A STUDY OF FACTORS THAT INFLUENCE THE IDENTIFICATION OF ENGLISH SOUNDS IN LIPREADING

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ABSTRACT

A STUDY OF FACTORS THAT INFLUENCE THE IDENTIFICATION OF ENGLISH SOUNDS IN LIPREADING

by John Richard Franks

The general purpose of this study was to examine the influence of factors other than visibility on the identification of English sounds by lipreading. The influence of redundancy derived from the association of a sound with other elements of a word was studied. The specific approach used was to investigate the influence of the known -VC (vowal-consonant) stems of monosyllabic words on the identification by lipreading of the initial consonants of the words. The basic hypothesis tested was that the same consonant united with different stems would be identified with different degrees of accuracy when the stems were known by the subjects but the initial consonants could be identified only by lipreading.

To test this hypothesis, each of seven consonants--[f, k, p, r, ʃ, t, θ]-- were united with different -VC endings so that seven sets of monosyllabic stimulus words were developed. The words within each set had the same initial consonant, and the vowel environment for the consonant in each set was also held constant. Thus the monosyllables within a set differed only as to final consonant.

Four speakers were filmed uttering the resulting seventy-six stimulus words. The silent film was shown to four groups of twenty subjects each. Before each word was seen by the subjects, they

heard the -VC stem of the word; and were also able to read the possible printed forms of the auditory stem on their answer sheets. With the stem known, the subjects were then shown the full stimulus word and were asked to identify the initial consonant.

Analyses of variance were made of the differences in the number of errors of identification among the words in each separate consonant set. On the basis of the results of these analyses, the following conclusion seemed justified:

The degree of accuracy of identification by lipreading of the same initial consonant united with different -VC stems is influenced by the linguistic characteristics of the stem, if the stem is known but the initial consonant is unknown. However, the magnitude of the influence is not the same for all speakers.

In addition to the examination of the basic hypothesis discussed above, three corollary hypotheses were investigated. It was postulated that the differences found in the identification of the same consonant united with different stems were related to the influence of three factors: (1) the frequency of occurrence of the stimulus word, (2) the number of rhyming alternatives suggested by knowing the stem of the stimulus word, and (3) the frequency of the rhyming alternatives in relation to the frequency of the stimulus words.

For each consonant set, correlations were determined between error scores for the stimulus words and corresponding values of each of the hypothesized factors. On the basis of the statistical findings the following conclusions seemed warranted:

1. Accuracy of identification of an initial consonant by lipreading is not influenced by the frequency of occurrence of the word formed by the union of that initial consonant and a known -VC stem.

2. In some cases the accuracy of identification of an initial consonant by lipreading is inversely related to the number of alternative rhyme words suggested by a known -VC stem; however, this relationship cannot be generalized to all cases.

3. Accuracy of identification of an initial consonant by lipreading has an inverse relationship in some cases to the relative frequency of the alternative rhyme words suggested by the known stem; but this relationship cannot be concluded to exist in all cases.

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By

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

Lipreading can be described as a process of communication in which information is received by visual means from a speaker through a medium to the lipreader. The elements involved in this process can be shown to conform roughly to the schematic used by Shannon in his description of a mathematical theory of communication.[1] He pictures the electronic communication process as involving an information source and transmitter, the signal, the transmission medium, and the receiver and destination. In lipreading, the source of information is the mind of the speaker; the transmitter is the physical speech mechanism of the speaker; the signal consists of the visible aspects of the speech situation; the transmission medium in the normal face-to-face situation is the space between the speaker and lipreader; and the eyes and mind of the lipreader constitute the receiver and destination of the signal.

However, it will be recognized that in order for communication to take place, a signal must carry the potential to evoke some meaning. The signal becomes potentially meaningful when it is arranged into a symbolic pattern representing a concept. This is referred to as

[1] C. E. Shannon, "A Mathematical Theory of Communication," Bell System Technical Journal, XVII (1948), 379-423, 623-656.

coding. The information originating in the mind of the speaker must, therefore, be encoded into a symbolic signal pattern; and in order for the signal to be meaningful to the lipreader, it must be decoded at its destination. Thus, if in an analysis of the lipreading process, one follows the above analogy, one must consider (1) the mind and encoding process of the speaker, (2) the nature of the encoded signal, (3) the medium through which the signal travels, (4) its reception through the visual sense organs, and (5) the decoding process at its destination in the mind of the lipreader.

As in an electronic communicaton system, each of the above elements is critical; trouble at any particular point can cause failure in the communication process. Furthermore, in an electronic system, the process of improvement of the system to avoid failure of communication and to increase the efficiency of the system involves a thorough understanding of each sub-system involved. So in lipreading, if one is to improve the system, each aspect of the process must be thoroughly understood. It is the objective of this study to contribute some fundamental information relating to one particular aspect of the complex process of lipreading.

Continuing the analogy cited, the signal in lipreading is considered as being made up of the visible elements of the lipreading situation, which may include gesture and facial expression, as well as movements of the articulators. This signal is rendered potentially meaningful by developing a coded pattern of signals which symbolizes a concept or concepts. The code in lipreading would thus appear to be made up of two parts: (1) the signal itself and (2) the patterned arrangement of the signal.

There has been a significant though inconclusive amount of research concerning the aspects of the code in lipreading related to the signal, but little reasearch has been conducted which considers that aspect of the code which results from the patterning of the signal. This study will be concerned with this latter aspect.

When patterning of the signals in communication is considered carefully, it is quickly recognized that the patterning is actually the arrangement of the signals into symbolic language, and that the characteristics of the patterning are governed by the rules of the language structure of a particular culture. Hence, a study of the signal patterns involved in the code in lipreading becomes a study of the characteristics of language structure, and the present investigation becomes an inquiry into the influence of an aspect of language structure on the perception of the code through lipreading.

There are certain weaknesses and failures in the oral language process--elements of the code are not always distinctly discriminable from some of the other elements; there are frequent interferences such as noise; and the listener is not always absolutely attentive and accurate in his preception of the code. Consequently, in speech communication, essential parts of the code may be lost and the message may be rendered confused and ambiguous. Cherry speaks of speech communication as involving a listener's testing hypotheses concerning a speaker's message by means of fragmentary evidence provided in the speech signal.[1] This would seem to be a rather apt description of the

[1]Colin Cherry, On Human Communications: A Review, a Survey, and a Criticism (New York: The Technology Press of Massachusetts Institute of Technology and John Wiley and Sons, Inc., 1957), p. 233.

situation and can be said to be true for lipreading even more than for normal speech communication, since the signal reaching the lip-reader represents only a fraction of the original message.

Fortunately, however, language structure has been evolved in such a way that its characteristics are uniquely suited to the human communication system. Language has been structured so that in most cases there is a surplus of evidence carried by the speech code. This makes the loss of fragments of the code of less consequence, since reserve evidence in the surplus may serve to identify accurately the symbol to be correctly associated with its referent. This surplus of evidence is referred to as redundancy. Redundancy may occur from a number of sources. In fact-to-face speech communication, the redundancy involved in seeing the production of a speech sound and also being able to hear it is obvious. But there are less obvious sources of redundancy that are of more concern in this study. The sources to be considered here result from the statistical and semantic structure of the language.

The studies of Shannon,[1] Black,[2] and Garner and Carson[3] distinguish two sources of statistical redundancy--that resulting from the independent distributional characteristics of the language

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[1]Shannon, loc. cit.

[2]John W. Black, "The Information of Sounds and Phonetic Diagrams of One- and Two-syllable Words," Journal of Speech and Hearing Disorders, XIX (1954), 397-411.

[3]W. R. Garner and D. H. Carson, "A Multi-Variate Solution of Redundancy of Printed English," Psychological Reports, VI (1960), 131-141.

elements and that due to the sequential nature of language. Distributional redundancy exists due to the fact that some elements in the language occur with greater frequency than others, and so have a greater probability of use. Sequential redundancy results from the fact that succeeding sounds, letters, or words depend to a certain degree on the number and nature of the preceding element. There is a certain amount of constraint imposed by the structure of the language that restricts what language elements may appear together and in what order they may appear. This latter source of redundancy is also referred to as transitional probability, or constraint due to context, and has been shown by Garner and Carson to contribute substantially more information than distributional redundancy or constraint.[1]

The redundancy resulting from the distributional and sequential constraint of written language was shown in one study by Shannon to be about 50 per cent,[2] and in another study to be as much as 75 per cent.[3] This means that it is possible that one-half or even three-fourths of what we write is determined by the structure of the language, and the remainder is chosen freely.

That the statistical structure of English also influences oral communication has been shown by Miller, Heise, and Lichten,[4]

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[1] Ibid., p. 124.

[2] Shannon, op. cit., p. 398.

[3] C. E. Shannon, "Prediction and Entropy of Printed English," Bell System Technical Journal, XXX (1951), 50.

[4] George A. Miller, George A. Heise, and William Lichten, "The Intelligibility of Speech as a Function of the Context of the Test Materials," Journal of Experimental Psychology, XLI (1951), 329-335.

and others,[1,2,3] However, statistical estimates of the magnitude of the redundancy are not given by these studies and may be expected to differ somewhat from that of written language.

Redundancy resulting from the semantic structure of language has been demonstrated by word association studies in which one word of a pair acts as a stimulus for the recall of the second word of a pair. It has been demonstrated that some words are associated more frequently than others because of certain semantic interdependencies.[4] However, Johnson has shown that even semantic redundancy may have a basic statistical origin, since it was found that words that are associated most frequently are those which, to a large degree, occur most frequently in the language.[5] Perhaps it would be the safest procedure to refer to statistical and semantic types of redundancy as merely constraint due to the structure of the language and not attempt to discriminate them.

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[1] John W. Black, "Accompaniments of Word Intelligibility," *Journal of Speech and Hearing Disorders*, XVII (1952), 409-417.

[2] Davis Howes, "On the Relation Between the Intelligibility and Frequency of Occurrence of English Words," *Journal of the Acoustical Society of America*, XXIX (1957), 296-305.

