucial point is that the feature set necessary to discriminate a particular word from all other words is not simply the sum of the features necessary to identify component letters individually.

It is pointed out by Smith (1971) that the stored feature set which allows a word to be identified in its entirety does not necessarily contain all of the features that would be necessarily present to unambiguously identify the component letters if they were presented in isolation. For example, if only three out of seven potential features were extracted for each letter, this information in the proper spatial array would, nonetheless, be sufficient to make clear what word had been presented.

An actual visual demonstration taken from Kreuger (1975) will, perhaps, make Smith's position more easily understood. Consider the set of line segments shown in Figure 2, example a. The configuration may be likened to the result of the feature extraction process for a single letter contained in a word. These lines probably do not seem to unambiguously represent any particular letter. Nor do the other sets shown in Figure 2, examples b, c, and d. Let us now, however, put

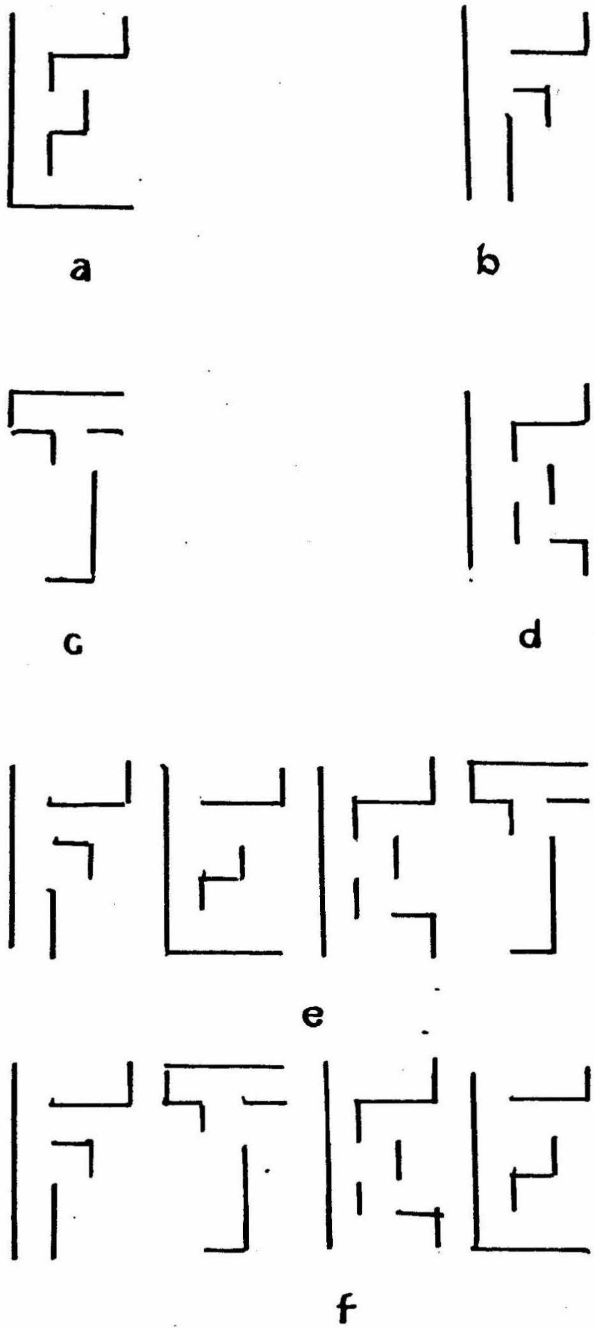

Fig 2. Illustration of feature extraction process according to the Feature Redundancy model.

the four sets of line segments together in a positional arrangement such as that found for the letters contained in a word. This is shown in example e of Figure 2. It should now be readily apparent that taken together these sets of lines represent the word FEET. Considered individually, however, it is unlikely that such a conclusion could have been reached so easily. It is equally unlikely that the groups of line segments placed in a random postional arrangement would elucidate the component letters (cf. Figure 2, example f).

This simple demonstration conveys the essence of the Feature Redundancy model of word identification. Skilled readers analyze words as whole patterns and individual letters are unimportant except for the featural information which they yield in making this feat possible. Smith (1971) maintains that fluent reading is for the most part a visual process; therefore, the reader goes directly from print to meaning. Semantic concepts can be associated directly with visual representations and the recoding of visual information into an acoustic form is certainly not a necessity.

This last point may also be vividly illustrated through a simple demonstration; this one taken from Brewer (1972). If word identification is necessarily accomplished by the recoding of visual information into acoustic form, one would expect to encounter little ambiguity while reading the following sentence. "The none tolled hymn that she had scene a pear of bear feat in the haul." The sentence, however, is not easily understood without considerable effort. Clearly, the actual visual information contained in the word (i.e., its spelling) is an important factor in appropriately identifying a word and setting up

correct expectancies for words which will follow in a sentence. This visual information can not be sacrificed for a mere acoustic coding.

The demonstrations which have been provided certainly compel one to accept the fact that processes such as those described by F. Smith (1971) do, in fact, occur, at least, in some instances. However, the "Feature Redundancy" model as stated thus far is not without problems. If words are identified by matching extracted features against stored feature sets for words as a whole, how are the "Familiarity Effects" discussed earlier to be explained. In particular, why are pronounceable pseudowords which have probably never been encountered before more easily identified than unrelated letter strings. According to the whole-word approach taken by Smith (1971), it would seem that both cases would force a letter-by-letter analysis; no general feature set would likely be stored for either type of item. Perhaps an even more basic question is how an individual acquires the featural sets necessary for identifying words as whole units. For a Feature Redundancy model of word identification, these two questions are quite interrelated and they will be considered together as the model is elaborated.

According to Smith (1971), the earliest form of reading may be an individual analysis of letters with subsequent mapping into sound. Early reading instruction first devotes considerable attention to the process of discriminating letters or put another way, learning the critical feature sets for the alphabetic characters. Once this basic code has been established, the beginning reader is able to tap into the vocabulary which is already known in an aural fashion by translating graphemes into phonemes. But already, the irregularities found in

recoding from letter to sound must be confronted. This problem is usually overcome via phonics training in which invariant relationships are demonstrated between letter combinations and sounds. Thus, SPs, in the sense discussed by Gibson (1970), are learned.

Smith (1971) maintains that these SPs are then structured into featural sets or schemas of featural information and become single perceptual units during word identification. By this, it is meant that featural redundancy is beginning to operate for SPs in the same way described initially for whole words. For example, the featural information needed to identify the combination "TH" would not simply be the sum of the features needed to identify the letters in isolation. While the relationship of SPs to sound guides the early reader in establishing higher-order units, these units, once established, can function in a purely visual fashion. The matching process is operating on chunks of featural information larger than a letter but smaller than a whole word. For unusual combination of letters, the Feature Redundancy model assumes that featural information must be analyzed on a letter-by-letter basis.

Laberge and Samuels (1974) have discussed the role of attention in the process of word identification and their work fits well into the model being described here. Their position may be described in the following manner. Once featural information has been extracted from a word, a matching process operates automatically with whatever stored feature sets or schemas that are available. In Laberge and Samuels' terms, the highest possible code or unit (i.e., a word, a SP, a letter) is activated directly by the visual information without the aid of focal attention. If a word can not be identified as a whole by matching

extracted features against stored schemas, attention must be devoted to unambiguously categorizing the extracted features in terms of smaller units (i.e., a letter or a SP) and then constructing a unitary coding for the word. In these situations, acoustic representations do become necessary.

The word "THORN" may be used as an example. Let us suppose that a young reader is encountering this vocabulary item for the first time in a visual fashion. The reader, therefore, has no complete featural description for this word. When the visual system begins processing the word, the extraction process generates featural information and the matching process takes over. The pattern "TH" is identified immediately because this SP has become familiar and the reader has a stored schema to use in its identification. However, the word as a whole can not be identified immediately and attention must be directed back to the graphic representation so that the features necessary to individually identify the remaining three letters are extracted. Now, in order for the reader to assign meaning to the string of letters, some unitary coding must be constructed. For word identification of this type, acoustic recoding is necessary. Not only must the last three letters be combined with the initial SP but the SP must be maintained while the identification of the remainder of the word is competed. Translation into a more durable acoustic code (cf. Conrad, 1972) makes this fragmented type of word identification possible. It should be noted that the example presented has not involved a strictly serial identification of letters with a subsequent recoding process. Rather, an attempt was first made to identify the word with higher-order schemas

of featural information, the portion identified in this manner is translated into an acoustic code so that it may be preserved while the remaining portion of the word is identified. The remaining letters were then acoustically coded as they were identified. F. Smith (1971) has referred to operations such as those just described as sound mediated word identification.

Although word identification may be accomplished through nediated processes, the Feature Redundancy model assumes that the ultimate aim of the reader is to reach the point where all frequently occurring words can be identified by matching extracted features directly to schemas for the entire word. It is only through continued experience with the reading process that this state-of-affairs can be approximated. During intermediate stages of reading, many different variations of mediated word identification will occur depending upon the specific structure of a word and the type of featural sets which the reader has previously established.

The studies of Gibson, Pick, Osser, and Hammond (1962) and Gibson, Pick, and Osser (1963) suggest that feature sets for high-frequency SPs are established and employed very early in the acquisition of the reading skill. The research with deaf individuals gives added weight to the position taken by the Feature Redundancy model that SPs function as purely visual units (Gibson, Shurcliff, & Yonas, 1970).

Although the feature sets for SPs may eventually be replaced by complete featural descriptions for the identification of some words, the schemas for SPs will not be lost and can be used when unfamiliar words or pseudowords are encountered. The "Familiarity Effects" discovered

in the probe-recognition experiments could then be explained along these lines.

It seems reasonable to suggest, however, that SPs in the simple sense of two or three consonant combinations (e.g., ch, str) with invariant mapping to sound are not the only type of higher-order perceptual unit employed in word identification prior to the establishment of complete featural sets for the identification of words. As mentioned earlier, children continue to develop word identification skills beyond the third grade when SPs appear to be employed in an efficient manner.

The "syllable effect" discovered by Spoehr and Smith (1973) and incorporated into the "VCG-Recoding" model also seems to have potential implications for a Feature Redundancy model of word identification. It may be suggested that syllables or vocalic center groups begin to function as perceptual units with continued reading experience. Like SPs, the structure of syllabic units may be detected through the relationship between graphemes and phonemes because a syllable forms the basic unit of articulation in speech (cf. Liberman, Ingram, Lisker, Delattre, & Cooper, 1969). Again like SPs, featural sets may be established for syllabic units and begin to function as visual units during the matching process in word identification with the advantage of feature redundancy.

The "Feature Redundancy" model of word identification may now be summarized with a number of basic propositions. First, feature informationis extracted from a presented word with the extraction process operating on the visual configuration of the word as a whole. Second, the extracted information is matched against stored schemas of featural information, the most basic schema describing an individual letter.

Third, experience with written material will result in the establishment of higher-order schemas of information which define more specific visual configurations. These higher-order schemas represent common SP units, possibly syllabic units, and ultimately entire words. Further, the schemas are stored in purely visual-spatial terms, independent of their phonemic representations. Fourth, during the matching process, the highest order schemas available will be automatically employed in identifying the extracted features. Fifth, auditory recoding is only necessary when higher-order schemas can not be used to identify the entire word and attention must be devoted to analyzing the word on a fragmented basis.

Overall, the Feature Redundancy model views the perceptual process of word identification as proceding under a system of analysis-by-synthesis such as that proposed by Neisser (1967). Neisser's view maintains that perception is not a one-way street with all information flowing from peripheral stages of processing to more central levels. Rather, the Feature Redundancy model suggests that schemas of featural information stored in memory contact the features extracted from a presented word. If the schema called up from memory is consistent with the extracted features, the entire unit can be identified or, at least, attention may be directed to the unidentified part of the word so as to extract salient features necessary for an unambiguous identification.

Comparison of the Two Models

Before concluding this section, it will be helpful to contrast the VCG-Recoding model and the Feature Redundancy model in terms of major similarities and differences. For both models, an extraction pro-

cess is included as the initial stage of word identification and both view this process in basically the same terms. That is, they are in agreement regarding the nature of the features (i.e., lines, angles, curves) extracted by the visual system.

Important differences, however, are found in subsequent stages of processing where the extracted information is interpreted. The VCG-Recoding model maintains that there is a preliminary identification of letters in which stored schemas representing individual letters are matched with the sets of extracted features. Alternatively, the Feature Redundancy model maintains that the matching process is not necessarily at the level of single letters. In fact, this position holds that that the matching will be made at the level of higher-order perceptual units whenever possible. It is assumed that schemas of featural information are stored for whole words, SPs, and possibly syllabic units in addition to those representing single letters.

In the VCG-Recoding model, a parsing operation subsequently groups the individual letters into syllabic units for eventual recoding into a phonemic form. The Feature Redundancy model includes nc parsing operation of this type. Instead, it has been hypothesized that a syllabic unit is one dimension along which higher-order schemas may be formed.

Finally, the VCG-Recoding model as formulated necessarily includes a translation process in which the syllabic units generated by the parsing operation are recoded into some sound representation. The Feature Redundancy model, on the other hand, does not necessarily involve phonemic recoding if a word can be identified using schemas representing its entirety. Recoding is only necessary in cases of fragmented identification.

THE PRESENT RESEARCH

The present experiments are concerned with the role of syllables and the role of acoustic recoding in the identification of briefly presented words. While investigating these issues, the characteristics of the stimulus words have been taken into account by including samples of common and uncommon words in each of the experiments conducted. Additionally, the subjects' own experience with the reading process has been considered by observing the identification of words by both adult and grade-school readers. It should be kept in mind, however, that the more general intent of the this research is to provide a better understanding of the manner in which words are normally identified during the process of reading.

A basic strategy followed throughout the series of investigations has been to formulate research hypotheses so as to test predictions drawn from the VCG-Recoding model. The reason for this strategy lies in the fact that the VCG-Recoding model specifies very definite and supposedly universal stages of processing and, therefore, lends itself to rigorous investigiation. When possible, however, predictions and inferences drawn from the Feature Redundancy model will be indicated.

The first two experiments deal with the "syllable effect". Because a syllabic unit occupies a potentially important role in both of the models which have been described, further assessment of the manner in which the syllabic structure of a word influences their identification appears warranted. Parenthetically, no subsequent investigations have repli-

cated or elaborated upon the finding of a "syllable effect" since the original study by Spoehr and Smith (1973). Therefore, the notion of a syllable as a higher-order perceptual unit has remained virtually uninvestigated.

The third experiment deals with the question of acoustic recoding during word identification. An attempt is made to determine if and when such a process is necessary. No specific tests of the Spoehr and Smith (1975) phonemic recoding scheme have been made.

For all of the experiments, a full-report technique has been employed. This procedure requires that the subject report the entire word or, at least, as much of the word as possible following a very brief exposure of the stimulus item.

There are a number of reasons for using the full-report method as opposed to the more rigorously controlled probe-recognition technique developed by Reicher (1969). To begin with, the original Spoehr and Smith (1973) study had demonstrated the "syllable effect" with both full-report and probe-recognition responses. Secondly, pilot work suggested that the sixth-grade students to be tested in Experiments II and III might experience difficulty in comprehending the mechanics of the probe-recognition technique and, thus, perform inadequately in the experimental setting. Therefore, in deference to the younger subjects, the full-report method appeared more appropriate here.

An additional and even more important reason for employing the full-report technique is that this experimental task appears more generalizeable to the actual reading process. In probe-recognition, the sample of stimulus words would need to be restricted to those items where al-

ternative letters could be presented so that both would form a word. In trying to include stimuli representing a wide range of word frequency as well as stimuli varying in syllabic structure, the added requirements of the probe-recognition task would result in a very limited pool of stimulus words. The full-report method, on the other hand, does not as severely limit the number of potential stimulus items.

