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THE EFFECTS OF WORD LENGTH, VISUAL COMPLEXITY AND PHONEME DIFFERENCES ON PROCESSING TIMES IN THE NAMING RESPONSE

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THE EFFECTS OF WORD LENGTH, VISUAL COMPLEXITY

AND PHONEME DIFFERENCES ON PROCESSING

TIMES IN THE NAMING RESPONSE

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CHAPTER I

INTRODUCTION

One of the oldest ideas in experimental psychology is that the time elapsing between the presentation of a stimulus and the making of a response is occupied by a series of processes or stages which are arranged in such a way that one process does not begin until the preceding one has ended (38). Although stage theory has been criticized for a number of years (18, 36), it was influential in stimulating the study of response time which in turn has proven to be useful in gaining an understanding of the structure of various mental activities.

It is generally accepted that brain-damaged individuals are slower in almost all aspects of central nervous system information processing than non-brain-damaged individuals. Nonverbal reaction time experiments have been shown to be a simple way to demonstrate this deficit. Bruhn and Parsons (9) have noted, for example, that the deficit in information processing is so consistent in brain-damaged individuals that simple reaction time tests have merit as diagnostic tools equivalent to those found in more sophisticated and complicated psychological tests.

It has further been demonstrated that increased verbal reaction times in object-naming tasks also are characteristic of brain-damaged individuals. Oldfield and Wingfield (31, 32) note that, in language disturbances associated with cerebral damage or disease, patients have consistent difficulty with object-naming and that increased object-naming latencies are detectable in patients whose language appears otherwise intact. Object-naming latencies have also been studied in stuttering children (6) and more recently in cleft palate children (7) in order to investigate word finding and visual-perceptual-motor abilities of these children.

Identifying and responding with the name of an object are more complex processes than they might seem at first. It has been suggested that the measurement of verbal response time provides a useful technique in better understanding both normal and abnormal naming processes. However, many factors are involved in object identification and naming and all of these factors have not as yet been investigated. Some factors that have been found to, or are thought to, affect the naming latency are age, verbal intelligence, stimulus discriminability, stimulus complexity, number of response alternatives, phoneme differences in verbal responses, length of response, word frequency differences, recency of learning, practice, and motivation. In order to increase the clinical usefulness of reaction time tasks, the effects of these factors on reaction time must be better specified.

The purpose of the present study was to investigate the effects of word length, visual complexity of the stimulus, and phoneme differences on the processing times in the naming response.

CHAPTER II

REVIEW OF THE LITERATURE

To better understand the process of seeing an object and naming it, many authors have studied verbal reaction time. Verbal reaction time can be defined as the amount of time between the onset of a stimulus and the onset of a verbal response. The object-naming latency (ONL), that is, the verbal reaction time when the stimulus is an object or a picture of an object and the response is the name of the object, has been investigated with an interest in the word storage and word retrieval systems of the human brain.

It was noted earlier that many factors are thought to affect verbal reaction time. This review of the literature is concerned with those factors which are most pertinent to the present investigation. The interested reader is referred to Milianti (27) and Teichner (39) for more comprehensive summaries of this literature.

Effect of Word Frequency on Verbal Reaction Time

The word frequency effect refers to the fact that an inverse linear relationship has been found between the mean ONL and the $\log_{10}$ frequency of occurrence of the words in print in the English language (29, 31, 32, 44). As word frequency increases, the time it takes to name a pictured object decreases. The inverse relationship between the ONL and the $\log_{10}$ of the frequency of occurrence of the names in print has been corroborated in studies with children although the relationship was not as pronounced in children as it was in adults (6, 28).

Oldfield (30) stated that an economical storage and retrieval system for words would involve some type of a dichotomous or binary search system. He reasoned that a binary system would store all items equidistant in terms of decision steps. Oldfield argued that the presence of a word frequency effect during ONL tasks demonstrated that more common words are more readily accessible and, since a good storage system would minimize access time, the word frequency effect would rule out a pure binary search system. He suggested a two step process for word retrieval. First, an object's name is allotted to a particular word frequency range and, secondly, there is a binary search for the word within that frequency range. In other words, an object is first identified as having a certain degree of familiarity and this allows the organism to decide if the word falls into a category of items readily available or whether more elaborate sources of identification or response choice must be mobilized (30).

Carroll and White (10), however, speculate that the age at which a word is learned is the most important variable in object-naming. In a study with adult subjects, these authors estimated the age at which names were learned and found that objects' names which were judged to have been learned early were named faster. Words then might be stored according to a chronological dimension in which new words are stored at the cortex periphery and early learned words are stored deeper in the cortex where they would be more readily accessible. The authors suggest that word retrieval may be a one-stage process that depends on the age at which a word is learned with the naming latency reflecting the distance traveled from central processing to retrieve the word.

Effect of Word Frequency on Perceptual Identification

The time for the visual analysis and perceptual identification of a pictured object is necessarily involved in the time taken to name an object. Wingfield (44) suggested that differences in naming latencies between common and rare objects could be due to differences in the time required for their visual analysis and perceptual identification or to differences in the availability of the objects' names.

Wingfield (44) designed two experiments in order to evaluate the effects of visual analysis and perceptual identification on the naming latency. In his first experiment, he obtained visual duration thresholds (VDTs) and ONLs from normal adult subjects. The VDT was defined as the amount of stimulus exposure time necessary for the subjects to detect enough information from the visual stimulus to identify the pictured object. Wingfield found a significant, inverse, linear relationship between the $\log_{10}$ frequency of occurrence of the word and the VDT. He argued that the amount of information required to identify an object varies inversely with the object's a priori probability of occurrence.

The fact that the word frequency effect was found in the VDT task led Wingfield to speculate that in the ONL there is a confounding of the time required for the perceptual identification of the object and for the search for the name of the object. In other words, differences in naming latencies for common and rare objects might not be due only to the time required for the search for the name of an object <u>after</u> perceptual identification was completed.

Since the total time involved in the perceptual identification of a stimulus must include enough information processing to determine some type of perceptual categorization, Wingfield designed a second experiment to determine the effects of such processing on the naming latency. The experimenter presented the name of an object aloud to adult subjects and, after a short interval, presented a picture of an object. The subjects were instructed to say "yes" if the name and the picture were the same and "no" if they were different. One of the results of this experiment was that there were nonsignificant differences for the mean name-picture-matching latencies for common and rare objects. Since the matching latencies were not different across the word frequency range, Wingfield reasoned that the identification time for common and rare objects is relatively constant. He attributed the word frequency effect found in naming latencies to the time needed to search for the appropriate name of an object once the perceptual identification had been completed.

Another interesting result of this experiment was that matching latencies for "no" responses were longer than for "yes" responses. Wingfield attributes this finding to difficulties in rejecting an initial "set" or in handling negative propositions in general.

In summary, an inverse linear relationship has been found between word frequency and the ONL (6, 29, 31, 32, 44) and between word frequency and VDT (20, 44) although the latter relationship is considerably smaller. It has further been demonstrated that the word frequency effect is not apparent in matching response latencies (28, 44).

A Simplified Model of Word Retrieval in Object-Naming

The perceptual identification of an object was described by Wingfield (44) as a two-stage sequential process involving the visual analysis of the stimulus and the processing of the detected information to complete the perceptual identification. In addition to these times and to the time required for the search for the name of the object, Brennan and Cullinan (7) have added the time it takes to initiate speech once the name of the object has been located. These authors then present a simplified four-stage process involved in naming an object: (1) the visual analysis of the stimulus, (2) the processing of the detected information in completing the perceptual identification, (3) the search for the name of the object, and (4) the initiation of the spoken response once the name has been located. These stages correspond well to the general choice reaction time paradigm which consists of four steps: (1) stimulus preprocessing, (2) stimulus categorization, (3) response selection, and (4) response execution (36).

Brennan and Cullinan (7) note that, contrary to stage theory, these four steps or stages may well be overlapping in time. From identification errors observed in their experiment with cleft palate children during the visual duration threshold task, they noted that subjects appeared to be continually processing some of the information included in the stimulus. It has also been suggested that the distinction between perceptive processes and verbal coding in the object-naming task may be artificial and that the verbal processing of the visual stimulus may not simply follow the perceptual one but may interact with it from the beginning (5). Lastly, it is also conceivable that the subject begins to get prepared at least to initiate speech prior to the final location of the name (7)

Recently there has been an interest in the possible role of verbal coding on information processing in visual perception. Colegate and Eriksen (11) state that sensory information is conveyed to higher centers in the brain where it persists as an image or icon before it decays rapidly. A scanning or noting process encodes the information from the icon into the short-term memory system. The nature of the encoding system is not clearly understood, but Colegate and Eriksen speculate that this encoding process may be verbal, that is, as though one were saying the name of the object to oneself. These authors explored the possibility that the encoding process from iconic storage to short-term memory consists of an implicit naming response.

One group of subjects was taught one-syllable names for eight nonsense forms and a second group of subjects learned three-syllable responses for eight nonsense forms. After the criteria for learning had been met, each subject was tachistoscopically presented a display containing three or six nonsense forms. After the termination of the display, a probe was presented which designated the location of one of the elements of the display and the subject was asked to name the nonsense form that had been in the specified location. It is important to note that the probe was presented at temporal intervals after the termination of the display that were too long for iconic storage to persist. The authors hypothesized that the subjects in the one-syllable response group would encode a larger number of nonsense forms from the display before the icon decayed than subjects in the three-syllable response group.

The major results of this experiment were that correct identification of both three- and six-form displays were significantly superior for the one-syllable response group. This is consistent with the assumption that the encoding process consists of implicit naming. The longer the implicit naming response requires, the more the icon has decayed before the next item can be encoded or named. The authors suggest that there is a relation between response length and encoding information in visual perception.

Effect of Word Length on Visual Duration Threshold

Howes and Solomon (20) found an inverse relationship between $\log_{10}$ word frequency and VDTs during a reading task. They did not employ the factor of word length as an experimental variable, but reported that word length had no significant bearing on their results. McGinnies, Comer, and Lacy (26) note that the absence of a relationship between recognition threshold and word length is surprising since there is evidence that longer words occur less frequently in the language system (45).

In the McGinnies *et al.* (26) study, words of five, seven, nine, and eleven letters were selected so that each of the four categories of word length contained five words whose frequencies of occurrence approximated five frequency levels. The experiment was designed so that the results for each subject could be summarized in a multiple regression equation in which the regression of threshold of recognition upon both word length and word frequency could be determined.

The results of this experiment indicated that recognition thresholds increased significantly as word length increased. Secondly, there was a significant increase in recognition thresholds with decreasing word frequency. Thirdly, there was a significant interaction of word frequency with word length. This interaction was described in the following manner: (1) an increase in word frequency lowers the recognition thresholds of long words more than for short words, and (2) longer words are accompanied by higher recognition thresholds to a greater extent in the case of low frequency words than in the case of high frequency words. The frequency effect then is most apparent with long words while word length is the most striking factor with words of low frequency. The authors state that one cannot predict the effect of either word frequency or word length upon recognition thresholds without considering the interaction between the two.

Effect of Word Length on Verbal Reaction Time

It has been proposed that, in tachistoscopic word recognition tasks, a subject may implicitly speak a word before overtly verbalizing it (14). It would seem then that the longer the encoding process in terms of implicit verbalization, the longer the latency should be before the subject would overtly vocalize the word.

Eriksen, Pollack, and Montague (14) investigated the effects of varying word length, in terms of number of syllables, on verbal reaction times. Five subjects were presented 30 word-pairs selected from the Thorndike-Lorge word list which met the following criteria: (a) one word of each pair would be a one-syllable word and the other a three-syllable word; (b) the three-syllable word would have the same first syllable as the one-syllable word; (c) the three-syllable word would be accented on the first syllable; (d) the longer word would have phonetically distinct syllables (e.g., camera could also be pronounced camra and would therefore be unacceptable); and, (e) the word-pair would be closely correlated in word frequency. The experimenter presented one of the test words aloud and the subject was instructed to vocalize the word as rapidly as possible upon seeing a signal light. The response latency (simple reaction time) was measured from the initiation of the presentation of the signal light to the initiation of the verbal response.

The results of this experiment indicated that there were no significant differences between one- and three-syllable words. This suggests that when a subject knows a verbal response beforehand, the latency is independent of word length. The authors state that these results are consistent with an interpretation that, when the verbal response is known beforehand, perceptual encoding has been completed and thus the response latency is independent of the encoding process.

A second experiment was conducted to determine whether a latency difference would exist between one- and three-syllable words when the subject did not know the response until it was flashed on a viewing screen. Ten word-pairs from the first experiment which showed the smallest intrapair differences in latencies were used as stimuli. The subjects were instructed to speak the word aloud as quickly as possible when the printed word appeared on the screen.

The results of the second experiment indicated that three-syllable words required a significantly longer time to begin saying than one-syllable words. The authors suggest that subjects covertly or implicitly say a word before speaking it aloud. However, while all of the one-syllable words were composed of three-letter symbols, the three-syllable words were composed of six to ten letters. The difference in the latencies then could be attributable to longer sensory processing times due to the greater number of letters in the three-syllable words.

A third experiment was designed to further investigate the role of stimulus size on the verbal response latency. In this experiment twenty-seven, two-digit numbers were used as stimuli. The numbers were composed of nine two-syllable numbers (e.g., twenty), nine three-syllable numbers (e.g., thirty-nine), and nine four-syllable numbers (e.g., seventy-nine). This arrangement allowed the experimenters to hold visual stimulus size constant while varying the number of syllables in the vocal response. The subjects were instructed that they were to read two-digit numbers which would appear on the screen as rapidly as possible.

The results of the third experiment indicated that three-syllable digits took significantly longer to start saying than two-syllable digits and that four-syllable digits took significantly longer to start saying than three-syllable digits. These results were interpreted as corroborating the results of Experiment II in addition to supporting the notion that the increased latencies found for three-syllable responses in Experiment II were not due to increased visual stimulus size.

In summary, the authors concluded that, when confronted with a word, subjects implicitly speak the word to themselves before they vocalize the word. Therefore, the more syllables the word has, the longer it takes to implicitly speak it. Since word frequency was controlled in the word-pairs, latency differences in words of different syllable length apparently would not be due to the word frequency effect.

Klapp (21) stated that the results of the Eriksen et al. study could be interpreted to indicate that implicit speech may only be required to "set up" the vocal apparatus. If this were the case, then increases in response latency with increases in word length would only occur if the subject must pronounce the stimulus. Klapp designed three experiments to investigate the role of implicit speech in "language" comprehension.

The first experiment attempted to replicate Experiment III in the Eriksen et al. study. Subjects were required to read two-digit numbers aloud as rapidly as possible upon a signal. Additionally, in Klapp's first experiment, the subjects were presented a set of two two-digit numbers requiring two, three, and four syllables when pronounced and were instructed to respond "yes" if the two numbers were the same and "no" if the two numbers were different. The results of the first experiment may be summarized as follows: (1) there was no syllable effect in simple reaction time latencies when digits were used as stimuli; (2) in the matching task, response latencies significantly increased as the number of syllables associated with the digit pair increased. The first finding corroborates the results of Eriksen et al. The second finding suggested to Klapp that an implicit speech process in involved in number comprehension since the subjects demonstrated increased response latencies associated with increased word length during a matching task in which an overt number pronouncing response was not required. Klapp also noted that the latencies for "yes" responses were significantly faster than the latencies for "no" responses although he did not speculate as to the reason for this result.

A second experiment was conducted using the same-different matching condition with the exception that the response modality was changed to a manual response. Subjects were instructed that, if the two two-digit numbers were the same, a response switch would be moved as quickly as possible to the left. If the numbers were different, the response switch would be moved to the right. The mean latency across same and different responses increased with increases in word length even when the response was made manually rather than vocally. Again, significantly faster latencies were recorded for "same" than for "different" decisions.

Klapp noted that in the use of two-digit numbers, the properties of the numbers are confounded with the number of syllables. For example, most of the two-syllable numbers contain the number "0" while most of the four-syllable numbers contain the number "7". It is possible that these properties of the digits may have produced the syllabic effect. A third experiment was designed in which subjects were required to respond by pressing a switch if two printed words were the same while making no response if the two printed words were different. For a second block of trials this response condition was reversed. The fifty-six one- and two-syllable word-pairs were matched for frequency of occurrence, each pair began with the same consonant, and all of the words were composed of three consonants and two vowels (e.g., court-court; false-frame; honor-honor; paper-power). The results of the third experiment confirmed the major results of the first two experiments, namely, that matching latencies involving two-syllable stimuli were greater than latencies associated with one-syllable stimuli and latencies for "different" decisions were longer than latencies for same decisions.

These results were interpreted to suggest that an implicit representation of speech is involved in the comprehension of printed words and numbers. For these tasks which involved comprehension of written language symbols the data seem to be consistent with the theory that an implicit speech process may be involved in language comprehension.

Henderson, Coltheart, and Woodhouse (19) replicated the number-naming studies of Eriksen et al. (14) and Klapp (21) using the nine two-, three-, and four-syllable numbers. Only five of their fifteen subjects demonstrated a monotonic increase in median reaction time with increases in number of syllables. There were no significant differences between the latencies of three- and four-syllable numbers. Two-syllable numbers, however, were named significantly faster than both three- and four-syllable numbers. Since the two-syllable numbers were composed mostly of decades, the authors concluded that the two-syllable numbers may be easier to visually identify than the three- and four-syllable numbers.

A second experiment was conducted which used three sets of number stimuli: (1) a two-syllable "teens" set (13, 14, 15, 16, 18, 19); (2) a two-syllable "decades" set (30, 40, 50, 60, 80, 90); and (3) a four-syllable "seventies" set (73, 74, 75, 76, 78, 79). The "decades" set of numbers were named significantly faster than the "teens" set even though both sets of digits were associated with two-syllable responses. There was a nonsignificant difference between the response latencies of the "teens" set and the "seventies" set. The authors concluded that their two experiments failed to detect evidence of a syllabic effect in number recognition. Their results would be inconsistent with the assertion that a syllable-dependent implicit speech process is a necessary stage in the recognition of graphemes.

Klapp and Bischoff (22) investigated the effects of word length on matching response latencies for nonsense forms. Ten nonsense forms were selected and paired with five, five-letter one-syllable words and five, five-letter two-syllable words for which a difference in latency had been found in Klapp's previous experiment (21). After the paired-associate learning procedures, the subjects participated in the experimental condition. Two nonsense forms to be judged "same" or "different" were presented simultaneously to each subject. Both forms in each pair had been associated with response words of the same length. The subject gave a manual response (button pushing) for the same-different decision.

The results of this experiment indicated that forms which had been associated with two-syllable responses did not yield longer latencies than forms which had been associated with one-syllable responses. At face value, it would appear that the results of this experiment would suggest that subjects do not use implicit speech in making same-different responses when stimuli are nonsense forms and when response length varies from one to two syllables and word length, in terms of number of letters, is constant.

Two specific objections were raised by Klapp and Bischoff to this interpretation. First, the experiment may not have been sensitive enough to detect a syllable effect. Mean latencies for five, five-letter one-syllable words were compared to mean latencies for five, five-letter two-syllable words. The time required to implicitly speak these two types of verbal stimuli may not differ sufficiently to show the syllable effect. Secondly, English words were learned as paired-associates to the nonsense forms. The use of "true" words with nonsense froms could result in the subjects using strategies during the experimental task in which they did not use the particular responses learned in the paired-associated task. In other words, other properties of the English words may have influenced the subjects' response strategies.

Effect of Phoneme Differences on Verbal Reaction Time

Eriksen *et al*. (14) noted that word-pairs beginning with the "stop consonants /b/, /k/, and /v/" were associated with shorter latencies than words beginning with the other initial consonants. It appears that /v/ is a misprint in their article and probably should have read "/d/". The authors stated that these differences could be due to either actual differences in initial verbalization latencies or they may reflect differential sensitivity of the voice key. It is interesting to note that the three consonants differ in either place of production and/or voicing. The /b/ phoneme is a bilabial, voiced plosive, the /k/ phoneme is a velar, voiceless plosive and the /d/ phoneme is a lingua-alveolar, voiced plosive. Due to the broad differences in mode of production among these three consonants, it would seem that differential sensitivity of the voice key might not be an adequate explanation for latency differences. However, verbal reaction time differences associated with place of articulation, manner of articulation, voicing, and phoneme frequency have not as yet been systematically investigated.