[3] M. R. Rosensweig, "Intelligibility as a Function of Frequency of Usage," *Journal of the Acoustical Society of America*, XXVIII (1956), 759.

[4] G. H. Kent and A. J. Rosanoff, "A Study of Association in Insanity," *American Journal of Insanity*, LXIX (1956), 125-127.

[5] Donald M. Johnson, "Word Association and Word Frequency," *American Journal of Psychology*, LXIX (1956), 125-127.

Regardless of the basic origin of structural redundancy in the language, it is the influence of such constraint in lipreading that will be the focus of this study.

Definition of Terms

Alternative rhyming words.--The term alternative rhyming words refers to the rhyming words that can be derived from a given stimulus word. Thus the alternative rhyming words for the word tense are dense, fence, flense, hence, pence, sense, thense, and whence. If the stem "_ense" of the word tense were known, but the initial consonant were unknown, then the identification of the word would involve a choice from the rhyming alternatives listed.

Consonant category.--In this study each of seven consonants is used as an initial consonant with vowel-consonant endings to form seven sets of monosyllabic words. A consonant category is composed of those words which have the same consonant as their initial sound.

Criterion variable.--In multiple regression and multiple correlation calculations, the criterion variable is the variable about which prediction is being made--the dependent variable. In this investigation the criterion variable refers to the error scores associated with the stimulus words.

Digram.--The term digram is used to refer to paired letters in written English. Shannon uses the term in reference to units of two symbols in which the second symbol of the pair is chosen on the basis of its frequency of occurrence with the first symbol.[1]

[1]Claude E. Shannon and Warren Weaver, The Mathematical Theory of Communication (Urbana, Illinois: University of Illinois Press, 1949), p. 13.

Entropy.--This term has been borrowed by the communication theorists from thermodynamic theory and is used to express the degree of freedom of choice available in the construction or reconstruction of a message. Weaver states that "In the physical sciences, the entropy associated with a situation is a measure of the degree of randomness . . . in the situation," and he explains further:

> That information be measured by entropy is after all, natural when we remember that information, in communication theory, is associated with the amount of freedom of choice we have in constructing messages. Thus for a communication source one can say, just as he would say it of a thermodynamic ensemble, "This situation is highly organized, it is not characterized by a large degree of randomness or of choice--that is to say the information (or entropy) is low."[1]
>
> . . . .
>
> The ratio of the actual to the maximum entropy is called relative entropy of the source. If the relative entropy of a certain source is, say .8, this roughly means that this source is, in its choice of symbols to form a message, about 80 per cent as free as it could possibly be with these same symbols. One minus the relative entropy is called redundancy. This is the fraction of the structure of the message which is determined not by the free choice of the sender, but rather by the accepted statistical rules governing the use of the symbols in question.[2]

Error score.--In this experiment error score refers to the total number of errors in the identification of the initial consonant of a given stimulus word.

Experimental variables.--In correlation and regression the term experimental variable refers to the predictor or independent variables. Specifically, in this study, these variables include (1) the frequency of occurrence of the stimulus words, (2) the number of alternative rhyme words, and (3) the ratio of the mean frequency of the five most frequent rhyme words to the frequency of the stimulus words.

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[1] Ibid., pp. 103-104.

[2] Ibid., p. 104.

Order of approximation to the statistical structure of English.--This refers to the amount of statistical constraint employed in arranging linguistic units in a sequence. Zero-order approximation would involve a completely random selection of units. A first-order approximation would result from selection of the symbols on the basis of their independent frequency of occurrence in the English language. A second-order approximation would be based on the frequency of occurrence of pairs of language units, and higher order approximations would be based on the frequency of progressively larger numbers of interdependent units.

Redundancy.--A general definition of redundancy is given by Cherry as follows: ". . . redundancy is a property of languages, codes, and sign systems which arise from a superfluity of rules, and which facilitates communication in spite of all the factors of uncertainty acting against it."[1] When applied to communication theory, redundancy is defined by the following formula:

$$\frac{H_{max} - H}{H_{max}} \times 100 \text{ per cent}$$

where H equals the observed information rate (bits per sign, or second) and H_{max} equals the maximum information rate which it could possess if recoded into the same alphabet of signs by equalizing all sign probabilities, thus rendering them independent.[2] (See also the definition of entropy.)

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[1] Cherry, op. cit., p. 18.

[2] Ibid.

Stem.--In this study stem refers to a linguistic unit composed of a vowel followed by a consonant or consonant combination which, when united with an initial consonant or consonant combination, forms a monosyllabic word. An example of a stem as here defined is the unit "_og" which, when united with the consonant [d], forms the monosyllabic word "dog."

Stimulus word.--This term refers to any one of the words in this study which was formed by the union of seven selected initial consonants with vowel-consonant endings and were spoken by a filmed speaker for identification by lipreading subjects.

Trigram.--A trigram is a combination of three letters in written English that occur together in a sequence. In communication theory, a trigram may refer to combinations based on the frequency of their occurrence together as a unit.

Statement of the Problem and Hypotheses

This project was conducted to investigate the influence of the perceived stem of monosyllablic words on the identification of initial consonants by lipreading. The basic hypothesis is that the identification of an initial consonant is influenced by the stem associated with the initial consonant, when the stem is known and the consonant is unknown. In other words, when a certain stem is known but the initial consonant is unknown, a configuration of expectancy and probability is associated with the linguistic structure of the stem that will assist or hinder the correct identification of the initial consonant by lipreading.

It is further postulated that (1) the familiarity of the word formed by the union of an initial consonant and a given stem, (2) the number of possible alternative rhyming words that may be derived from a particular stem, and (3) the degree of familiarity of the alternative rhyming words are factors associated with the stem of a particular monosyllable that influence the identification of the initial consonants.

More specifically, the hypotheses to be considered in this study are stated as follows:

I. Basic Hypothesis

If the stem of a monosyllabic word is known and the initial consonant is unknown, the correct or incorrect identification of the initial consonant by lipreading is influenced by the linguistic characteristics of the known stem. Hence the number of errors of identification of the same initial consonant by lipreading will differ from word to word due to the differential influence of the known stems.

For example, let us suppose that [r] is united with stems having common vowels, so as to control the immediate sound environment of [r], but that the stems have different consonant endings so that several monosyllabic words are formed which differ only as to stem. Let us further suppose that these -VC stems are known by a group of subjects, but the initial consonant is unknown. The subjects are then confronted with the task of identifying by lipreading the initial consonant of these words when each stem is known. It is postulated that the correct identification of the initial consonant, and hense the word, will vary significantly from word to word and that the difference will be due to the influence of the stems, since the stem is the only uncontrolled variable present.

II. Corollary Hypotheses

Now let it be assumed that the basic hypothesis is supported by the findings of the study, so that it is confirmed that the stem of a monosyllable does influence the identification of the initial consonant. The question then may be asked as to what factors associated with the stems of the words account for the variation in identifying the initial consonants. In an attempt to answer this question, the following hypotheses have been formulated:

A. Errors in the identification of initial consonants of monosyllables occur in inverse proportion to the frequency of occurrence of the word formed by the union of an initial consonant and a given stem. For example, it is suggested that [t] associated with the stem [-un] (tune) would be incorrectly identified more frequently than [t] associated with the stem [-u] (to), if the stems are known; since "to" is a highly familiar word, being among the 500 most frequently used words according to the Thorndike count; and tune is less familiar, since it occurs only 32 times per million words according to the Thorndike count.[1]

B. The frequency of errors in the identification of an initial consonant united with different stems differs in proportion

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[1]Edward L. Thorndike and Irving Lorge, The Teacher's Word Book of 30,000 Words (New York: Bureau of Publications, Teachers College, Columbia University, 1959).

to the number of alternative rhyming words that may be formed from a given stem. For example, it is hypothesized that [r] will be identified incorrectly more frequently with the stem [-Ill], which can produce twenty-five rhyming words, than with [-Isk], which will produce ten rhyming words.

C. The frequency of errors in the identification of an initial consonant united with different stems varies proportionately with the relative frequency of occurrence of the alternative rhyming words that may be derived from a given stem. Stated in another way, it is hypothesized that there will be more errors in the identification of the initial consonant associated with a given stem if the possible alternative rhyming words are of comparable or greater familiarity in relation to the actual stimulus word.

CHAPTER II

REVIEW OF LITERATURE

Introduction

There has been a limited amount of research and writing directly concerned with the code in lipreading. As O'Neill and Oyer point out, " . . . this area seems to offer the greatest possibility for future, controlled research."[1] Thus, a review of the literature directly relating to the code in lipreading can not be very extensive. However, there is an area in which a significant amount of research has been done which seems to relate quite meaningfully to the nature of the code as it is used in lipreading. This is the area of psycholinguistics--an area which has received far too little attention from the investigators of lipreading.

Since in this review of the literature some attention will be given to related psycholinguistic studies as well as studies concerned directly with lipreading, the review is divided into two parts. Part I contains a review of the literature concerned directly with the code in lip reading and Part II reviews some of the pertinent research carried out in studies in the area of psycholinguistics.

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[1]John J. O'Neill and Herbert J. Oyer, Visual Communication for the Hard of Hearing: History, Research, and Methods (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1961), p. 47.