Also, a number of investigators have cautioned that the perceptual strategies engaged by an individual during a probe-recognition experiment where only a single letter response is required may not reflect the processes engaged during actual reading (cf. Brewer, 1972; Manelis, 1974). The full-report method, however, requires that the subject attempt to identify the entire stimulus word is necessary during reading.

While it is true that guessing or verbal inference on the part of the subject may contribute to the overall level of performance with the full-report method, there is no a priori reason to assume that these factors will differentially affect the report of one and two syllable words which is the distinction of primary concern for the present investigation. This assumption has, in fact, been confirmed by post hoc analyses of the stimulus items in terms of measures of sequential and positional redundancy. These analyses will be noted later in the appropriate places. The question of interest here is whether our experimental manipulations will influence the identification of words in a relatively natural situation where unrestrained response is permitted.

EXPERIMENT I

Experiment I replicates the "syllable effect" reported by Spoehr and Smith (1973) under an extended range of experimental conditions. The "VCG-Recoding" model predicts that words which can be parsed into a single VCG should be more readily identified than words which must be parsed into two VCG's provided that the possibilities for verbal inference are equated for the two word types. Thus, the "syllable effect" should be equally apparent in samples of both common and uncommon words. That such is the case, however, is not clear from the Spoehr and Smith (1973) study. In that experiment, one and two syllable words were matched for length and frequency of occurence in language but the actual range of frequencies was not reported. The examples provided were all high frequency words. Therefore, Experiment I has observed the report of one and two syllable words which have also been systematically varied in terms of Thorndike-Lorge frequency, samples of very high and very low frequency words being included among the stimulus items.

While it is expected that high frequency words will overall be identified more accurately than low frequency words due to their higher probability of being generated as a response, the crucial prediction drawn the "VCG-Recoding" model is that one syllable words will be better identified than two syllable words within each of the frequency categories.

The present experiment has also systematically varied the processing time allowed for the various stimulus types. In the Spoehr and Smith (1973) study, the role of processing time was not considered.

A threshold for 75% accuracy was established pre-experimentally for each subject and was then maintained throughout the experimental sessions.

This manipulation of processing time was included primarily for purposes of speculation about the two models rather than for the pur= pose of making specific predictions based on the models. It should be remembered that the "VCG-Recoding" model maintains that an entire series of stages is necessary for the unambiguous identification of a word. When experimental conditions reduce the amount of time available for identification, it follows that the possibility of completing the series of stages will be reduced. It should also be noted that the final phonemic recoding stage will be the first affected for the stages are assumed to occur in serial order. Because the "syllable effect", according to the VCG-Recoding" model, is produced by the shorter time needed to recode one as opposed to two VCG's, it would seem that the magnitude of the "syllable effect" would be affected as processing time became progressively shorter. The phonemic recoding stage would be seriously disrupted and verbal inferences would be more important in producing correct reports.

The "Feature Redundancy" model, on the other hand, would not necessarily expect the influence of syllable structure to diminish as overall performance declines. According to this model, the potential role of syllables is in the use of an active perceptual strategy whereby extracted information is matched directly to schematic representations stored in memory. In other words, the same perceptual strategy would be employed despite changes in available processing time.

Method

Subjects. The subjects were 18 Loyola University students who participated in partial fulfillment of a psychology course requirement. All subjects were required to have normal or corrected-to-normal vision.

Materials and Apparatus. The stimuli consisted of 60 five-letter words varied in terms of the number of syllables which they contained and in terms of their Thorndike-Lorge frequency count. The words were comprised of either one or two syllables and were either high or low frequency. High frequency stimuli were listed as either A or AA words in the Thorndike-Lorge count while low frequency words were listed as occurring between 1 and 15 times per million. Combination of these two factors resulted in four stimulus types; High Frequency-One Syllable words (HF-1), High Frequency-Two Syllable words (HF-2), Low Frequency-One Syllable words (LF-1), and Low Frequency-Two Syllable words (LF-2). The stimulus set contained 15 of each of these different types. Each one syllable word was matched with a two syllable word having the same initial letter and a comparable frequency count. The mean frequency for LF-1 words was 7.27 as compared to 5.80 for LF-2 words. The complete list of stimuli is presented in Appendix A.

The stimuli were presented on a Digital Equipment Corporation Cathode-Ray Tube (CRT), a VR-14, under the control of a PDP-8 digital computer. The surface of the CRT screen is coated with a fast-decaying phosphor (P24), having a decay time of less than 5 microseconds. The stimulus words were displayed such that each letter was constructed within a 5 X 7 matrix of points with these points corresponding to the geometry of a particular upper-case letter being illuminated.[1]

The stimulus words were .6 cm in height and 4.5 cm in width, subtending a vertical angle of 0°50' and a horizontal angle of roughly 5°0' from a viewing distance of 80.5 cm. The masking stimulus employed throughout the experiment consisted of 5 adjacent blocks of points. Each block was constructed by illuminating all of the points within the 5 X 7 matrices in which the letters composing a word were formed.

For this experiment, the screen of the CRT was covered with black construction paper except for a small rectangular aperture bordered in white which was sufficiently large to encompass the size of the experimental displays. Both the stimulus words and the masking stimulus appeared as a pale green color against a black background.

Procedure and Design. Throughout the experiment, a single trial consisted of the presentation of a stimulus word for 15 msec, followed by an interstimulus interval (ISI) of variable duration before the onset of the masking stimulus for 500 msec. The masking stimulus (i.e., the five blocks of points) completely covered the exact area on the CRT screen in which the five-letter word had appeared.

The experiment is embodied in a 2 X 2 X 5 X 5 within-subjects design. The first two factors refer to the two stimulus dimensions (syllables and frequency) described above. The third factor refers to the ISI between the stimulus word and the masking stimulus. Interstimulus intervals of 5, 10, 15, 20, and 25 msec were included. An experimental session consisted of 300 test trials which were divided

[1] The program used for displaying the stimulus items was written at New York University by Mr. F. Distenfeld.

into five blocks of 60 presentations. Trial blocks constituted the fourth factor in the experimental design. Within a block, all 60 stimulus words were presented once. Twelve words were displayed at each of the 5 ISI conditions, 3 of each 12 at a given ISI being selected from the four different types of stimulus words. Across the blocks, each stimulus word was presented under each of the five ISI durations. The order of the stimulus words was randomized within a block of 60 trials and using a randomized block procedure, each subject was shown a unique ordering of the five trial blocks.

At the outset of each session, the subjects were given 15 practice trials with words not included in the experimental set. The items used during the practice trials consisted of 8 high frequency and 7 low frequency items. During these trials, the subjects familiarized themselves with the procedure of signalling the experimenter when they were set for another trial. For the 300 experimental trials, observations were recorded on specially prepared response sheets. Numbers from 1 to 60 were listed on each sheet, ordered in two columns of 30. Following each number, five blank spaces were provided in which the subjects were to print the five letters contained in each stimulus word. Pre-experimental instructions indicated that partial responses were acceptable and that identified letters should be placed in the spaces corresponding to the serial positions where the subject believed the letters to have occurred. During the course of the experiment, rest periods on the order of a few minutes were installed after the first, second, and fourth block of trials. Following the third block, a rest period of approximately 5 min. was given during which the subjects were allowed to leave the exper-

imental room. Also, within a block of trials, there were brief pauses after the initial 30 trials to insure that the subjects were at the appropriate place on their response sheets. The sessions ranged from 75 to 90 min. in length and were conducted under dim illumination sufficient for the subjects to record their observations. At the close of the experiment, each subject was shown the complete list of stimulus items and asked to indicate any of the words whose meanings were not known. None of the subjects, however, indicated that any of the words were unfamiliar.

Results

The data collected in Experiment I as well as in the subsequent two experiments were analyzed in two fashions. The first analysis considered the subjects' responses in terms of whether or not the words as a whole were reported correctly. Therefore, partially correct responses were considered wrong. The second analysis took into account partial word reports by treating the data in terms of all letters reported in the correct spatial position regardless of whether the word as a whole was reported correctly.

Whole-Word Analysis. Table 1 shows the mean proportion of correct whole-word reports for the various stimulus types at the five levels of ISI. Inspection reveals that report accuracy increased with lengthened ISI except for LF-1 items where there is a slight drop in performance from an ISI of 20 to 25 msec. Additionally, it may be observed that one syllable words hold a consistent advantage over two syllable words for high frequency items at each ISI while two syllable words show a

Table 1

Mean Proportion of Correct Whole-Word Reports for

One and Two Syllable High and Low Frequency

Words at Different ISI's in Experiment I

	Inter-Stimulus Interval				
High Frequency	5 msec	10 msec	15 msec	20 msec	25 msec
One-Syll.	.44	.60	.69	.72	.73
Two-Syll.	.35	.49	.59	.62	.68
Low Frequency					
One-Syll.	.19	.24	.35	.42	.40
Two-Syll.	.26	.35	.40	.46	.53

consistent advantage for low frequency items.

These observations are confirmed in a four-way repeated measures analysis of variance (ANOVA) with Word Frequency (High & Low), Syllables (1 & 2), ISI (5, 10, 15, 20, & 25 msec) and Trial Blocks treated as the independent variables. Significant main effects were obtained for Frequency, F (1, 17)=86.04, $p<.001$; ISI, F (4, 68)=52.15, $p<.001$; and for Trial Blocks, F (4, 68)=25.99, $p<.001$. The differential effect of syllables on report accuracy in the two frequency categories is indicated by a significant Frequency by Syllable interaction, F (1, 17)= 41.29, $p<.001$. The main effect for Syllables as well as all other interactions were not found to be significant.

As expected, high frequency words were reported with greater accuracy than low frequency words. The overall proportion of high frequency words reported correctly was .590 as compared to .360 for low frequency words.

The Frequency by Syllables interaction is made clear in Fig. 3 where the mean proportion of correct identification for the four item types has been plotted. Simple effects analyses were conducted according to a procedure outlined by Winer (1973, pps. 544-5) in order to test the significance of variation attributable to the number of syllables at each frequency level. For high frequency words the advantage in report accuracy for one syllable words was found to be reliable, F (1, 17) =28.67, $p<.001$; while conversely, the advantage for two syllable words was found to be significant for low frequency items, F (1, 17)=19.33, $p<.001$.

The main effect for Trial Blocks can be described in terms of

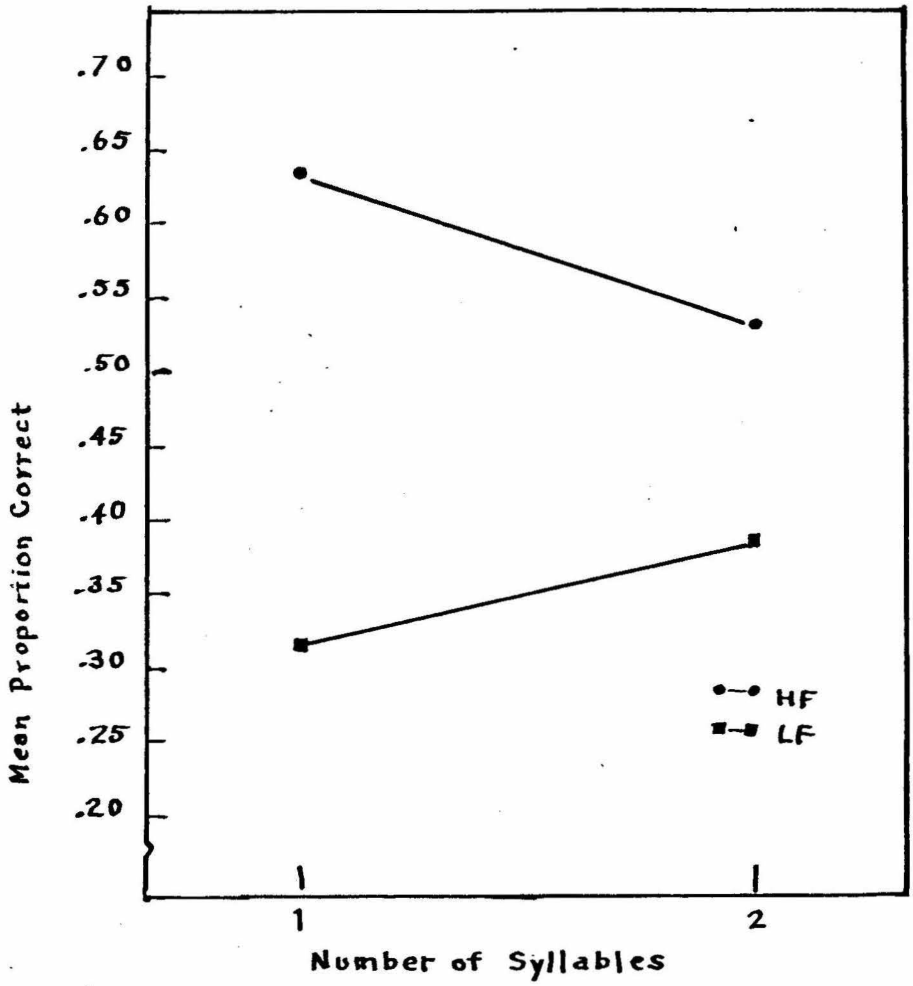

Fig. 3 Mean Proportion Correct Whole-Word Identification as a Function of Frequency and Number of Syllables in Experiment I.

progressively increasing report accuracy across the five experimental blocks. Collapsed over all other variables, the mean proportions of correct identifications were .36, .44, .50, .54, and .56, respectively, for the five trial blocks.

Errors. In order to provide a fuller picture of subject performance, the incorrect responses in the whole-word analysis were further classified according to three types of errors. A Partial Correct report refers to those responses were one or more letters were reported in the appropriate spatial position but the word as a whole was incorrect. An All Wrong report is a response in which some letters were reported but none were correct. Finally, an All Blank report means that no letters were reported. Table 2 gives the overall proportion of these three types of errors as well as the overall proportion of correct word identification. It may be noted that these proportions for correct identifications differ somewhat from the mean proportions plotted in Fig. 3.

Examination of Table 2 reveals that the pattern of errors is roughly the same for each of the item types; Partial Correct responses being the most common and All Blank errors being slightly more common than All Wrong errors. Comparison of a particular kind of error across item type, however, is not meaningful in that the proportion of possible errors is dependent on the level of correct identification.

To make such comparisons possible and to provide a more insightful look at the error data taking into account the performance of individual subjects, the following procedure was undertaken. For each subject, the errors for each type of item were classified according to the three categories described above. Subjectwise proportions were determined by

Table 2

Overall Proportion of Correct Word Identification and Partial Correct, All Wrong, and All Blank Errors for Four Item Types in Experiment I

	Type of Response			
High Frequency	All Correct	Partial Correct	All Wrong	All Blank
One-Syll.	.57	.24	.09	.10
Two-Syll.	.49	.30	.09	.12
Low Frequency				
One-Syll.	.29	.47	.11	.13
Two-Syll.	.35	.40	.11	.15

dividing the number of errors falling into each category by the total number of errors for a particular item type. Mean proportions were then computed and these are shown in Table 3.

Inspection of this table reveals an interesting pattern. It can be seen that for high frequency items, the mean proportion of Partial Correct responses is somewhat higher for two syllable as compared to one syllable words while the mean proportion of All Blank reports is somewhat higher for the one syllable stimuli. For low frequency items, however, the pattern is reversed; the mean proportion of Partial Correct reports is higher for one syllable words and the mean proportion of All Blank reports is higher for the two syllable stimuli. In both frequency categories, the All Wrong reports are virtually identical.