Effect of Stimulus Visual Complexity on Verbal Reaction Time

It is generally believed that the failure of aphasic patients to recall the name of objects is due to a difficulty in word retrieval with the visual perceptual mechanism assuming a less significant role. Bisiach (4) investigated the effects of redundancy of visual stimuli on the naming process in adult aphasic patients. The results of the investigation indicated that naming varied with the amount of information transmitted through the visual channel. Fraisse and Elkin (16) have also noted that the speed of visual perception is related to the simplicity of the visual stimuli used. Specifically, detailed drawings resulted in lower VDTs than outline drawings.

A review of the literature suggests that visual stimulus size and complexity have been controlled to greater and lesser extents. The complexity of the visual stimuli used in verbal reaction time tasks would appear to be an important factor affecting response latency. However, the effect of systematically varying the complexity of visual stimuli on verbal reaction times while controlling word length and word frequency has not yet been investigated.

In summary, it has been demonstrated that the word frequency effect is a factor in determining verbal response latencies. But it is known that word length is related to word frequency and that longer and less frequently occurring words are usually associated with more complex pictures. Then the seemingly straight-forward relationship of naming latency to word frequency might actually be confounded by the factors of word length, complexity of the visual stimuli, and phoneme differences.

CHAPTER III

DESIGN OF THE INVESTIGATION

This study was designed to investigate the effects of word length, visual complexity, and phoneme differences on some of the processing times involved in the naming response. The following research questions were formulated for this investigation:

1. What is the effect of variation in word length, in terms of number of syllables, on simple reaction times, visual duration thresholds, matching response latencies, and naming response latencies?

2. What is the effect of variation in the level of visual complexity of stimuli on simple reaction times, visual duration thresholds, matching response latencies, and naming response latencies?

3. Are there systematic differences in simple and choice reaction times associated with various phonemes?

4. Do reading reaction times increase as the number of phonemes in a nonsense sequence increase?

Two experiments were conducted to answer these research questions.

Experiment I: Word Length and Visual Complexity

The purpose of the first experiment was to investigate the effects of variations in word length and visual complexity of stimuli on processing times in the naming response. Nonsense words of varying length were paired with nonsense visual forms. Visual and verbal nonsense stimuli were chosen to control the complexity of the visual stimuli, the word frequency effect, phoneme differences among words of varying length, recency of learning, number of response alternatives, and number of letters per syllable.

Subjects

Thirty graduate students in the Department of Communication Disorders, University of Oklahoma Health Sciences Center, served as subjects for this study. Criteria for selection of subjects included the following: (a) normal articulation, voice, and hearing acuity; (b) normal visual acuity as indicated on a visual screening test (1), with aided vision if glasses or contact lenses were to be worn during the experimental tasks; (c) normal perceptual-motor skills as indicated in graduate school performance and as screened by the Bender-Gestalt Test (2); and (d) completion of at least one graduate level course in phonetics. The thirty subjects were randomly assigned into three subject groups with ten subjects in each group.

Selection of Verbal Stimuli

Measures of meaningfulness and ease of pronunciation were obtained for twenty-one one-syllable nonsense words, twenty-one two-syllable nonsense words, and twenty-one three-syllable nonsense words from a panel of eight judges. The judges were all members of the faculty or staff of the University of Oklahoma Health Sciences Center's Department of Communication Disorders. The nonsense words were so constructed that each one-syllable nonsense word served as the first syllable of one of the two-syllable nonsense words and each of the two-syllable nonsense words served as the first two syllables of one of the three-syllable nonsense words (e.g., /bud/, /budon/, /budonom/). To obtain a measure of meaningfulness, each judge was presented cards containing one nonsense word per card. The nonsense words were written in phonetic symbols in order to better standardize the pronunciation of the words across judges. He was instructed to pronounce the words to himself and, if the syllable reminded him of a real word or words, to record the word(s) on a response sheet. If the nonsense word did not remind the judge of a real word(s), he checked "no" on the response sheet. The experimenter emphasized that he was interested in the judges' initial reactions to the word. Each judge, therefore, was encouraged to pronounce the word and to immediately record word associations, if any.

The judges then were asked to rate relative ease of pronunciation of each word when compared to the other twenty words of the same length. The words were rated on a three-point scale whereby _1_ represented a word easier to pronounce than most, _2_ represented a word with average ease of pronunciation, and _3_ represented a word more difficult to pronounce than most. The appropriate number was written on the response sheet.

The measures of meaningfulness and ease of pronunciation obtained from the eight judges for the nine nonsense words selected for use in this experiment are presented in Table 1. These nine nonsense words were selected from the sixty-three nonsense words presented to the judges according to the following criteria: (a) 75 per cent or more of the judges rated the word as having average ease of pronunciation; (b) the word reminded 25 per cent or less of the judges of a real word; and, (c) one of the one-syllable nonsense words was the first syllable of one of

TABLE 1

MEASURES OF MEANINGFULNESS AND EASE OF PRONUNCIATION OBTAINED FROM EIGHT JUDGES FOR THE NINE NONSENSE WORDS USED IN THIS INVESTIGATION

Nonsense Words	Number of Judges Who Reported a Word Association	Ease of Pronunciation Ratings 1	2	3
/zov/	1	0	6	2
/zovig/	1	0	8	0
/zovigid/	0	0	7	1
/mob/	1	2	6	0
/moben/	0	1	6	1
/mobenez/	0	0	6	2
/duv/	1	1	6	1
/duvid/	2	2	6	0
/duvidib/	1	1	6	1

the two-syllable nonsense words and one of the two-syllable nonsense words composed the first two syllables of one of the three-syllable nonsense words. The nine words selected were: /zov/, /zovig/, /zovigid/, /mob/, /moben/, /mobenez/, /duv/, /duvid/, and /duvidib/. In order to insure that syllabic stress patterns were constant across stimuli, the unstressed schwa vowel was substituted for the vowel in the second syllable. Therefore, the first and third syllables were always stressed and the second syllable was always unstressed. The nine stimuli, thus, became /zov/, /zovəg/, /zovəgid/, /mob/, /mobən/, /mobənez/, /duv/, /duvəd/, and /duvədib/.

Selection of Visual Stimuli

Forty-five visual stimuli were chosen from the Abstract

Reasoning Subtest of the Differential Aptitude Tests, Form L (13). These forms were presented to six judges, all graduate students at the University of Oklahoma Health Sciences Center's Department of Communication Disorders. The judges were instructed to rate each visual form on a three-point scale where 1 represented visual symbols which were less complex than most, 2 represented symbols of average visual complexity, and 3 represented symbols more complex than most.

After rating the complexity of each form, the subjects were asked to describe each form as completely as possible so that a person who had not seen the form would be able to draw it from the description. The subjects' verbal descriptions were tape recorded and the number of words used to describe each form were counted at a later time by the experimenter. Thus, two measures of visual complexity, visual complexity ratings and average number of words used to describe the visual forms, were obtained for each stimulus.

Nine visual forms were chosen for use in this experiment. Three forms best fitting the following criteria were chosen for each of the three visual complexity levels. The three forms selected for Complexity Level 1 stimuli were judged as less complex than most by at least four of the six judges and required the least number of words to describe them. Also, an attempt was made by the experimenter to select stimuli which were not visually similar in form to the other two forms selected. The three forms selected for Complexity Level 2 stimuli were judged as presenting average complexity by at least four of the six judges and were not considered to be visually similar in form by the experimenter. The three forms selected for Complexity Level 3 stimuli were judged as more complex than most by at least four of the six judges and required the most number of words to describe them while not being considered, by the experimenter, to be visually similar in form to the other two forms selected. The nine visual forms, the form number from the Differential Aptitude Test, the complexity ratings, and the mean number of words needed to describe each of the nine forms are presented in Table 2. The total

TABLE 2

VISUAL FORMS, TEST NUMBERS, COMPLEXITY RATINGS AND MEAN NUMBER OF WORDS TO DESCRIBE EACH FORM FOR THE NINE VISUAL STIMULI

Visual Form	Differential Aptitude Test Numbers	Complexity Ratings 1	2	3	Mean Number of Words to Describe Each Form
	6-4	6	0	0	12.3
	12-2	5	1	0	14.3
	6-c	4	2	0	19.5
	28-e	1	5	0	34.2
	44-4	1	4	1	28.5
	19-e	1	4	1	32.3
	42-4	0	2	4	59.3
	20-b	0	1	5	49.5
	17-a	0	1	5	68.3

complexity rating was computed for each form by assigning values of one, two, and three points to complexity ratings of _1_, _2_, and _3_, respectively. The Pearson Product-Moment Correlation Coefficient of the total complexity rating and the mean number of words needed to describe each form was 0.95.

Pre-experimental Learning Task

A conventional paired-associate method (flash-card technique) was used to teach the nine nonsense words as names for the nine nonsense visual forms. The paired-associates that were learned by each subject group are presented in Table 3. Subjects in Group I learned

TABLE 3

COMPLEXITY LEVELS, VISUAL FORMS, AND NONSENSE WORD-PAIRED WITH EACH FORM FOR EACH SUBJECT GROUP

Complexity Level	Visual Form	Subject Groups I	II	III
1		/zov/	/zovag/	/zovagid/
1		/mob/	/moban/	/mobanez/
1		/duv/	/duvad/	/duvadib/
2		/zovag/	/zovagid/	/zov/
2		/moban/	/mobanez/	/mob/
2		/duvad/	/duvadib/	/duv/
3		/zovagid/	/zov/	/zovag/
3		/mobanez/	/mob/	/moban/
3		/duvadib/	/duv/	/duvad/

one-syllable names paired with Complexity Level 1 visual stimuli, two-syllable names with Level 2 stimuli, and three-syllable names with Level 3 stimuli. Subject Group II learned two-syllable names paired with Level 1 visual stimuli, three-syllable names with Level 2 stimuli, and one-syllable names with Level 3 stimuli. Subject Group III learned three-syllable names for Level 1 visual stimuli, one-syllable names for Level 2 visual stimuli, and two-syllable names for Level 3 visual stimuli.

Prior to the paired-associate task, the phonetic symbols for the sounds in the names were presented to each subject to insure that each subject was familiar with the pronunciation associated with each symbol. The subjects were instructed to read the phonetic symbols on each flash card until the subjects pronounced all the sounds correctly, as judged by the experimenter, on two consecutive trials.

Each subject was then presented a set of flash cards containing the nine nonsense names. The subjects pronounced each name aloud until they had pronounced the names correctly on three consecutive trials. This procedure allowed the subjects to become familiar with the nonsense names and allowed the experimenter to be certain that the subjects pronounced the names correctly.

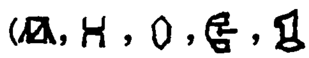
A flash card containing only a visual form on the side facing upward was presented to each subject. The subject turned the flash card over exposing the visual form paired with its nonsense name. The subject pronounced the name of the form aloud and proceded to the next card. This procedure was repeated until all nine forms and names were presented. The set of stimulus pairs were reordered randomly and the subject attempted to name each form. The subject would turn the card over to see if his naming response were correct and would again pronounce the name of the visual stimulus aloud. This procedure was repeated until the subject had correctly named the nine visual forms on three consecutive trials.

Overlearning trials were then presented until the subject named the stimuli correctly for five additional trials. For each trial on which there was an error, an additional trial was added.

A second series of overlearning trials were presented in which the subjects were encouraged to name the visual stimuli as rapidly as possible. The subjects were instructed to name the stimuli correctly within three seconds per stimulus for three trials. For each trial in which the subject either misnamed the visual stimulus or did not name the visual stimulus within three seconds, an additional trial was added. This task completed the first day's learning session. The time of this first session varied from thirty-five to sixty minutes per subject.

On the following day, the subjects again were presented the stimulus-pairs using the flash-card technique. The subjects were encouraged to name the visual forms as rapidly as possible until they had named the forms within three seconds per stimulus for five consecutive trials. After reaching this criterion, each subject participated in the experimental tasks.

Test Stimuli

The test stimuli consisted of black line-drawn tracings of the nine visual forms. The overall size of the visual forms was relatively uniform. The forms, however, did vary in their relative dimensions. The vertical dimensions of five of the nine forms () were approximately three inches and the horizontal dimensions were one to one and one-half inches. One form's () horizontal dimension was approximately three inches and the vertical dimension was one inch. The dimensions of the remaining three forms were approximately two inches by two inches. Each of the forms was centered on a plain white card.

Presentation of Stimuli

The experimental condition and equipment were similar to those previously described by Milianti and Cullinan (28) and Brennan and

Cullinan (7). A Harvard four-channel digital timer (Model 300-4T), lamp driver (Model 402), and the experimenter were in the control room of a two-room sound-treated suite. The subject, the experimenter's assistant, and the exposure cabinet of a two-field Harvard tachistoscope (Model T-2B) were in the experimental room. The lamp driver powered four, four-watt white lamps in the exposure cabinet. Two lamps provided uniform illumination for each field with a rise and decay time of less than 0.0002 seconds. A two-way intercom system allowed the experimenter to communicate with the subject.

The digital timer allowed selection of intervals of duration from one millisecond (msec) to 9900 msec in any of the four timer channels. Channels one and three of the timer were wired to fields one and two of the exposure cabinet. The other two channels were delay timers which provided intervals between exposure intervals.

The cards which contained the visual stimuli were placed in a card holder which was designed to hold a number of cards. The multiple card holder was attached to Field 1 of the exposure cabinet while a single card holder was attached to Field 2 of the cabinet. The exposure area of each card holder was 7 3/4 inches by 7 3/4 inches.

The experimenter's assistant monitored the subject's position insuring that the subject was prepared to respond to each stimulus presentation. After a visual stimulus had been exposed and the subject responded, the assistant removed the card, automatically advancing the next card into position for exposure.

Procedure

Following the second day's overlearning session, each subject participated in four experimental tasks: (1) simple reaction time (SRT); (2) visual duration threshold (VDT); (3) matching response latency (MRL); and (4) naming response latency (NRL). The four tasks lasted approximately thirty minutes. The tasks were randomly presented to the subjects in each group in such a way that each task occurred at least twice, but no more than three times, in any one of the four ordered positions. A sample of the randomization schedule is presented in Appendix A.

Simple Reaction Time

Each subject was seated at the exposure cabinet of the tachistoscope and the experimenter presented one of the nonsense names aloud. The subject was instructed to repeat the nonsense name to be sure that the subject had heard the experimenter correctly. A "ready" signal was then given followed by a two-to-three-second interval before a two-second presentation of a stimulus light. The subject was requested to produce the nonsense name as rapidly as possible upon seeing the signal light. Each subject received three practice trials with the nonsense syllables /ved/, /nuvagon/, and /vigab/. Following the practice trials, each subject was presented the nine nonsense names. The names were randomly presented to each subject and the task was performed in less than five minutes.

Visual Duration Threshold

Each subject was seated at the exposure cabinet and was instructed to name the nonsense forms which would appear briefly on the viewing screen. He was instructed that, if he were unable to see the pictured form, he was to say "no" and the form would be shown again for a longer time of exposure so that it would become easier to recognize.

Following the instructions, each subject was shown, by means of tachistoscopic presentation, a series of three practice pictures (cow, dog, baby) in order to familiarize him with the task. A "ready" signal was presented followed by a two-to-three-second interval before the presentation of the stimulus picture. Following a "no" response this procedure was repeated. Each form was initially presented for five msec and the time of exposure was increased in five-msec steps until the form was correctly named. The presentation of each visual form was immediately followed by a one-second masking stimulus in order to avoid the effects of visual after-image. The visual masking pattern was the same one used by Milianti and Cullinan (28).

Visual duration thresholds (VDTs) were obtained for the nine test stimuli. Four additional stimuli (copies of four of the nine experimental stimuli) were included bringing the number of stimuli to thirteen. These were added in order to reduce the possibility that the subjects might correctly guess the stimulus presented last in the sequence due to the process of elimination. The subjects were told in the instructions that some of the pictured forms might occur more than once. When the subject gave a correct response the stimulus picture was again presented at the same exposure time. When the subject gave the correct response for two consecutive presentations, the time for the first of these two responses was recorded as the threshold value. The thirteen stimulus pictures were randomized for each subject and the task was completed in approximately fifteen minutes.

Matching Response Latency

In this task, the names of the visual forms were presented aloud by the experimenter. Each subject was instructed that after the presentation of each name, he was to repeat the name to be sure that he had heard the experimenter correctly. Each subject was told that one of the nonsense forms would appear on the viewing screen and he was to say the word "yes" as quickly as possible if the name spoken by the experimenter were appropriate for the visual form. If the name were not appropriate for the form, the subject was instructed to say "no" as rapidly as possible. After the subject repeated the nonsense name, the experimenter gave a "ready" signal followed by a two-to-three-second interval prior to the presentation of the visual form. Three practice stimulus-pairs (bed-boy, house-house, leaf-fork) were presented before the presentation of the experimental stimuli. The stimulus pictures were exposed for a duration of three seconds and were immediately followed by a dark poststimulus field.

In the experimental condition, five stimulus-pairs required a "yes" response and four pairs required a "no" response for five subjects in each group. For the remaining five subjects in each group, four stimulus-pairs required a "yes" response and five pairs required a "no" response. The stimuli were arranged so that there were five "yes" and five "no" responses for each of the nine forms for each subject group. For the stimulus-pairs which required a "no" response, the incorrect name which was given was always the same word length as the correct name for the visual stimulus. Thus, only /zov/ or /mob/ was used as the incorrect name for the visual stimulus with the correct name of /duv/. The stimulus pairs are presented in Appendix B. The pairs were randomly presented to each subject and the task was completed in approximately five minutes.

Naming Response Latency

Each subject was seated at the tachistoscope and was instructed to name the visual forms as rapidly as possible. The practice pictures cup, cat, and finger were presented in order to familiarize the subjects with the task. The thirteen visual forms used in the VDT task were then presented to each subject. The experimenter gave a "ready" signal followed by a two-to-three-second interval before the three-second tachistoscopic presentation. A dark poststimulus field immediately followed the termination of each stimulus presentation. The task was performed in approximately five minutes.

Response Recording

During the SRT, NRL, and MRL tasks, the subjects' verbal responses were picked up by an Electro-Voice cardioid microphone (Model 664) and recorded on channel 1 of an Ampex two-channel tape recorder (Model 440). The start control of the digital timer which initiated the tachistoscopic presentation was wired in such a way as to simultaneously produce a stimulus voltage on channel 2 of the same tape recorder. The tape recorder was located in the control room while the microphone was located beneath the viewing aperature of the exposure cabinet.

The tape recorded samples were transferred to a Sanborn oscillographic chart recorder (Model 7702A) for the latency measurements. The stimulus voltage was recorded on one channel of the Sanborn and the verbal response was recorded on the second channel at a paper speed of 100 millimeters (mm) per second.

Criteria of Measurement

All signals plotted as chart recordings were carefully monitored both visually and auditorially. Care was taken to minimize both ambient background and environmental noise in the experimental room. However, in some instances, the onset of the verbal signals could not be differentiated from noise signals and these responses were excluded from analysis. A steady and flat baseline aided in locating the onset of the verbal response regardless of the initial phoneme in the response.

In general, stimulus onset was defined as the point at which the stylus moved from baseline in an upward direction. Specifically, the onset of the verbal response was measured at the point where there was: (1) a sudden extensive or "sharp" movement of the stylus away from the baseline; (2) a gradual rise of the stylus from baseline; (3) a minute fluctuation from baseline prior to sharp vertical movements; and, (4) a fluctuation in stylus movement due to sounds of the articulators contacting or separating or to respirations or subvocalizations connected with or immediately preceding the verbal response signal by no more than 50 msec. The latency was measured to the nearest one-half mm or five msec. The reliability of the experimenter in making this type of measurement has been previously established and reported (7).