PART I: REVIEW OF LITERATURE DEALING WITH THE CODE IN LIPREADING

The Contributions of the Visible Aspects of Speech to Communication

The fact that the visible manifestations of speech, which constitute the code in lipreading, are useful to communication is well accepted; but it is of interest to examine the degree to which the visible aspects of speech are useful and the nature of its interaction with auditory stimuli. The relative contribution that lipreading makes in person-to-person communication has been studied by O'Neill. Thirty-two experimental subjects listened to each of three speakers under eight experimental conditions. These consisted of four speech-to-noise ratios. In each of these four conditions, the listeners viewed and did not view the speakers. It was found that individuals with normal hearing made appreciable use of visual cues to gain information. Visual recognition was always greater than non-visual recognition for all materials under all four of the speech-to-noise ratios employed in the study. The results showed that vision contributed 44.5% to understanding of vowels, 72% for constants, 64.1% for words, and 25.9% for phrases.[1]

Another investigation relating to the contribution of vision to communication was conducted by Neely. Using the Pensacola-Ohio State Multiple-Choice Intelligibility Tests, Forms C and D, Neely had each of thirty-five listeners listen to the two lists with the speech

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[1]John J. O'Neill, "Contributions of the Visual Components of Oral Symbols to Speech Comprehension," Journal of Speech and Hearing Disorders, XIX (1954), 429-439.

masked by 100 db of white noise. Each listener sat at each of eleven test positions. At test positions 1, 2, and 3, the observers sat at an angle of 90 degrees to the speaker at distances of 3, 6, and 9 feet. Test positions 4, 5, and 6 were situated at the same distances with the observers facing the speaker at an angle of 45 degrees. At test positions 8, 9, and 10 the observers faced the speaker directly at the same distances as before. At test positions 7 and 11 the observers heard the speaker with earphones while facing away from the speaker. Positions 7 and 11 differed in that in the former the answer sheet was before the observer, while in the latter the observer did not see the answer sheet.

Results of the study indicated no difference in the correctness of responses in relation to distance from the speaker; but a significant difference was shown with regard to the angle of viewing the speaker. There was a highly significant difference in scores between seeing and not seeing the speaker. It was found that the addition of visual cues to auditory cues raised the intelligibility of received speech by approximately twenty per cent.[1]

The contribution of the visible elements of speech to the communication of deaf children is illustrated by a study conducted by Numbers and Hudgins. Twenty-five subjects ranging in age from ten to sixteen were given the task of identifying fifty familiar monosyllables. With a hearing aid only, 21 per cent correct responses were obtained; with lipreading and the hearing aid, 65 per cent correct

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[1]Keith K. Neely, "Effect of Visual Factors on the Intelligibility of Speech," Journal of the Acoustical Society of America, XXVIII (1956), 1275—1277.

responses were obtained.[1]

The studies just cited indicate the relative general importance of the visual component of the speech code in situations where communication by means of the auditory modality is made difficult. Other studies examine more minutely the nature of the visual component of speech that is utilized for lipreading.

The Visibility and Discriminability of Sounds in Lipreading

One of the earliest analytic studies relating to the code in lipreading was conducted by the New York Board of Education. In this study visibility values of English sounds were derived.[2] By "Paying meticulous attention to the formulation and revelation of each sound,"[3] a chart was developed which rated the visibility of each sound by giving it a value of 1, .75, .5, or 0. A rating of "1" represented high visibility and the other numbers represented consecutive degrees of decreasing visibility. The visibility values which were derived for the various English sounds are shown in Table 1.

A more recent study of the comparative visibility of English sounds was carried out by Heider and Heider.[4] This investigation made use of students at the Clarke School for the Deaf. Two tests were developed in their investigation, one for vowels and one for consonants.

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[1]M. Numbers and C. V. Hudgins, "Speech Perception in Present Day Education for Deaf Children," The Volta Review, L (1948), 449-456.

[2]New Aids and Materials for Teaching Lip-Reading (Washington, D.C.: The American Society for the Hard of Hearing, 1943), 1-23.

[3]*Ibid.*, p. 22.

[4]F. K. Heider and G. M. Heider, "An Experimental Investigation of Lip-Reading," Psychological Monographs, LI (April, 1960), 124-153.

TABLE 1

VISIBILITY VALUES FOR THE SOUNDS OF ENGLISH[1]

Consonants

b as in baseball . 1	ng as in song 0
c " " comb 0	p " " puppy ... 1
ch " " child 1	r " " rain 5
d " " dad 5	s " " sign 5
f " " face 1	sh " " ship 1
g " " game 0	t " " tar 5
g " " gem 1	th " " thumb ... 1
h " " horse 0	th " " this 1
k " " kite 0	v " " veil 1
l " " laugh .... .75	w " " wind 1
m " " mail 1	wh " " whip 1
n " " nine 5	y " " yacht ... *
z " " azure 1	z " " zebra 5

Vowels and Diphthongs

a as in make ..... .75	ir as in bird 5
a " " father.... 1	o " " no 1
a " " all 1	o " " move..... 1
a " " cat 1	o " " not 5
e " " he .... .75	oi " " oil 5
e " " pen 5	ou " " house ... 1
i " " night .... .75	u " " male 1
u " " full 5	u " " hut 5

[1]New Aids and Materials for Teaching Lip-Reading (Washington, D. C.: The American Society for the Hard of Hearing, 1943), p. 23

*Fuses with vowel that follows and therefore receives no separate value.

The vowel test was made up of sixteen syllables like "parp," "pip," and "poop." The consonant test was composed for forty nonsense syllables, twenty with the diphthong [ɔɪ] and twenty with the vowel [ɪ]. The per cent of cases in which a sound was recognized correctly by eighty-one subjects is presented in Table 2.

TABLE 2

PER CENT OF CASES IN WHICH SOUND WAS RECOGNIZED CORRECTLY[1]

Per Cent Correct	Consonants	Vowels
90	l, r, th	oo
80	f	ur, ou, aw
70		ee, o-e, i-e
60	s, k, v	oi, u-e, -i-, ar
50	h, m,	
40	t, n	
30	d, p, sh, j	
20	b, g	-e-, -u-
10	ch, y	-a-

[1]F. K. Heider and G. M. Heider, "An Experimental Investigation of Lip Reading," Psychological Monographs, LII (April, 1940), 124.

It was also found that there was a surprisingly high correlation between ability to understand single vowels on the lips and general lipreading ability; however, this was not true for consonants. Heider and Heider suggest that the reason is found in the fact that each vowel is different and the good lipreader learns the difference; whereas there are more homophenous sounds among the consonants which makes it impossible to learn the differences.

O'Neill examined the relative visibility of a small number of English consonants and vowels and made comparisons of his ratings with those of the two studies reviewed immediately above. In this study, visibility ratings of seven vowels and seven consonants were obtained. The visibility values given the sounds considered by O'Neill were as follows--for consonants: [f], 83; [p], 83; [ʃ], 73; [θ], 73; [k], 70; [t], 56; for the vowels: [o], 60; [u], 53; [i], 53; [U], 50; [e], 36: [I], 27: [ɛ], 27.[1]

A comparison of these ratings with the ratings given the same sounds in the study by the New York Board of Education[2] showed no apparent correspondence between the two ratings. However, comparison with visibility ratings obtained from the study by Heider and Heider[3] resulted in a coefficient of correlation for consants of .58, and for vowels a coefficient of correlation of .55.[4]

Brannon and Kodman investigated the relative intelligibility by lipreading of the basic elements of the speech code and compared the intelligibility of these elements for skilled and unskilled lipreaders. The words from PB List Number Six were used as the lipreading material analysed.[5]

The relationship of intelligibility of (1) rated visibility, (2) vertical mouth opening, and (3) the frequency of occurrence of the

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[1]O'Neill, op. cit., p. 433.

[2]New Aids and Materials for Teaching Lip-Reading (Washington, D. C.: The American Society for the Hard of Hearing, 1943), pp. 1-23.

[3]Heider and Heider, loc. cit.

[4]O'Neill, loc. cit.

[4]John B. Brannon and Frank Kodman, "The Perceptual Process in Speechreading," A.M.A. Archives of Otolaryngology, LXX (1959), 114-119.

PB words was studied. It was found that words composed of highly visible elements were identified correctly with greater frequency by both the skilled group and the unskilled group. A small positive but non-significant correlation was shown in a comparison of intelligibility and vertical mouth opening; and the same type of relationship was found between the intelligibility of the words and the frequency of occurrence of the words.

It was determined that the most intelligible isolated sounds for the skilled group were [w], [f], [m], and [s] among the consonants and [ɑU], [i], [aI], and [ɔU] among the vowels and diphthongs. For the unskilled group, the most intelligible consonants were [f], [w], [θ], and [p]; the most intelligible vowels and diphthongs were [aU], [u], [ɚ], and [a].

The rank order of the intelligibility of the sounds relative to phonetic class was found to be labio-dentals, labials, postdentals, lingua-dentals, velars, and glottals.

For both groups word fragments and sounds were more easily identified than words.

Closely related to the visibility of sounds and perhaps more important in lipreading is the relative discriminability of sounds from each other. In association with the John Tracy Clinic, Woodward and Barber have conducted rather extensive investigations of the relative visibility of differences among phonemes.[1]

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[1]Mary F. Woodward and Carrol G. Barber, "Phoneme Perception in Lipreading," Journal of Speech and Hearing Research, III (1960), 212-222.

In an initial study, Woodward and Barber used a paired-comparisons technique to determine discriminability of word-initial allophones of English consonants.[1]

Two hundred and twenty-nine monosyllabic nonsense words were presented to 185 subjects. The 229 monosyllables represented a selection from 525 syllable pairs which were derived by varying both the initial consonant and syllable order. The task of the subjects was to respond to each pair as "alike" or "different.

According to the results of this study, there are only four groups of consonants that are visually contrastive; and hence the sounds within each of these groups are essentially homophenous. The sounds according to their groupings are presented as follows:[2]

Unit 1: [p, b, m]
Unit 2: [w, hw, r]
Unit 3: [f, v]
Unit 4: [t, d, n, l, θ, ð, s, z, t, dʒ, ʃ, ʒ, j,
k, g, h]

A high visibility value was inferred for the "labial and labialized consonants (Units 1, 2, and 3) since they were found to contrast with all the members of all other units."[3]

In a follow-up of the initial study cited above, 198 English monosyllables were presented for identification by 219 subjects in order to investigate additional variables relating to perception of

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[1] Ibid.   [2] Ibid., p. 219.