Letter Analysis. Table 4 presents the mean proportion of letters identified in each spatial position for the four types of items at each level of ISI. The data on which these means are based were initially analyzed in a four-way repeated measures ANOVA treating Word Frequency, Syllables, ISI, and Letter Position as the independent variables. Significant main effects were discovered for Frequency, F (1, 17)=74.12, $p < .001$; Syllables, F (1, 17)=18.74, $p < .001$; ISI, F (4, 68)=67.42, $p < .001$; and Letter Position, F (4, 68)=8.87, $p < .01$. Straight-forward interpretation of these variables, however, is complicated by the following significant interactions; Frequency by Syllables, F (1, 17)= 11.17, $p < .01$; Frequency by Letter Position, F (4, 68)=9.00, $p < .01$; Frequency by Syllable by Letter Position, F (4, 68)=7.23, $p < .01$; and Frequency by ISI by Letter Position, F (16, 272)=2.32, $p < .05$.

Table 3

Mean Proportion of Partial Correct, All Wrong,

and All Blank Errors for Four Item Types

in Experiment I

	Type of Error		
High Frequency	Partial Correct	All Wrong	All Blank
One-Syll.	.60	.16	.24
Two-Syll.	.62	.16	.22
Low Frequency			
One-Syll.	.68	.15	.18
Two-Syll.	.64	.15	.21

Table 4

Mean Proportion of Letters Correctly Identified

in Experiment I

ISI	Letter Position	Type of Item: High Freq. One-Syll.	High Freq. Two-Syll.	Low Freq. One-Syll.	Low Freq. Two-Syll.
5 msec					
	1	.52	.48	.39	.37
	2	.49	.45	.34	.28
	3	.49	.36	.29	.30
	4	.50	.39	.33	.28
	5	.54	.45	.33	.37
10 msec					
	1	.67	.60	.59	.52
	2	.66	.56	.47	.43
	3	.64	.51	.40	.41
	4	.60	.55	.46	.39
	5	.64	.58	.44	.47
15 msec					
	1	.74	.69	.66	.64
	2	.76	.68	.58	.54
	3	.68	.62	.47	.50
	4	.68	.67	.47	.51
	5	.72	.73	.53	.60
20 msec					
	1	.76	.72	.71	.64
	2	.77	.74	.63	.51
	3	.76	.64	.54	.49
	4	.76	.66	.57	.51
	5	.77	.72	.60	.60
25 msec					
	1	.78	.79	.74	.75
	2	.77	.74	.65	.70
	3	.74	.65	.54	.62
	4	.74	.70	.55	.60
	5	.77	.73	.66	.73

The Frequency by ISI by Letter Position interaction is graphed in Fig. 4. For high frequency words, the proportion of identified letters increases with ISI although there appears to be little difference between times of 20 and 25 msec. The Letter Position curves are also not entirely uniform across the five levels of ISI. For low frequency words, however, lengthened ISI results in a more regular increase in letter identification with all of the Letter Position curves assuming a basically bow-shaped appearance although they are less concave at the shorter ISIs.

Fig. 5 depicts the nature of the Frequency by Syllable by Letter Position interaction. An examination of the figure reveals that HF-1 words result in a virtually flat Letter Position curve while the curve for HF-2 words is bow-shaped in appearance. For low frequency items, both one and two syllable words produce bow-shaped curves. It may also be noted in Fig. 5 that the proportion of letters identified for HF-1 words is consistently higher than the proportion identified for HF-2 words at each letter position. For low frequency items, such is obviously not the case.

Because both of the three-way interactions just described involved frequency, it was decided to further analyze the data separately for each frequency category. Therefore, two three-way repeated measures ANOVAs were conducted considering Syllables, ISI, and Letter Position as the independent variables.

For high frequency words, a significant main effect was obtained for Syllables, $\underline{F}$ (1, 17)=29.22, $\underline{p} < .01$; for ISI, $\underline{F}$ (4, 68)=37.35, $\underline{p} < .01$; and for Letter Position, $\underline{F}$ (4, 68)=5.92, $\underline{p} < .01$. The Syllable

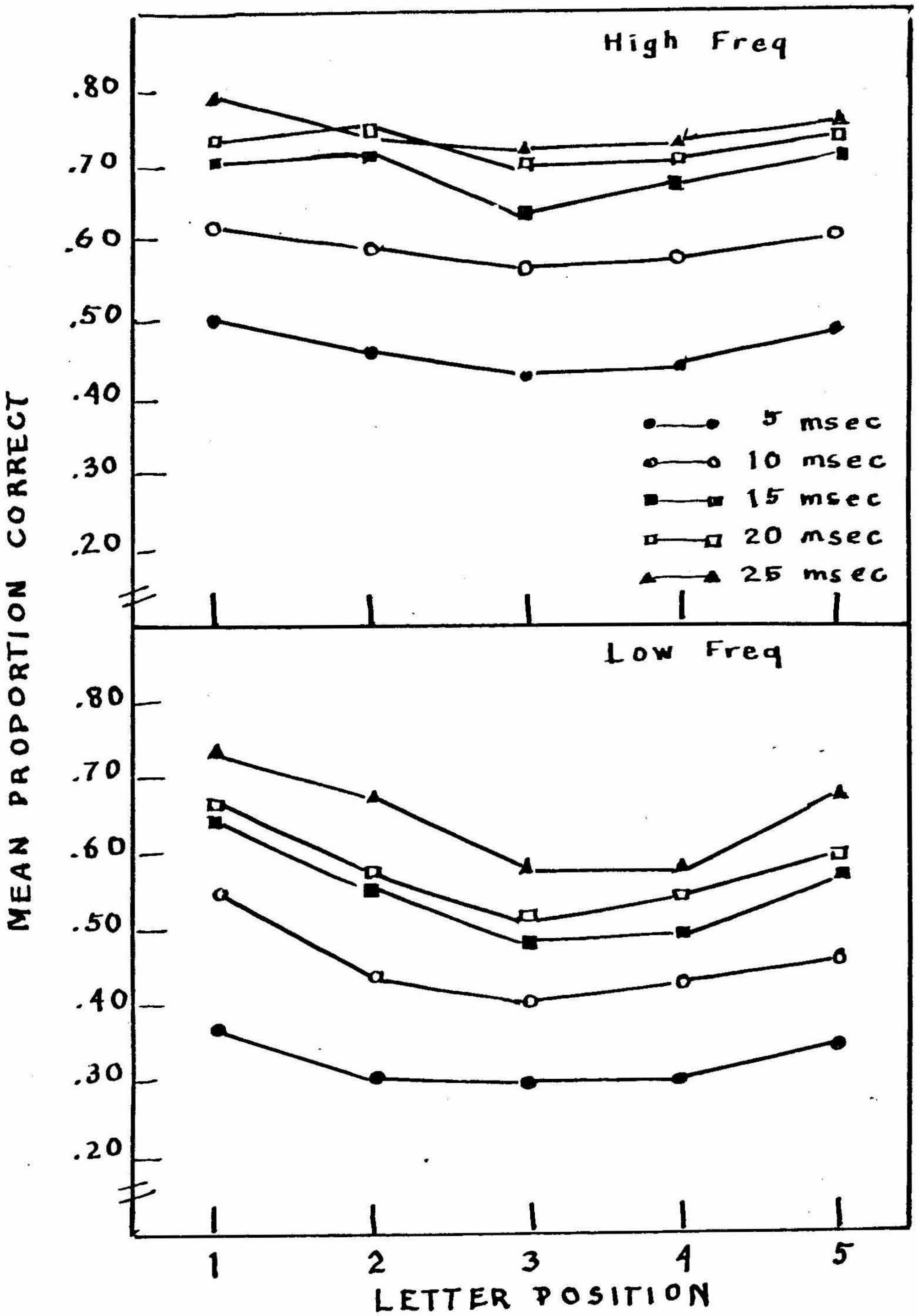

Fig. 4 Mean Proportion of Correctly Identified Letters as a Function of Frequency, ISI, and Letter Position in Experiment I.

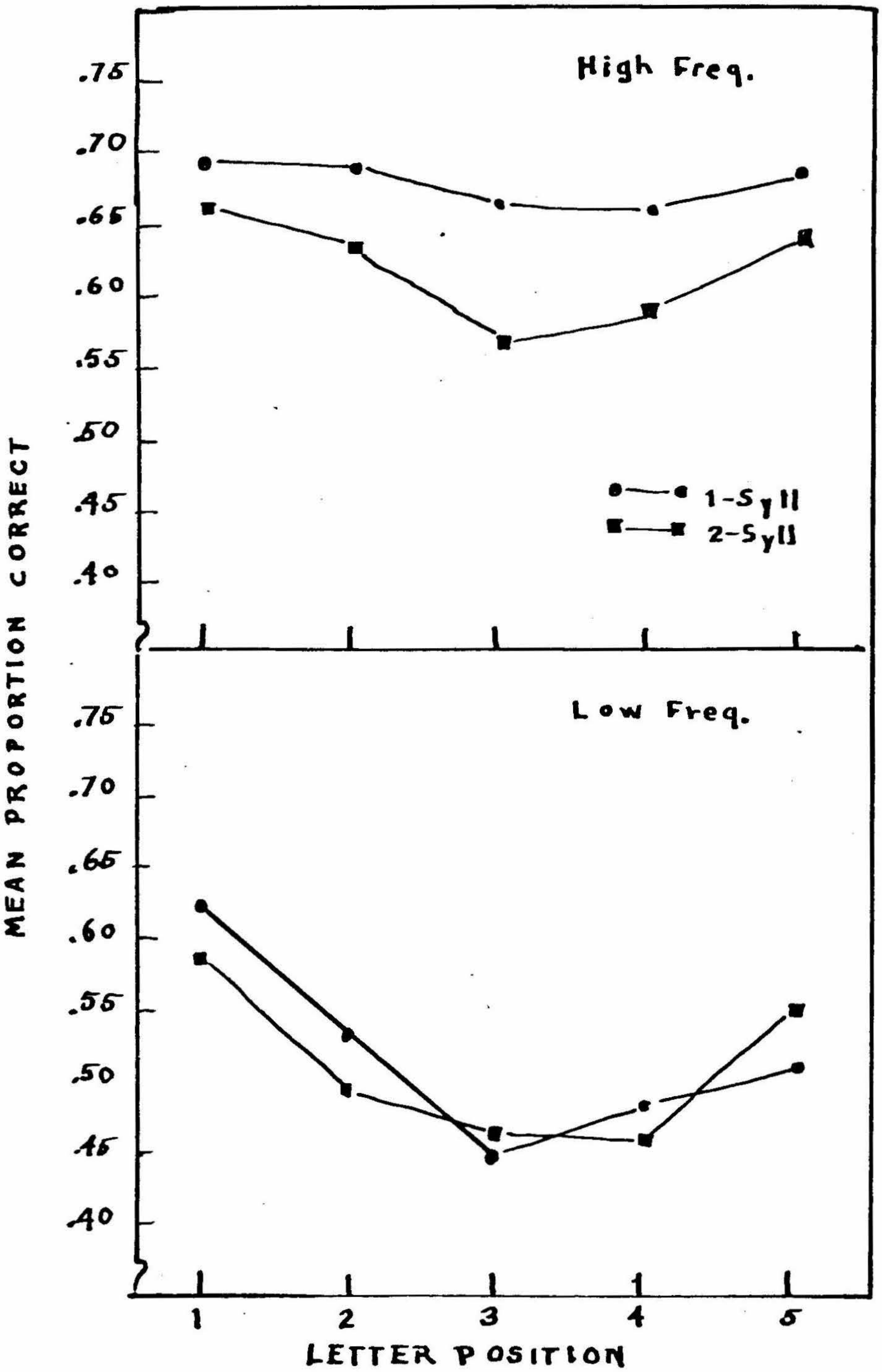

Fig. 5 Mean Proportion of Correctly Identified Letters as a Function of Frequency, Number of Syllables, and Letter Position in Experiment I.

by Letter Position interaction shown in the upper panel of Fig. 5 was also significant, F (4, 68)=6.02, $p < .01$. The nature of this interaction was further clarified by a trend analysis which resulted in a significant quadratic main effect, F (1, 17)=16.32, $p < .01$; but also a significant differencein quadratic trends between one and two syllable words, F (1, 17)=6.84, $p < .01$. Additionally, the simple main effect of Letter Position for one syllable words did not prove to be significant, F (1, 68) < 1.00.

The separate ANOVA for low frequency items resulted in significant main effects for ISI, F (4, 68)=65.58, $p < .001$; and for Letter Position, F (4, 68)=10.40, $p < .01$; but not for syllables. The mean proportion of letters identified for LF-1 items was .52 and for LF-2 items, .51. The Syllable by Letter Position interaction did, however, reach significance, F (4, 68)=3.49, $p < .05$. Trend analysis of the data graphed in the bottom panel of Fig. 5 revealed a significant difference in quadratic trend between LF-1 and LF-2 words, F (1, 17)=5.31, $p < .05$; as well as a significant quadratic main effect, F (1, 17)=23.47, $p < .01$.

Syllables as Units. In order to provide evidence that syllables function as perceptual units in the identification of words, the following analysis was conducted. If the letters which comprise a syllable are treated as a single unit, then the identification of letters within a syllable should be highly correlated. Therefore, within a syllable, an incorrect report on letter "n" should not be followed by a correct report on letter "n+1". Likewise, within a syllable, a correct report of a letter in position "n" should not be followed by an incorrect report of a letter in position "n+1". The correlation between report

accuracy on position "n" and "n+1" may be assessed by adding the obtained probabilities of the two types of alterations, correct on position "n" and error on position "n+1" plus error on position "n" and correct on position "n+1". A similar analysis was conducted by Spoehr and Smith (1973) and they called the resulting measure the probability of alteration, P(A). The same terminology will be used here. If syllables function as units in word identification, a higher P(A) value should be found for the letter pair where the syllable break occurs in two syllable words as compared to the corresponding pair in one syllable words.

Initially, P(A) values were calculated for each subject at the four possible letter pairs in the five-letter stimuli for the different word types. The mean P(A) values are shown in Fig. 6. Looking at the upper panel depicting high frequency items, one may observe that the P(A) values for the two syllable words are somewhat higher than the values for one syllable words but that the greatest difference occurs at letter pair 2 & 3. It is between these two letters where the syllable break occurs in the two syllable words used in this experiment according to the parsing scheme discussed by Spoehr and Smith (1973).

A two-way repeated measures ANOVA was conducted in order to analyze the data on which the upper panel of Fig. 6 is based. The results indicated significant main effects for Syllables, $\underline{F}$ (1, 17)= 16.98, $\underline{p} < .01$; and for Letter Pairs, $\underline{F}$ (3, 51)=11.37, $\underline{p} < .01$; but the expected Syllables by Letter Pair interaction did not reach significance, $\underline{F}$ (3, 51)=1.45, $\underline{p} < .05$.