Experiment II: Phoneme Differences

The purpose of the second experiment was to investigate the effects of phoneme differences on simple reaction times and choice reaction times, during oral reading, while controlling stimulus length in terms of number of syllables. Isolated vowels (V), consonant-vowel combinations (CV), consonant-vowel-consonant combinations (CVC), and consonant-vowel-consonant-vowel combinations (CVCV) were used in this experiment.

Subjects

Subject Group 1 from Experiment I was randomly chosen from the three groups to participate in Experiment II. Since these subjects participated in Experiment I, they had met all of the criteria for subject selection set for that experiment.

Stimuli Selection

Five vowels were selected for inclusion in this study: /i/ /e/, /ʌ/, /ɑ/, and /u/. These vowels represent a range of articulatory positions on the classical cardinal vowel diagram while at the same time they are dissimilar enough to result in a reduction in articulatory or perceptual confusions. Vowel frequency of occurrence was not a consideration in vowel selection because reported vowel frequency is highly variable from study to study due, at least in part, to incomparable phonetic transcriptions across studies (12, 40, 41).

Twenty-two consonants, which would yield the most information concerning the effects of voicing, place, manner, and frequency of occurrence were selected. Since consonant phoneme frequency is not excessively variable from study to study (12, 41), the consonant phoneme frequency norms presented by Tobias (40) were used as representative of consonant frequency. The frequency norms for the phonemes used in this investigation are presented in Table 4.

Test Stimuli

The test stimuli consisted of black, hand-printed phonetic symbols and letters. Since all subjects were familiar with phonetic transcription, it was felt that less confusion would occur among subjects if phonetic vowel symbols were used. However, some phonetic symbols for consonants might be read more quickly than others because the symbols are similar to English grapheme representations with which the subjects are more familiar and experienced. Therefore, English graphemes for consonants were used in an effort to reduce the differences due to familiarity. In the CV, CVC, and CVCV tasks, the vowel in the various consonant-vowel combinations was always the neutral vowel /ʌ/. This vowel was chosen in order to minimize the effects of consonant-vowel coarticulation.

Three sets of test stimuli were used in the four experimental tasks. One set of stimuli was composed of the five isolated vowel phonemes and twenty-two CV combinations. A second set of sixteen stimuli was composed of CVC combinations, and the final set of sixteen stimuli was composed of CVCV combinations. The size of the visual stimuli was relatively uniform. The vowels were approximately one-half inch high and the consonants ranged from one-half to one inch in height. The stimuli were centered on a plain white card.

Procedure

Each subject participated in four experimental tasks: (1) simple reaction time (SRT) for vowels (V) and consonant-vowel (CV)

TABLE 4

PHONEME FREQUENCY AND THE SYMBOL USED IN THE PRESENT INVESTIGATION FOR THE TWENTY-SEVEN VOWELS AND CONSONANTS UNDER STUDY

Phoneme	Symbol Used in the Present Study	Phoneme Frequency*
/t/	t	9.11
/n/	n	6.43
/d/	d	3.78
/s/	s	3.74
/l/	l	3.62
/ð/	~~th~~	3.62
/r/	r	3.31
/m/	m	3.16
/k/	k	2.93
/w/	w	2.74
/j/	y	2.40
/z/	z	2.13
/e/	/e/	1.94
/o/	/o/	1.93
/i/	/i/	1.82
/v/	v	1.76
/h/	h	1.49
/f/	f	1.48
/b/	b	1.44
/g/	g	1.39
/p/	p	1.37
/ʌ/	/ʌ/	1.32
/u/	/u/	1.20
/θ/	th	0.81
/ʃ/	sh	0.49
/tʃ/	ch	0.31
/dʒ/	j	0.28

* Per cent of occurrence according to Tobias (39)

combinations; (2) choice reaction time (CRT) for vowels (V) and consonant-vowel (CV) combinations; (3) choice reaction time (CRT) for consonant-vowel-consonant (CVC) combinations; and (4) choice reaction time (CRT) for consonant-vowel-consonant-vowel (CVCV) combinations. The four tasks took less than 25 minutes and were randomly presented to the subjects in such a way that each task occurred at least twice but no more than three times in any one of the four ordered positions (see Appendix C).

Simple Reaction Time

Each subject was seated at the exposure cabinet of the tachistoscope and the experimenter presented one of the five vowel phonemes aloud. The subject was instructed to repeat the vowel to be sure that he had heard the experimenter correctly and then he was instructed to produce the vowel as rapidly as possible upon seeing a signal light. A "ready" signal was then given followed by a two-to-three-second interval before a two-second presentation of the stimulus light. The five vowels were presented randomly in this fashion. The twenty-two CV combinations were then presented randomly to each subject under the same conditions.

Choice Reaction Time (V and CV)

Each subject was asked to read a set of flash cards which contained the five vowels and the twenty-two CV combinations. The experimenter carefully reviewed how the vowels and consonants were to be pronounced. The subjects were instructed to read aloud the symbols on the flash cards until they had pronounced all of the symbols correctly on two consecutive trials.

Each subject was then seated at the tachistoscope and was instructed to read aloud the vowels and the twenty-two CV combinations as rapidly as possible. The experimenter gave a "ready" signal followed by a two-to-three-second interval prior to the tachistoscopic presentation.

Choice Reaction Time (CVC)

A set of flash cards containing sixteen CVC combinations were presented to each subject. The sixteen CVC combinations were composed in such a way that the initial and final consonant was always the same. The sixteen CVCs chosen for study are presented in Table 5. Five of the

TABLE 5

CVC AND CVCV COMBINATIONS USED IN EXPERIMENT II

CVC	CVCV
1. t ʌ t	1. t ʌ t ʌ
2. d ʌ d	2. d ʌ d ʌ
3. n ʌ n	3. n ʌ n ʌ
4. p ʌ p	4. p ʌ p ʌ
5. g ʌ g	5. g ʌ g ʌ
6. b ʌ b	6. b ʌ b ʌ
7. f ʌ f	7. f ʌ f ʌ
8. v ʌ v	8. v ʌ v ʌ
9. z ʌ z	9. z ʌ z ʌ
10. k ʌ k	10. k ʌ k ʌ
11. m ʌ m	11. m ʌ m ʌ
12. s ʌ s	12. s ʌ s ʌ
13. sh ʌ sh	13. sh ʌ sh ʌ
14. ch ʌ ch	14. ch ʌ ch ʌ
15. th ʌ th	15. th ʌ th ʌ
16. ~~th~~ ʌ ~~th~~	16. ~~th~~ ʌ ~~th~~ ʌ

twenty-two original consonants (w, r, h, l, and y) were eliminated from inclusion in this task because these CVC combinations do not occur in the English language. The "j" consonant was eliminated because its pronunciation in the CVC trigram (dʒʌdʒ) is a standard English word. The subjects were instructed to read the symbols on each flash card until they had pronounced all of the CVC combinations correctly on two consecutive trials.

Each subject was then seated at the exposure cabinet of the tachistoscope for the experimental task. The subjects were instructed to read the CVC combinations as rapidly as possible. The experimenter gave a "ready" signal which was followed by a two-to-three-second interval, prior to the two-second stimulus presentation.

Choice Reaction Time (CVCV)

A set of flash cards containing sixteen CVCV combinations were presented to each subject. The construction of the CVCV combinations was similar to the CVC combinations with the exception that a second neutral vowel /ʌ/ occurred in the final position. A complete list of these stimuli is presented in Table 5. The subjects were instructed to read aloud the CVCV combinations until they had pronounced all of the combinations correctly for two consecutive trials.

The subjects were seated at the exposure cabinet of the tachistoscope and were instructed to read the CVCV combinations as rapidly as possible. The experimenter gave a "ready" signal followed by a two-to-three-second interval prior to the two-second presentation of the CVCV combination.

Response Recording

The procedure for response recording and the criteria of measurement are the same as those described for Experiment I. The subjects' verbal responses were tape recorded for all four tasks and the tape recorded samples were then transferred to a Sanborn oscillographic chart recorder for the latency measurements.

CHAPTER IV

RESULTS AND DISCUSSION

Experiment I: Word Length and Visual Complexity

The range and mean number of trials for each subject group for the paired-associate learning sessions are presented in Table 6. The differences in the mean number of trials required for each subject group in each of the four learning and overlearning sessions did not exceed one trial, and in three of the four experimental tasks the differences among the three groups did not exceed one-half trial. These data suggest that the paired-associates for any one group were not appreciably more difficult to learn on the average than those for any other subject group.

Simple Reaction Time

In the Simple Reaction Time (SRT) task, each subject was presented each of nine nonsense names and was instructed to repeat each name as rapidly as possible upon seeing a signal light. The simple reaction time, that is, the latency from the onset of the stimulus light to the onset of the verbal response, was obtained for each subject for each of the nonsense names. The SRTs for each subject and the mean SRT for each name for each group of subjects are presented in Appendix D. In Table 7 are presented the mean SRT for each combination of word length

TABLE 6

RANGE AND MEAN NUMBER OF TRIALS FOR EACH SUBJECT GROUP
FOR THE PAIRED-ASSOCIATE LEARNING SESSIONS

	First Day						Second Day		
	Learning Trials		Overlearning Trials		Timed Overlearning Trials		Overlearning Trials		Total Mean No. of Trials
Group	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Mean
I	9-22	13.9	5-8	5.7	3-6	3.9	5-10	5.9	29.4
II	8-22	13.4	5-6	5.4	3-7	4.3	5-8	5.9	29.0
III	7-10	13.2	5-7	5.5	3-6	4.3	5-8	5.7	28.7

TABLE 7

MEAN SRT (IN MSEC) FOR EACH COMBINATION OF WORD LENGTH AND VISUAL COMPLEXITY, AND THE MEAN SRT AND STANDARD ERROR OF THE MEAN FOR EACH LEVEL OR WORD LENGTH AND VISUAL COMPLEXITY

Visual Complexity Levels	Word Length One-Syllable	Two-Syllable	Three-Syllable	Mean	Standard Error
1	346	318	368	344	8
2	351	363	331	348	9
3	329	348	380	352	9
Mean	342	343	360		
Standard Error	8	9	10		

and visual complexity and the mean SRT and standard error of the mean for each level of word length and visual complexity.

The mean SRTs across subjects and visual complexity levels were 342 msec for one-syllable names, 343 msec for two-syllable names, and 360 msec for three-syllable names. The mean SRTs across subjects and word lengths were 344 msec, 348 msec, and 352 msec for names which had been associated with stimuli from visual complexity levels one, two, and three, respectively. These means and the corresponding standard errors of the means are displayed graphically in Figures 1(a) and 1(b).

The SRT task was performed primarily to determine if a relationship exists between SRTs and word length. The nonsense words had not been learned in isolation, however, but as names for nonsense forms representing various visual complexity levels. Since the data for the

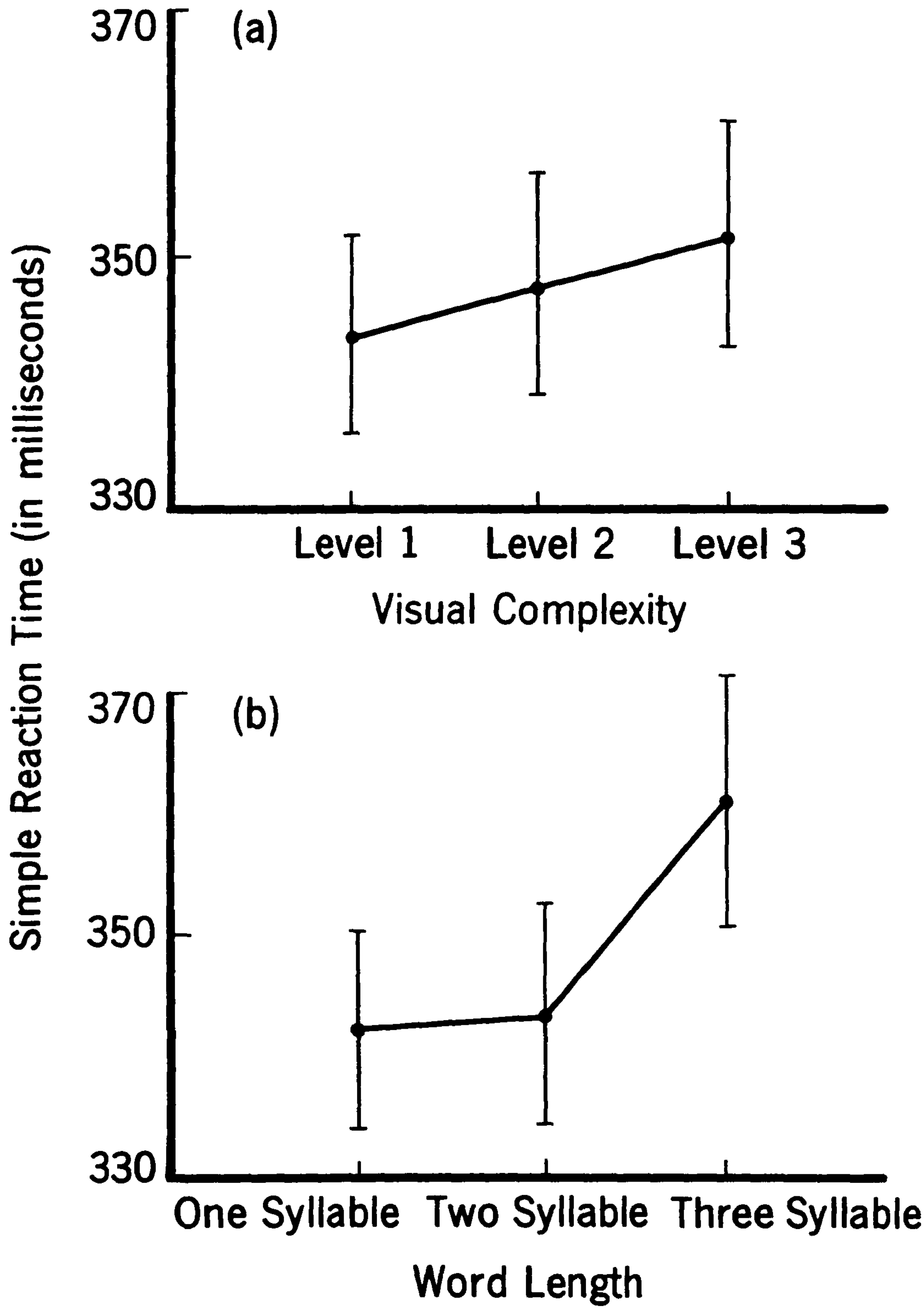


Figure 1.--(a) Mean simple reaction time and standard error of the the mean for each level of visual complexity. (b) Mean simple reaction time and standard error of the mean for each word length.

remaining tasks in this experiment are to be analyzed in relation to level of visual complexity, it seemed desirable to determine if mean SRTs are related to the level of visual complexity of the forms with which the names are associated. Since the visual stimuli were not actually used in obtaining the SRTs, a relationship between SRT and level of visual complexity was not predicted.

To test the significance of the differences among the means of word length and among the means of visual complexity, a Lindquist Type II Mixed Design analysis of variance (25) was employed. A summary of the analysis of variance is presented in Table 8. Both of the interactions and the visual complexity main effect were clearly not statistically significant. Since the main effect of word length could be considered significant at the 0.10 level, the sums of squares for the main effect of visual complexity, the word length by visual complexity (Within)

TABLE 8

SUMMARY OF THE ANALYSIS OF VARIANCE FOR EVALUATING THE EFFECTS OF WORD LENGTH AND VISUAL COMPLEXITY ON SIMPLE REACTION TIME

Source of Variation	df	SS	MS	F	Conclusion
Between Subjects	29	285481.91			
AB (Between)	2	30395.93	15197.97	1.60	NS
Error (Between)	27	255085.98	9447.63		
Within Subjects	60	62231.36			
Word Length (A)	2	6068.62	3034.31	3.09	$p < .10$
Visual Complexity (B)	2	947.07	473.53	.48	NS
AB (Within)	2	2192.34	1096.17	1.12	NS
Error (Within)	54	52023.33	981.91		
Total	89	347713.27			

interaction term, and the within subjects error term were pooled and the Duncan's New Multiple Range Test (24) was used to test the differences among the treatment means of the three word lengths. The results of this analysis are presented in Table 9. Significant differences ($p < .05$)

TABLE 9

SUMMARY OF THE DUNCAN'S NEW MULTIPLE RANGE TEST FOR EVALUATING THE DIFFERENCES IN MEAN SIMPLE REACTION TIME IN RELATION TO WORD LENGTH

Groups	Word Lengths	Difference	SSR	Conclusion
3	One-Syllable to Three-Syllable	18.33	17.04	$p < .05$
2	Two-Syllable to Three-Syllable	16.33	16.18	$p < .05$
2	One-Syllable to Two-Syllable	1.00	16.18	NS

were found between the treatment means of the one- and three-syllable names and of the two- and three-syllable names. The difference between the means of the one- and two-syllable names was not significant.

The findings in this experiment were comparable in magnitude of mean SRTs and in increase in mean SRTs with number of syllables to those reported for SRTs for numbers by Eriksen, Pollack, and Montague (14) and by Klapp (21). Eriksen et al.'s subjects yielded mean SRTs of 362 msec for one-syllable numbers and 370 msec for three-syllable numbers in the first of six blocks of trials. The data from this individual block of trials were not tested for statistical significance. Their statistical analysis did fail to show a significant syllable effect when all six blocks of trials were included in the analysis, but it is possible that practice results in a decreased syllable effect. Klapp reported mean SRTs of 391 msec for two-syllable numbers and 398 msec for three-syllable numbers. Klapp, however, reported that there was no apparent effect of syllables on SRT.

Eriksen et al. (14) suggested that when a subject knows a verbal response ahead of time in a SRT task, implicit speaking of the word should have been completed prior to the signal to respond. In the present experiment there was a two-to-three-second interval between the experimenter's presentation of the nonsense name and the presentation of the signal light. This ought to be sufficient time for the implicit speaking of the name, if such occurs, to be completed. The mean SRT for three-syllable names was found to be significantly longer than for one- and two-syllable names, however. This could indicate that implicit speech occurs, but not until after the presentation of the signal light.

It was previously noted that there was not a significant difference between the means of the one-syllable and two-syllable names in the present experiment. Differences in degrees of stress of the syllables may explain the larger increase in SRTs from two- to three-syllable names than from one- to two-syllable names. Stressed vowels in vocalized speech tend to be associated with longer durations than unstressed vowels (17). In this investigation, the one-syllable names were stressed, the first syllable of the two-syllable names was stressed and the second syllable was unstressed, and the first and third syllables of the three-syllable names were stressed and the second syllable was unstressed. Adding a stressed syllable to a name may add more time to implicitly speak the name than by adding an unstressed syllable. If implicit speech occurs after the presentation of the signal light and if syllabic duration variations in implicit speech parallel those in spoken words, a greater difference in response latency between two- and three-syllable names than between one- and two-syllable names would be anticipated.

In this case, it would also be expected that the difference in the time it took the subjects to overtly vocalize the three-syllable names as compared to the two-syllable names, would be greater than the difference in the time taken to vocalize the two-syllable names as compared to the one-syllable names. The duration of each of the 270 verbal responses (nine names for each of the thirty subjects) obtained during the SRT task was measured. The duration of the verbal response was defined as the amount of time from the onset of the verbal response to the termination of the verbal response. The mean duration for all subjects was 361 msec for one-syllable names, 419 msec for two-syllable names, and 592 msec for three-syllable names. These means and the standard errors of the means are presented in Figure 2.