[3] Ibid., pp. 219-220.

phonemes. The discriminability of vowels was one of the variables examined in this study. The following groups of vowels were found to be visually contrastive to a limited degree:[1]

Unit 1: [i, I, ɛ, æ, ai, ʌ , ɑ]
Unit 2: [ɜI]
Unit 3: [aU]
Unit 4: [u, U, ɔU, ɔ]

It was reported that " . . . even though the groups contrast with each other, the internal confusions are sometimes considerable and correct responses to individual vowel nuclei are sometimes very low."[2]

It is interesting to note that an analysis of the confusions in the identification of the consonants revealed a great deal of non-reciprocity. It was found that [r] is frequently perceived as [w], but the reverse is not true. The same is true of [l] and the dental spirants. The sound [n] was perceived as a velar just as often as an alveolar. And [j] had more alevolar responses than any other kind, but only three subjects identified any of the seventy-five initial consonants as [j]. The consonant [m] was identified as [p] or [b] 88 per cent of the time, while [p] and [b] were rarely identified as [m] . It was found also that combined responses of all voiceless-voiced pairs showed higher frequencies for the voiceless member of the pairs.[3]

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[1]Mary F. Woodward and Carrol G. Barber, Education of the Aurally Handicapped: A Psycholinguistic Analysis of Visual Communication, School of Education, Cooperative Research Project No. 502, University of Southern California (Los Angeles: John Tracy Clinic, 1960), p. 47.

[2]Ibid., p. 46.

[3]Ibid., pp. 53-56.

Investigations of Other Characteristics of the Code of Lipreading

The visibility and discriminability of individual speech sounds most certainly are to be considered as factors which contribute to the relative ease or difficulty with which material is lipread. But other characteristics associated with the code have also been shown to affect the ease or difficulty of lipreading. Brannon investigated the effect of the visibility of the phonetic components of words on the lipreadability of the words, and in addition he compared the relative difficulty encountered in lipreading three different kinds of material.[1]

The material consisted of the Utley Lipreading Test, PB words (List Number Six), and ten Spondee words. The PB words were divided into six categories of visibility based on phonetic composition. The ten Spondee words were divided equally into two categories of visible and less visible words.

It was found that there were more correct identifications of both PB and Spondee words in the categories of words with the greatest numbers of visible elements. In addition the results showed that when words were presented in sentences (Utley Test Form A), they were identified with 50 per cent accuracy, whereas only 35 per cent of the PB words and 30 per cent of the Spondee words were identified correctly. These latter findings suggest that words in context are easier to lipread than words in isolation. The influence of context on accuracy of

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[1] J. B. Brannon, "Speechreading of Various Speech Materials," Journal of Speech and Hearing Disorders, XXVI (1961), 348-353.

perception will be examined in more detail later in this chapter.

Another study which investigated variables associated with the code in lipreading was that of Taaffe and Wong.[1] The stimulus material analyzed in this investigation was a filmed sentence test of lipreading. Results were obtained from 52 male and 121 female examinees.

A number of variables were found to show relationships to difficulty of lipreading the items on the test used. One of the parameters which showed a relationship to lipreading difficulty was the number of words in a sentence. Some irregularity of relationship was shown, but in general the greater the number of words in the sentence, the more difficult it was to lipread. The numbers of syllables per sentence was also examined and a significant positive correlation was found between the number of syllables in each sentence and lipreading difficulty. When the number of consonants and vowels per sentence were considered, a relationship was shown to exist between the number of consonants and sentence difficulty and between the vowel-consonant ratio and sentence difficulty. But the number of vowels per sentence did not appear to be related to lipreading difficulty.

The relative difficulty of interrogative and declarative sentences was another variable analyzed. The results showed that, on the average, declarative sentences were more difficult to lipread than the questions.

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[1]Gordon Taaffe and Wilson Wong, "Studies of Variables in Lip Reading Stimulus Material," John Tracy Clinic Research Papers, III (Los Angeles: John Tracy Clinic, 1957).

Another part of the analysis dealt with the relationship between parts of speech and lipreading. It was found that sentences with fewer nouns tended to be more easily lipread. The authors contend, however, that this could be related to sentence length, which was not controlled in the analysis. The number of verbs and pronouns did not appear to relate to success or difficulty in lipreading sentences. It was revealed also that pronouns and verbs were easiest to lipread, and nouns, adverbs, adjectives, and prepositions were next in order of difficulty.

Further analysis examined the relationship of the lipreading difficulty of the test sentences to the visibility of the speech sounds as rated by the study of the New York Board of Education.[1] No significant relationship was found.

An examination of word position and word size in relation to lipreading difficulty revealed that there were no consistent trends regarding the effect of word position, but that word size did seem to be a factor relating to ease or difficulty in lipreading. Three-letter words were found to be easier to lipread than one- or two-letter words, but words longer than three letters were systematically more difficult to lipread.

Further information concerning characteristics of the code in lipreading was provided in a study by Morris.[2] She corroborated the

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[1] New Aids and Materials for Teaching Lip-Reading, op. cit., pp. 1-23.

[2] D. M. Morris, "A Study of Some of the Factors Involved in Lip Reading" (unpublished M.A. thesis, Smith College, 1944).

findings of Wong and Taaffe[1] that the longer a sentence is the more difficult it is to lipread, and she produced some additional findings as well. Morris found that the lipreadability of a sentence is not markedly influenced by its position within a group of sentences; and that there is no influence on lipreading performance of the position of a group of sentences within a sequence of groups.[2]

Since the visual and auditory aspects of speech are conjoint manifestations of a single process, the question arises as to the intelligibility relationship between the two modalities. The relationship of the intelligibility of the auditory speech code masked by noise to the intelligibility of the code when lipread has been examined by McEachern and Rushford. Comparable forms of a lipreading test were used for the investigation. It was concluded that although lipreading and listening to masked speech are related, they are not related in a linear manner. The authors suggest that further research into these relationships is necessary.[3]

In an application of the techniques of the information theorists to lipreading, Tatoul and Davidson[4] conducted a study which deals with the synthetic ability of lipreaders, but also makes use of the code in

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[1]Taaffe and Wong, op. cit., pp. 3-5.

[2]Morris, op. cit., pp. 19-20.

[3]A. W. McEachern and Georgina Rushford, "Lipreading Performance as a Function of Characteristics of Unknown Communicators," John Tracy Clinic Research Papers, VIII (Los Angeles: John Tracy Clinic, 1958), 12-17.

[4]Corrine Tatoul and G. Don Davidson, "Lipreading and Letter Prediction," Journal of Speech and Hearing Research, IV (1961), 178-181.

a way that would seem to have some relationship to the present study. The purpose of the investigation was to determine whether good lipreaders were significantly better than poor lipreaders in their ability to synthesize, as measured by their scores on a letter prediction test. Twenty sentences from a lipreading test were used. A key word was given and then each of 100 subjects attempted to predict, one at a time, the letters of each word of the twenty sentences, the space between the words included. If the subject failed to predict a letter correctly on the first try, the examiner supplied the letter and the subject attempted to predict the succeeding letter.

"The results provided no evidence of a difference between good and poor lipreaders with respect to letter prediction ability or of any important relationship between lipreading ability and letter prediction ability."[1]

However, it should be noted that with a possible maximum prediction score of 56.8, the good lipreaders obtained a mean score of 49.8 and the poor lipreaders obtained a mean score of 49.3.[2] This would seem to suggest that although degrees of lipreading ability do not appear to be differentiated by letter prediction scores, information resulting from the transitional constraint of language structure was utilized by the subjects in making correct predictions. And even though letter prediction did not play a differentiating role, it would seem likely that the redundancy demonstrated by letter prediction

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[1] *Ibid.*, p. 181.

[2] *Ibid.*, p. 179.

might be considered a factor that would assist in the lipreading task--perhaps in a way and to a degree that is generally the same for all lipreaders.

PART II. REVIEW OF PERTINENT PSYCHOLINGUISTIC LITERATURE

The part of psycholinguistics which is of concern in this study related to the probability structure of language and the effects of language habits on perception. Linguists, information theorists, learning theorists, experimental psychologists, acousticians, and speech and hearing scientists have all contributed to knowledge in this area. Consequently, the findings reviewed here come from a number of disciplines and represent a variety of points of view. But it is believed that all may contribute something to the understanding of the influence of language structure on communication through lipreading.

Language structure has been spoken of as though it were an autonomous physical entity, but in reality this is not true. Language exists only for those who use language, and the influence of its structure depends entirely on the learning of the users of the language. Therefore, learning theory is fundamental to an examination of the influence of language structure.

This relationship can be seen in theories of learning such as Tolman's Sign-Gestalt Theory which is summarized by Osgood as follows:

> This system stresses contiguity of stimuli in building up expectations. The closer in time two stimuli occur the

> greater the likelihood that an expectation will be set up. Practice plays a role in confirming and strengthening expectations. The more often S_2 follows S_1 the higher is the expectancy. It may be seen that expectancy can be viewed as a cognition of the probability that a given event will follow another.[1]

The direct application of such a theory to language is explained by Osgood who states that,

> Since the linguistic structure of the language and 'semantic structure' of the culture is such that certain message events co-occur more often than others (frequency of S-R) and certain message events appear closer together in the temporal sequence than others (contiguity of S-R), it must follow that . . . Hierarchies of habits of varying strength will be developed, and these will correspond to sets of transitional probabilities.[2]

Studies of Language Habits and Statistical Probability in Communications

What Osgood has stated as theory has been demonstrated by a number of studies of transitional dependency in language which illustrate the operation of language habits and show their possible influence in communication.

One of the earliest studies was that of Shannon. This study involved prediction of letters from a short passage of printed material which was unfamiliar to the person who was to do the predicting. Each subject was asked to guess the first letter in the passage. If the guess was correct, he was so informed, and proceeded to the prediction of the second letter. If the guess was not correct, he was told the correct letter and proceeded to guess the second letter. In one such experiment Shannon found that for a total of 129 letters, eighty-nine

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[1] C. E. Osgood, Psycholinguistics: A Survey of Theory and Research Problems, Part II Supplement to Vol. XLIX of the Journal of Abnormal and Social Psychology (October, 1954), p. 29.