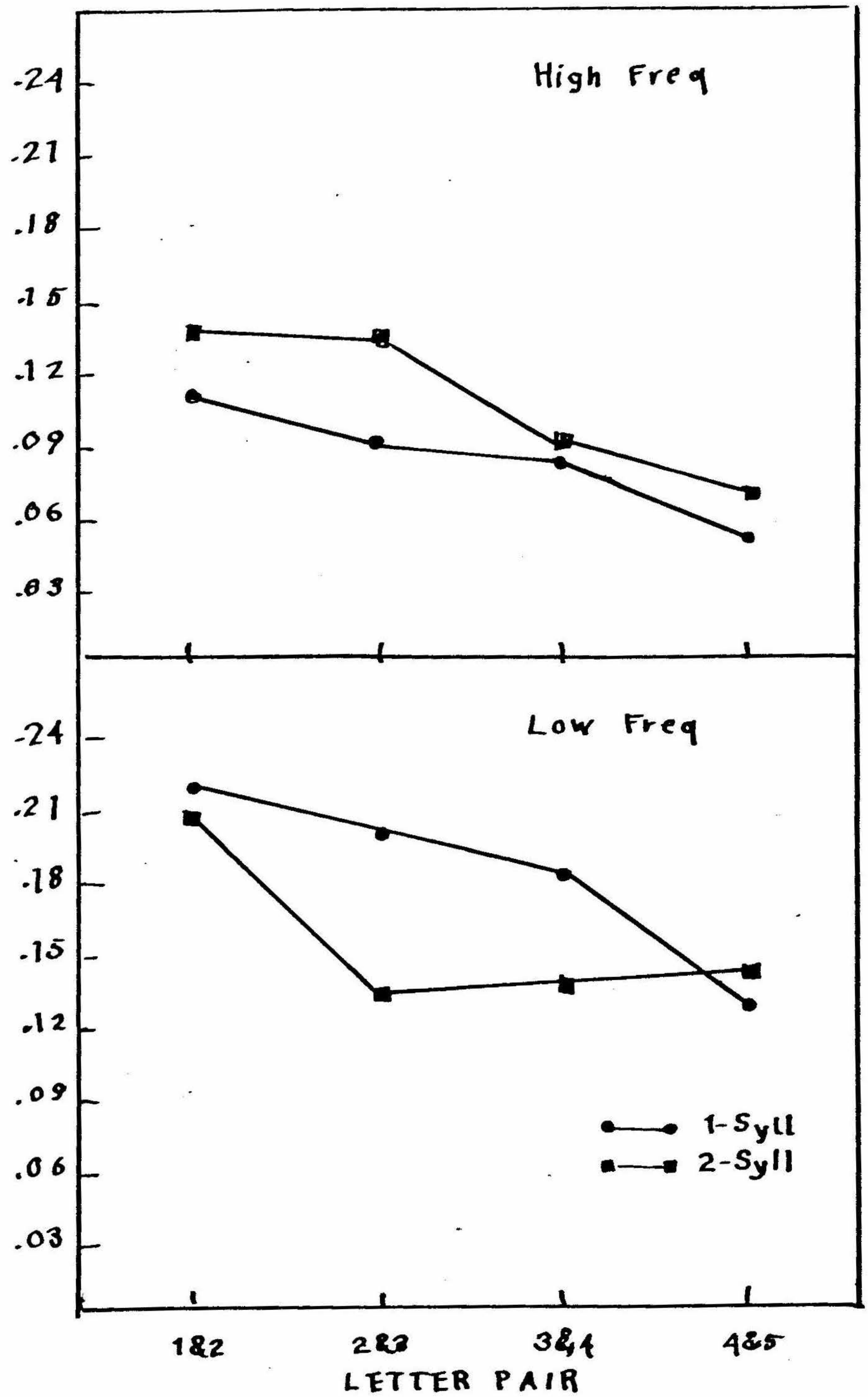

Fig. 6 Mean Probability of Alteration as a Function of Frequency, Number of Syllables, and Letter Pair in Experiment I.

The bottom panel of Fig. 6 shows a markedly different situation for low frequency words. Here, the P(A) values for one and two syllable words are nearly identical for letter pairs 1 & 2 and 4 & 5 but the values for one syllable words greatly exceed the two syllable values for the remaining two pairs. An ANOVA conducted on this data revealed significant main effects for Syllables, F (1, 17)=6.56, $p < .01$; and Letter Pair, F (3, 51)=9.42, $p < .01$; as well as a significant interaction effect, F (3, 51)=3.25, $p < .05$.

Discussion

The results of Experiment I do not support the major prediction drawn from the VCG-Recoding model that one syllable words should result in higher levels of identification than two syllable words for both high and low frequency stimuli. This conclusion may be reached by considering the results of either the whole-word analysis or the letter-analysis although the two analyses produce somewhat different results.

The whole-word analysis indicated that one syllable words do result in superior word identification as compared to two syllable words for high frequency items across all temporal conditions. Therefore, the number of syllabic units does appear to be a factor in the probability of identifying high frequency words. The error data presented in Table 3 are also suggestive of the role of syllables in word identification. The mean proportion of total blank responses was slightly higher for HF-1 as compared to HF-2 words while the mean proportion of partially correct responses was somewhat higher for the two syllable words. These observations lend some credence to the notion that a one syllable word tends to be identified in its entirety whereas a two

syllable word tends to be identified in terms of two units and therefore, more likely to result in a partially correct response. A partially correct response, however, was the most common error for both HF-1 and HF-2 words.

For low frequency items, the whole-word analysis indicated that two syllable words were actually superior to one syllable words. This finding is clearly in contrast with the prediction drawn from the VCG-Recoding model. A tentative explanation might be that the possibility of processing the word in terms of syllable units is actually an aid in the identification of low frequency items which would other wise entail a letter-by-letter analysis.

The consistent advantage of HF-1 words in comparison to HF-2 words across the five levels of ISI also seems to be at variance with earlier speculation about the role of processing time in the VCG-Recoding model. Because of the importance of each of the stages in the model, it would seem that the "syllable effect" should be affected as a limit on processing time disrupts completion of the series of stages. However, Spoehr and Smith's (1975) uncertainty about the temporal relationship between the parsing operation and the phonemic recoding scheme does not allow this finding to be taken as firm evidence against the VCG-Recoding model. The finding, however, does fit easily with earlier speculation about the role of processing time in the Feature Redundancy model.

As mentioned, the results of the letter-analysis are somewhat different as compared to the results of the whole-word analysis. For high frequency items, the proportion of letters identified was sub-

stantially greater for one syllable words. This finding is consistent with the whole-word analysis. However, there was little overall difference in the proportion of letters identified for LF-1 and LF-2 words. The whole-word analysis indicated an advantage for the LF-2 words. The reason for this discrepency is apparently due to the larger number of partially correct responses for LF-1 as compared to LF-2 items.

The most interesting findings of the letter-analysis, however, are the differences observed in the Letter Position curves (cf. Fig. 5). The flat curve for HF-1 items suggests that these words are either reported correctly in their entirety or when an error does occur, it is equally likely in each of the five letter positions. For the HF-2 words, the bow-shaped curve indicates that errors are most likely to appear in the middle of the word at the syllable break. These observations are confirmed to a certain degree by the results of the P(A) analysis. Here, it was discovered that alterations tended to occur more often at the syllable break for two syllable words as compared to the corresponding letter pair for one syllable words. Both the letter-analysis and the P(A) analysis are then suggestive of the role of syllables as a perceptual unit in the identification of high frequency words.

The Letter Position curves for low frequency items present a considerably different picture. The curves for both one and two syllable words are basically bow-shaped in appearance with equally steep drops in the level of letter identification from position 1 to 2. The central portion of the curves, however, are somewhat different. For LF-1 words the level of identification continues to drop sharply from position 2

to 3 but then shows an increase from position 3 to 4. The corresponding portion of the curve for LF-2 words shows a gradual drop in the level of identification from position 2 to 4. Both curves show a rise in the level of identification from position 4 to 5.

The P(A) analysis also reflects differences in the identification of letters across letter position for low frequency items. The P(A) values for the initial letter pair are nearly identical, probably reflecting the initial drop in the level of identification of letters for both one and two syllable words. The P(A) curve for one syllable words shown in the bottom panel of Fig. 6 indicates that the probability of alteration gradually decreases across the four letter pairs. For two syllable words, however, the probability of alteration drops sharply at position 2 & 3 and remains relatively constant across the remaining pairs. The marked differences resulting in the P(A) values for letter pairs 2 & 3 and 3 & 4 are undoubtedly related to the fact that LF-1 words resulted in more partially correct reports whereas LF-2 words produced more All Blank responses.

In contrast to the findings for high frequency words, the letter analysis and P(A) analysis do not clearly implicate a syllable as a perceptual unit in the identification of low frequency words. In general, the highly bow-shaped appearances of LF-1 and LF-2 Letter Position curves seem to suggest a letter-by-letter type of analysis. Such a position predicts decreasing accuracy of letter identification across letter position with the elevated identification of the final letters attributed to a freedom from lateral masking effects (cf. Townsend, Taylor, & Brown, 1971). Nonetheless, the significant statistical

differences in linear trend between the two curves and the differences discovered in the P(A) analysis remain unexplained and a subject for future research.

One final point of discussion which should be raised regarding the results of Experiment I concerns the general adequacy of the full-report responses used in this study. As mentioned previously, this type of response is susceptible to contamination by guessing on the part of the subject. It may then be suggested that the observed differences between one and two syllable words in the two frequency categories may not be due to differences in the items' perceptibility but rather to certain idiosyncratic properties of the words which might differentially affect the possiblities for guessing. That is , the possibility for guessing may not be the same for one and two syllable words within a frequency category. Therefore, two checks were made on this possibility.

The first check was somewhat indirect and involved an analysis of the level of identification for individual items. If guessing were a problem, it might be expected that some items were guessed correctly very often and therefore, resulted in a high level of identification. Should all of these items have only one syllable, for example, an overall advantage for one syllable words could result. Therefore, the proportion of correct whole word reports was determined for each stimulus item. Once these proportions were obtained, the variance among items was calculated for the four stimulus types. It was discovered that the variance for HF-1 (.015) did not differ considerably from the variance for HF-2 words (.023) just as the variance for LF-1 words

(.009) was not noticeabley different from the variance for LF-2 words (.011).

The second check was more direct and involved obtaining a redundancy measure for each stimulus item. Redundancy generally refers to linguistic regularity in a set of letters which makes it possible to predict unidentified letters. The particular measure used here has been called "spatial redundancy" by Mason (1975) and it is specifically defined as the probability of a particular letter falling in a certain position (i.e., the first letter etc.) in a word of a given length. To obtain an overall measure of spatial redundancy for a word, one simply adds the frequency counts provided by Mayzner and Tresselt (1965) showing the number of times that a letter falls in a particular spatial position. As an example, for the word TRAIN, one finds the number of times that T falls in the first position of a five letter word, R in the second position, A in the third, I in the fourth, and N in the fifth and adds these values together. Mason's (1975) research has suggested that this particular measure of redundancy is more important in predicting the ability to identify a set of letters than sequential measures using positional bigram and trigram counts as discussed by Gibson, Shurcliff, and Yonas (1970).

For high frequency items, the mean spatial redundancy measures for one syllable words was 1407.07 as compared to 1285.07 for two syllable words. A correlated t-test was conducted using the redundancy measures for the matched one and two syllable words as the paired observations. The result of this test was not significant, $t\ (28)=.36$, $p < .05$. For low frequency items, the means of the spatial redundancy

measures were 1319 and 1277, respectively, for one and two syllable words. The correlated _t_-test conducted on these measures also failed to reach an acceptable level of significance, _t_ (28)=.06, $p < .05$.

EXPERIMENT II

Experiment II assesses the role of syllables in the identification of words by a population of readers other than college age persons. The subjects were sixth grade students. The basic intent of this study is to determine whether or not the influence of syllabic structure observed in the previous experiment can be generalized to individuals having less experience with the reading process.

The choice of sixth grade students was determined in part by theoretical considerations and in part, by the constraints of the experimental task. Theoretically speaking, previous research has demonstrated that by the third grade, children make efficient use of the presence of SP units in printed material (Gibson et al., 1963; Rosinski & Wheeler, 1972). Earlier discussion has suggested that a syllabic unit may be a dimension along which knowledge of othographic structure is organized other than the notion of SP units. It, therefore, seems reasonable to begin investigating this type of structure at an age somewhat beyond the third grade where SP units are mastered and the child's sight vocabulary consists of a sufficiently large number of words varying in syllable structure.

It should also be noted that Lott and Smith (1973) have shown that a sixth grader's knowledge of sequential redundancy found in English words is equivalent to that of an adult reader. Mason's (1975) research has also shown that by the sixth grade, an individual is capable of using the spatial type of redundancy which she discusses.

These are important considerations in that knowledge of redundancy promotes guessing which, as has been indicated, can influence the full-report responses required in the present research. But because adult and sixth grade individuals have been shown to have similar knowledge of redundancy, it may be reasoned that the guessing strategies of the sixth graders in Experiment II and the college students in Experiment I do not differ substantially as a result of this factor.

On the practical side, pilot work indicated that the sixth grade was the earliest age at which grammar school students could reasonably perform the current experimental task. Younger readers required presentation times of such considerable length that comparisons with the performance of the adults in the previous experiment would be rendered useless if a similar range of presentation times were to be employed for grade school students. Nonetheless, the limited availability of the sixth graders for testing still required certain procedural changes from Experiment I.

Method

Subjects. The subjects were 16 students from the sixth grade at St. Ignatius Grammar School. The students were given one dollar in payment for participation and were required to have normal or corrected-to-normal vision.

Materials and Apparatus. The 60 stimulus words presented in this experiment were identical to those used in Experiment I. The same CRT screen was employed and the size parameters for the stimulus words and the masking stimulus were maintained as was described for the first experiment.

Procedure and Design. Again, a single trial consisted of a stimulus word presented for 15 msec followed by a variable ISI before the onset of the masking stimulus for 500 msec.

An experimental session consisted of 180 trials and lasted approximately 45 minutes. The experiment may be characterized as a 2 X 2 X 3 X 3 within-subjects design where the first two factors refer to the stimulus variables; frequency and number of syllables and the remaining two factors refer to ISI and trial block. The series of test trials was divided into three blocks of 60 trials with each stimulus word occurring in a block. Within a block, 20 words were presented under ISIs of 15, 20, and 25 msec. The 20 words presented at a given ISI were equally divided among the four types of stimulus words (i.e., HF-1, HF-2, LF-1, and LF-2). Across blocks, each word was presented once under the three ISI durations. Five or six subjects were run under three different orderings of the trial blocks.

The subjects were given 15 practice trials at the beginning of an experimental session. Observations were recorded on response sheets like those used in Experiment I. Partial responses were accepted and analyzed and the basic procedural considerations described for the previous experiment were again implemented.

At the completion of the experiment, each student was shown the entire list of stimulus words and asked to indicate what each word meant by providing a definition or by using the word in a sentence. All of the students were able to adequately define the entire set of high frequency items although some low frequency words could not be defined by individual students. Six of the 16 students failed to de-

fine one or more of the low frequency items although no student failed to define more than 3 items. In these cases, the undefined words were not included in the calculation of the subject's percentage of identification.

Results

Whole-Word Analysis. The mean proportion of correct whole-word reports for the various stimulus types at three levels of ISI are shown in Table 5. Examination of the table indicates that one syllable words generally resulted in a higher level of identification than two syllable words for both high and low frequency items. Report accuracy also increased with lengthened ISI but not in an entirely regular fashion for each of the item types.

A four-way repeated measures ANOVA resulted in significant main effects for each of the four independent variables; Frequency, F (1, 15) =111.83, $p < .001$; Syllables, F (1, 15)=8.17, $p \leq .01$; ISI, F (2, 30)= 13.53, $p < .01$; and Trial Blocks, F (2, 30)=35.98, $p < .001$. No interaction effects, however, were significant.

Overall, the mean proportion of high frequency words correctly reported was .71 as compared to .37 for low frequency items. For both high and low frequency items, one syllable words held roughly a 6% advantage over their two syllable counterparts. The mean proportion of HF-1 words correctly identified was .74 as compared to .68 for HF-2 words and the mean proportion of LF-1 words correctly identified was .40 as compared to .34 for LF-2 words.