Twenty-nine of the thirty subjects presented increasing mean response durations from one- to two-syllable names and all thirty subjects presented increasing mean response durations from two- to three-syllable names. The difference between the means of one- and two-syllable responses was 58 msec while the difference between the means of two- and three-syllable responses was 173 msec. A two-way analysis of variance with repeated measures on one factor (42) was employed to test the differences among the means of word length. The results of this analysis are summarized in Table 10. This analysis also allowed the testing of differences between groups and testing of group by word length inter-

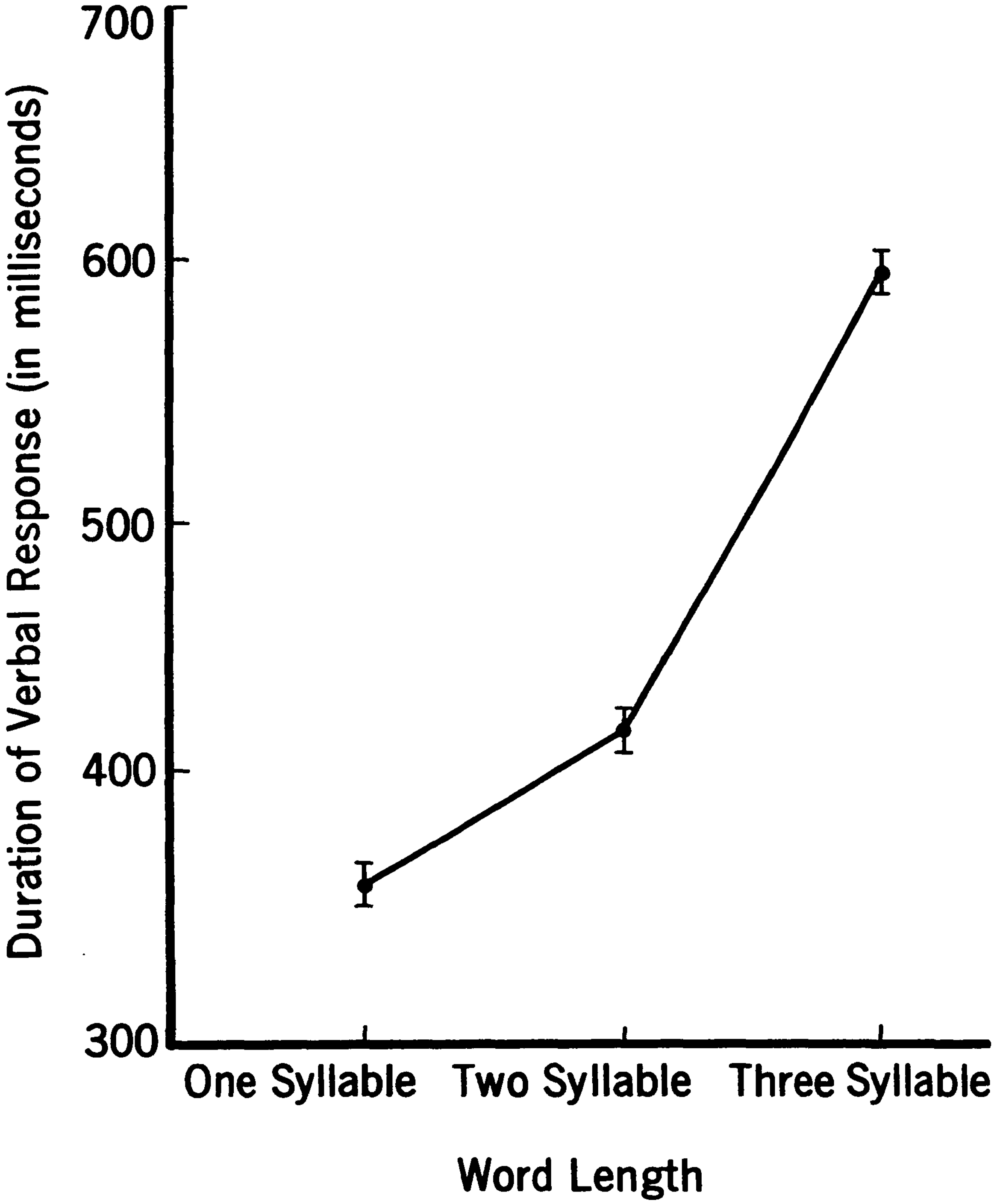


Figure 2.--Mean duration of verbal responses and standard error of the mean for each word length.

TABLE 10

SUMMARY OF THE ANALYSIS OF VARIANCE FOR EVALUATING DIFFERENCES IN VERBAL DURATION IN RELATION TO WORD LENGTH

Source	df	SS	MS	F	Conclusion
Between Subjects	29	367861.33			
Groups (A)	2	30661.77	15330.88	1.22	NS
Subjects Within Groups	27	337199.56	12488.87		
Within Subjects	60	923901.89			
Word Length (B)	2	861551.17	430775.58	389.36	$p < .01$
AB	4	2606.26	651.57	.59	NS
B X S Within Groups	54	59744.46	1106.38		
Total	89	1291763.22			

action. The main effect of word length was significant ($p < .01$) while the differences between groups and the group by word length interaction were not significant.

Thus, the data indicate that adding the third syllable to the word increased the total duration of the spoken word by about three times as much time as adding the second syllable. This relationship between number of syllables and response duration is similar to the relation between word length and SRT in that there was a larger increase in time from two- to three-syllables than from one- to two-syllables. These results are consistent with the contention that implicit speech does occur prior to the spoken response in the SRT task but following the presentation of the stimulus (signal light in this case).

If this hypothesis is true, then, as Colgate and Eriksen (11) suggest, there is not a one-to-one temporal transformation between overt speech and implicit speech. The difference in mean duration between one- and three-syllable names, for example, in overt speech is much greater than the difference in SRT for the one- and three-syllable names. Landauer (23) has stated that implicit speech requires roughly the same duration as overt speech. It would seem, then, that either (1) Landauer is right and, therefore, implicit speech is not occurring following the stimulus presentation in the SRT task; or (2) Landauer is in error and implicit speech and overt speech do not require the same duration; or (3) the term "implicit speech" as used in this study and by Colegate and Eriksen, and others, does not refer to the same verbal behavior as it does when used by Landauer.

If the syllable effect observed in this study is not due to "implicit speech" as defined by Landauer, that is, the conscious and intentional recitation of a familiar series of words, then how is this effect to be explained? It may be that subjects in Landauer's study performed some of the neuromuscular responses associated with overt speech whereas implicit speech in the SRT task involved only a more central process of motor planning for speech. One might speculate that the time involving motor planning for speech increases with the length of the verbal response. Further, this motor planning may have to occur immediately prior to initiation of the overt speech and, thus, would not occur until the signal light is presented in the SRT task. It would seem that further research is necessary for understanding the reasons for the existence of the syllable effect in the SRT task.

Visual Duration Threshold

In the visual duration threshold (VDT) task, each subject was presented each nonsense form at a duration below the subject's threshold of recognition. The time of stimulus exposure was then increased in five-msec steps until the pictured form was correctly named, the assumption being that the duration of the exposure represented the amount of exposure time needed for recognition. The VDTs for each subject and the mean VDT for each form for each group of subjects are presented in Appendix E. One subject misnamed the form associated with /zovəg/ and the threshold for this word for this subject was not included in any analyses. In Table 11 are presented the mean VDT for each combination of word

TABLE 11

MEAN VDT (IN MSEC) FOR EACH COMBINATION OF WORD LENGTH AND VISUAL COMPLEXITY AND THE MEAN VDT AND STANDARD ERROR OF THE MEAN FOR EACH LEVEL OF WORD LENGTH AND VISUAL COMPLEXITY

	Word Length				
Visual Complexity Levels	One-Syllable	Two-Syllable	Three-Syllable	Mean	Standard Error
Level 1	29	33	38	33	2
Level 2	27	33	32	30	2
Level 3	24	28	33	28	1
Mean	26	31	34		
Standard Error	1	2	2		

length and visual complexity and the mean and the standard error of the mean for each level of word length and visual complexity. The mean VDTs across all groups and levels of visual complexity were 26 msec for one-syllable responses, 31 msec for two-syllable responses, and 34 msec for three-syllable responses. The mean VDTs across all groups and word lengths were 33 msec, 30 msec, and 28 msec for stimuli associated with complexity levels one, two, and three, respectively. These means and the corresponding standard errors of the means are displayed graphically in Figures 3(a) and 3(b).

A Lindquist Type II Mixed Design analysis of variance (25) was employed to test the significance of the differences among the means of word length and among the means of visual complexity. A summary of the analysis of variance is presented in Table 12. The main effects for word

TABLE 12

SUMMARY OF THE ANALYSIS OF VARIANCE FOR EVALUATING THE EFFECTS OF WORD LENGTH AND VISUAL COMPLEXITY ON VISUAL DURATION THRESHOLD

Source of Variation	df	SS	MS	F	Conclusion
Between Subjects	29	5084.82			
AB (Between)	2	70.30	39.15	0.21	NS
Error (Between)	27	5006.52	185.43		
Within Subjects	60	3173.25			
Word Length (A)	2	1008.18	504.09	15.15	$p < .01$
Visual Complexity (B)	2	334.93	167.47	5.03	$p < .01$
AB (Within)	2	33.77	16.89	0.51	NS
Error (Within)	54 (53)	1796.37	33.27		
Total	89	8258.07			

length and visual complexity were significant ($p < .01$). None of the interactions was significant.

Wingfield (44) has suggested that the inverse relationship between word frequency and VDT may be a function of stimulus probability. That is, pictured objects whose names occur more frequently in a language

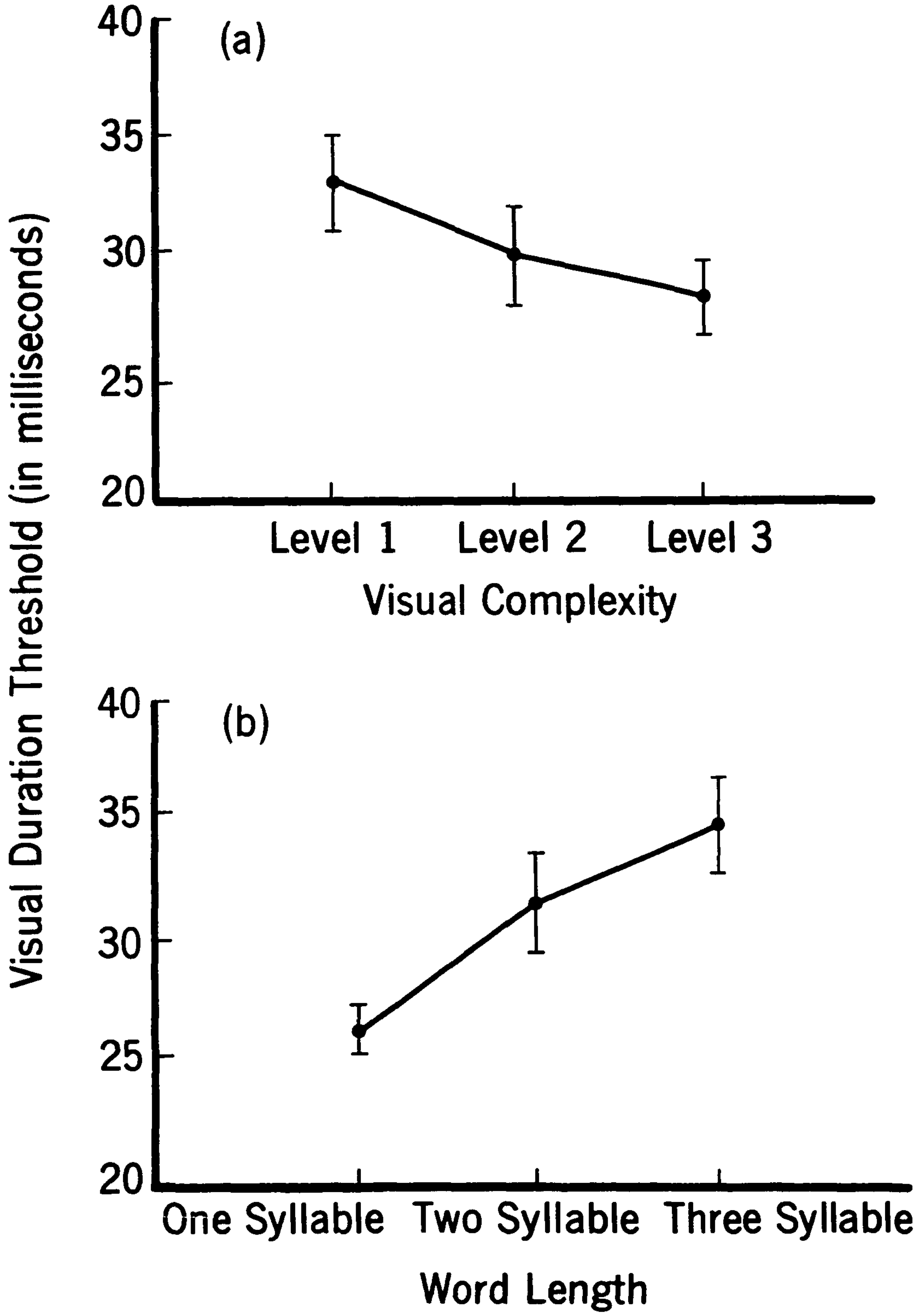


Figure 3.--(a) Mean visual duration threshold and standard error of the mean for each level of visual complexity. (b) Mean visual duration threshold and standard error of the mean for each word length.

have a greater probability of occurrence because they are more common and are, therefore, more readily recognizable. In the present experiment, however, each stimulus item had an equal probability of occurrence. Stimulus probability, then, would not be an appropriate explanation for the syllable effect found for VDTs in this experiment.

Wingfield (44) presented a VDT task to normal, adult subjects under two conditions. In the "No Masking" condition, each picture presentation was immediately followed by a plain white poststimulus field. In the "Poststimulus Masking" condition, each stimulus picture was followed by a complex visual noise pattern. Under the poststimulus masking condition, the obtained VDTs ranged from approximately 80 to 120 msec while in the no-masking condition, the VDTs ranged from approximately 10 to 30 msec.

The VDTs obtained in the present experiment, in which a visual masking pattern was used, are lower than those for the common objects in Wingfield's poststimulus masking condition. The difference between the threshold levels in the two experiments is most likely due to the limited number of response alternatives in the present experiment. Subjects in this experiment knew that their responses must be chosen from among nine alternative responses whereas in the Wingfield experiment many more alternatives were available.

The effect of a visual noise pattern is to curtail the visual afterimage of a pictured object. When the icon is curtailed, subjects require longer exposures to recognize pictured objects. Wingfield suggested that it could be argued that information derived from a visual display must be coded in some more durable form than a visual image if it is to be retained through the masking pattern (44). Although Wingfield does not speculate as to the nature of the coding of the visual display, Colegate and Eriksen (11) have suggested that this information may be coded in some verbal form.

Colegate and Eriksen (11) state that the subject, through a scanning or noting process, encodes information from the visual after-image. They designed an experiment to test the hypothesis that the encoding of visual information may consist of implicit speech. These authors found that subjects were able to encode a significantly greater number of one-syllable responses than three-syllable responses during a memory probe task. They argued that the longer the implicit naming requires, the more the icon has decayed before the next item in a display could be encoded or named.

Spoehr and Smith (37) have postulated three stages in the tachistoscopic recognition of printed words: (1) an analysis stage in which the words are analyzed letter by letter; (2) a unitization stage in which the results of the analysis are parsed into higher-order units; and (3) a translation stage which, in conjunction with the unitization stage, translates the output of analysis into a phonological representation. The authors note that these three events are true perceptual stages. The translation of visual stimuli (printed words or visual symbols) into a "phonological representation" then, is a part of perceptual identification.

The finding that word length is a factor in VDTs may add support to the hypothesis of Colegate and Eriksen that the visual image is translated into a more durable form, namely, an implicit speech response.

If, for example, it would take longer to encode visual images associated with three-syllable responses, perhaps the subjects may need to see the visual symbols for longer durations in order to complete the encoding process for perceptual identification. Then VDTs may increase as a function of the number of syllables in the verbal response associated with the visual stimulus.

The time represented by the VDT is only a portion of the time needed for perceptual identification (30, 44). It is unlikely that the search for the correct name could be completed in the time indicated by the VDT. It has been suggested by various experimenters that prior to searching for the name of the visual stimulus, there is some sort of stimulus categorization. For example, Oldfield (30) suggests that the first stage in perceptual identification consists in allotting the object to its correct frequency range by a means which does not involve any actual identification and naming. He suggests further that the second stage consists of a binary search of the ensemble of words belonging to this frequency range.

The finding in the present study and in the McGinnies *et al.* (26) study that VDT is significantly related to word length, independent of word frequency, might indicate that the form or object is allotted not necessarily to a particular frequency range, as suggested by Oldfield (30), but perhaps to the category of forms or objects having names of varying lengths. Just how the visual stimulus or word can be allotted to a particular sub-group without its being identified is not clear at this time.

The inverse relationship (20, 26, 44) between VDTs and the word frequency of occurrence may be due not only to stimulus probability but, at least in part, to the interaction between word frequency and word length. McGinnies et al. (26) noted that, in reading, longer words are accompanied by higher VDTs to a greater extent for low frequency words than for high frequency words. Thus, the effects of word length would be most apparent with words of low frequency. The verbal stimuli used in this investigation would appear to function more like words with low rather than high frequencies of occurrence since words with high frequencies of occurrence have undergone more overlearning. The results of the VDT task could be interpreted as supporting the word length effects presented by McGinnies et al.

An inverse relationship was found between VDTs and visual complexity levels in this experiment. Fraisse and Elkin (16) investigated the effects of four modes of stimulus presentation on VDTs and found that the easiest mode to recognize was detailed drawing followed by real object, photograph, and, finally, outline drawing modes. Fraisse and Elkin suggested that outline drawings were most difficult to recognize because the lack of detail in the stimuli created ambiguities in recognition. The association of lower VDTs with visual symbols from Complexity Level 3 may be due to the greater detail in the drawings of that level. Conversely, the comparative lack of detail in Complexity Level 1 drawings may have created more ambiguities at below threshold exposures and thereby resulted in increased thresholds.

Matching Response Latency

In the Matching Response task, the name of one of the nonsense forms was presented verbally by the experimenter. Each subject was then shown a nonsense form and was to respond as rapidly as possible with "yes" if the name were appropriate for the form and "no" if it were not. The matching response latency (MRL) for each name for each subject and the mean MRL for each name for each group of subjects are presented in Appendix F. One subject in Group II and one subject in Group III gave incorrect responses for /zovag/. These two responses were not included in the analyses. In Table 13 are presented the mean MRL for each combination of word length and visual complexity and the mean MRL and the standard error of the mean for each level of word length and visual complexity. The mean MRLs across all levels of visual complexity were 617 msec for one-syllable responses, 645 msec for two-syllable responses, and 669 msec for three-syllable responses. The mean MRLs across all word lengths were 657 msec, 641 msec, and 631 msec for stimuli associated with visual complexity levels one, two, and three, respectively.

TABLE 13

MEAN MRL (IN MSEC) FOR EACH COMBINATION OF WORD LENGTH AND VISUAL COMPLEXITY AND THE MEAN MRL AND STANDARD ERROR OF THE MEAN FOR EACH LEVEL OF WORD LENGTH AND VISUAL COMPLEXITY

	Word Length				
Visual Complexity Levels	One-Syllable	Two-Syllable	Three-Syllable	Mean	Standard Error
Level 1	630	688	654	657	28
Level 2	608	644	672	641	25
Level 3	612	601	680	631	20
Mean	617	645	669		
Standard Error	19	28	29		

These means and the corresponding standard errors of the means are displayed graphically in Figures 4(a) and 4(b).