[2] Ibid., p. 96.

(or 69 per cent) of the letters were guessed correctly on the first attempt.

An extension of the experiment described above required the subject to guess the letters in the same manner, but he was told if he had guessed wrong and was asked to continue to guess until he found the correct letter. He was informed when he found the correct letter and proceeded to guess the second letter in the same manner. In one such experiment, out of 102 symbols, the subject guessed seventy-nine letters correctly on the first guess, two on the fourth and fifth guesses. Only eight letters required more than five guesses.

In order to determine how predictability depends on the number of preceding letters known to a subject, a more involved experiment was carried out. One hundred samples of English text were selected at random from a book. Each sample was fifteen letters in length. The subject was asked to guess the text, letter by letter, for each sample. "To aid in prediction the subject made such use as he wished of various statistical tables, letters, digram and trigram tables, a table of the frequencies of initial letters in words, a list of the frequencies of common words and a dictionary."[1]

The data obtained from the subjects on the basis of the 100 samples were summarized in a table. The entries in the columns of this table corresponded to the number of preceding letters known to the subject plus one; the row was the number of the guess. The entry in column N at row S was the number of times when (n-1) letters were

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[1] C. E. Shannon, "Prediction and Entropy of Printed English," Bell Telephone System Technical Publications, Monograph 1819 (January, 1951), 1-15.

known. It was found that the prediction gradually improved with increasing knowledge of the past (preceding letters known to the subject).[1]

In a study patterned after Shannon's, Burton and Licklider examined the extent to which estimates of redundancy of English texts are dependent upon the number of preceding letters known to the subjects. The findings indicate that relative redundancy did increase as the knowledge of the previous text was extended from zero to approximately thirty-two letters, but that increasing the known number of letters beyond thirty-two does not result in any notable rise in redundancy.[2]

The effect of language habits in letter prediction was also shown by Mulder. In this study, each subject was provided with six answer sheets. Each answer sheet consisted of fifteen columns of twenty-seven symbols each and was coded by means of a chemical solution with a message in English which was fifteen letters in length. Each subject predicted the letters by marking the symbols in each column with green ink. When the correct letter was found, the green ink turned brown. Three scores were obtained for each subject: (1) the total number of trials, not exceeding ten; (2) the total number of correct predictions on the first trial; and (3) the total number of correct predictions after ten or more previous trials.

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[1] Ibid., p. 14.

[2] N. G. Burton and J. C. R. Licklider, "Long Range Constraints in the Statistical Structure of Printed English," American Journal of Psychology, LXVIII (1955), 650-655.

A statistical comparison was then made between native and non-native speakers of English. On all three scores native speakers were significantly more successful than non-native speakers. This would seem to indicate the influence of native language habits in determining expectancy in the letter prediction.[1]

The effect of redundancy due to language probability was also studied by Black.[2] Samples of five-syllable phrases of similar length were selected from the language of flight instruction and newspapers and were presented to subjects who were asked to predict the successive letters with a knowledge of the preceding ones.

It was ascertained that the subjects were somewhat familiar with the statistics of English, since approximately 60 per cent of the first guesses to phrases were divided between [t] and [ə], which are the two most frequent sounds in the initial position. It was also determined that,

> Young male adults know with eleven per cent accuracy the letter that will begin a phrase; there is one chance in three that they know the second letter, given the first. With three to five letters of a phrase known there is one chance in two that they know the next letter, and their ability to predict a next letter may exceed two chances in three with a single line of newsprint.[3]

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[1] R. L. Mulder, "A Comparative Study of the Competence of Groups of International and Native Students in Aspects of Language that Hold Relevance to Speech" (unpublished Ph. D. dissertation, Ohio State University, 1953), pp. 87-144.

[2] John W. Black, The Prediction of the Words of Varied Materials, Joint Project Report No. NM 001 104 500.57 (Pensacola, Florida: The State University Research Foundation and U. S. Naval School of Aviation Medicine, 1955).

[3] *Ibid.*, p. 11.

The potency of the influence of increased knowledge of preceding material on the ability of a subject to predict succeeding material is shown by the accuracy with which the final letters of the phrases were guessed. Seventy-six per cent of the terminal letters were guessed and 73 per cent of the letters which preceded the terminal letters were guessed.

It was also found that increased length of a language unit, whether a word or a phrase makes prediction easier when averaged over the entire unit. Furthermore it was found that the letters of words were less predictable than three letter words irrespective of the word in the phrase.

In another study Black examined redundancy characteristics of individual sounds and sounds treated in pairs as well.[1] He concluded that English sounds in words do not have the same frequency in the language both in isolation and as paired units and that the occurrence of these sounds depends to a degree on the preceding and succeeding sounds.

When two sounds were considered as paired units, the average redundancy was found to be at least .20, and within the categories of words sampled reached .37. The data indicated that in a sequence of English sounds, transitional probabilities exist to a degree that there is at least one chance in ten that a particular sound will be next. And in some cases these chances may be greater than one in three.

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[1] Black, "The Information of Sounds and Phonetic Digrams of One- and Two-syllable Words," op. cit., pp. 397-411.

The influence on communication of redundancy due to the different probabilities of sound sequences is shown more directly by a study by Miller, Bruner, and Postman.[1] They used a tachistoscope to present pseudo-words to subjects at exposure durations varying from 10 to 500 milliseconds. Recognition thresholds were obtained for eight-letter pseudo-words composed according to zero-, first-, second-, and fourth-order approximations to the statistical structure of English. For the first-order words the letters were selected according to their relative frequency of occurrence in written English. For the second-order words, selection was made on the basis of relative frequency of pairs of letters, and for the fourth-order the relative frequency of four-letter sequences was used as the basis for selection.

The results showed that the fourth-order words were consistently easier to recognize than the zero-order words, and the first- and second-order words fell in between.

Investigations of the Effects of Context in Communication

The redundancy due to the interdependence of language parts is also shown by the studies of the effects of context on the accuracy of communication. As in the case of letter prediction, these studies show that language patterns exist and that they can contribute information which is greater than the sum of the contributions of the individual components in isolation. The information provided by these patterns provides insurance against errors and can assist perception in difficult communication situations.

[1] G. A. Miller, S. J. Bruner, and Leo Postman, "Familiarity of Letter Sequences and Tachistoscopic Identification," Journal of General Psychology, L (1954), 129-139.

An investigation in this direction was carried out by Brown and Hildum.[1] Using ( )vc contexts such as [(θ) ɔl] as stimulus units, the experimenter pronounced the monosyllables and the subjects were asked to supply an initial consonant cluster. Sometimes the experimenter would pronounce a consonant cluster that actually occurs in that position in English, thereby making an English word, e.g., [θr ɔl] thrall. In other cases the experimenter used a consonant cluster that does occur in English in the initial position, but does not result in a word, e.g. [pr ɔl]. A final variation was the pronunciation of a syllable with an initial consonant cluster that never occurs in that position in English.

The sets of syllable triplets were presented to two groups of subjects. One group was linguistically trained, the other was not. There were thirty-seven subjects in the naive group and twelve subjects in the trained group. The findings are summarized as follows:

> When subjects uninstructed in linguistics hear speech that is expected to be in the native language, their perceptual identifications are directed by their knowledge of sequential probabilities in the language as well as by the acoustic stimulus. When the speech includes an initial consonant cluster that never occurs in that position in the native language, and when acoustic conditions are not perfect, nearly everyone fails to identify the cluster correctly. The identifications made tend to stay close to the presented stimulus. Most errors involve only one phoneme and most changes of one phoneme involve only one distinctive feature (e.g. [p] to [t], [k], [b], or [f]). When subjects err by as much as two or more phonemes it seems to be in order that they may identify what they have heard as a relatively probable occurrence--an actual word. When subjects who mistake only a single phoneme

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[1]Roger W. Brown and Donald C. Hildum, "Expectancy and the Perception of Syllables," Language, XXXII (1956), 411-419.

> mistake that phoneme by as much as two distinctive features, they also are usually following the lure of an actual word. It would seem that the confidently identified portions of a syllable operate as a context in which some phonemes are probable and others improbable. When a given phoneme or cluster of phonemes is so probable as to yield a familiar word, the presented syllable may be identified as that word even though considerable distortion of the stimulus is involved. When a given phoneme or cluster of phonemes is very improbable, the presented stimulus is unlikely to register accurately with anyone, in the less-than-perfect acoustic conditions we have used.[1]

It will be noted that the experimental task involved in the study of Brown and Hildum resembles somewhat the experimental task in the present study. In the latter, however, the focus is on the stem as the context variable rather than the initial consonant cluster. Nevertheless, it is probable that some of the same linguistic forces are operating in both studies.

The influence of context on the recognition of intelligibility test materials has been studied by O'Neill.[2] Thirty-nine subjects listened to fifty sentences which were part of a sentence intelligibility test. The subjects also listened to 291 words taken out of the context of the same sentences. These materials were presented at five speech-to-noise ratios, -12 db, -6 db, 0 db, + 6 db, and + 12 db. The recognition of the words in context was then compared to the recognition of the words in isolation. It was found that the intelligibility scores for the isolated words tended to be lower than for the same words in context. The conclusion drawn by O'Neill was that "Words have context

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[1] _Ibid_., pp. 417-418.

[2] John J. O'Neill, _Recognition of Intelligibility Test Materials in Context and in Isolation_, Joint Project Report NM 001 064.01.23 (Pensacola, Florida: The Ohio State University and U. S. Naval School of Aviation Medicine, 1954).

intelligibility values as well as isolation intelligibility values and with this accepted, the possibility arises that various uncontrolled features of context may affect the intelligibility value of a word differentially."[1]

The effect of context on perception was also studied by Elmo Miller.[2] He used tachistoscopic exposure to present fifty sentences twice to each of sixteen subjects. The sentences were presented once in the form of a single story, and once in random order. The sentences were exposed for 0.15 seconds. The difference in correct perception in favor of the meaningful order was found to be statistically significant for letters and for words.