Collapsed over all other variables, the mean proportions of correct identification for ISIs of 15, 20, and 25 msec were, respective-

Table 5

Mean Proportion of Correct Whole-Word Reports for One and Two Syllable High and Low Frequency Words at Different ISI's in Experiment II

	Inter-Stimulus Interval		
High Frequency	15 msec	20 msec	25 msec
One-Syll.	.70	.78	.75
Two-Syll.	.62	.72	.70
Low Frequency			
One-Syll.	.35	.41	.45
Two-Syll.	.31	.35	.35

ly, .49, .57, and .56. A Newman-Keuls analysis indicated that the level of identification at 15 msec was significantly different from the levels achieved at 20 and 25 msec which did not differ significantly from one another (significant p's .05). Finally, across Trial Blocks, the mean proportions of correct report were .43, .59, and .62.

Errors. The incorrect responses in the whole-word analysis were further assessed in the manner described for the first experiment. Table 6 shows the overall proportion of the three types of errors as well as the overall proportion correct. For all item types, Partial Correct responses were the most common type of error with Total Blank responses being more common than All Wrong responses.

Again, as in Experiment I, the proportion of each type of incorrect response in a subject's total errors for the different item types was determined. The resulting mean proportions are found in Table 7. For high frequency items, it may be observed that there is little difference between one and two syllable words in each of the error categories. For low frequency items, however, more partially correct responses are associated with one syllable words and more totally blank responses are discovered for two syllable words.

Letter Analysis. Table 8 shows the mean proportion of letters correctly identified for each combination of the Frequency, Syllable, ISI, and Letter Position variables. The data on which these means are based was first analyzed in a four-way repeated measures ANOVA. Significant main effects were found for Frequency, $F\ (1, 15)=58.44$, $p < .01$; for Syllables, $F\ (1, 15)=16.52$, $p < .01$; for ISI, $F\ (2, 30)=18.05$, $p <$

Table 6

Overall Proportion of Correct Word Identification and Partial Correct, All Wrong, and All Blank Errors for Four Item Types in Experiment II

	Type of Response			
High Frequency	All Correct	Partial Correct	All Wrong	All Blank
One-Syll.	.68	.14	.06	.11
Two-Syll.	.65	.15	.08	.12
Low Frequency				
One-Syll.	.37	.38	.08	.17
Two-Syll.	.32	.33	.09	.25

Table 7

Mean Proportion of Partial Correct, All Wrong, and All Blank Errors for Four Item Types in Experiment II

	Type of Error		
High Frequency	Partial Correct	All Wrong	All Blank
One-Syll.	.46	.18	.36
Two-Syll.	.46	.17	.37
Low Frequency			
One-Syll.	.61	.12	.26
Two-Syll.	.50	.13	.37

Table 8

Mean Proportion of Letters Correctly Identified

in Experiment II

ISI	Letter Position	Type of Item: High Freq. One-Syll.	High Freq. Two-Syll.	Low Freq. One-Syll.	Low Freq. Two-Syll.
15 msec					
	1	.74	.68	.62	.53
	2	.70	.65	.55	.45
	3	.70	.62	.45	.40
	4	.67	.62	.48	.42
	5	.68	.67	.51	.50
20 msec					
	1	.79	.80	.65	.58
	2	.77	.76	.60	.43
	3	.74	.72	.51	.39
	4	.77	.73	.56	.42
	5	.79	.75	.58	.47
25 msec					
	1	.77	.79	.64	.54
	2	.77	.76	.63	.45
	3	.73	.72	.55	.41
	4	.75	.70	.59	.42
	5	.76	.73	.63	.49

.01; and for Letter Position, F (4, 60)=7.34, $p < .01$. The following interactions also reached an acceptable level of significance; Frequency by Syllables, F (1, 15)=15.71, $p < .01$; Frequency by Letter Position, F (4, 60)=6.65, $p < .01$; and Frequency by Syllables by Letter Position, F (4, 120)=2.82, $p < .01$.

The three-way interaction is graphed in Fig. 7. It may be readily discerned that the Letter Position curves for high and low frequency items are markedly different in shape. For high frequency items, both one and two syllable words produce slightly bow-shaped curves. On the other hand, the curves for low frequency words are highly bow-shaped in appearance. One should also observe that while the level of correct identification is consistently higher for one syllable words at each letter position for both high and low frequency items, the differences are considerably more pronounced for the low frequency stimuli.

Because all of the significant interactions involved word frequency it was again decided to separately analyze the data in each frequency category. This entailed two three-way repeated ANOVAs considering Syllables, ISI, and Letter Position as the independent variables.

The ANOVA for high frequency words resulted in significant main effects for ISI, F(2, 30)=13.33, p .01; and for Letter Position, F (4, 60)=3.86, $p < .05$. The main effect for Syllables failed to reach significance, F (19, 15)=2.42, $p < .05$ as did the Syllable by Letter Position interaction, F (4, 60)=1.55, $p < .05$. The Syllable by ISI by Letter Position interaction did, however, reach an acceptable level of significance in this analysis, F (8, 120)=2.82, $p < .01$. Fig. 8 shows that the nature of this interaction is obviously due to variations in the Letter

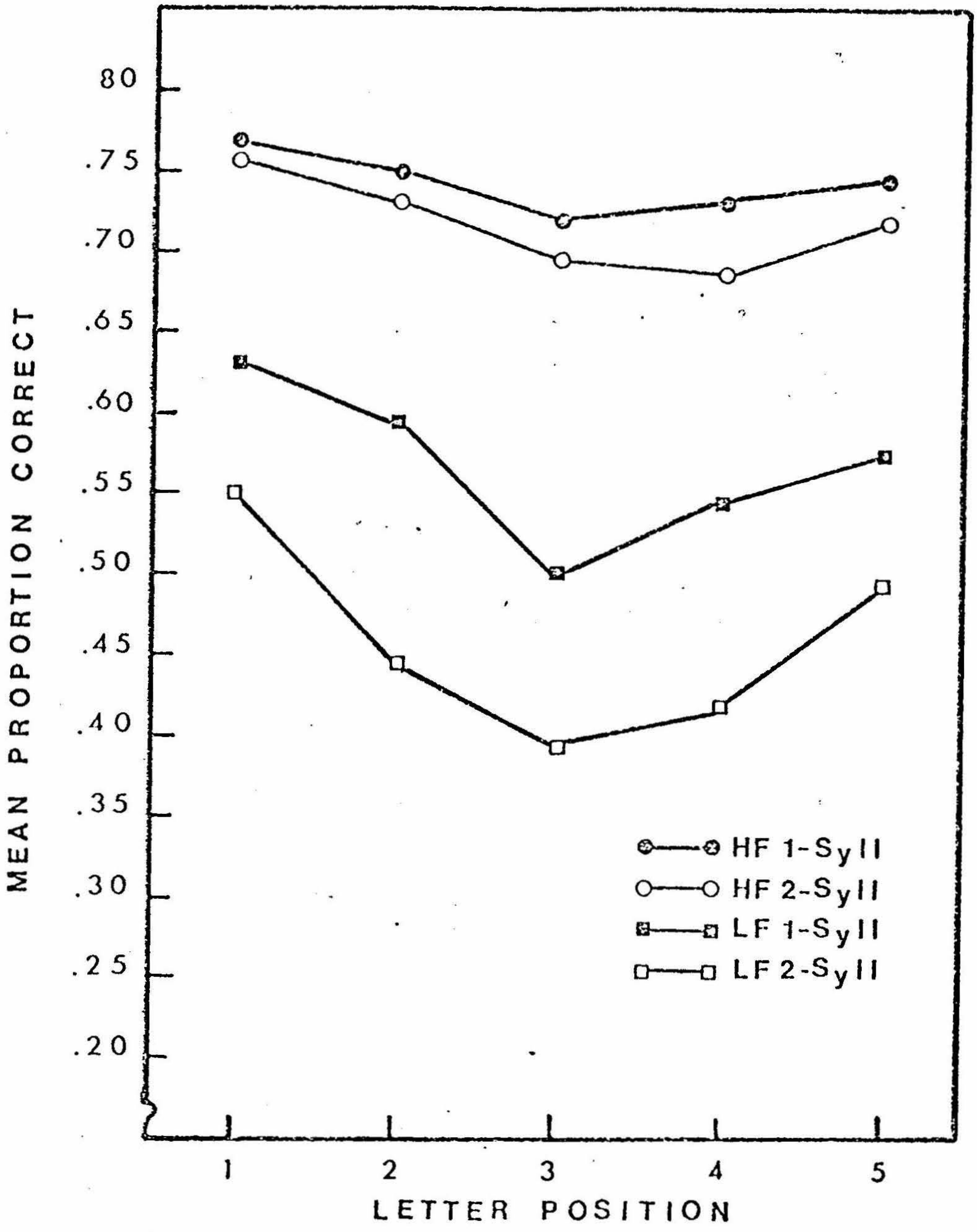

Fig. 7 Mean Proportion of Letters Correctly Identifed as a Function of Frequency, Number of Syllables, and Letter Position in Experiment II.

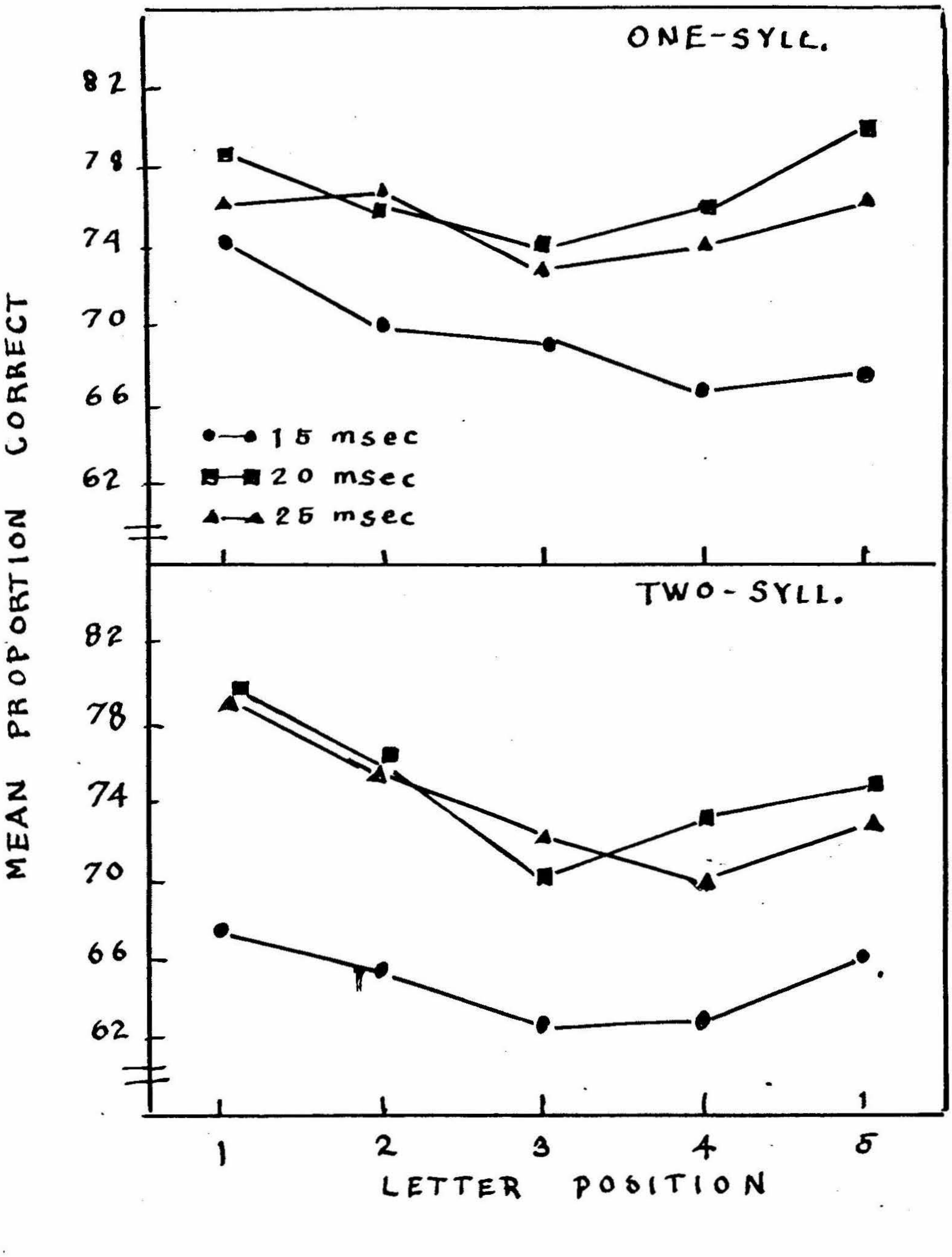

Fig. 8 Mean Proportion of Letters Correctly Identified in High Frequency Words as a Function of Number of Syllables, ISI, and Letter Position in Experiment II.

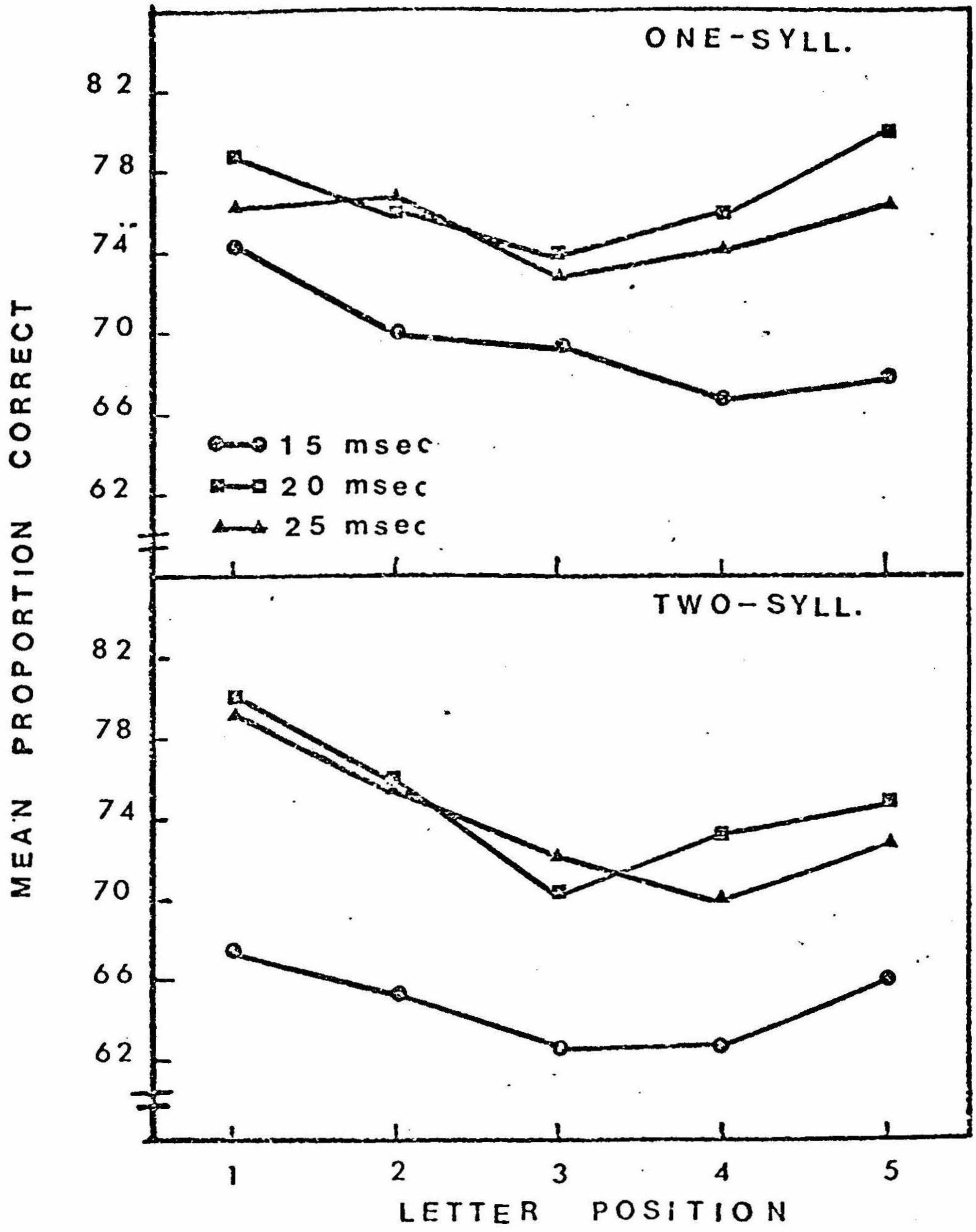

Fig. 8 Mean Proportion of Letters Correctly Identified in High Frequency Words as a Function of Number of Syllables, ISI, and Letter Position in Experiment II.