A Lindquist Type II Mixed Design (25) analysis of variance was employed to test the significance of the differences among the means of word length and among the means of visual complexity. A summary of the analysis of variance is presented in Table 14. Both of the main effects

TABLE 14

SUMMARY OF THE ANALYSIS OF VARIANCE FOR EVALUATING THE EFFECTS OF WORD LENGTH AND VISUAL COMPLEXITY ON MATCHING RESPONSE LATENCY

Source	df	SS	MS	F	Conclusion
Between Subjects	29	1187749.03			
AB (Between)	2	24791.88	12395.94	0.29	NS
Error (Between)	27	1162957.15	43072.49		
Within Subjects	60	893931.72			
Word Length (A)	2	41862.48	20931.24	1.37	NS
Visual Complexity (B)	2	13185.23	6592.61	0.43	NS
AB (Within)	2	14402.50	7201.25	0.47	NS
Error (Within)	54 (52)	824481.51	15268.18		
Total	89	2081680.75			

and both of the interactions were not significantly different from zero ($p > .05$).

In Table 15 are presented the mean "yes" and "no" latencies for each word length across visual complexity levels and subject groups. The mean MRLs for "yes" and "no" responses for the three word lengths for each subject group are presented in Figure 5.

The results of the MRL task suggest a tendency for matching

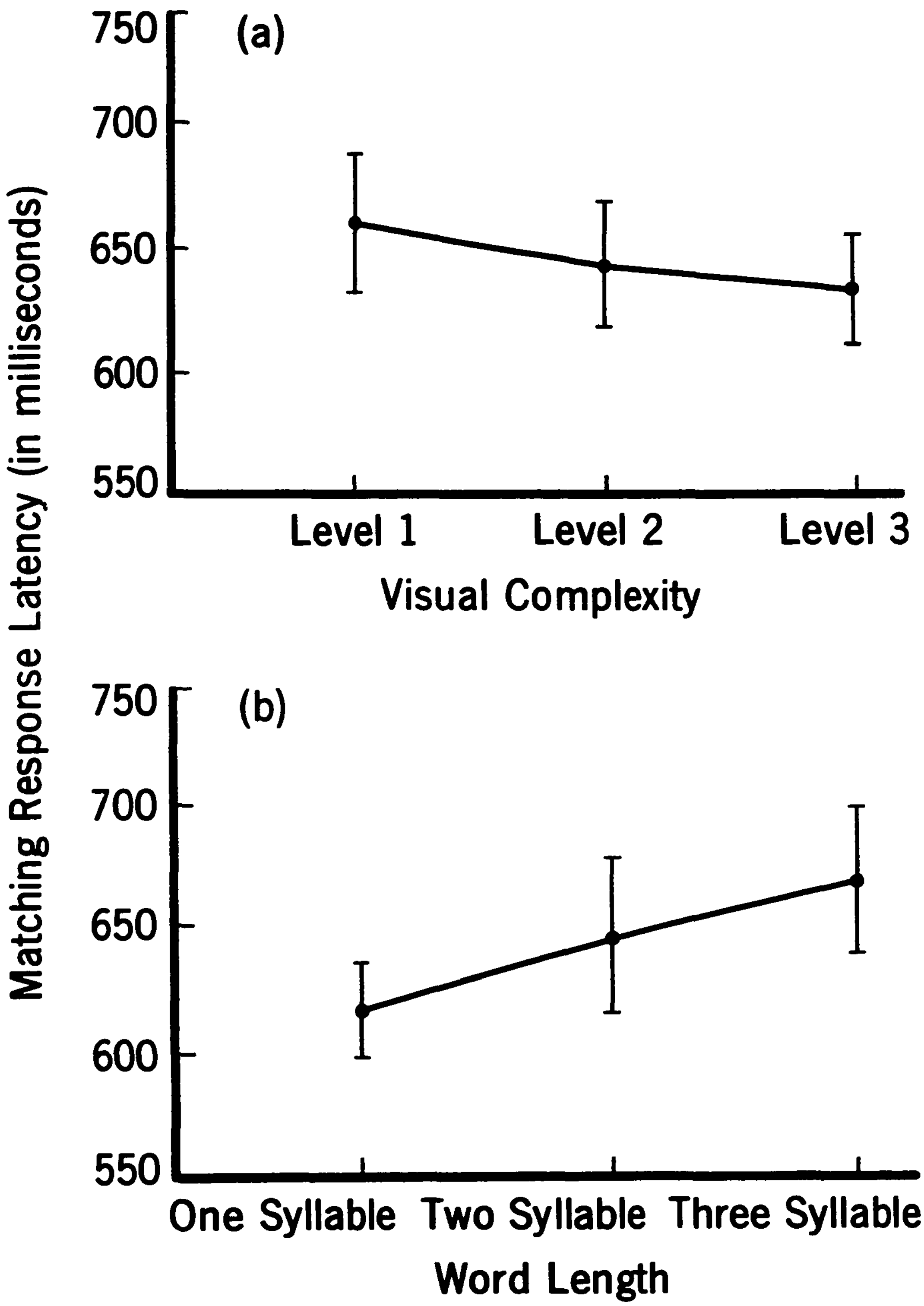


Figure 4.--(a) Mean matching response latency and standard error of the mean for each level of visual complexity. (b) Mean matching response response latency and standard error of the mean for each word length.

TABLE 15

MEAN MRLs FOR "YES" AND "NO" LATENCIES FOR EACH WORD LENGTH ACROSS VISUAL COMPLEXITY LEVELS AND SUBJECT GROUPS

	Word Length			
	One-Syllable	Two-Syllable	Three-Syllable	Mean
"yes"	598	633	600	610
"no"	635	653	737	675
Mean	617	644	669	

latency to increase as the number of syllables involved in the response increases. This trend, however, did not reach statistical significance. In using the analysis of variance employed to test the data, it is assumed that certain interactions in the Lindquist Type II Mixed Design are zero. Figure 5 suggests that there may be an interaction for "yes" responses involving word lengths and subject groups. For all three subject groups, "no" response latencies increase monotonically as stimulus word length increases from one to three syllables. On the other hand, the relationship of "yes" response latencies to word length varied with each subject group. In Group I, "yes" response latencies increased monotonically, in Group II increased and then markedly decreased, and in Group III decreased and then increased as word length increased from one to three syllables. The interaction involving "yes" latencies may have influenced the results of the analysis of variance.

The fact that the main effect of word length did not reach statistical significance should be interpreted cautiously. Although the tendency for MRL to increase as word length increases could have occurred

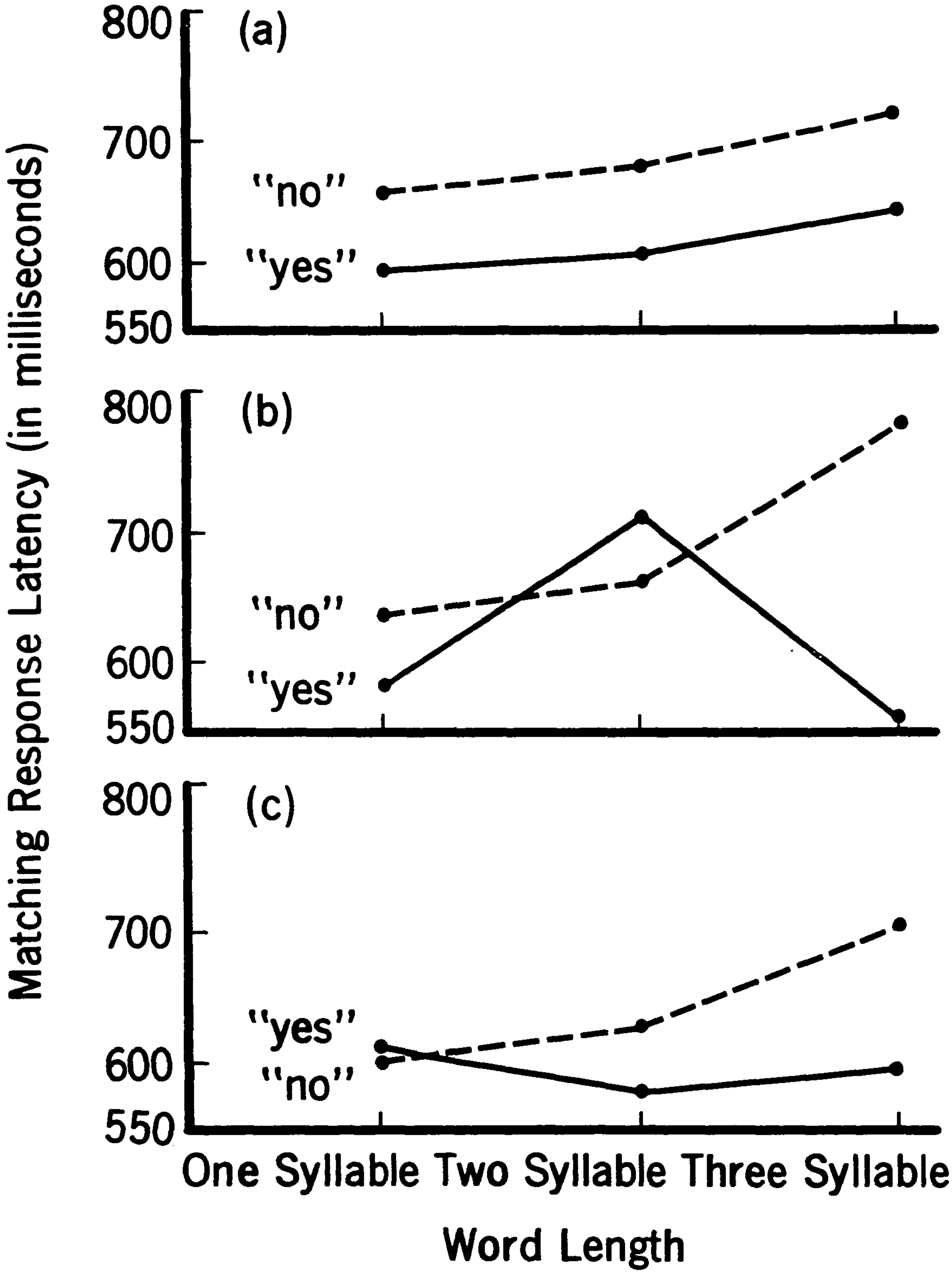


Figure 5.--Mean "yes" and "no" matching response latencies for (a) subject Group I, (b) subject Group II, and (c) subject Group III.

by chance alone, it has already been suggested that the complex interactions between word lengths and subject groups for "yes" response could have resulted in a failure of the analysis of variance to show significant differences. Secondly, the tendency for MRL to increase as a function of word length is very similar in direction to the results demonstrated for the effects of word length in the VDT and NRL tasks. Lastly, the data obtained in the present experiment for "yes", "no", and mean "yes"-"no" responses for word length are comparable in magnitude of the MRLs and in increasing MRLs with increases in the number of syllables to those reported by Klapp (21) for visually presented digits. For example, the mean matching latencies for "yes" and "no" reported by Klapp were 645 msec and 662 msec for two- and three-syllable numbers, respectively, compared to mean MRLs of 644 and 669 msec found in the present experiment. In addition, the mean "yes" latency reported by Klapp was 649 msec while the mean "no" latency was 675 msec. In the present experiment, the mean "yes" latency was 610 msec and the mean "no" latency was 675 msec. It should also be noted that the difference between the means of "yes" and "no" latencies and the differences among the means of word length across "yes" and "no" responses in the Klapp experiment were significant ($p < .001$). The major difference between the results of the present experiment and the Klapp experiment was that, in the latter experiment, "yes" latencies increased from two- to three-syllable responses while in the present experiment mean "yes" latencies decreased from two- to three-syllable responses.

It is interesting, however, that in another section of the Klapp study, using visually presented words and button-pushing responses substituted for verbal "yes"-"no" responses, the mean MRL for the "same" responses was 662 msec for both one- and two-syllable words but for the "different" responses were 705 msec for one-syllable and 751 msec for two-syllable words. It may be that "yes" or "same" responses are not related to word length in the same way as "no" or "different" responses. Bamber (2) has proposed that subjects employ two distinct stimulus-comparison processes simultaneously with a "fast identity reporter" subserving "same" decisions and a "slower serial processor" subserving "different" decisions. Wingfield (44) has suggested that a subject has an initial set for a "same" decision and the need to reject this set for a "different" decision results in longer matching latencies. Another possible explanation for this finding is that the handling of negative propositions in general requires longer processing times (44) and, therefore, "different" decisions would be associated with longer response latencies than "same" decisions.

Klapp and Bischoff (22), who failed to find a syllable effect for matching latencies, have suggested that subjects did not use an implicit speech process to mediate "same"-"different" decisions with printed names and nonsense forms. The present experiment differed from the Klapp and Bischoff experiment in four major ways: (1) Klapp and Bischoff used two word lengths while three word lengths were used in the present experiment; (2) all ten verbal responses in the Klapp and Bischoff experiment consisted of five letters whereas word length varied from three to five to seven letters in the present experiment; (3) Klapp and Bischoff paired "real" words to nonsense forms whereas nonsense words were paired with nonsense forms in the present experiment; and (4) two nonsense forms were simultaneously presented to subjects in the Klapp and Bischoff experiment but in the present experiment spoken names were presented first and then the visual stimuli were presented.

It is questionable how much implicit speech involving the associated names would be used in a picture-picture matching task. Posner and Mitchell (34) propose that the "same"-"different" judgment in a case such as this is based on "physical identity." Since both forms would be present in the perceptual field at the same time, it is possible for a match of this type to be made even if the stimuli had never been seen before. This type of match, then, may be completely free of any prior learning effects. In addition, if the verbal responses are used by the subjects in the picture-picture matching task, questions may be raised as to the effects of the subjects' prior experience with the "real" words on the syllable effect.

Another possible explanation for the lack of a syllable effect in the Klapp and Bischoff experiment may involve the nature of the response words themselves. Their ten words were: clear, false, heard, learn, taste, color, fifty, happy, labor, and table. It should be noted that the first syllable of the two-syllable words is stressed and the second syllable is unstressed. Therefore, the two syllable words were comparable in stress to the two-syllable words in the present investigation. It has already been suggested that the addition of an unstressed syllable might not increase the time required for implicit speech as much as adding a stressed syllable. In addition, three of the five one-syllable words used by Klapp and Bischoff were composed of three phonemes while the remaining two one-syllable words were composed of four phonemes.

Three of the two-syllable words were composed of four phonemes and two were composed of five phonemes. In the present study, all two-syllable words were composed of five phonemes and all the one-syllable words contained only three phonemes. Response latency differences may be more apparent in comparing three-phoneme one-syllable responses to five-phoneme two-syllable responses as in the present study, than when comparing one- and two-syllable responses which differ, on the average, by only one phoneme as in the Klapp and Bischoff study.

Wingfield (44) and Milianti and Cullinan (28) have suggested that there is no word frequency effect in matching response latencies. In both studies, however, a small, nonsignificant inverse relationship between MRL and frequency of occurrence of the words in the English language is suggested. Though word frequency did not appear to be related to MRLs per se, one might expect a tendency for an inverse relationship between word frequency and the MRL due to the effects of word length. Since longer words tend to occur less frequently in a language and since the present experiment has suggested a possible relationship between word length and MRL, the trends described by Wingfield and Milianti and Cullinan may have been due to the effects of word length.

Naming Response Latency

In the Naming Response task, each subject was instructed to name each nonsense form as rapidly as possible. The naming response latencies (NRLs) for each subject and the mean NRL for each name for each group of subjects are presented in Appendix G. Of a total of 270 possible responses, three responses involved misnamings, two responses occurred after the three-second stimulus presentation, and four responses could not be measured due to extraneous noise occurring simultaneously with the verbal response. These nine responses were not included in any analyses. In Table 16 are presented the mean NRL for each combination of word

TABLE 16

MEAN NRL (IN MSEC) FOR EACH COMBINATION OF WORD LENGTH AND VISUAL COMPLEXITY AND THE MEAN NRL AND STANDARD ERROR OF THE MEAN FOR EACH LEVEL OF WORD LENGTH AND VISUAL COMPLEXITY

	Word Length				
Visual Complexity Levels	One-Syllable	Two-Syllable	Three-Syllable	Mean	Standard Error
Level 1	1014	1217	1197	1142	45
Level 2	858	1083	1321	1087	45
Level 3	1003	1014	1119	1045	40
Mean	958	1104	1212		
Standard Error	35	41	50		

length and visual complexity and the mean and the standard error of the mean for each level of word length and visual complexity. The mean NRL across all levels of visual complexity was 958 msec for one-syllable names, 1104 msec for two-syllable names, and 1212 msec for three-syllable names. The mean NRL across all word lengths was 1142 msec, 1087 msec, and 1045 msec for stimuli associated with visual complexity levels one, two, and three, respectively. These means and the corresponding standard errors of the means are displayed graphically in Figures 6(a) and 6(b).

A Lindquist Type II Mixed Design analysis of variance (25) was employed to test the significance of the differences among the means of word length and among the means of visual complexity. A summary of the

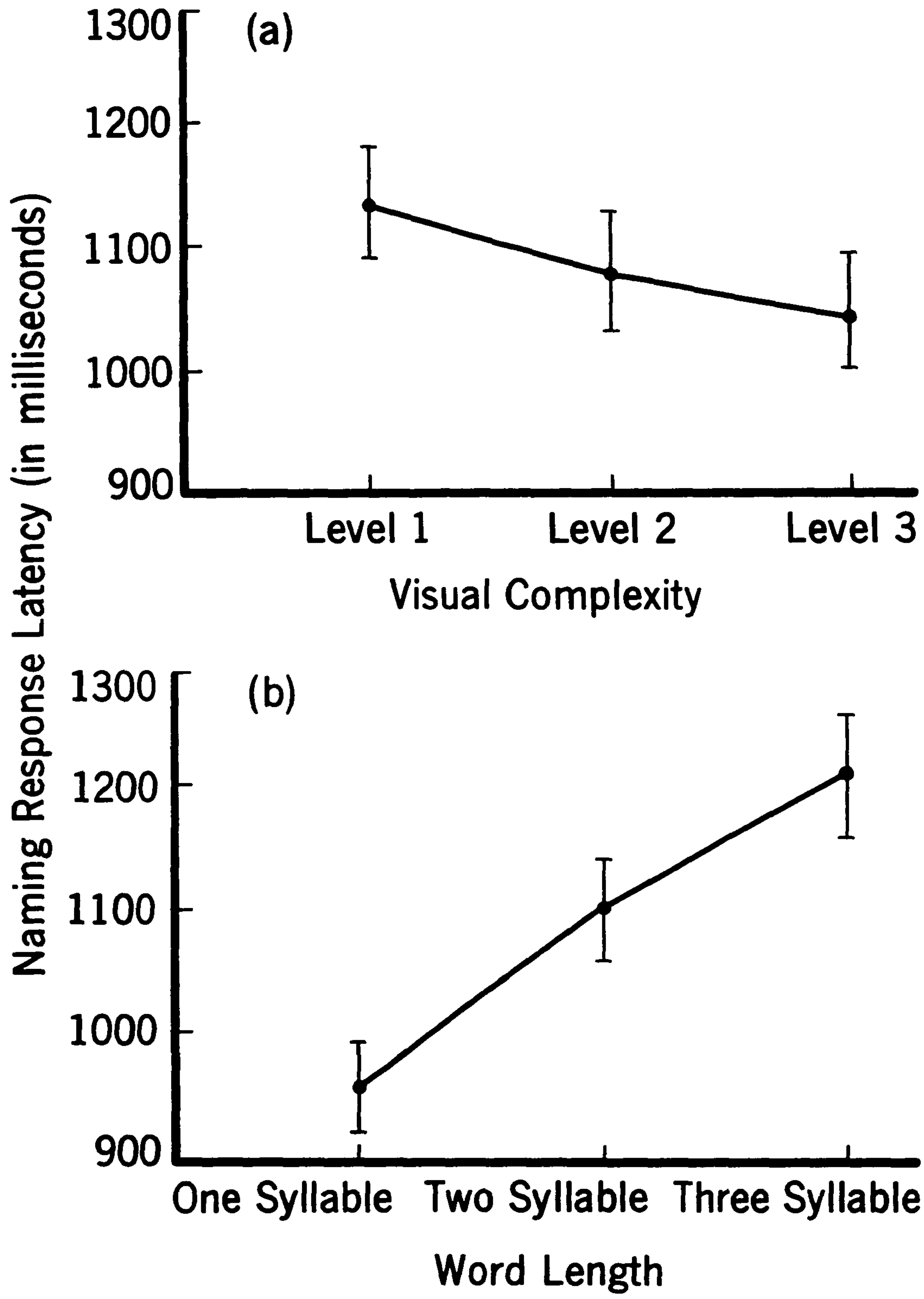


Figure 6.--(a) Mean naming response latency and standard error of the mean for each level of Visual Complexity. (b) Mean naming response latency and standard error of the mean for each word length.

analysis of variance is presented in Table 17. The main effects of word

TABLE 17

SUMMARY OF THE ANALYSIS OF VARIANCE FOR EVALUATING THE EFFECTS OF WORD LENGTH AND VISUAL COMPLEXITY ON NAMING RESPONSE LATENCY

Source of Variation	df	SS	MS	F	Conclusion
Between Subjects	29	5367931.02			
AB (Between)	2	219484.81	109742.41		
Error (Between)	27	5148446.21	190683.19	0.58	NS
Within Subjects	60	2224520.42			
Word Length (A)	2	637599.37	318799.69	12.43	$p < .01$
Visual Complexity (B)	2	183961.23	91980.62	3.59	$p < .05$
AB (Within)	2	18059.84	9029.92	0.35	NS
Error (Within)	54(45)	1384899.98	25646.30		
Total	89	7592451.44			

length and visual complexity were significant ($p < .05$) while none of the interactions was significant.