Miller and Selfridge extended the investigation of the attributes of context to the recall of sequences of symbols with various degrees of contextual constraint in their composition.[3] Sequences of words were arranged in orders of approximation of English ranging from zero-order through the seventh-order of approximation. The actual text was included as an eighth-order of approximation. At each order four lists of different length--10, 20, 30, and 50 words--were constructed. The lists were recorded on a wire recorder and presented to two groups of ten subjects. They were instructed to listen to a list until it was finished and then write what they had heard.

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[1] Ibid., p. 4.

[2] Elmo E. Miller, "Context in the Perception of Sentences," American Journal of Psychology, LXIX (1956), 653-654.

[3] G. A. Miller and J. Selfridge, "Verbal Context and the Recall of Meaningful Material," American Journal of Psychology, LXIII (1950), 176-185.

The results showed that the percentage of words recalled increased as the order of approximation increased, and decreased as the length of the list was increased. Furthermore, it was found that the longer the passage the greater was the usefulness of contextual association.

It was also discovered that orders of approximation above three were remembered almost as well as the actual text. From this Miller and Selfridge conclude that,

> When short range contextual dependencies are preserved in nonsense material, the nonsense is as readily recalled as is meaningful materials;

and that

> Contextual dependencies extending over five or six words permit positive transfer, and that it is these familiar dependencies, rather than meaning *per se*, that facilitates learning.[1]

If this is true in the recall of language material, one might also conjecture that it would be true of the initial perception of language material, since initial perception has been shown to be influenced by memory of language patterns much as the recall of the language material which was described in the above study.

Further investigation of the effect of context was carried out by George A. Miller together with Heise and Lichten. They examined "The Intelligibility of Speech as a Function of the Context of the Test Materials."[2] The study consisted of three parts--each examining a different aspect of context. The first part of the study involved presenting three types of speech stimuli in an environment of masking

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[1] *Ibid*., pp. 185.

[2] Miller, Heise, and Lichten, *op. cit*., pp. 329-335.

noise. The signal-to-noise ratio at which 50 per cent of the items were discriminated correctly was determined for each type of stimulus material. The intelligibility of digits, words in sentences, and nonsense syllables was tested. These results showed that the signal-to-noise ratio was -14 db for digits, -4 db for words in sentences, and +3 db for nonsense syllables. Miller, Heise, and Lichten attributed this difference not so much to phonetic composition as to the <u>alternatives</u> involved in a choice of the correct word. The digits limit the listener's freedom of choice because all have different vowel sounds except for five and nine; thus it is possible to respond correctly with only marginal perception. In the case of nonsense syllables intelligibility is difficult because the choice of alternatives is infinite--the subject knows that any phonetic combination might occur.

In an attempt to examine further the effect of the relative degree of freedom of choice on intelligibility, subjects were told that the test word would be one of the items from word lists containing 2, 4, 8, 16, 32, 256, and 1000 words. The subjects were given each list of words in advance and were instructed to study each particular list involved. Then, for each list, a word from that list was spoken in a background of masking noise, and thresholds were obtained as before. It was determined that the mean threshold for the two-word vocabulary was -14 db; for the 256-word vocabulary it was -4 db; and for the full list of 1,000 words it was +4 db. These findings lend substantial support to the influence of the number of alternatives on intelligibility.

In the second part of the study, sentences containing five key words were spoken in a background of noise and the signal-to-noise thresholds were determined. The key words were then taken out of the context of the sentences, scrambled, and presented as isolated words. It was found that the threshold was changed 6 db in favor of the sentences by taking the words out of context. These results are interpreted as showing the influence of the context of preceding and following words on intelligibility.

The final type of context investigated involved the effect of the context of repetition on intelligibility. It was hypothesized that if the original message reduces alternatives, the perception of the repeated message should be more accurate. Two different repetition effects were examined: automatic repetition of the test words and requested repetition of the test words. The results showed that the improvement resulting from simple repetition was slight; and that there was only a slight difference in improvement between automatic repetition and requested repetition, in favor of the automatic condition. It is pointed out, however, that when the time factor is considered, requested repetition is superior in terms of efficiency.

Investigations of the Reconstruction of Mutilated Text

Redundancy and the influence of context is also demonstrated by studies involving the reconstruction of language material which has been mutilated by word deletion or rearrangement, etc.

Newman and Gerstman conducted a study in which they asked subjects to reconstruct printed English text when various proportions of the letters were randomly deleted.[1] It was found that perfect reconstruction was possible in spite of the deletion of letters but that the deletion could not exceed 10 per cent.

In 1957 Morrison and Black investigated the effect of the mutilation of printed material by deleting from one to six words from each of 130 twelve-word sentences. In addition, three conditions of deletion were superimposed upon the variation of the number of deletions. The conditions consisted of simple omission, omission with blanks indicated, and omission plus randomization of the words in the sentences.[2] It was concluded that the probability of predicting a specified word in one of the twelve-word sentences did not exceed .5, and that when more than one word was omitted, the probability decreased progressively. It was also found that omission plus randomization reduced the proportion of correct responses even further.

The effect of the omission of varied quantities of single words and varied quantities of adjacent words was examined by MacGintie. With restoration of omitted words as the task, it was found that

> (a) Words were equally restorable when every 24th, 12th, or 6th word was omitted, but every 3rd word made restoration more difficult. (b) Words omitted in pairs were equally restorable regardless of whether 22, 10 or only 4 words of context were left between each omitted pair. (c) Words omitted in groups of four were more difficult to restore than words omitted in pairs, and pairs were more difficult to restore than single words. (d) Omitting an adjacent word made restoration more

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[1] E. B. Newman and L. S. Gerstman, "A New Method of Analyzing Printed English," Journal of Experimental Psychology, XLIV (1952), 114-125.

[2] Helen Minor Morrison and John W. Black, "Prediction of Missing Words in Sentences," Journal of Speech and Hearing Disorders, XXII (1957), 263-240.

> difficult, but restoration was equally difficult whether the additional omitted word preceded or followed the word to be restored.[1]

Taylor studied the effect of word deletion on two different essays, one of which was judged to be easy to read and the other difficult to read.[2] Five deletion versions which together took out all words were prepared for each essay. These deletion versions were presented to 287 subjects for reconstruction. The results showed that the "easier" selection was reconstructed with greater accuracy than the "difficult" selection when considered over all the deletion versions, but there was tendency for the percentage scores to converge for the deletion versions as more words were taken out--the scores seemed to stabilize within the first twenty to forty words.

It is interesting to note that a close correlation was shown between the reconstruction scores and the entropy of the various deletion versions. The rank-difference correlation was found to be -.87.

In 1957 Miller and Friedman made a rather extensive investigation of the effects of various types of mutilations of English texts. The effects of (1) substitution, (2) indicated substitution, (3) deletion, (4) abbreviation, and (5) insertion were studied.[3]

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[1]Walter H. MacGintie, "Contextual Constraint in English Prose Paragraphs," Journal of Psychology, LI (1961), 121-130.

[2]Wilson L. Taylor, "Application of 'Close' and Entropy Measures to the Study of Contextual Constraint in Samples of Continuous Prose," Dissertation Abstract, XV (1955), 464-465.

[3]G. A. Miller and E. A. Friedman, "The Reconstruction of Mutilated English Texts," Information Control, I (1957), 38-55.

When subjects were asked to reconstruct texts which had been mutilated by the five methods indicated above, it was found that the order of difficulty of reconstruction was--substitution, abbreviation, indicated substitution, deletion, and insertion.

Another aspect of mutilation studied was the comparative affect of omitting letters from the beginning or the end of a word. The effect of the omission of 2, 3, 4, and 5 letters was examined. It was determined that the subjects were more successful in restoring omitted letters at the ends of words than at the beginnings and that random omissions were more difficult to restore than omissions at the beginning or the end.[1]

As another part of their study, Miller and Friedman progressively abbreviated the texts by deleting the most frequent letters first and proceeding to the less frequent letters. This produced mean abbreviation percentages of 18, 28, 34, and 59. In each case the subjects were told which characters had been omitted. It was found that even with 59 per cent of the characters omitted, the subjects were able to restore more than half the missing characters. The investigation was carried still further by omitting characters that most frequently follow each other. The omissions were extended progressively from one to two and then three of the most frequent successors to a character of the text. This yielded 25, 36, and 50 per cent abbreviation, respectively. It was found that the subjects had much less success

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[1]Similar findings have been obtained in a study by Bruner and O'Dowd using typographical reversals as the method of mutilation. Jerome S. Bruner and Donald O'Dowd, "A Note on the Informativeness of Parts of Words," Language and Speech, I (1958), 98-101.

with this type of deletion than with the first-order omissions. This was attributed to the fact that in the first-order omissions, the subjects had a small set of alternatives to insert into the abbreviated text.

This study demonstrates again the ability of individuals to make use of the redundancy of language to reconstruct messages from fragmentary evidence, and that the nature of the fragments influences the success encountered in the reconstruction.

Investigations of the Effects of Preparatory Set and Word Frequency on Communication

The study of Miller, Heise, and Lichten, cited above, pointed out the influence of a knowledge of the alternatives in the preception of a message.[1] A knowledge of the possible alternatives appeared to create a preparatory _set_ or state of expectancy that assisted the preception of a message in difficult listening conditions. The effects of preparatory set have been shown more specifically by Siipola. Words were presented by means of a tachistoscope to two groups in which dissimilar sets had been established by instruction. It was found that they perceived a common list of stimulus items differently in accordance with the two preparatory sets.

> The operation of the sets produced effects of the following types: facilitation of correct perception of those stimulus words which filled the sets, distortion of irrelevant stimulus-words to form words related to the sets, and conversion of ambiguous items (not actual words) into words appropriate to the sets.[2]

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[1]Miller, Heise, and Lichten, _loc. cit_.