Position curves associated with the various ISIs for one and two syllable words. The significance of this pattern of variation, however, is not readily apparent at the present time.

The separate ANOVA for low frequency items found that all three of the main effects were significant; Syllables, $\underline{F}$ (1, 15)=25.27, $\underline{p} <$ .01; ISI, $\underline{F}$ (2, 30)=5.15, $\underline{p} <$.05; and Letter Position, $\underline{F}$ (4, 60)=8.63, $\underline{p} <$.05; as well as the Syllables by Letter Position interaction, $\underline{F}$ (4, 60) =4.18, $\underline{p} <$.05. Trend analysis revealed a significant quadratic component in the curves for both LF-1 and LF-2 words, $\underline{F}$ (1, 15)=30.24, $\underline{p} <$ .01; as well as a significant difference in quadratic trends between the two curves, $\underline{F}$ (1, 15)=4.76, $\underline{p} <$.05.

Syllables as Units. In order to more carefully assess the influence of syllabic structure in the identification of words, a P(A) analysis such as that described for the previous experiment was conducted. The major findings of this analysis are graphed in Fig. 9.

Looking first at the curves for high frequency items, there appears to be no substantial difference in the probability of alteration between one and two syllable words at any of the letter pairs. A two-way repeated measures ANOVA conducted on the P(A) values for high frequency words bears this observation out in that the only significant source of variation was attributable to Letter Pairs, $\underline{F}$ (3, 45)=5.47, $\underline{p} <$.05. Neither the main effect for Syllables nor the interaction was significant.

For low frequency items, the situation is considerably different. At letter pairs 1 & 2 and 4 & 5, the P(A) values for one and two syllable words are nearly identical. For the middle two letter pairs, the

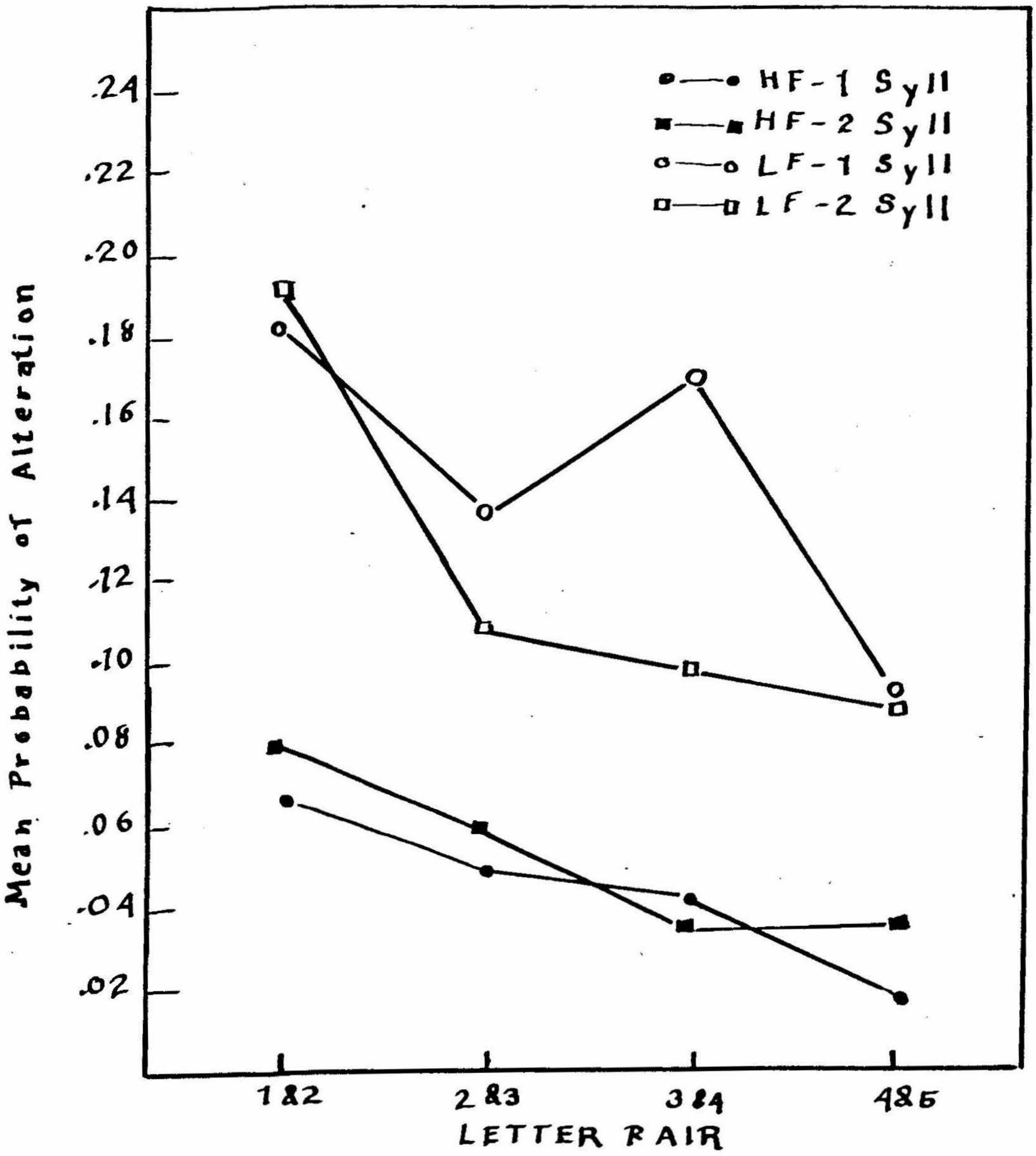

Fig. 9 Mean Probability of Alteration as a Function of Frequency, Number of Syllables, and Letter Pair in Experiment II.

P(A) for one syllable words are considerably higher than the corresponding values for two syllable words; this is particularly the case at letter pair 3 & 4.

These observations are confirmed in a two-way repeated measures ANOVA conducted on the P(A) values for low frequency items. The results of this analysis produced a significant main effect for Letter Pair, F (3, 45)=10.47, $p < .01$, as well as a significant Syllable by Letter Position interaction, F (3, 45)=4.26, $p < .05$.

Discussion

The results of Experiment II provide some indication that syllable structure may influence the identification of words by sixth grade students although in considering the entire pattern of results in this experiment, the exact nature of this influence remains unclear. Additionally, an analysis of report accuracy for individual stimulus items suggests that differences in inter-item variability for the various stimulus types may be a potentially confounding factor in interpreting the results of the present experiment. This problem will be considered in more detail in the following discussion.

To begin with, the whole-word analysis presents findings that are generally in keeping with the major premise of the VCG-Recoding model. That is, one syllable words resulted in higher levels of identification than two syllable words for both high and low frequency items. At a first glance, this finding would suggest that syllable structure plays a straightforward role in word identification with one syllable items tending to be processed in their entirety as a single unit and hence, more accurately identified and two syllable items

processed in terms of two units and hence, more likely to result in a partial report. The error data presented in Table 7 do not, however, support this interpretation. There is virtually no difference in the mean proportion of All Blank and Partial Correct responses for one and two syllable high frequency words and the opposite of what would be expected under this interpretation for low frequency items.

The letter analysis also detracts from the findings of the whole-word analysis. While the proportion of letters identified for HF-1 words was somewhat higher than for HF-2 words, the separate ANOVA conducted on high frequency items failed to produce a significant main effect for syllables. Even more importantly, inspection of the Letter Position curves for high frequency items shown in Fig. 7 fails to reveal the marked differences in the shape of the curves for HF-1 and HF-2 words as was observed in the previous experiment with college students. The level of letter identification for two syllable words does not tend to drop sharply at the middle letter position where the syllable break occurs.

Furthermore, the P(A) analysis provides no clue that syllables serve as perceptual units in the identification of high frequency words in this experiment. The probability of alteration was not higher for two syllable words at Letter Pair 2 & 3 where the syllable break occurs as compared to the corresponding pair in the one syllable words. In fact, the P(A) curves for HF-1 and HF-2 words shown in Fig. 9 are very similar across all letter pairs.

For low frequency items, the letter analysis did confirm the advantage for one syllable words found in the whole-word analysis.

However, the Letter Position curves for LF-1 and LF-2 words are both essentially bow-shaped and do not point to any obvious differences in the performance between one and two syllable words other than the overall differences in the level of word identification.

The findings of the P(A) analysis also do not clearly implicate syllable structure in the identification of low frequency items. In fact, one syllable words show a higher probability of alteration at the middle letter pairs; this is contrary to what would be expected if syllables were functioning as perceptual units. Careful examination of the subjects' protocols does, however, suggest a reason for the considerably higher P(A) values at letter pairs 2 & 3 and 3 & 4 for one-syllable words. It was discovered that in response to the one syllable stimulus, BELCH, nearly all subjects reported either the word, BENCH, or the word, BEACH, when a complete response was given (i.e. five letters were reported). This tendency would then result in many alterations from positions 2 to 3 as well as alterations from positions 3 to 4. Presuming that this unusual occurence can account for much of the difference in the P(A) values at these letter pairs, the curves for the LF-1 and LF-2 words would then be fairly similar in shape.

As a final note, the results of Experiment II must be interpreted with considerable caution in light of the findings of an item analysis similar to the one described for the previous experiment. This cautionary note particularly applies to the findings regarding low frequency items. After calculating the proportion of correct whole-word reports for each stimulus item, the variance among items within each stimulus category (i.e. HF-1, HF-2, LF-1, LF-2) was computed. It was

discovered that the variance among LF-2 words was substantially larger than the variance among LF-1 words. This difference in variability is apparently due to four LF-2 words (gamut, harem, pagan, and cadet) which resulted in very low levels of identification (less than 10%) as compared to the remaining LF-2 words and hence, served to lower the overall level of identification for LF-2 items. No substantial differences in inter-item variability was discovered, however, between one and two syllable high frequency items.

EXPERIMENT III

Experiment III is an attempt to generate evidence for the phonemic recoding scheme proposed by Spoehr and Smith (1975). Essentially, Spoehr and Smith maintain that identification accuracy is determined in part by the amount of recoding that must be undertaken in translating visual information into phonemic form. At present, however, evidence for the process rests entirely on differences observed in the tachistoscopic recognition of pronounceable and unpronounceable letter strings. There is no sound evidence that the phonemic recoding scheme can predict report accuracy for actual English words which differ in the amount of phonemic recoding specified under the Spoehr and Smith (1975) scheme although it is presumed that such is the case.

In the current experiment, a set of five-letter words, all having a single syllable, were presented to both sixth grade and college students. The words were varied according to their frequency values (high and low) and according to the number of nodes that would be generated in a Spoehr and Smith (1975) recoding diagram.

For college students, the VCG-Recoding model predicts that report accuracy will decrease with greater amounts of phonemic recoding (i.e more generated nodes) for both frequency levels. Because all the words only contain one VCG (i.e., the parsing process should not be involved), it would seem that the same prediction would be made under the VCG-Recoding model for the sixth grade students. Phoneme-grapheme correspondences are important in phonemic recoding and the children pre-

sumably know these (cf. Gibson et al., 1963; Rosinski & Wheeler, 1972).

On the other hand, the Feature Redundancy model clearly predicts that no differences should be found in report accuracy for high-frequency words by the college students. This prediction follows from the position taken by F. Smith (1971) that fluent readers identify common words as whole units with no intermediate acoustic recoding. It may be expected, however, that phonemic recoding may play some role in the identification of low frequency words by college students and in the identification of both high and low frequency words by sixth-grade students. According to the Feature Redundancy model, phonemic recoding will be implicated in mediated word identification when higher-order schemas are not available. In short, the mediated word identification is likely to occur when the reader's own experience is lacking or when the graphic material is particularly unfamiliar.

Method

Subjects. The subjects were 11 volunteer college students and 11 students from the sixth grade at St. Ignatius Grammar School. The grammar school students were paid for participation. All subjects were required to have normal or corrected-to-normal vision.

Material and Apparatus. The stimulus words were 54 one syllable words, five letters in length. Twenty-seven of these stimuli were high frequency A or AA words as listed in the Thorndike-Lorge count. The remaining 27 stimuli were low frequency words with listings netween one and fifteen times per million. For both high and low frequency items, the words were also varied with respect to the amount of phonemic recoding

specified by the Spoehr and Smith (1975) scheme whereby visual information is translated into acoustic representations. Nine words within each frequency type required the generation of three levels of recoding and 8 total nodes in the diagramatic scheme described by Spoehr and Smith. An additional nine words also required three levels of recoding but only six total nodes. The remaining nine words within each frequency category necessitated the generation of two levels of recoding and four total nodes. These six different types of items will be referenced with regard to the number of nodes generated and designated in the following manner: HF-8N, HF-6N, HF-4N, LF-8N, LF-6N, and LF-4N. Examples of the different item types are shown in Fig. 10 with accompanying recoding diagrams as would be generated under the Spoehr and Smith (1975) scheme.

The stimuli were displayed on a CRT screen as described for Experiments I and II with a subsequent masking stimulus identical to that used in the previous experiments.

Procedure and Design. Each subject was presented 162 trials during a 45 minute experimental session. The series of trials was divided into three blocks of 54 items with each stimulus word being presented within a block. On each trial, the stimulus word was displayed for 15 msec with an ISI of 15 msec prior to the onset of the masking stimulus for 500 msec. The items were randomly positioned within each block of trials and three different order of the blocks were presented during the experiment. In each age group, four subjects were tested under two of the orders and three subjects were tested under the third.