An inverse relationship (28, 29, 31, 32) exists between naming latencies and frequency of occurrence of words in print in the English language. In addition, the results of the present experiment indicate a relationship between NRLs and word length. Since longer words tend to occur less frequently in a language, it would appear that there may be a confounding of word length and word frequency in studies of the naming response. In the present study, word frequency is controlled. Thus, NRL seems to be a function of word length independently of word frequency.

The data indicate also an inverse relationship between NRL and visual complexity. It was previously suggested that stimuli from Visual Complexity Level 3 were much easier to recognize because of their lower degree of ambiguity. Stimuli associated with Complexity Level 3 may have been named faster because they have lower thresholds of recognition. However, the difference in VDTs of Complexity Level 1 stimuli and Complexity Level 3 stimuli was only five msec while the difference in NRLs between level one and level three stimuli was 97 msec. The small difference in recognition thresholds would not seem to account for the larger differences in the NRLs.

The increase in NRL as a function of word length is consistent with an interpretation that an implicit speech process may be a part of the total time required for the naming response. Since it would take longer to implicitly speak a three-syllable name than a one-syllable name, the time required for covert pronunciation of the name would affect verbal reaction time. As the time required for implicit speech increases, the NRL would be expected to increase.

As previously noted, Landauer (23) found that implicit speech requires roughly the same duration as overt speech. Colegate and Eriksen (11) found that the spoken one-syllable words in their study had durations ranging from 200 to 250 msec whereas the three-syllable words had a duration of approximately 500 msec. Thus, the one- and three-syllable words differed in duration by about 250 to 300 msec when spoken. In the present study, the average durations for the spoken one-syllable words and three-syllable words were 361 and 592 msec, respectively, and differed by 231 msec. The mean NRLs in the present study for one- and three-syllable words differed by 254 msec. Thus, it could be that the difference in NRLs for one- and three-syllable names were due to differences in the time needed for the implicit speaking of the names.

It is interesting that the difference between the mean difference for NRLs, 254 msec, and for name durations, 231 msec, is close to the difference in SRTs, 18 msec, for the one- and three-syllable names. Further, the difference in VDTs for one- and three-syllable names was 8 msec. The sum of the differences in the SRTs, VDTs, and overt response duration for the one- and three-syllable names equals 257 msec which is quite similar to the 254 msec difference for the NRLs for the one- and three-syllable names. This might suggest that the differences in NRLs, then, reflects the sum of the differences between one- and three-syllable names in (a) allotting the object or form to the appropriate stimulus category, (b) motor planning needed to speak the word, and (c) the implicit speaking of the word. This would imply that the time needed for the search for the correct name is independent of word length once the correct category is selected. Further study is certainly indicated before one would consider formally proposing this as an hypothesis.

Differences in Number of Learning Trials

Carroll and White (10) have suggested that objects whose names are learned early in life are named faster, that is, they have shorter NRLs. They suggest, further, that word-retrieval may be a one-stage process that depends upon the age at which a word is learned. Since nonsense stimuli were used in the present study, the findings cannot be explained in terms of age at which the names were learned. The question does arise, however, as to whether there might not exist relationships between the various processing times studied and the order in which the paired-associates were learned. While this experiment was not designed specifically to answer this question, some information bearing on the question can be obtained from the available data.

The number of the trials in the first learning session in which each subject learned the correct association between each nonsense name and nonsense form was recorded for each of the thirty subjects and these data are presented in Appendix H. The criterion for learning of an association was defined as the third consecutive trial in which the subject correctly named the visual form.

Pearson product-moment correlation coefficients were obtained as measures of the relationships between mean number of trials to learn and mean SRTs, VDTs, NRLs, and MRLs. The results of these analyses are presented in Table 18. The coefficients indicate that SRTs, VDTs, NRLs,

TABLE 18

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS FOR MEAN NUMBER OF TRIALS TO LEARN AND MEAN SRTs, VDTs, MRLs, AND NRLs

	r	"t"	Conclusion
Learning Trials and SRTs	.33	1.748	$p > .05$
Learning Trials and MRLs	.57	3.469	$p < .05$
Learning Trials and VDTs	.75	5.669	$p < .05$
Learning Trials and NRLs	.89	10.324	$p < .05$

and MRLs all tend to be positively related to the number of trials required to learn the nonsense names with the obtained coefficients for VDTs, NRLs, and MRLs being significantly greater than zero ($p < .05$).

It was previously noted that "yes" and "no" response latencies in the MRL task may not be similarly related to word length. For this reason the correlation coefficients were obtained for the mean "yes" and "no" response latencies for each pair of stimuli with the mean number of trials to learn obtained from the data for all ten subjects who learned the particular association. Correlation coefficients were also obtained for the mean latency for the "yes" responses with the mean number of trials to learn based on the data from those five subjects for each stimulus pair who gave "yes" responses and for the mean latency for the "no" responses with the mean number of trials to learn based on the data from the five subjects for each stimulus pair giving the "no" responses. These correlations are presented in Table 19.

TABLE 19

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS FOR MEAN NUMBER OF LEARNING TRIALS AND MEAN MRLS FOR "YES" AND "NO" RESPONSES

	r	"t"	Conclusion
Learning Trials (Mean of Ten Subjects):			
"Yes"	.52	3.044	$p < .05$
"No"	.28	1.458	$p > .05$
Learning Trials (Mean of Five Subjects):			
"Yes"	.35	1.868	$p > .05$
"No"	.49	2.810	$p < .05$

The correlation coefficient for "yes" latencies with the learning data based on all ten subjects is significantly different from zero ($p < .05$) but when the "yes" latencies are paired with the learning data based on the five subjects giving the "yes" responses, the coefficient is not significant. The opposite trend is noted for "no" responses. Thus, the data indicate that mean MRLs are positively related to the number of trials needed to learn the paired-associates. The relationship of mean MRLs for either "yes" or "no" responses to mean number of trials to learn, however, is not clear in view of the fact that significant and nonsignificant relationships exist for "yes" and "no" responses depending upon the manner in which the learning data are averaged.

Up to this point, then, it appears that some of the processing times obtained in this experiment are related to word length and to level of visual complexity. It appears, also, however, that the times may be related to the order in which the names were learned. These observations suggest that the number of trials to learn also may be related to word length and to level of visual complexity.

Word length particularly might be a factor in the order in which the pairs are learned. Brown (8) suggests that, while the frequency-brevity principle does not prevail in all cases, when a name is taught to a child, there is an especially strong and universal belief "that children have trouble pronouncing long names and so should always be given the shortest possible names." Thus, words learned at an early age tend to be short words. In a learning task such as the one contained in this experiment, it is also possible that the shorter names would be learned first because they are easier to remember and, therefore, easier for the subject to rehearse to himself. The mean number of trials required to learn the one-syllable paired-associates was 7.1 trials, for two-syllable paired associates was 8.9 trials, and for three-syllable paired associates was 9.1 trials.

A Lindquist Type II Mixed Design analysis of variance (25) was employed to investigate the effects of word length and visual complexity on the number of trials needed to learn the paired associates. The results of this analysis are summarized in Table 20. The main effect of

TABLE 20

SUMMARY OF THE ANALYSIS OF VARIANCE FOR EVALUATING THE EFFECTS OF WORD LENGTH AND VISUAL COMPLEXITY ON THE NUMBER OF LEARNING TRIALS

Source of Variation	df		MS	F	Conclusion
Between Subjects	29	360.77			
AB (Between)	2	16.44	8.22	.64	NS
Error (Between)	27	344.33	12.75		
Within Subjects	60	253.63			
Word Length (A)	2	69.26	34.63	10.36	$p < .01$
Visual Complexity (B)	2	2.60	1.30	.39	NS
AB (Within)	2	1.19	.60	.18	NS
Error (Within)	54	180.58	3.34		
Total	89	614.40			

word length was significant ($p < .01$) but the main effect of visual complexity and the interactions were not significant. The sums of squares for the main effect of visual complexity, the word length by visual complexity (within) interaction term, and the within subjects error term were pooled and the Duncan's New Multiple Range Test (24) was used to test the differences among the treatment means of word length. The results of this analysis are presented in Table 21. Significant differences ($p < .01$) were found between the treatment means of one- and three-syllable responses and between one- and two-syllable responses. The difference between the means of the two- and three-syllable responses was not significant.

TABLE 21

SUMMARY OF THE DUNCAN'S NEW MULTIPLE RANGE TEST FOR EVALUATING THE DIFFERENCES IN WORD LENGTH FOR THE NUMBER OF LEARNING TRIALS

Groups	Varieties	Difference	SSR	Con-clusion
3	One-Syllable to Three-Syllable	1.95	1.27	$p < .01$
2	One-Syllable to Two-Syllable	1.87	1.22	$p < .01$
2	Two-Syllable to Three-Syllable	.18	1.22	NS

Since in the first learning session, all nine pairs were practiced until all nine visual stimuli were named correctly on three consecutive trials, those pairs which were learned first underwent more overlearning trials than those learned in the later trials. Thus, the relationships noted between the various processing times and the number of trials to learn might actually reflect relationships between the times and the amount of practice or overlearning for the pairs. The design of the present experiment permits neither an investigation of the effects of number of trials to learn nor the number of overlearning trials on the various processing times independent of each other. One reason for this is that the number of trials to learn is confounded with the number of overlearning trials in that the subjects in the three groups participated in different numbers of trials in the learning session. Thus, while four trials to learn might be accompanied by five overlearning trials for one subject, it might be associated with ten overlearning trials for another subject.

It might also be asked if the various processing times are actually related to word length or just appear to be so because both the times and the word lengths are related to the number of trials to learn and/or the number of overlearning trials. Again, this study was not designed to answer the question. Some information bearing on the issue can be obtained, however, by observing whether or not SRTs, VDTs, and NRLs increase as a function of word length when the number of trials to learn and the number of overlearning trials in the first learning session are balanced for names having differing numbers of syllables. To accomplish this, mean SRTs, VDTs, and NRLs were computed for those subjects whose responses to words containing the same initial syllable showed the same number of learning trials. Thus, the data for a pair of words differing only in word length would come from the same subject, and since the number of learning trials is equal for the two words, then the number of overlearning trials would also be equal. For example, if for a particular subject, /mob/ were learned in five trials, /mobən/ in six trials, and /mobənez/ in five trials, response latencies for /mob/ and /mobənez/ could be compared because they both were learned in an equal number of trials. Further, if the subject met the criteria for the first learning session in twelve trials, then both /mob/ and /mobənez/ would have undergone seven trials of overlearning. The subject numbers, the words, the number of trials to learn, and the VDTs, SRTs, and NRLs which could be used in this type of analysis are presented in Appendix I. The mean VDTs, SRTs, and NRLs, for comparing one- and two-syllable names, one- and three-syllable names, and two- and three-syllable names are contained in Table 22.

There were only five instances where a subject learned all

TABLE 22

MEAN RESPONSE TIMES (IN MSEC) FOR SRT, VDT, AND NRL TASKS FOR COMPARING WORD LENGTH WHEN THE NUMBER OF LEARNING TRIALS ARE CONTROLLED

Experimental Tasks	Number of Responses	Word Length One-Syllable	Two-Syllable	Three-Syllable
		One-Syllable versus Two-Syllable		
SRT	12	333	335	-
VDT	12	20	30	-
NRL	11	933	939	-
		One-Syllable versus Three-Syllable		
SRT	15	322	-	348
VDT	15	25	-	29
NRL	15	1023	-	1108
		Two-Syllable versus Three-Syllable		
SRT	19	-	332	352
VDT	19	-	30	28
NRL	17	-	1056	1136
		One- versus Two- versus Three-Syllable		
SRT	18	337	337	361
VDT	18	23	28	28
NRL	16	856	952	1096

three names beginning with the same syllable in the same number of trials. To compare the VDTs, SRTs, and NRLs for one-, two-, and three-syllable names, the data were used when the number of trials for each of the three words beginning with the same syllable differed by no more than one trial. In the previous example, /mob/, /moban/, and /mobanez/ could be used in this analysis because they were all learned within one trial of one another. The data used, and the mean SRTs, VDTs, and NRLs obtained are presented in Appendix J and in Table 22, respectively.

While the relationship of the means and word length are of interest, these means are not completely satisfactory since (a) in some comparisons some subjects contribute more data than others, (b) all names do not occur the same number of times, (c) all groups of subjects are not represented equally, and (d) word length and visual complexity level are confounded.

Response latencies for the MRL task were not computed because of the confounding effect of "yes" and "no" latencies. For example, one-, two-, and three-syllable responses could not be compared because, due to the randomization scheme for "yes" and "no" responses, there would be no instance in which the responses for the three word lengths would be either all "yes" or all "no". Therefore, differences in latencies might not be due to effects of word length, but rather may be due to a longer time associated with a "no" response as opposed to a "yes" response.

When number of learning trials is controlled, SRTs did not increase from one to two syllables, but did increase from one to three and from two to three syllables. Across all three word lengths, the increase in SRT is similar in magnitude and direction to the results for SRTs reported earlier in this chapter. Since the effects of learning were controlled in this analysis, it would appear that the increase in SRTs from one to three and from two to three syllables would be due at least in part to the effects of word length and not entirely, if at all, to the number of learning or overlearning trials. In addition, a small, nonsignificant correlation was found between mean SRT and mean number of learning trials. This finding is expected in view of the fact that the visual forms were not used in the SRT task, and, therefore, one would not expect learning of pairs involving the visual forms to be a factor in SRT.

VDTs increased from one to two syllables and from one three syllables, however, VDTs decreased slightly from two- to three-syllables. These general trends were noted when VDTs were compared across all three word lengths. These data, in conjunction with the significant correlation between VDT and the number of learning trials can be taken to suggest that number of learning trials may be a factor in perceptual identification of nonsense forms.

When number of learning trials is controlled, NRLs increase from one to two, from two to three, and from one to two to three syllables. These data suggest that word length, and not number of learning trials, may be the primary factor affecting NRLs. However, a significant positive correlation was found between NRLs and the number of learning trials. These two findings are not inconsistent inasmuch as longer words may be both more difficult to learn and to initiate in overt speech.

In summary, SRTs, VDTs, and NRLs are related to word length. In addition, there is a tendency for MRLs to increase with increases in word length, particularly for "no" responses. However, the effects of word length on VDTs, MRLs, and NRLs may be confounded, at least in part, with the number of trials needed to learn the paired-associates or with the number of overlearning trials. Lastly, VDTs and NRLs are related to complexity of the visual stimuli. The data are consistant with an interpretation that an implicit speech process may be a part of the total time required for the naming of nonsense forms.

Experiment II: Phoneme Differences

The purpose of the second experiment was to investigate the effects of phoneme differences on simple reaction times (SRTs) and on choice reaction times (CRTs), the latter obtained during oral reading tasks. Stimulus length was controlled in terms of number of phonemes and number of syllables by using isolated vowels (Vs), consonant-vowel combinations (CVs), consonant-vowel-consonant combinations (CVCs), and consonant-vowel-consonant-vowel combinations (CVCVs). Subject Group I from the first experiment was randomly chosen from the three available groups to participate in the second experiment.

In the SRT task, the experimenter orally presented each of the five vowel (V) phonemes one at a time and then presented the twenty-two consonant-vowel (CV) combinations to each of the ten subjects who were instructed to produce the V or CV as rapidly as possible upon seeing a signal light. The mean SRT for each of the vowels and CV combinations is presented in Table 23. Five verbal responses could not be measured because noise occurred simultaneously with the verbal response and were excluded from further analysis. The mean SRT for the five vowels was 323 msec and for the twenty-two CV combinations, 316 msec.

In the choice reaction task for vowels and CV combinations, five vowel phonemes were presented tachistoscopically to each subject followed by the presentation of the twenty-two CV combinations. The subjects were instructed to read the stimulus items aloud as rapidly as possible. The mean choice reaction time (CRT) for each of the five vowels and twenty-two CV combinations is presented in Table 23. There

TABLE 23

SIMPLE AND CHOICE REACTION TIMES (IN MSEC) FOR THE FIVE VOWELS AND TWENTY-TWO CV COMBINATIONS AND CHOICE REACTION TIMES FOR CVC AND CVCV COMBINATIONS

Experimental Tasks							
SRT		CRT: V and CV		CRT: CVC		CRT: CVCV	
Stimulus	SRT	Stimulus	CRT	Stimulus	CRT	Stimulus	CRT
tʌ	319	tʌ	544	tʌt	626	tʌtʌ	568
dʌ	305	dʌ	467	dʌd	503	dʌdʌ	534
nʌ	299	nʌ	495	nʌn	571	nʌnʌ	548
pʌ	296	pʌ	492	pʌp	592	pʌpʌ	526
gʌ	311	gʌ	540	gʌg	562	gʌgʌ	510
bʌ	334	bʌ	492	bʌb	544	bʌbʌ	523
fʌ	371	fʌ	605	fʌf	626	fʌfʌ	623
vʌ	276	vʌ	543	vʌv	535	vʌvʌ	595
zʌ	295	zʌ	537	zʌz	562	zʌzʌ	563
kʌ	325	kʌ	534	kʌk	520	kʌkʌ	486
mʌ	281	mʌ	529	mʌm	512	mʌmʌ	514
sʌ	331	sʌ	553	sʌs	558	sʌsʌ	565
shʌ	357	shʌ	524	shʌsh	571	shʌshʌ	608
chʌ	307	chʌ	588	chʌch	625	chʌchʌ	574
rʌ	302	rʌ	566				
lʌ	325	lʌ	524				
hʌ	324	hʌ	564				
wʌ	306	wʌ	479				
yʌ	318	yʌ	569				
jʌ*	346	jʌ*	741				
thʌ	319	thʌ	716	thʌth*	829	thʌthʌ*	809
~~th~~ʌ*	320	~~th~~ʌ*	799	~~th~~ʌ~~th~~*	770	~~th~~ʌ~~th~~ʌ*	806
/e/	338	/e/	569				
/a/	328	/a/	486				
/i/	317	/i/	637				
/u/	308	/u/	549				
/ʌ/	323	/ʌ/	628				

* Data excluded from analysis

were six incorrect verbal responses and four responses which could not be measured and which were excluded from further analysis. The mean CRT for the five vowels was 574 msec and for the twenty-two CV combinations, 564 msec.