[2]E. M. Siipola, "A Group Study of Some Effects of Preparatory Set," _Psychological Monographs_, XLVI, no. 6 (1935), 38.

These findings suggest that where incomplete and possibly ambiguous signals are received in a communication situation--such as lipreading--that a preparatory set may help or hinder the correct identification of the message. In lipreading the possible sources of preparatory sets are multifarious. It would seem reasonable to suppose that even the perception of a fragment of the actual message itself might create an expectation or set that could assist or hinder the synthesis of the whole message by inference. Thus in an experimental task such as that used in the present investigation, it is possible that the preparatory set created by the knowledge of the stem of the stimulus word may facilitate or interfere with the correct identification of the initial consonant necessary to complete the word. This is the basic hypothesis of the present experiment.

One of the factors that is considered in this study as a possible source of preparatory set in the identification of initial English sounds, is word frequency. The inclusion of word frequency as a possible factor is justified by a number of studies showing its influence in the perception of language stimuli.

Howes studied the effect of word frequency on the intelligibility of words presented in a background of wide-spectrum noise. The words were presented to college students at signal-to-noise ratios of -12, -9, -6, +6, +9, +12, and +20 db. Thresholds of intelligibility were then obtained. It was shown that the threshold of intelligibility for the words presented was a decreasing function of the frequency with which the word occurs in general usage. The drop in threshold was shown to be about 4.5 db per logarithimic unit of word frequency.[1]

It was determined that for words of three to eleven letters, an average of 69 per cent of the intelligibility variance at each length could be attributed to the factor of word frequency.

Similar studies of the effect of frequency on auditory intelligibility have been conducted by Black, Rosensweig, and Owens with comparable results.[2,3,4]

Howes and Solomon examined the effect of word frequency on the visual identification of printed words.[5] They used the Thorndike-Lorge word counts as an index of the relative frequency with which a word is used in the English language and found that visual duration thresholds for tachistoscopically presented word stimuli "seem to approximate a linear, inverse function of the logarithm of frequency of usage."[6] The coefficients of correlation between the thresholds and relative frequency of occurrence of words were found to range from .60 to .90.

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[1]Howes, loc. cit.

[2]Black, "Accompaniments of Word Intelligibility," op. cit., pp. 409-417.

[3]Rosensweig, op. cit., p. 759.

[4]Elmer Owens, "Intelligibility of Words Varying in Familiarity," Journal of Speech and Hearing Research, IV (1961), 113-129.

[5]D. H. Howes and R. L. Solomon, "Visual Duration Threshold as a Function of Word Probability," Journal of Experimental Psychology, XLI (1951), 401-410.

[6]Ibid., p. 409.

A similar study using tachistoscopic exposure of words was made by McGinnies, Comer, and Lacy.[1] The findings of this study confirmed the findings of Howes and Solomon.

Riegel and Riegel studied the relationships of forty parameters to the recognition thresholds of fifty words that were presented tachistoscopically. The following were found to be the best predictors of the thresholds: "Classification of words into concrete nouns vs. all others; (b) Classification of words with vs. without prefices; (c) Logarithms of word-frequencies; (d) Number of letters."[2] These parameters were included in a multiple regression equation which resulted in a multiple correlation of .74. The correlation with the logarithms of word-frequencies was .50. These correlations were considered by the authors to be surprisingly low.

Because of the high correlation between the thresholds and the classification into nouns with concrete referents as opposed to abstract nouns, adjectives, and verbs, the authors concluded ". . . that recognition of words is to a greater degree dependent on the frequency with which subjects had prior experiences with objects (or perceptual images) rather than on the frequency with which subjects had perceived or used the names attached to them."[3] They also

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[1]E. McGinnies, P. B. Comer, and O. L. Lacy, "Visual Recoginition Thresholds as a Function of Word Length and Word Frequency," Journal of Experimental Psychology, XLIV (1952), 65-69.

[2]E. F. Riegel and R. M. Riegel, "Prediction of Word Recognition Threshold on the Basis of Stimulus Parameters," Language and Speech, IV (1961), 157.

[3]Ibid., p. 170.

indicated that higher correlations of threshold to word frequency might be obtained by using children's counts rather than adult word counts.

It has been pointed out by Riegel and Riegel and Howes that the word counts available for use as parameters may not be the best indicators of word familiarity and that if a more accurate index of word familiarity were used, its relationship to word recognition would be shown to be even stronger than has been demonstrated.[1,2] In an attempt to avoid dependence on word counts as a parameter, several investigations have been carried out in which subjects have been exposed to repetitions of nonsense words which have been arranged so that some occur more frequently than others.[3,4,5] In the study by King-Ellison and Jenkins, each subject was presented with a pack of 100 cards on which nonsense words were printed. In each pack two of the nonsense words appeared twenty-five times; two appeared ten times; two appeared five times; two appeared twice; two appeared once; and the remaining cards were dummy cards. Tachistoscopic recognition thresholds were then obtained for fifteen subjects.[6]

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[1] Ibid. [2] Howes, loc. cit.

[3] R. L. Solomon and Leo Postman, "Frequency of Usage as a Determinant of Recognition Thresholds for Words," Journal of Experimental Psychology, XLIII (1952), 195-201.

[4] Patricia King-Ellison and James J. Jenkins, "Durational Threshold of Visional Recognition as a Function of Word Frequency," American Journal of Psychology, LXVII (1954), 700-703.

[5] D. W. Forrest, "Auditory Familiarity as a Determinant of Visual Threshold," American Journal of Psychology, LXX (1957), 634-636.

[6] King-Ellison and Jenkins, loc. cit.

When the mean exposure-times for each frequency of presentation was compared to the logarithm of the frequency of presentation, a correlation of -.99 was obtained. These results and those of other investigations would seem to justify the conclusion so succinctly stated by Solomon and Postman that "Given a population of associations, the one which has been exercised most frequently will have the greatest probability of being elicited relative to other associations."[1]

The question arises as to whether it is the frequency of past exposure to the stimuli or the frequency of past usage that is the important factor operating in word recognition. An attempt to answer this question was made by Postman and Conger.[2] In this experiment, three-letter English words were used as stimuli. The words chosen were not only words in their own right, but were also to be found as trigram components of other words. Two separate frequency parameters were obtained for each such word--its frequency as a word and its frequency as a trigram. The former may be considered to represent the frequency of usage of the three-letter combination as a word and the latter the general frequency of exposure to the three-letter combination in any form.

Twenty-seven such words were presented by means of a tachistoscope and recognition thresholds were obtained. No significant correlation of threshold and trigram frequency was found, but a significant inverse relationship was shown between frequency of word usage and

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[1] Solomon and Postman, op. cit., p. 199.

[2] Leo Postman and Veverly Conger, "Verbal Habits and the Visual Recognition of Words," Science, CXIX (1954), 671-673.

recognition threshold. These results support the point of view that frequency of response to stimulus units, rather than mere frequency of visual exposure is the significant determinant of speed of recognition. Furthermore, on the basis of the results, the following explanation is presented by the authors:

> When a word is presented rapidly and with low illumination, only a part of the stimulus pattern is likely to be discriminated. On the basis of such incomplete cues, the subject may then attempt to reconstruct the stimulus word. The stimulus fragments that have been discriminated may form part of several different words. Which of these words will be elicited by a given stimulus fragment depends, we assume, on the relative frequencies with which the alternative verbal responses have been given in the past. If the stimulus is a high frequency word, a correct response in the presence of incomplete cues is highly probable.[1]

The effect of frequency of usage of stimuli on the recognition of the stimuli has been shown for both auditory and visual modalities separately, but none of the investigations thus far has examined the questions of whether the magnitude of the influence of frequency of usage are comparable for both modalities or whether a transfer effect exists across the two modalities. Experimental work dealing with these questions has been carried out by Postman and Rosenswieg.[2]

The experimental materials were three-leter nonsense syllables. They were matched for initial ease of discrimination as visual and auditory stimuli. Different syllables were then given different frequencies of exercise ranging from zero to fifteen repetitions. Half of the subjects were trained visually and the other half auditorily. Following the training the subjects were given tests of recognition

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[1] Ibid., p. 672.

[2] Leo Postman and M. R. Rosensweig, "Practice and Transfer in the Visual and Auditory Recognition of Verbal Stimuli," American Journal of Psychology, LVI (1958), 376-379.

of the syllables. Half of the group who received auditory training were tested with the auditory stimuli presented in varying degrees of masking noise, and half were tested with auditory training stimuli presented as printed words projected by means of a tachistoscope. Likewise, half of the visually trained group were tested using the visual modality with visual training material and half were tested using the auditory modality with the nonsense words encountered in the visual training. In each case mean recognition thresholds were determined for the subjects.

In all cases the recognition thresholds dropped with increasing frequency of exercise. It was also found that the greatest success in visual recognition resulted from visual training and that the greatest success in auditory recognition resulted from the auditory training. However, the effects of previous training on recognition was more pronounced in the case of the training with auditory stimuli. Furthermore, although it was found that training through one modality transferred to recognition through the other modality, the transfer effects resulting from the aduitory training were more pronounced than was the case for the visual training.

Also, when the percentages of incorrect responses that consisted of one, two, and three letters were examined, it was found that auditory stimulation resulted in more complete responses than visual stimulation. This was interpreted to mean that auditory perception is in syllable units but that visual perception is more analytical.