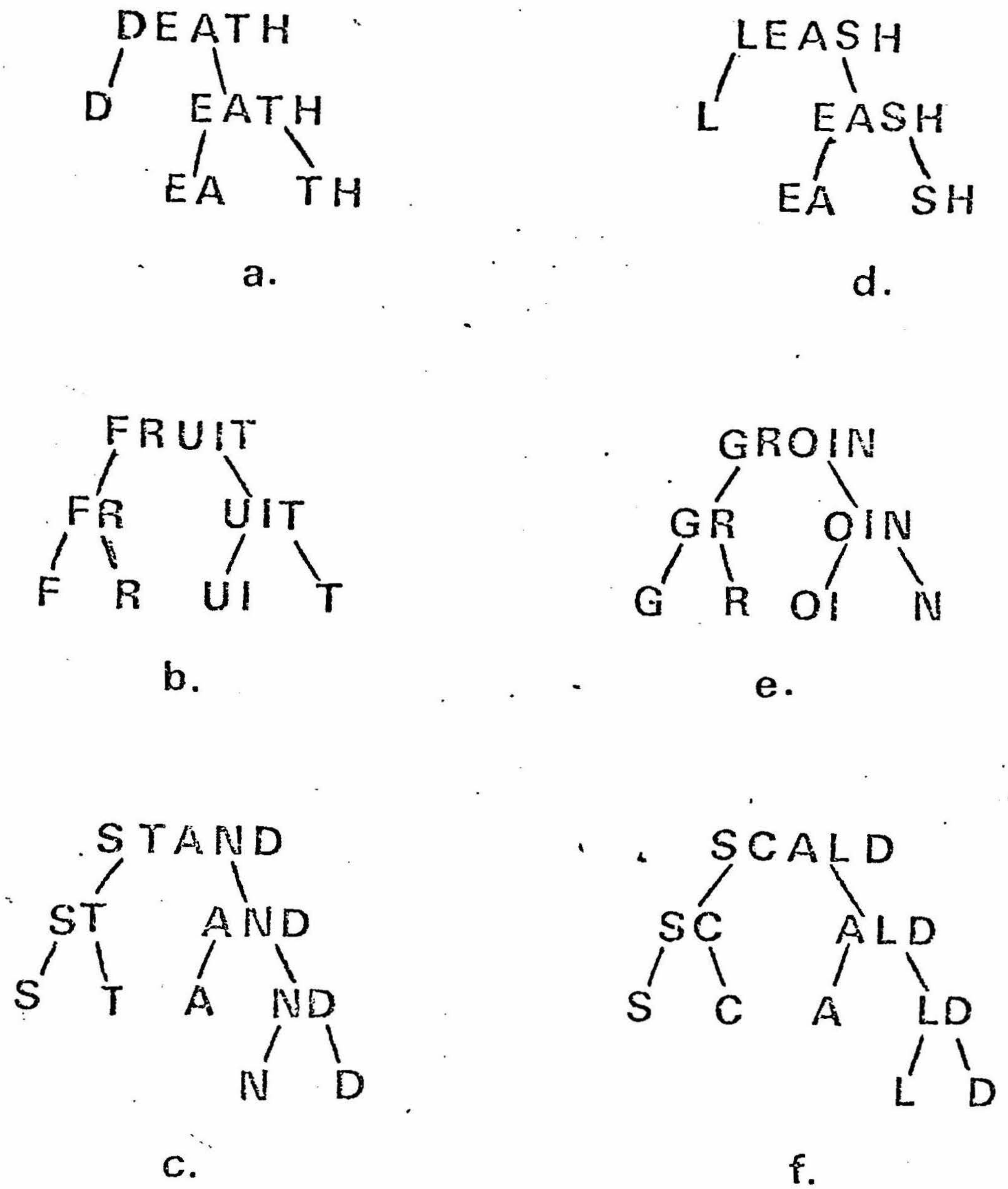

Fig. 10 Sample Stimuli with Accompanying Recoding Diagrams for Experiment III.

The basic testing procedure described for the previous experiments was followed. The subjects were given 15 practice trials at the outset of a session and short rest periods were installed after each block of 54 trials. Observations were recorded on response sheets like those used in the first two experiments. Partial responses were again accepted and analyzed.

Results

The performance of the college students and the sixth-grade students in Experiment III was analyzed independently. For both, a whole-word analysis and a letter analysis were conducted.

College Students. The upper portion of Table 9 presents the mean proportion of correct whole-word reports for the various stimulus types. Examination of the table indicates that high frequency words generally resulted in a higher level of identification than low frequency words but that there does not appear to be any systematic differences in the identification of high and low frequency words due to the number of nodes generated for the items under the Spoehr and Smith (1975) phonemic recoding scheme. A three-way repeated measures ANOVA considering Frequency, Nodes, and Trial Blocks as the independent variables confirmed these observations. A significant main effect was discovered for Frequency, F (1, 10)=62.41, $p < .01$; and for Trial Blocks, F (2, 20)=7.02, $p < .01$ while the main effect for nodes failed to reach significance. In addition, none of the interaction effects reached an acceptable level of significance

Overall, the mean proportion of high frequency words identified

Table 9

Mean Proportion of Correct Whole-Word Reports

in Experiment III

	Number of Nodes		
College Students	4	6	8
High Freq.	.72	.74	.73
Low Freq.	.48	.49	.47
6th-Grade Students			
High Freq.	.79	.78	.76
Low Freq.	.40	.41	.40

was .73 as compared to .48 for low frequency items. Performance increased regularly over trial blocks with the following mean proportions of correct identification associated, respectively, with the three experimental blocks; .54, .61, and .67.

To further analyze the performance of the college subjects, a letter analysis was conducted in which the proportion of all letters corrertly reported in their appropriate position taken into account. To do this, a three-way repeated measures ANOVA was conducted with Frequency, Nodes, and Letter Position being treated as the independent variables. Again, a significant main effect was discovered for Frequency, $\underline{F}$ (1, 10)=30.95, $\underline{p} < .01$. The proportion of letters correctly identified was .82 for high frequency words and .69 for low frequency words. Letter Position also produced a significant main effect, $\underline{F}$ (4, 40)=4.96, $\underline{p} < .05$. Across positions in a word the mean proportions of letters correctly identified were .81, .78. .73, .71, and .74. As in the whole-word analysis, however, the main effect for Nodes did not reach significance nor did any of the interaction effects.

Sixth-Grade Students. The results for the grade school students are very similar to those obtained for the college students. The lower portion of Table 9 shows the mean proportion of correct whole-word reports made by the sixth-graders for the different stimulus types. Here again, it may be noted that high frequency words tend to produce a higher level of identification as compared to low frequency words but that the number of nodes generated under the Spoehr and Smith (1975) scheme does not substantially influence the identification of either high or low frequency items. A three-way repeated measures ANOVA conducted on

the sixth-graders' whole-word data produced significant main effects for Frequency, F (1, 10)=61.13, $p < .01$; and for Trial Blocks, F (2, 20)= 24.68, $p < .01$. The main effect for Nodes, however, as well as all interaction effects were not significant.

Overall, the mean proportion of correct whole-word reports by sixth-graders was .78 for high frequency words and .40 for low frequency words. Again, performance increased regularly across the three trial blocks. The mean proportion of correct identification was .52 for Block 1, .60 for Block 2, and .66 for Block 3.

A letter analysis was also conducted by means of a three-way repeated measures ANOVA considering Frequency, Nodes, and Letter Position as the independent variables. The results were the same as the corresponding analysis for the college students. A significant main effect was discovered for Frequency, F (1, 10)=48.54, $p < .01$; and for Letter Position, F (4, 40)=13.08, $p < .01$; but once again the main effect for Nodes did not reach an acceptable level of significance as was also true for all of the interaction effects. The mean proportion of letters correctly identified for high frequency words was .84 and .62 for low frequency words. For letter positions 1 to 5, the mean proportions of letters correctly identified were, respectively, .81, .72, .69, .68, and .74.

Discussion

The results of Experiment III are clearly in conflict with expectations drawn from the VCG-Recoding model. This model predicts that the identification of both high and low frequency items should decrease as the amount of phonemic recoding becomes greater. However,

neither the college students or the sixth grade students provide evidence that the level of word identification is influenced by the number of nodes generated under the Spoehr and Smith (1975) phonemic recoding scheme.

While these findings are certianly not consistent with the VCG-Recoding model, they also are not clearly supportive of predictions based on the Feature Redundancy model. The Feature Redundancy model does predict that the amount of phonemic recoding (i.e. the number of nodes) should not influence the identification of high frequency words by college students. Presumably, complete schemas of feature information are established for these words and thus preclude the necessity for phonemic recoding. The Feature Redundancy model, however, also predicts that the identification of low frequency items by college students should be influenced to some extent by the amount of required recoding because these items are likely in some instances to require a sound-mediated form of identification. Additionally, the Feature Redundancy model expects the role of phonemic recoding to be especially evident in the identification of low frequency items by sixth grade students where complete visual schemas are probably not established and sound-mediated identification is most likely to occur. Neither of these latter two expectations, however, are confirmed by the results of Experiment III.

The total null effect found for the number of nodes contained in the stimulus items, therefore, seems to suggest that the Spoehr and Smith (1975) recoding scheme is not an adequate way to conceptualize the process of phonemic or acoustic recoding required in the identifica-

tion of words. It should be remembered that Spoehr and Smith developed the recoding scheme on the basis of research predicting differences in report accuracy between pronounceable and unpronounceable letter strings, and that, perhaps, the scheme does not fully apply in the identification of actual words.

GENERAL DISCUSSION AND CONCLUSIONS

The present research has focused on two major issues, the role of syllables and the role of phonemic or acoustic recoding in the identification of words by both children and adults. In this closing discussion, the major findings regarding these issues will be summarized in light of the two models of word identification described earlier in this paper. Additionally, a cursory discussion of the general meaning of perceptual processing during reading will also be included.

The Role of Syllables

The performance of college students in Experiment I demonstrates that syllable structure can influence the identification of words. The findings, however, indicate that the "syllable effect" discovered by Spoehr and Smith (1973) applies only to the identification of high frequency items. That is, one syllable words result in a higher level of report accuracy than two syllable words only in the case of familiar stimuli. Supplementary analyses considering the identification of individual letters, the nature of response errors, and the processing of syllables as units all provide some indication that syllables tend to function as single units in the identification of high frequency words.

The findings of Experiment I regarding low frequency items are considerably different. Analysis of the data in terms of whole-word reports indicates that two syllable words actually result in a higher level of identification than comparable one syllable items. However,

analyzing the data in terms of individual letters shows that there is little overall difference in the proportion of letters identified for one syllable and two syllable low frequency words. Error data clearly show that this lack of difference in the proportion of letters identified is due to more partially correct responses for one syllable words combined with more complete ommissions for two syllable words. Also, the shape of the Letter Position curves shown in Fig. 6 for low frequency items suggests that there is a tendency for both one and two syllable words to be processed on a letter-by-letter basis in some instances. Therefore, the superiority of two syllable words in the low frequency stimulus category must be limited to the subjects' ability to provide correct whole-word reports.

The differential effect of syllable structure for high and low frequency words points out that the VCG-Recoding model is not an adequate explanation of the processing of printed English words. According to this model, one syllable words should have resulted in superior identification in both frequency categories. The rationale for this prediction lies in the fact that the VCG-Recoding model views the formation of syllable-like units via a parsing process as an intermediate step in the identification of words which facilitates an appropriate recoding of visual information into a phonemic form. This recoding is believed to occur in the identification of all alphabetic stimuli whether they be pronounceable pseudowords, infrequent words, or highly common words. The recoding of a single syllable unit is presumed to be easier than the recoding of two syllable units and hence, the predicted superiority of one syllable words in both frequency cat-

gories. The present findings, however, indicate that the processes set out in the VCG-Recoding model are not universally applicable to the identification of words varying in familiarity.

As indicated earlier, no specific predictions have been drawn from the Feature Redundancy model regarding the role of syllables in the identification of high and low frequency words by skilled readers. Instead, it has merely been noted that this model assumes schemas of feature information are stored in memory and that these schemas are matched against extracted information during the identification of words. According to F. Smith (1971), the schemas may represent a letter or some higher-order unit such as a spelling pattern or even an entire word. The basic premise of the Feature Redundancy model is that higher-order schemas are employed whenever possible in the identification which precludes an entirely letter-by-letter analysis with subsequent recoding into sound. The possibility, however, has been raised in the present paper that syllable structure might be another dimension along which schemas of visual information could be organized.

The pattern of results obtained in Experiment I is suggestive of this possibility. Using the basic ideas concerning visual schemas incorporated in the Feature Redundancy model, the following interpretation may be given to the findings of Experiment I.

Schemas of feature information along the lines of syllable structure are developed by college students as a result of experience with the reading process. For frequently encountered items, syllable structure would dictate that a single schema be organized for the identification of one syllable words. For two syllable words, however,

syllable structure would tend to work against organizing a schema for the entire word and identification would tend to proceed in terms of schemas representing the individual syllable units with some combinational process being necessary for identifying the word as a whole. This added processing would then explain the poorer identification of familiar two syllable items in the present research.

For unfamiliar words, however, the situation is different. Although the structure of a one syllable word encourages the development of a single schema, the infrequent occurrence of some single syllable words makes it unlikely that such a schema will be organized. Therefore, the only recourse for identifying low frequency one syllable words is on a letter-by-letter basis with, perhaps, the aid of a schema for a common spelling pattern as discussed by Gibson (1970). For infrequent two syllable words, however, the syllable structure will still, in some cases, make it possible to employ schemas for common syllable units and, therefore, less likely that identification will entail a letter-by-letter analysis.

The important point which should be noted in this interpretation based on the Feature Redundancy model is that the process of word identification depends upon the characteristics of the material to be identified as well as the reader's experience with this material. These are considerations that are not taken into account in the VCG-Recoding model.

The purpose of the second experiment in the current investigation was to consider in greater detail the relationship between stimulus characteristics and the subject's experience with the reading process.

To do this, the role of syllables in the identification of words by grade school students was studied.

Unfortunately, it is difficult to give an entirely reliable interpretation to the performance of the sixth grade students tested in Experiment II. This difficulty is due to the findings of an item analysis. Very poor levels of identification for some low frequency items makes it dangerous to attribute the overall difference in identification between one and two syllable low frequency words soley to the general characteristics of syllable structure. Extensive analysis of these words in terms of their orthographic characteristics, however, has failed to reveal any specific property responsible for such low levels of performance. But, perhaps, this finding, in itself, serves to point out the importance of assessing the relationship between stimulus characteristics and the reader's experience with stimulus material before developing wide-ranging models of word identification.

If only the identification of high frequency words by sixth grade is considered, where item differences are not a problem, one still sees apparent contrasts with the performance of the college students. For whole-word reports, one syllable words are identified at a higher level than two syllable words. However, the difference between one and two syllable items is not as great as the difference observed for the college students. Comparing the overall proportion of one and two syllable words identified by college students (cf. Table 2) with the overall proportion of one and two syllable words identified by grade school students (Table 6), it may be noted that one syllable words hold roughly an 8% advantage for the older subjects but

just under a 4% advantage for the younger subjects.

Even more important is the fact that the difference between one and two syllable words is not statistically significant when the proportion of letters identifed is considered. Also, the Letter Position curves shown in Fig. 8 as well as other supplementary analyses fail to provide strong evidence that syllables are being treated as units in the processing of high frequency words by sixth graders. At the present time, however, further speculation about the performance of sixth grade students does not seem warranted in light of the problem mentioned above regarding the low frequency items. But to reiterate, future research dealing with the processing of words should carefully assess the nature of the stimulus material as well as the subjects' experience with the material and the reading process in general before models of word identification are attempted.

The Role of Phonemic Recoding

The results of Experiment III have failed to provide evidence that phonemic recoding as envisioned by Spoehr and Smith (1975) influences the identification of either high or low frequency words. As previously mentioned, the lack of correspondence between amount of recoding and levels of report accuracy is totally at odds with the VCG-Recoding model which includes the translation of visual information into a sound form as an important and final stage in the process of identifying words. But even the Feature Redundancy model expects that some acoustically mediated recoding is necessary when stimulus material is particularly unfamiliar.