The CRTs for the CV combinations "jʌ", "thʌ", and "~~th~~ʌ" were 741, 716, and 799 msec, respectively. These CRTs are considerably longer than those for the other nineteen CV combinations. Subjects reported confusions in either perceptual identification or pronunciation of thʌ and ~~th~~ʌ. Further, the English grapheme j, as in judge, was pronounced by its phonetic pronunciation /j/ as in yellow, by three of the ten subjects. Four of the remaining seven subjects presented unusually long CRTs (greater than 794 msec) for "jʌ". Since it appeared that confusions in either perceptual identification or pronunciation may have resulted in longer CRTs for these three CVs, the data for these three CVs were excluded from further analysis. The mean CRT for the remaining nineteen CV combinations was 531 msec.

The mean CRTs for sixteen CVC combinations are presented in Table 23. The mean CRT for all sixteen CVCs was 594 msec. The CRTs for "thʌth" and "~~th~~ʌ~~th~~" seemed excessively long as compared to the other stimuli. Subjects reported confusions in perceptual identification and pronunciation for these two CVC combinations. These data were eliminated from further analysis and the mean CRT for the remaining fourteen CVCs was 565 msec.

The mean CRTs for sixteen CVCV combinations also are presented in Table 23. Five responses could not be measured and were therefore not included in the data analysis. The mean CRT for all sixteen CVCVs was

584 msec. Subjects reported confusions in perceptual identification or pronunciation for "thʌthʌ" and "~~th~~ʌ~~th~~ʌ". The data for these two CVCVs were excluded from further analysis. The mean CRT for the remaining fourteen CVCVs was 552 msec.

In order to compare the results of the SRT task and the CRT task for Vs and CVs, the SRTs for "thʌ", "~~th~~ʌ", and "jʌ" were excluded and a revised mean SRT of 315 msec for the nineteen remaining CV combinations was obtained. The mean SRT for the five vowels, 323 msec, was 8 msec longer than for the nineteen CVs, 315 msec, and the mean CRT for the five vowels, 574 msec, was 40 msec longer than for the nineteen CVs, 531 msec.

Assuming that the articulatory requirements for the production of a CV combination would be more complex than for producing an isolated vowel, it might be considered surprising that the CRTs for vowels were found to be longer on the average than the CRTs for CV combinations. However, this finding should be interpreted cautiously. Many subjects reported a difficulty in visually focusing on the isolated vowel grapheme as compared to visually focusing on the two grapheme CV combination. This was especially true for the vowels /i/ and /ʌ/ which in turn were associated with longer reaction times than the other vowels. The mean CRT for the vowels /i/ and /ʌ/ was 633 msec while the mean CRT for the three remaining vowels was 535 msec. An increase in the time required for visual analysis and perceptual identification for the vowels would then result in increased verbal reaction times.

Mean response latencies for all three CRT tasks are nearly one-half those for the mean naming response for one-syllable nonsense words in Experiment I. It is generally accepted that verbal reaction time is longer in the naming process than in the reading process because naming is a more complex process than reading (15). Specifically, there is a high compatibility between a written word and its oral pronunciation whereas in naming there is a low compatibility between a pictured object and its name. The longer reaction time for naming is due to the need to associate the response with the stimulus, or, in other words, due to an uncertainty of coding because of an increased number of response alternatives.

Mean verbal response time (CRT) for the fourteen consonants occurring in all three CRT tasks increased from CVs (528 msec) to CVCs (565 msec) and then decreased from CVCs to CVCVs (552 msec). The increase was observed for eleven of the fourteen consonants from CVs to CVCs (the other three showing just slight decreases) and decreases were observed for eight of the fourteen consonants from CVCs to CVCVs. The Wilcoxon Matched-Pairs Signed Ranks Test (35) indicated a significant difference in CRT between the CV and CVC conditions ($T=9$; $N=14$; $p < .01$), but nonsignificant differences between the CVC and CVCV ($T=36$; $N=14$; $p > .05$) and between CV and CVCV conditions ($T=22$; $N=14$; $p > .05$).

Klapp (21) has suggested that there is implicit speech in the comprehension of printed words. It would follow then that choice reaction time would increase as the number of syllables in a printed word increased. In the present experiment, CRT increased from CVs to CVCs even though both responses were one-syllable responses. It could be argued that the increased CRT for CVCs may have been due to increased perceptual processing time for a three-grapheme sequence. If this is true, one would expect longer CRTs for CVCVs than for CVCs due to an increase in the number of syllables. However, CVCVs presented shorter CRTs on the average than CVC responses.

Mean SRTs and CRTs for the five cognate pairs which appeared in all four experimental tasks are presented in Table 24. In all four

TABLE 24

MEAN SIMPLE AND CHOICE REACTION TIMES (IN MSEC) FOR THE FIVE COGNATE PAIRS WHICH APPEARED IN ALL FOUR EXPERIMENTAL TASKS

	Experimental Tasks			
	SRT	CRT		
Cognate Pairs	CV	CV	CVC	CVCV
/b/	334	492	544	522
/p/	296	492	592	526
/g/	311	540	562	510
/k/	325	534	520	486
/d/	305	467	503	534
/t/	319	544	626	568
/v/	276	543	535	595
/f/	371	605	626	623
/z/	295	537	562	563
/s/	331	553	558	565
Mean Voiced	304	516	541	545
Mean Voiceless	328	545	584	553

tasks, voiceless consonant combinations yielded longer mean SRTs and CRTs than voiced combinations.

The effects of voicing can be investigated while controlling place of articulation, manner of articulation, and phoneme frequency of occurrence. Although each cognate pair was alike in terms of place and manner of articulation, only the pairs /f/ - /v/ and /p/ - /b/ differed by less than 1 per cent in their frequency of occurrence. The difference in frequency of occurrence was 0.28 per cent for /f/ and /v/ and 0.07 per cent for /p/ and /b/. In all four tasks, the /f/ phoneme was associated with longer mean reaction times than its voiced cognate /v/. On the other hand, the /b/ phoneme presented longer mean reaction times on the SRT task, /b/ and /p/ presented equal mean CRTs on the CV task, and /p/ presented a longer CRT on the CVC task and a slightly longer CRT (only 4 msec) on the CVCV task.

It could be expected that reaction times associated with voiced phonemes would be longer than those associated with voiceless phonemes since the additional requirement of voicing must be added to the speech signal. The results of the present experiment do not support this hypothesis. Milianti (27) and Brennan and Cullinan (7), however, have noted that the detection of the onset of voiceless continuant phonemes is more difficult using the instrumentation described in this study than measuring the onset of voiced phonemes. It seems possible that the results obtained for voicing may be confounded by difficulty in determining precise onset of voiceless continuants.

Mean SRTs and CRTs according to manner of articulation for all consonants are presented in Table 25. Nasals and plosives yielded shorter reaction times than fricatives, the affricate, semivowels, and frictionless continuants.

The effects of manner of articulation may be confounded by voicing. Both nasal phonemes are voiced, three of the six plosive phonemes

TABLE 25

MEAN SIMPLE AND CHOICE REACTION TIMES (IN MSEC) FOR CV, CVC, AND CVCV COMBINATIONS ACCORDING TO MANNER OF PRODUCTION OF THE CONSONANT

	SRT	CRT		
Manner of Production	CV	CV	CVC	CVCV
Nasals m , n	290	512	542	531
Plosives p , b , k , g , t , d	315	511	558	524
Fricatives f , v , s , z , sh	324	550	570	590
Affricate ch	307	588	625	574
Semivowels r, l	313	545		
Frictionless Continuants w, y	312	524		

are voiced, both semivowels are voiced, and both frictionless continuants are voiced. On the other hand, only two of the six fricative phonemes are voiced in the SRT and V and CV tasks and only two of the five fricatives in the CVC and CVCV tasks are voiced. In addition, the affricate "ch" is voiceless. It was previously noted that voiced consonants tended to yield shorter reaction times than voiceless consonants. The manner of articulation categories which resulted in longer reaction times (fricatives and the affricate) were composed primarily of voiceless phonemes. The tendency for plosives to have shorter CRTs than many other categories of phonemes would seem to support the Eriksen et al. (14) speculation that words beginning with /b/, /k/, and /d/ were associated with shorter latencies. It should be noted, however, that two of the three stop plosives in the Eriksen et al. study were voiced and three of the other four initial phonemes used were voiceless. Thus, the shorter latencies for /b/ and /d/ in their study might have been due as much to their being voiced as to their being plosives.

The effects of manner can be investigated while controlling place, voicing, and frequency of occurrence within 1 per cent by comparing /m/ and /w/, /d/ and /l/, and /d/ and /r/. These comparisons can only be made for the SRT and CV tasks since /w/, /r/, and /l/ did not occur in CVC or CVCV tasks. The mean SRT for the /m/ phoneme was 281 msec while the mean SRT for the /w/ phoneme was 306 msec. In the CV task, the mean CRT for the /m/ phoneme was 529 msec while the mean CRT for the /w/ phoneme was 479 msec. The mean SRT for the /d/ phoneme was 305 msec while the mean SRT for the /r/ and /l/ phonemes were 302 and 325 msec, respectively. In the CV task, the mean CRT for the /d/ phonemes was 467 msec while the mean CRTs for the /r/ and /l/ phonemes were 567 and 524 msec, respectively. It would be difficult to generalize effects of manner from such limited data.

Mean SRTs and CRTs according to place of articulation for all consonants are presented in Table 26. Bilabial and velar consonants tended to yield short mean SRTs and CRTs while labiodental, palatal-alveolar, and palatal consonants tended to yield long SRTs and CRTs.

The bilabial consonant group was composed of three voiced and one voiceless phoneme and of one nasal, two plosives, and one frictionless continuant. The velar consonant group consisted of two plosives, one voiced and one voiceless. The alveolar consonant group was composed

TABLE 26

MEAN SIMPLE AND CHOICE REACTION TIMES (IN MSEC) FOR CV, CVC AND CVCV COMBINATIONS ACCORDING TO PLACE OF PRODUCTION OF THE CONSONANTS

	SRT	CRT		
Place of Articulation	CV	CV	CVC	CVCV
Bilabial				
m, p, b, w	304	498		
m, p, b	307	505	549	520
Alveolar				
t, d, n, s, z, l, r	310	526		
t, d, n, s, z	310	519	564	556
Velar				
k, g	318	537	541	498
Labiodental				
f, v	323	574	580	609
Glottal				
h	324	564		
Palatal-Alveolar				
ch	307	588	625	574
Palatal				
sh, y	338	547		
sh	357	524	571	608

of two plosives, two fricatives, one nasal, and two semivowels. The remaining four places of articulation groupings, which resulted in longer reaction times, were composed primarily of voiceless phonemes. It is difficult to interpret the effects of place of articulation without considering the possible confounding effects of manner and, especially, voicing.

The effects of place can be investigated while controlling manner, voicing, and frequency of occurrence within 1 per cent for three phoneme pairs: /b/ and /g/, /v/ and /z/, and /h/ and /f/. The bilabial plosive /b/ presented longer SRTs and CVCVs than the velar plosive /g/ whereas /g/ presented longer CRTs in the CV and CVC tasks. The labiodental fricative /v/ presented longer reaction times in CV and CVCV tasks than the alveolar fricative /z/ whereas, /z/ presented longer reaction times in the SRT and CVC tasks. Lastly, the glottal fricative /h/ presented shorter SRTs and CVs than the labiodental fricative /f/. In general, the results of the place of articulation analysis do not appear to suggest consistent trends in the effects of place of articulation on verbal reaction time.

Mean SRTs and CRTs for all consonants for five phoneme frequency ranges are presented in Table 27. Examination of the table reveals a

TABLE 27

MEAN SIMPLE AND CHOICE REACTION TIMES (IN MSEC) FOR CV, CVC, AND CVCV COMBINATIONS FOR THE FIVE PHONEME FREQUENCIES

	SRT	CRT		
Phoneme Frequency*	CV	CV	CVC	CVCV
6 per cent and above				
t, n	309	519	599	558
3 to four per cent				
d, s, l, r, m	308	527		
d, s, m	306	516	524	605
2 to three per cent				
k, w, y, z	311	530		
k, z	310	536	541	556
1 to two per cent				
v, h, f, g, b, p	320	539		
v, f, g, b, p	318	535	572	523
Less than 1 per cent				
sh, ch	322	556	596	591

*Frequency norms presented by Tobias (40).

tendency for response latency to increase as phoneme frequency decreases for the SRT, CV, and CVC tasks. Pearson product-moment correlation coefficients were obtained to estimate the relationship between verbal reaction time and $\log_{10}$ phoneme frequency of occurrence according to the normative data presented by Tobias (40). The correlation coefficients for each task are presented in Table 28. A small inverse relationship

TABLE 28

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS FOR MEAN VERBAL REACTION TIME (IN MSEC) AND LOG_{10} PHONEME FREQUENCY OF OCCURRENCE FOR THE FOUR EXPERIMENTAL TASKS

	Experimental Tasks			
	SRT	CRT		
	V AND CV	V AND CV	CVC	CVCV
Correlation Coefficients	-.246	-.296	-.251	-.294

exists between verbal reaction time and $\log_{10}$ phoneme frequency of occurrence, although none of the correlation coefficients are significantly different from zero ($p > .05$).

Interpretation of the regression analysis is difficult in view of the fact that each frequency level is variously composed of phonemes which differ in place, manner, and voicing. Further, any phoneme pair which might be investigated for frequency effects will necessarily be confounded by the effects of place, manner, and/or voicing. Five pairs of phonemes were selected which differed only by voicing and phoneme frequency. The frequency differences and reaction times for these five cognate pairs are presented in Table 29. If phoneme frequency is related

TABLE 29

PHONEME FREQUENCIES, DIFFERENCES IN PHONEME FREQUENCY, AND MEAN SIMPLE AND CHOICE REACTION TIMES FOR THE TEN PHONEMES USED TO INVESTIGATE THE EFFECTS OF PHONEME FREQUENCY

Phonemes	Phoneme Frequency in Per Cent	Difference in Phoneme Frequency	Experimental Tasks			
			SRT	CV	CVC	CVCV
/t/	9.11	5.33	319	544	626	568
/d/	3.78		305	467	503	534
/k/	2.93	1.54	325	534	520	486
/g/	1.39		311	540	562	510
/s/	3.74	1.16	331	553	558	565
/z/	2.13		295	537	562	563
/v/	1.76	.28	276	543	535	595
/f/	1.48		371	605	626	623
/b/	1.44	.07	334	492	544	522
/p/	1.37		296	492	592	526

to reaction time, one would expect larger differences in reaction times for cognates whose frequencies are more diverse. However, the /t/ phoneme, which occurs approximately three times more frequently than the /d/ phoneme, also presents longer reaction times in all four tasks. The /f/ phoneme, which differs from /v/ by -.28 per cent in frequency also presents longer reaction times in all four tasks. It would appear that the effects of phoneme frequency for these two cognate pairs may be confounded with the effects of voicing. The /k/ phoneme, which differs by +1.54 per cent in frequency from /g/, presented shorter reaction times on three of the four experimental tasks. On the other hand, the /s/ phoneme, which differs by +1.16 per cent in frequency from /z/, presented longer mean reaction times on three of the four tasks. In the case where the frequency difference was negligible, between /p/ and /b/, /p/ presented longer mean reaction times on two of the four tasks.

In summary, conclusive statements concerning differences in SRTs and CRTs for vowels and consonants are difficult to make on the basis of this experiment. The apparent trends in some of the data, such as for voiced consonants to have longer reaction times than voiceless consonants, suggest that further study of phoneme differences is merited.

CHAPTER V

SUMMARY

This study consisted of two tachistoscopic experiments designed to investigate the effects of word length, visual complexity, and phoneme differences on verbal reaction time. The first experiment explored the effects of word length and visual complexity on verbal reaction times while controlling differences in word frequency. Thirty normal adult subjects learned nine nonsense names which varied from one to three syllables in length for nine nonsense forms varying in degree of visual complexity. Measurements of simple reaction time, visual duration threshold, matching response latency, and naming response latency were obtained from each subject. The second experiment explored the effects of phoneme differences on simple reaction times for vowels and consonant-vowel combinations and choice reaction times for vowels and consonant-vowel, consonant-vowel-consonant, and consonant-vowel-consonant-vowel combinations. English graphemes and phonetic symbols were used as stimuli to elicit the verbal responses. Ten subjects from the first experiment participated in the second experiment.

The main findings of this study were:

1) Average simple verbal reaction times are positively related to word length. Differences in mean simple reaction time were found between one- and three- and two- and three syllable names but not between one- and two-syllable names.

2) Average visual duration thresholds are related to both word length and visual complexity level.

3) Average (combining "same" and "different" responses) matching response latencies were not found to be significantly related to word length or visual complexity level. "Different" response latencies were found to be longer than "same" response latencies. "Different" response latencies also appear to be related to word length in a different manner than are "same" response latencies.

4) Average naming response latencies are related to word length and visual complexity level.

5) The order in which names are learned, or differences in the amount of practice with a name, may account, in part, for some of the obtained results.

6) Choice reaction time for CVs are significantly shorter than for CVCs. Differences in CRT between CVs and CVCVs and between CVCs and CVCVs are not significant. Trends in simple reaction times and choice reaction times related to phoneme differences suggest the need for further study.

The above findings were discussed in relation to implicit speech and stages in the naming process.

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APPENDICES

APPENDIX A

The Randomization Schedule for the Presentation of the Experimental Tasks in Experiment 1

Randomization Schedule	Order of Presentation 1	2	3	4
a	SRT	VDT	MRL	NRL
b	VDT	MRL	NRL	SRT
c	MRL	NRL	SRT	VDT
d	NRL	SRT	VDT	MRL
e	NRL	MRL	VDT	SRT
f	MRL	VDT	SRT	NRL
g	VDT	SRT	NRL	MRL
h	SRT	NRL	MRL	VDT
i	SRT	MRL	VDT	NRL
j	MRL	SRT	NRL	VDT

Subject Number	Randomization Schedule Group 1	Group 2	Group 3
1	f	a	a
2	e	i	b
3	a	h	g
4	c	c	e
5	i	b	f
6	g	j	c
7	d	d	i
8	b	f	d
9	h	g	j
10	j	e	h

APPENDIX B

Schedule of Stimulus-Pairs for the Matching Response Task

Correct Name Associated with the Visual Symbols	Verbal Stimuli Given to Subjects: Subject 1	Subject 2	Subject 3	Subject 4	Subject 5
/zov/	/zov/	/zov/	/mob/	/zov/	/duv/
/zovəg/	/mobən/	/zovəg/	/duvəd/	/zovəg/	/zovəg/
/zovəgid/	/zovəgid/	/zovəgid/	/mobənez/	/duvədib/	/zovəgid/
/duv/	/zov/	/duv/	/mob/	/duv/	/duv/
/duvəd/	/duvəd/	/duvəd/	/duvəd/	/mobən/	/zovəg/
/duvədib/	/mobənez/	/zovəgid/	/duvədib/	/duvədib/	/mobənez/
/mob/	/mob/	/duv/	/mob/	/zov/	/zov/
/mobən/	/duvəd/	/duvəd/	/mobən/	/mobən/	/mobən/
/mobənez/	/mobənez/	/duvədib/	/mobənez/	/zovəgid/	/mobənez/

Correct Name Associated with the Visual Symbols	Verbal Stimuli Given to Subjects				
	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10
/zov/	/mob/	/mob/	/zov/	/duv/	/zov/
/zovag/	/zovag/	/moban/	/zovag/	/duvad/	/moban/
/zovagid/	/duvadib/	/mobanez/	/zovagid/	/zovagid/	/mobanez/
/duv/	/duv/	/zov/	/duv/	/zov/	/mob/
/duvad/	/zovag/	/moban/	/zovag/	/duvad/	/duvad/
/duvadib/	/duvadib/	/dubadib/	/zovagid/	/zovagid/	/duvadib/
/mob/	/duv/	/mob/	/duv/	/mob/	/mob/
/moban/	/moban/	/moban/	/zovag/	/duvad/	/zovag/
/mobanez/	/zovagid/	/mobanez/	/duvadib/	/mobanez/	/duvadib/

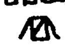
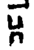
APPENDIX C

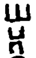
The Randomization Schedule for the Presentation of the Experimental Tasks in Experiment II

Subject Number	Order of Presentation 1	2	3	4
1	SRT	V+CV	CVC	CVCV
2	V+CV	CVC	CVCV	SRT
3	CVC	CVCV	SRT	V+CV
4	CVCV	SRT	V+CV	CVC
5	CVCV	CVC	V+CV	SRT
6	CVC	V+CV	SRT	CVCV
7	V+CV	SRT	CVCV	CVC
8	SRT	CVCV	CVC	V+CV
9	SRT	CVC	V+CV	CVCV
10	CVC	SRT	CVCV	V+CV

APPENDIX D

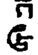
Simple Reaction Times (in Msec) for the Nine Nonsense Names
for Each Subject and Mean Simple Reaction Times
for Each Name for Each Subject Group

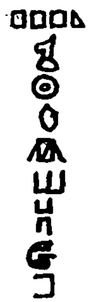
Stimulus Names	Visual Forms	Subjects 1	2	3	4	5	6	7	8	9	10	Mean
Group I												
/mob/		420	270	285	440	240	280	305	315	555	345	346
/mobən/		470	270	295	505	335	320	305	270	335	345	345
/mobənez/		365	235	265	425	360	305	305	305	325	380	327
/duv/		320	240	380	440	325	325	275	280	300	350	324
/duvəd/		375	470	330	475	305	405	275	315	310	370	363
/duvədib/		300	315	435	715	320	400	385	345	545	465	423
/zov/		405	320	335	600	340	330	330	405	295	320	368
/zovəg/		330	290	605	535	320	320	310	330	415	365	382
/zovəgid/		350	290	320	535	410	440	320	315	550	395	393
Group II												
/mob/		255	315	350	360	290	350	320	275	280	240	304
/mobən/		265	265	285	300	210	345	370	310	350	325	303
/mobənez/		265	335	370	430	245	305	395	255	250	280	313
/duv/		245	310	330	455	285	310	405	340	325	260	327
/duvəd/		255	235	330	400	260	350	465	210	270	320	310
/duvədib/		225	355	305	370	300	430	305	305	450	285	333
/zov/		350	310	290	465	240	510	445	385	345	235	358
/zovəg/		310	305	285	450	245	470	495	235	285	330	341
/zovəgid/		285	245	360	415	320	455	455	405	285	245	347

Stimulus Names	Visual Forms	1	2	3	4	5	6	7	8	9	10	Mean
<u>Group II</u>												
/mob/		335	390	330	295	300	310	415	330	245	320	327
/mobən/		365	400	305	320	330	280	365	335	245	385	333
/mobənez/		305	425	305	275	475	320	465	295	245	605	372
/duv/		365	425	365	280	430	340	360	350	315	410	364
/duvəd/		390	455	360	250	495	245	325	370	300	345	354
/duvədib/		430	470	330	225	460	275	435	375	295	335	363
/zov/		295	500	415	315	370	315	470	325	310	310	363
/zovəg/		375	330	525	265	425	390	395	345	220	315	359
/zovəgid/		315	445	335	335	455	390	380	380	275	395	371

APPENDIX E

Visual Duration Thresholds (in Msec) for the Nine Visual Stimuli and Mean Visual Duration Thresholds for Each Stimulus for Each Subject Group

Nonsense Names	Visual Forms	Subjects 1	2	3	4	5	6	7	8	9	10	Mean
Group I												
/mob/		10	15	35	20	15	15	30	20	20	10	19
/moban/		10	35	30	50	20	35	35	30	25	35	31
/mobanez/		15	35	25	45	20	40	25	20	35	15	28
/duv/		25	25	15	20	30	30	25	30	25	40	27
/duvad/		15	20	30	45	15	35	40	25	40	20	29
/duvadib/		30	35	70	45	25	50	35	25	45	20	38
/zov/		40	55	60	40	40	25	45	35	35	35	41
/zovag/		25	35	50	50	35	45	45	60	40	15	40
/zovagid/		20	25	35	45	25	45	35	30	45	35	34
Group II												
/mob/		20	25	15	20	25	30	15	20	25	25	22
/moban/		10	25	10	25	15	40	15	15	20	15	19
/mobanez/		25	45	15	35	45	20	15	15	25	30	27
/duv/		25	20	10	40	35	35	10	35	20	20	25
/duvad/		15	50	25	50	35	75	15	55	35	30	39
/duvadib/		25	45	20	35	20	30	25	20	IR*	15	26
/zov/		15	30	20	25	35	35	20	25	20	20	25
/zovag/		30	50	30	55	35	60	25	35	60	20	40
/zovagid/		25	60	10	40	35	80	25	50	65	25	42

Nonsense Names	Visual Forms	Subjects 1	2	3	4	5	6	7	8	9	10	Mean
Group III												
/mob/		45	30	40	15	20	20	20	25	15	20	25
/moban/		30	15	35	15	15	20	20	25	15	20	21
/mobanez/		25	20	20	20	10	20	30	30	15	15	20
/duv/		25	20	30	15	15	20	20	20	25	20	21
/duvad/		50	45	55	20	15	20	40	35	25	25	33
/duvadib/		30	65	55	30	40	45	30	45	45	30	42
/mov/		55	50	40	20	20	25	45	25	30	25	34
/zovag/		50	35	45	15	20	35	20	30	25	25	30
/zovagid/		55	65	75	50	35	50	35	50	45	50	51

*Incorrect Response

APPENDIX F

Matching Response Latencies (in Msec) for the Nine Nonsense Names for Each Subject and Mean Matching Response Latencies for Each Name for Each Subject Group

Nonsense Names	Visual Forms	Subjects 1	2	3	4	5	6	7	8	9	10	Mean
Group I												
/mob/		395*	285*	585	685	765	595	405*	785	500*	505*	551
/moban/		530	505*	645	815*	715*	420*	465*	620	640	870	623
/mobanez/		625*	460*	710	915	775*	545	525*	520	580*	865	652
/duv/		485	375	595*	880*	800*	685*	645	515*	715	625	632
/duvad/		390*	410*	670*	745	675	705	575	660	390*	1140*	636
/duvadib/		435	460*	1030	925*	645	550*	480*	940	940	1445*	785
/zov/		525*	405	660*	665*	1535	460	510	830*	730	740*	708
/zovag/		455	580	645*	735*	980*	450*	695	420*	1245	525	673
/zovagid/		620*	475	655*	640	680*	625	675	450*	405*	810	604
Group II												
/mob/		345*	765	465*	875	630	570	515*	685	475*	485*	581
/moban/		420	685	460*	710*	645*	570*	665*	555	500	770	598
/mobanez/		450*	620	495*	705	435*	810	800*	595	760*	440	611
/duv/		440	475*	640	800*	565*	425*	635	1220*	695	625	652
/duvad/		440*	460*	1625*	715	490	1080	625	1470	625*	955*	840
/duvadib/		460	1790	460*	780*	455	550*	545*	800	835	345*	702
/zov/		500*	595*	480	780*	485	680	815	620*	585	475*	602
/zovag/		400	705*	IR**	780*	900*	610*	615	570*	585	405	619
/zovagid/		405*	615*	665	830	550*	1670	605	510*	685*	505	704

Nonsense Names	Visual Forms	Subjects 1	2	3	4	5	6	7	8	9	10	Mean
Group III												
/mob/		815*	700	420*	545	770	630	605*	620	485*	500*	609
/moban/		965	495	495*	530*	870*	485*	520*	600	510	555	603
/mobanez/		350*	680	470*	530	645*	935	590*	650	470*	745	607
/duv/		595	615*	415	570*	700*	790*	610	615*	575	470	596
/duvad/		605*	645*	425*	505	890	610	665	675	460*	550*	603
/duvadib/		495	700	510*	385*	810	630*	850*	595	575	845*	640
/zov/		675*	565*	490	600*	700	640	795	525*	525	675*	619
/zovag/		IR**	545*	525	705*	690*	585*	680	585	510	565	599
/zovagid/		1030*	520*	435	540	650*	1590	745	550*	485*	605	715

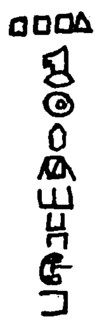
*Indicates a "yes" response, remaining responses were "no"

**Incorrect Response

APPENDIX G

Naming Response Latencies (in Msec) for the Nine
Nonsense Names for Each Subject and Mean
Naming Response Latencies for Each
Name for Each Subject Group

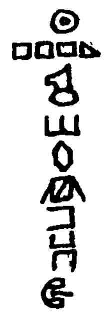
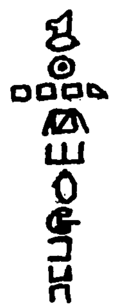
Nonsense Names	Visual Forms	Subjects 1	2	3	4	5	6	7	8	9	10	Mean
Group I												
/mob/		890	700	680	CNM*	700	675	990	460	1015	825	711
/moban/		750	730	685	835	860	750	840	775	825	1035	809
/mobanez/		845	1195	1405	1115	980	910	790	650	810	1445	1015
/duv/		1390	1065	960	1655	1025	1020	805	1050	1090	1535	1160
/duvad/		1945	940	895	1215	785	990	1710	815	825	1005	1113
/duvadib/		1085	1060	1115	1505	1165	LR**	910	1830	615	1170	1162
/zov/		1275	950	1160	1125	850	1335	1050	885	1420	1055	1111
/zovag/		1665	1295	1135	1490	1475	1420	CNM*	1015	1300	1155	1328
/zovagid/		1205	745	1225	1815	945	1095	990	955	810	2025	1181
Group II												
/mob/		650	725	940	1125	640	1365	850	1040	650	670	866
/moban/		600	715	845	975	580	1165	880	1145	865	635	841
/mobanez/		565	830	1185	1030	770	1330	945	1725	725	810	992
/duv/		1020	1115	1065	1360	700	1190	1015	2665	755	815	1170
/duvad/		1290	1465	1110	1210	980	1385	1345	1220	CNM*	2095	1344
/duvadib/		770	1515	895	1485	905	1185	1240	1140	930	1605	1167
/zov/		675	1425	850	900	820	1080	1175	1145	880	780	973
/zovag/		935	1405	1650	1935	1745	2385	1345	1455	955	845	1466
/zov agid/		785	1280	1205	LR**	IR*	1905	2305	2915	2830	1200	1803

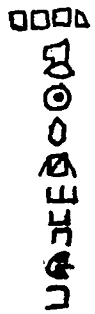
Nonsense Names	Visual Forms	Subjects 1	2	3	4	5	6	7	8	9	10	Mean
Group III												
/mob/		480	830	495	695	855	690	755	710	655	665	683
/moban/		710	1825	540	1095	1560	730	795	820	685	680	944
/mobanez/		2200	1105	680	1345	1125	1075	535	955	785	710	1051
/duv/		1235	815	705	810	1100	525	785	700	835	750	826
/duvəd/		IR***	1775	720	770	1210	1190	765	1005	1025	795	1028
/duvadib/		935	1255	CNM*	805	2355	1715	1000	1230	980	930	1245
/zov/		1340	IR***	745	810	1455	1535	970	950	960	825	1066
/zovag/		1195	845	770	1325	1660	1125	825	985	1105	855	1069
/zovagid/		1605	1215	830	945	1895	1910	1280	1120	820	1320	1294

*Response could not be measured
**Late response, occured after more than three seconds after stimulus presentation
***Incorrect response

APPENDIX H

Number of Trials to Learn the Paired-Associates and the Mean Number of Learning Trials for the Nine Nonsense Names for All Subjects in Each Group

Nonsense Names	Visual Forms	Subjects 1	2	3	4	5	6	7	8	9	10	Mean
Group I												
/mob/		4	4	4	6	4	4	7	4	5	6	4.8
/moban/		5	6	10	7	11	4	6	5	8	6	6.8
/mobanez/		4	6	6	10	13	6	12	4	22	7	9.0
/duv/		6	10	11	8	12	10	7	11	6	11	9.2
/duvad/		7	9	5	8	10	12	11	10	13	13	9.8
/duvadib/		8	6	6	6	19	6	10	11	14	7	9.3
/zov/		4	8	12	14	11	7	10	7	5	9	8.7
/zovag/		9	10	10	12	19	8	11	10	14	10	11.3
/zovagid/		5	10	4	12	14	4	10	12	9	9	8.9
Group II												
/mob/		4	6	5	5	5	6	4	9	6	6	5.6
/moban/		4	7	5	5	6	9	4	6	6	7	5.9
/mobanez/		4	6	6	5	16	7	4	6	9	7	7.0
/duv/		14	7	7	5	8	11	5	10	4	9	8.0
/duvad/		10	12	8	7	21	11	11	8	4	8	10.0
/duvadib/		7	9	6	6	22	11	6	10	11	8	9.6
/zov/		12	13	5	7	13	8	5	12	6	5	8.6
/zovag/		10	16	8	8	22	14	6	9	12	13	11.8
/zovagid/		10	11	9	8	22	13	11	11	7	13	11.5

Nonsense Names	Visual Forms	Subjects 1	2	3	4	5	6	7	8	9	10	Mean
Group III												
/mob/		4	6	5	4	4	4	6	5	4	4	4.6
/moban/		10	16	6	8	7	5	5	7	7	5	7.6
/mobanez/		10	5	8	12	7	6	5	5	4	6	6.8
/duv/		8	5	5	8	6	6	7	6	8	5	6.4
/duvad/		15	7	9	6	11	7	5	8	4	5	7.7
/duvadib/		12	13	8	9	9	12	5	11	7	6	9.2
/zov/		15	9	5	10	7	8	8	9	10	4	8.5
/zovag/		6	7	10	12	10	7	9	9	11	6	8.7
/zovagid/		9	19	11	10	7	13	10	8	11	7	10.5

APPENDIX I

Subject Numbers, Number of Trials to Learn, Nonsense Words, and VDTs, SRTs, and NRLs (in Msec) for Comparing All Combinations of Two Word Lengths When Number of Learning Trials Is Controlled

Subjects		Learning Trials by Word Length			Experimental Tasks					
Group	Number	One	Two	Three	VDTs		SRTs		NRLs	
					One-Syllable versus Two-Syllable					
					/mob/	/mobən/	/mob/	/mobən/	/mob/	/mobən/
I	6	4	4	-	15	35	280	320	675	750
I	10	4	6	-	10	35	345	345	825	1035
II	1	4	4	-	20	10	255	265	650	600
II	3	5	5	-	15	10	350	285	940	845
II	4	5	5	-	20	25	360	300	1125	975
II	7	4	4	-	15	15	320	370	850	880
II	9	6	6	-	25	20	280	350	650	865
					/duv/	/duvəd/	/duv/	/duvəd/	/duv/	/duvəd/
I	4	8	8	-	20	45	440	475	1655	1215
II	6	11	11	-	35	75	310	350	1190	1385
II	9	6	6	-	20	35	325	270	-	-
III	10	5	5	-	20	25	410	345	750	795
					/zov/	/zovəg/	/zov/	/zovəg/	/zov/	/zovəg/
III	8	9	9	-	25	30	325	345	950	985

Subjects		Learning Trials by Word Length			Experimental Tasks					
Group	Number	One	Two	Three	VDTs		SRTs		NRLs	
					One-Syllable versus Three-Syllable					
					/mob/	/mobanez/	/mob/	/mobanez/	/mob/	/mobanez/
I	1	4	-	4	10	15	420	365	890	845
I	8	4	-	4	20	20	315	305	460	650
II	1	4	-	4	20	25	255	265	650	565
II	2	6	-	6	25	45	315	335	725	830
II	4	5	-	5	20	35	360	430	1125	1030
II	7	4	-	4	15	15	320	395	850	945
III	8	5	-	5	25	30	330	295	710	955
III	9	4	-	4	15	15	245	245	655	785
					/duv/	/duvadib/	/duv/	/duvadib/	/duv/	/duvadib/
I	8	11	-	11	30	25	280	345	1050	1830
II	6	11	-	11	35	30	310	430	1190	1185
II	8	10	-	10	35	20	340	305	2665	1140
					/zov/	/zovagid/	/zov/	/zovagid/	/zov/	/zovagid/
I	7	10	-	10	45	35	330	320	1050	990
I	10	9	-	9	35	35	320	395	1055	2025
III	4	10	-	10	20	50	315	335	810	945
III	5	7	-	7	20	35	370	455	1455	1895

Subjects		Learning Trials by Word Length			Experimental Tasks					
Group	Number	One	Two	Three	VDTs		SRTs		NRLs	
					Two-Syllable versus Three-Syllable					
					/moban/	/mobanez/	/moban/	/mobanez/	/moban/	/mobanez/
I	2	-	6	6	35	35	270	235	730	1195
II	1	-	4	4	10	25	265	265	600	565
II	4	-	5	5	25	35	300	430	975	1030
II	7	-	4	4	15	15	370	395	880	945
II	8	-	6	6	15	15	310	255	1145	1725
II	10	-	7	7	15	30	325	280	635	810
III	1	-	10	10	30	25	365	305	710	2200
III	5	-	7	7	15	10	330	475	1560	1125
III	7	-	5	5	20	30	365	465	795	535
					/duvad/	/duvadib/	/duvad/	/duvadib/	/duvad/	/duvadib/
II	6	-	11	11	75	30	350	430	1385	1185
II	10	-	8	8	30	15	320	285	2095	1605
III	7	-	5	5	40	30	325	435	765	1000
					/zovag/	/zovagid/	/zovag/	/zovagid/	/zovag/	/zovagid/
I	2	-	10	10	25	20	330	350	1295	745
I	4	-	12	12	50	45	535	535	1490	1850
II	1	-	10	10	30	25	310	285	935	785
II	4	-	8	8	55	40	450	415	-	-
II	5	-	22	22	35	35	245	320	-	-
II	10	-	13	13	20	25	330	245	845	1200
III	9	-	11	11	25	45	220	275	1105	820

APPENDIX J

Subject Numbers, Number of Trials to Learn, Nonsense Words, and VDTs, SRTs, and NRLs (in Msec) for Comparing All Three Word Lengths When Number of Learning Trials Is Controlled

Subjects		Learning Trials by Word Length			Experimental Tasks								
					VDTs N=18			SRTs N=18			NRLs N=18		
Group	Number	One	Two	Three	/mob/	/moban/	/mobanez/	/mob/	/moban/	/mobanez/	/mob/	/moban/	/mobanez/
I	1	4	5	4	10	10	15	420	470	365	890	750	845
I	8	4	5	4	20	30	20	315	270	305	460	775	650
I	10	6	6	7	10	35	15	345	345	380	825	1035	1445
II	1	4	4	4	20	10	25	255	265	265	650	600	565
II	2	6	7	6	25	25	45	315	265	335	725	715	830
II	3	5	5	6	15	10	15	350	285	370	940	845	1185
II	4	5	5	5	20	25	35	360	300	430	1125	975	1030
II	7	4	4	4	15	15	15	320	370	395	850	880	945
II	10	6	7	7	25	15	30	240	325	280	670	635	810
III	7	6	5	5	20	20	30	415	365	465	755	795	535
					/duv/	/duvad/	/duvadib/	/duv/	/duvad/	/duvadib/	/duv/	/duvad/	/duvadib/
I	8	11	10	11	30	25	25	280	315	345	1050	815	1830
II	6	11	11	11	35	75	30	310	350	430	1190	1385	1185
II	10	9	8	8	20	30	15	260	320	285	815	2095	1605
III	10	5	5	6	20	25	30	410	345	335	750	795	930
					/zov/	/zovag/	/zovagid/	/zov/	/zovag/	/zovagid/	/zov/	/zovag/	/zovagid/
I	7	10	10	10	45	45	35	330	310	320	-	-	-
I	10	9	10	9	35	15	35	320	365	395	1055	1155	2025
II	4	7	8	8	25	55	40	465	450	415	-	-	-
III	8	9	9	8	25	30	50	325	345	380	950	985	1120