It appears that the most parsimonious explanation of the present

findings is that the phonemic recoding scheme developed by Spoehr and Smith simply does not reflect the manner in which necessary acoustic recoding occurs during the identification of actual words. While the phonemic recoding scheme as operationalized in the present experiment may predict differences in the identification of unrelated letter strings and pronounceable pseudowords as demonstrated by Spoehr and Smith (1975), further evidence is necessary to demonstrate that it accurately reflects the processes occurring during reading.

The Meaning of Perceptual Processing

In this final section, attention will be briefly directed to a more general issue concerning word identification. This issue deals with the way in which different researchers have defined perceptual processing. Hopefully, it will become evident that, at the present time, the manner in which a researcher interprets experimental findings depends to a certain extent on his initial definition of the perceptual process.

As noted in the introduction to this paper, considerable debate has centered around the notion of higher-order perceptual units in the processing of words. Some investigators who have reported "Familiarity Effects" have argued that processing must occur in terms of orthographic units larger than a single letter (cf. Kreuger, 1975). The concept of visual schemas developed in the Feature Redundancy model is an example of this point-of-view. The VCG-Recoding model also included the notion of higher-order perceptual units. The point of contrast between these two models was not the existence of higher-order units but rather their specific role in the overall identification process.

Other investigators, however, have presented arguments suggesting that there is no such thing as a higher-order perceptual unit and that "Familiarity Effects" are actually due to guessing or response strategies employed by subjects who take advantage of the redundancy present in English words (cf. Thomson & Massaro, 1973; Massaro, 1973). These investigators believe that the letter is the only true unit of perception

Before one can truely comment on the validity of either sides' arguments, however, one must carefully examine the definitions of perception which they bring to their experimental work. In particular, how do they distinguish between perceptual and nonperceptual processes? It appears that this very basic consideration is the source of much of the controversy surrounding the notion of higher-order perceptual units.

For illustrative purposes, let us consider the work of one researcher advocating the single letter position. Massaro (1973), for example, has argued that feature information (i.e. lines, curves, etc.) resides in individual letter characters and, therefore, it is only a letter that can be identified soley on the basis of visual information. When the appropriate features are detected, a letter is perceived. According to Massaro (1973), any process which makes use of other information such as orthographic regularity is actually inferential in nature; capable of modifying the probability of reporting letters when they are presented in strings but not truely perceptual in nature. What all of this means, however, is that Massaro has primarily limited his definition of perception to an extraction process in which the visual system detects the feature properties of alphabetic characters.

As indicated by Smith and Spoehr (1974), nearly all investigators include such a process in their definition of perception but as we shall see shortly, a second process known as "matching" is often included under the heading of perceptual processing.

To return to Massaro's (1973) work, it should be noted that the experimental paradigm on which he bases his conclusions required that the subjects merely detect one of two possible letters throughout the experiment. One of the letters was either presented alone or in the context of a word or random letter string. The failure to find a facilitative effect for letters presented in orthographically regular contexts was taken as evidence that a letter is the true unit of perception and that evidence for higher-order perceptual units is lacking when redundant sources of information are properly controlled. The introduction of the present paper has already presented a fuller discussion of Massaro's (1973) reasoning.

Considering the present experimental work in light of Massaro's (1973) view of perception, the findings regarding syllable structure would not be attributed to the functioning of a syllable as a perceptual unit but rather to some differences in the orthographic regularity of words varying in syllable structure which affects the probability of providing a correct response.

The objection, however, must be raised that Massaro's (1973) experimental task very likely directs the subjects' attention to merely detecting the predetermined letters; a strategy which may not at all reflect the process engaged by an individual attempting to identify actual words. It may be suggested that Massaro's definition of per-

ception influenced the nature of his experimental task and the presumption that his findings can be generalized to the actual process of reading.

Researchers who have supported the notion of higher-order perceptual units, however, have typically used experimental tasks which require the subject to process an entire word or letter string. They have also worked with a very different definition of perception. According to F. Smith (1971), for example, features are extracted from individual letters but his view of perception also includes a matching process which in itself is inferential in nature. That is, attempts are made to match schemas of information against the extracted information. The schemas used in the matching process depend upon what the reader is trying to identify. Therefore, if only a few letters need to be identified, as in Massaro's (1973) task, only schemas for those particular letters would be used in the matching process. However, if the reader is trying to identify words, then schemas for words in their entirety or schemas for letter groupings such as syllables would be employed to facilitate identification. This hypothesis-testing view of perception is similar to Neisser's (1967) view of perception as an active response on the part of the observer to the stimulus at hand.

It should be pointed out, therefore, that while the present experimental findings regarding syllable structure have been interpreted in terms of higher-order perceptual units, the findings could be attributed to nonperceptual factors if the one were to adopt a definition of perception such as Massaro's (1973). The present author believes that at this time it is not possible to decide unequivocally which of the

two definitions of perception discussed in the most appropriate because the definitions, themselves, have dictated what experimental methodology is used to reveal the role of perception in the identification of words.

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APPENDIX A

Stimulus Words Used in Experiments I & II

HF-1	HF-2	LF-1	LF-2
Round	River	Flint	Focus
Plant	Paper	Graft	Gamut
Brown	Begin	Hoist	Harem
Night	Never	Cinch	Cider
March	Music	Pouch	Pagan
World	Woman	Trump	Tunic
Clock	Color	Mirth	Melon
Earth	Enjoy	Loath	Laser
Month	Money	Belch	Bigot
Stand	Seven	Chirp	Cadet
South	Sugar	Stork	Satin
Chair	Cover	Whisk	Wager
Heard	Human	Prowl	Pivot
Learn	Labor	Scarf	Solar
Train	Today	Chunk	Cubic

Stimulus Words Used in Experiment III

HF-4N	HF-6N	HF-8N
Laugh	Dream	Drink
Cheap	Field	Blind
Death	Fruit	Stand
Shout	Point	Strip
Teach	Speak	Plant
Doubt	Count	Print
Chief	Proud	Front
Faith	Sound	Stamp
South	Broad	Trust

LF-4N	LF-6N	LF-8N
Cough	Frail	Stunt
Shoal	Gourd	Grunt
Leash	Taunt	Graft
Sheik	Trait	Scald
Pouch	Vault	Slink
Whack	Realm	Crimp
Thumb	Trout	Trend
Loath	Groin	Crisp
Chalk	Moist	Blurb

APPENDIX B

Analysis of Variance Summary Table for Correct
Whole-Word Reports in Experiment I

Source	SS	df	MS	F
Subjects (S)	703.23	17	41.37	
Frequency (F)	217.01	1	217.01	86.04**
Syllables (SY)	.12	1	.12	< 1.00
Blocks (B)	85.35	4	21.34	25.99**
ISI (I)	161.67	4	40.42	52.15**
F X S	42.88	17	2.52	
SY X S	10.09	17	.59	
F X SY	27.63	1	27.63	41.29**
B X S	55.83	68	.82	
F X B	3.15	4	.79	1.37
SY X B	.79	4	.20	< 1.00
I X S	52.70	68	.78	
F X I	3.60	4	.90	1.62
SY X I	2.97	4	.74	1.31
B X I	7.37	16	.46	< 1.00
F X SY X S	11.37	17	.67	
F X B X S	39.09	68	.57	
SY X B X S	28.33	68	.42	
F X SY X B	.96	4	.24	< 1.00
F X I X S	37.83	68	.56	
SY X I X S	38.55	68	.57	
F X SY X I	1.05	4	.26	< 1.00
B X I X S	175.20	272	.64	
F X B X I	10.08	16	.63	1.08
SY X B X I	4.57	16	.28	< 1.00
F X SY X B X S	27.93	68	.41	
F X SY X I X S	44.27	68	.65	
F X B X I X S	158.12	272	.58	
SY X B X I X S	144.34	272	.53	
F X SY X B X I	9.38	16	.58	1.13
F X SY X B X I X S	140.81	272	.52	

** $p < .01$

Analysis of Variance Summary Table for Correctly
Reported Letters in Experiment I

Source	SS	df	MS	F
Subjects (S)	66.44	17	3.908	
Frequency (F)	7.97	1	7.968	74.61**
Syllables (SY)	.56	1	.556	18.74**
ISI (I)	20.51	4	5.127	67.42**
Letter Position (L)	2.53	4	.633	8.87**
F X S	1.81	17	.107	
SY X S	.51	17	.030	
F X SY	.32	1	.315	11.17**
I X S	5.17	68	.076	
F X I	.23	4	.057	1.88
SY X I	.33	4	.082	2.40
L X S	4.86	68	.071	
F X L	.42	4	.105	9.00**
SY X L	.11	4	.027	2.13
I X L	.13	16	.008	1.57
F X SY X S	.48	17	.028	
SY X I X S	2.04	68	.034	
F X I X S	2.32	68	.030	
F X SY X I	.10	4	.024	< 1.00
F X L X S	.79	68	.012	
SY X L X S	.87	68	.013	
F X SY X L	.23	4	.057	7.63**
I X L X S	1.39	272	.005	
F X I X L	.15	16	.010	2.32**
SY X I X L	.07	16	.004	1.00
F X SY X I X S	2.15	68	.031	
F X SY X L X S	.51	68	.007	
F X I X L X S	1.12	272	.004	
SY X I X L X S	1.14	272	.004	
F X SY X I X L	.09	16	.006	1.21
F X SY X I X L X S	1.30	272	.005	

** $p < .01$

Analysis of Variance Summary Table for Correct Whole-Word Reports in Experiment II

Source	MS	df	MS	F
Subjects (S)	433.23	15	28.88	
Frequency (F)	428.84	1	428.84	111.82**
Syllables (SY)	12.54	1	12.54	8.17*
Blocks (B)	99.32	2	49.66	35.98**
ISI (I)	14.96	2	7.48	13.53**
F X S	57.52	15	3.83	
SY X S	23.04	15	1.54	
F X SY	.39	1	.39	< 1.00
B X S	41.40	30	1.38	
F X B	.46	2	.23	< 1.00
SY X B	.27	2	.14	< 1.00
I X S	16.59	30	.55	
F X I	1.21	2	.61	1.18
SY X I	.36	2	.18	< 1.00
B X I	7.89	4	1.97	2.03
F X SY X S	10.63	15	.71	
F X B X S	28.59	30	.95	
SY X B X S	9.90	30	.33	
F X SY X B	.41	2	.20	< 1.00
F X I X S	15.34	30	.51	
SY X I X S	12.98	30	.43	
F X SY X I	1.38	2	.69	< 1.00
B X I X S	58.22	60	.97	
F X B X I	5.54	4	1.38	1.56
SY X B X I	.81	4	.20	< 1.00
F X SY X B X S	30.99	30	1.03	
F X SY X I X S	22.52	30	.75	
F X B X I X S	53.24	60	.89	
SY X B X I X S	66.83	60	1.11	
F X SY X B XI	4.18	4	1.03	< 1.00
F X SY X B X I X S	85.16	60	1.42	

** $p < .01$
 * $p < .05$

Analysis of Variance Summary Table for Correctly Reported Letters in Experiment II

Source	SS	df	MS	F
Subjects (S)	22.24	15	1.483	
Frequency (F)	10.97	1	10.966	58.44**
Syllables (SY)	1.12	1	1.116	16.52**
ISI (I)	.74	2	.371	18.05**
Letter Position (L)	1.13	4	.283	7.34**
F X S	2.82	15	.188	
SY X S	1.01	15	.068	
F X SY	.40	1	.404	15.71**
I X S	.62	30	.021	
F X I	.08	2	.042	1.83
SY X I	.02	2	.012	< 1.00
L X S	2.32	60	.039	
F X L	.20	4	.049	6.65**
SY X L	.05	4	.013	< 1.00
I X L	.03	8	.004	1.57
F X SY X S	.39	15	.026	
F X I X S	.68	30	.023	
SY X I X S	.72	30	.024	
F X SY X I	.14	2	.071	1.85
F X L X S	.44	60	.007	
SY X L X S	.84	60	.014	
F X SY X L	.04	4	.009	2.82*
I X L X S	.31	120	.003	
F X I X L	.03	8	.003	1.32
SY X I X L	.03	8	.004	1.33
F X SY X I X S	1.15	30	.039	
F X SY X L X S	.20	60	.003	
F X I X L X S	.30	120	.002	
SY X I X L X S	.34	120	.003	
F X SY X I X L	.01	8	.001	< 1.00
F X SY X I X L X S	.36	120	.003	

** $p < .01$
* $p < .05$

Analysis of Variance Summary Table for Correct Whole-Word Reports by College Students in Experiment III

Source	SS	df	MS	F
Subjects (S)	303.82	10	30.38	
Frequency (F)	86.75	1	86.75	62.41**
Nodes (N)	6.43	2	3.21	1.81
Blocks (B)	10.06	2	5.03	7.02**
F X S	13.90	10	1.39	
N X S	35.31	20	1.77	
F X N	4.50	2	2.25	2.44
B X S	14.34	20	.72	
F X B	.60	2	.29	< 1.00
N X B	1.04	4	.26	< 1.00
F X N X S	18.35	20	.92	
F X B X S	9.60	20	.48	
N X B X S	11.56	40	.29	
F X N X B	.88	4	.22	< 1.00
F X N X B X S	13.93	40	.35	

** $p < .01$

Analysis of Variance Summary Table for Letters Correctly Identified
by College Students in Experiment III

Source	SS	df	MS	F
Subjects (S)	12.50	10	1.25	
Frequency (F)	1.39	1	1.39	30.95**
Nodes (N)	.27	2	.13	2.20
Letter Position (L)	.46	4	.11	4.96**
F X S	.45	10	.04	
N X S	1.22	20	.06	
F X N	.19	2	.09	2.14
L X S	.94	40	.02	
F X L	.07	4	.02	1.00
N X L	.05	8	.01	$<$ 1.00
F X N X S	.89	20	.04	
F X L X S	.72	40	.02	
N X L X S	.65	80	.01	
F X N X L	.03	8	.003	$<$ 1.00
F X N X L X S	.33	80	.004	

** $p < .01$

Analysis of Variance Summary Table for Correct Whole-Word Reports
Sixth Grade Students in Experiment III

Source	SS	df	MS	F
Subjects (S)	113.59	10	11.36	
Frequency (F)	111.27	1	111.27	61.13**
Nodes (N)	7.11	2	3.56	2.20
Blocks (B)	18.67	2	9.34	24.58**
F X S	18.25	10	1.82	
N X S	32.30	20	1.62	
F X N	6.67	2	3.34	2.76
B X S	7.51	20	.38	
F X B	1.15	2	.58	1.45
N X B	1.85	4	.46	1.15
F X N X S	24.14	20	1.21	
F X B X S	6.44	20	.32	
N X B X S	15.96	40	.40	
F X N X B	2.04	4	.51	1.64
F X N X B X S	12.35	40	.31	

** $p < .01$

Analysis of Variance Summary Table for Letters Correctly Identified
by Sixth Grade Students in Experiment III

Source	SS	df	MS	F
Subjects (S)	6.79	10	.68	
Frequency (F)	3.88	1	3.88	48.54**
Nodes (N)	.20	2	.10	2.12
Letter Position (L)	.68	4	.17	13.08**
F X S	.80	10	.08	
N X S	.97	20	.05	
F X N	.12	2	.06	1.44
L X S	.53	40	.01	
F X L	.03	4	.01	1.20
N X L	.03	8	.01	1.00
F X N X S	.82	20	.04	
F X L X S	.21	40	.01	
N X L X S	.39	80	.01	
F X N X L	.04	8	.01	1.00
F X N X L X S	.28	80	.01	

** $p < .01$

APPROVAL SHEET

The dissertation submitted by Chris Gude has been read and approved by the following committee:

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The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and the dissertation is now given final approval by the Committee with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

November 30, 1977
Date

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Director's Signature