An additional interpretation derived from the data was that " . . . the more frequently a stimulus-item has been encountered or used in the past, the smaller is the fragment sufficient for identification of the total item, i.e., preliminary training reduces the number of alternative responses among which a subject will choose."[1]

A slightly different approach to the study of the effect of frequency of usage was demonstrated by Mayzner and Tresselt. They investigated the influence of word frequency and letter order on anagram solution time.[2] It was found that low word frequency and hard letter orders both produced marked increases in the time required to solve the anagrams. They suggest that ". . . if the solution to an anagram is a word having a high frequency of occurrence in the language, it will probably be relatively high in S's response repertoire, and therefore possess earlier implicit response than a word having a low frequency of occurrence."[3]

This reference to the influence of a response produced by word frequency introduces a controversy that has developed relative to the word frequency effect. The effect of frequency of word usage on word recognition would appear to be well supported by the studies cited above. However, there is some question as to the true nature of the frequency effect on the recognition of words. Does the frequency of a word affect the actual perception of the word or is the effect due to the observer's tendency to use more words of high word-frequency, thus producing a coincidental relationship with success of recognition?

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[1] Ibid., p. 223.

[2] N. S. Mayzner and M. E. Tresselt, "Anagram Solution Times: A Function of Letter Order and Word Frequency," Journal of Experimental Psychology, LVI (1958), 376-379.

[3] Ibid., p. 378.

Neisser carried out an experiment which was intended to show that the effect of previous exposure to stimuli was to promote seeing rather than saying the words presented.[1] Twelve subjects were given a list of ten words which they studied for one minute. Then five words from this list, five homonyms of items on the list, and five control words were presented by means of a tachistoscope at various durations of exposure. Recognition thresholds were obtained for the words. It was shown that the preliminary exposure to the words facilitated the recognition of the five actual words, but did not facilitate the recognition of their homonyms. These results were interpreted as an indication that the effect of previous exposure is to increase success of perceptual recognition rather than to facilitate the production of a response.

On the other hand, Goldiamond and Hawkins conducted an experiment which would tend to support the contention that the frequency effect is due to response bias rather than to perception of stimuli.[2] In their experiment 25 subjects were given training in which they repeated nonsense syllables at different frequencies. They were then told that these words would be flashed on a screen subliminally and they were to try to guess the word until they were successful. However, actually no words were presented to the subjects. An ascending method of limits was mimicked until success was attained. Success was defined as

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[1]Ulric Neisser, "An Experimental Distinction Between Perceptual Process and Verbal Response," Journal of Experimental Psychology, XLVII (1954), 339-402.

[2]Israel Goldiamond and William F. Hawkins, "Verxierverauch: The Log Relationship between Word-Frequency and Recognition Obtained in the Absence of Stimulus Words," Journal of Experimental Psychology, LVI (1958), 457-463.

responding with the word on the experimenter's score sheet. It was found that the words practiced more frequently were successfully guessed with greater frequency and that success was attained earlier for the frequently exercised words. The relationship was shown to be similar to the relationship found in previous recognition studies. These results were interpreted as challenging a perceptual interpretation of the word-frequency affect.

Brown and Rubenstein examined the response bias explanation of the frequency effect by creating an experimental design and constructing statistical formulas that ostensibly controlled response bias in a situation where subjects identified monosyllabic words presented in various degrees of masking noise.[1] It was found that controlling response bias eliminated the word-frequency effect for the most part but did not account for the entire effect of word frequency. The interpretation of this data given by the authors was that although the response-bias effect appeared to be a prominent factor, the acoustical properties of the words also contributed information.

This latter study suggests the possibility of an interaction of response bias and perception. It would seem likely that in a case where no perceptual clues are available, as in the Goldiamond and Hawkins study, that the frequency effect may be explained entirely by response bias, but that where fragments of stimuli are available, these may promote accuracy of recognition by confirming or contradicting the

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[1] Charles R. Brown and Herbert Rubenstein, "Test of Response Bias Explanation of Word Frequency Effect," Science, CXXXIII (1961), 280-281.

responses bias, or by contributing additional information because of the transitional redundancy of the elements of the stimulus fragment.

Summary

The material reviewed in this chapter tends to illustrate the numerous factors that may be involved in the perception of the code in lipreading. The studies cited have directly or indirectly suggested that visibility of language characters, the visual discriminability of fundamental speech units, the length and sequential arrangement of language units, the semantic qualities of the units, and the statistical structure of language may all have possible influences on the accuracy of communication by lipreading.

In an effort to understand and improve communication by lipreading it would seem appropriate to investigate some of these influences--especially those which have received little attention in previous investigations. Such is the purpose of this study.

CHAPTER III

SUBJECTS, EQUIPMENT, AND PROCEDURES

Subjects

The experimental population used in this study consisted of eighty college students divided into four groups of twenty each. The four groups were taken from four sections of a course in voice and articulation. The total of eighty subjects was made up of thirty-five males and forty-five females. The ages of the subjects ranged from eighteen to forty-six. The mean age was 19.9 and the median 19.0.

No criteria for selection of subjects was used. Thus, the experimental population may have included subjects with less than perfect auditory and visual acuity. One might reasonably expect such deficiencies of visual and auditory acuity to affect the responses of the subjects having such deficiencies, but if one is concerned (as in the case in this study) with results from a sample of a "normal" population of college students, one can accept visual or auditory responses as being a "normal" component of "normal-population" responses and not at all spurious. Furthermore, since this study is concerned more with reactions associated with verbal habits rather than factors relating to sensory acuity, the effect of the deficiencies of auditory or visual acuity may be considered to be even less significant.

Equipment

Movie camera.--An 8mm movie camera (Bolex Model H8, Serial Number 145052) was used for filming. The camera was equipped with a 36mm telephoto lens (Yvar, Serial Number 572258).

Film.--Kodachrome II film was used throughout the photographing.

Tape Recorder.--A tape recorder (Wollensak Model T 1500, Serial Number 161391) was used for the recording and playback of the stems of the stimulus words. For playback the tape recorder was coupled to an auxiliary loudspeaker (Ampex Model 620, Serial Number 11861).

Projector.--An 8mm movie projector (Bell and Howell Model 265A, Serial Number AR 54033) was used to project the image of the speaker.

Screen.--The image of the speaker was projected onto a screen (Radiant Imperial Champion) which was 40 x 40 inches square.

Procedures

Stimulus Material

The stimulus words used in this study consisted of monosyllablic words resulting from the union of a number of different stems with each of a selected number of consonants. The objective of the derivation of these monosyllabic words was to obtain stimuli to test the hypothesis that the linguistic nature of the word formed by uniting a given initial consonant with a given -VC stem influenced the identification of the initial consonant. (See statement of hypotheses.) Because of the necessity of limiting the total number of words to a practical quantity this investigation deals only with the following consonants: [f, k, p, r, ʃ, t, θ]. These sounds represent each of the seven categories of consonants that Woodward and Barber found to be visually contrastive;[1] they, therefore, presumably constitute a good cross section of consonant classes.

The actual stimulus words formed by uniting these consonants with a stem were chosen according to the following criteria:

1. This study was limited to a consideration of monosyllabic words.
2. In order to control the sound environment of the initial consonants used, the stems united with each consonant to form stimulus words were limited to those having the same vowel with respect to each consonant class. For each consonant class a vowel environment was chosen which would provide the greatest number of stimulus words possible while at the same time avoiding duplication of stems among different consonant classes. In order to avoid duplication of stems it was necessary to choose a different vowel for each consonant class. In some cases, the desire to avoid duplication prevented the use of a maximum number of stimulus words in a class. For example, combining [I] with [r] produces more [r] stimulus words than any other vowel that might be combined with this particular consonant. The most stimulus words for the consonant [f] can also be obtained by the use of the [I], but if [I] were used again, duplicate stems would result. The next greatest number

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[1]Woodward and Barber, _op. cit_., p. 59.

of stimulus words for [f] would result from a union with [ɔ]; however, [ɔ] is needed to produce a more adequate stimulus sample for [θ] ; therefore, [e] was finally chosen as the environment for [f] since it allows the greatest number of stimulus words without duplication of stems.[1]

3. Only words listed among Thorndike's 30,000 Words[2] were included as stimulus words.
4. Only the basic form of a word was used as a stimulus word. All semantic variations of the basic form of a word, such as past participle and plural forms, were eliminated.

Seventy-six monosyllabic stimulus words were derived which met the criteria listed above. The seventy-six words were distributed as follows among the seven initial consonants used in this study: [f], 11; [k], 12; [p], 12; [r], 16; [ʃ], 9; [t], 11; [θ], 5. The vowels united with these sounds to form monosyllables were [e], [ɑ], [ʌ], [ɪ], [i], and [ɔ], respectively.

Four stimulus lists were made using the seventy-six monosyllabic words described above. Each of the four lists consisted of the same monosyllabic words arranged in a different random order. Randomization of each list was accomplished by means of a table of random numbers.

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[1]The information described here was obtained from the tabulations of Henry Moser, John J. Dreher, and Herbert J. Oyer, One-Syllable Words, Cooperative Research Project No. 664 (Columbus, Ohio: The Ohio State University Research Foundation, 1957).

[2]Thorndike and Lorge, op. cit.

Speakers

Each of four speakers was filmed uttering a different randomized order of the stimulus words. The speakers consisted of two males and two females. All of the speakers were graduate students in Speech and Hearing Science at Michigan State University. Three of the speakers were of General American Dialect and one female speaker spoke with a Southern Dialect.

Filming Specifications

The photographing was done from a distance of twenty feet using a film speed of sixteen frames per second with an aperature of f:1.8. The view of the speaker photographed included the speaker's head and shoulders.

The speakers were photographed speaking each word beginning from closed-mouth position. There was an interval of five seconds between the uttering of each word. Timing of each utterance was accomplished by means of a metronome set for one beat per second. The stimulus words were read from transparencies projected by means of an overhead projector onto a screen in front of the speakers.

Presentation of Stimulus Material to the Subjects

Physical Arrangement

For viewing the filmed stimulus words, the subjects were seated in four rows of six chair each. The rows of chairs were arranged so that the backs of the chairs were located 7, 10, 13, and 16 feet from the wall on which the projection screen was hung. The chairs were 9 inches apart from seat to seat.

The projection screen was centered relative to the room and the chairs in which the subjects were seated. The screen was at a height such that the lips of the speakers were seen at a height of approximately 5 feet, 6 inches.

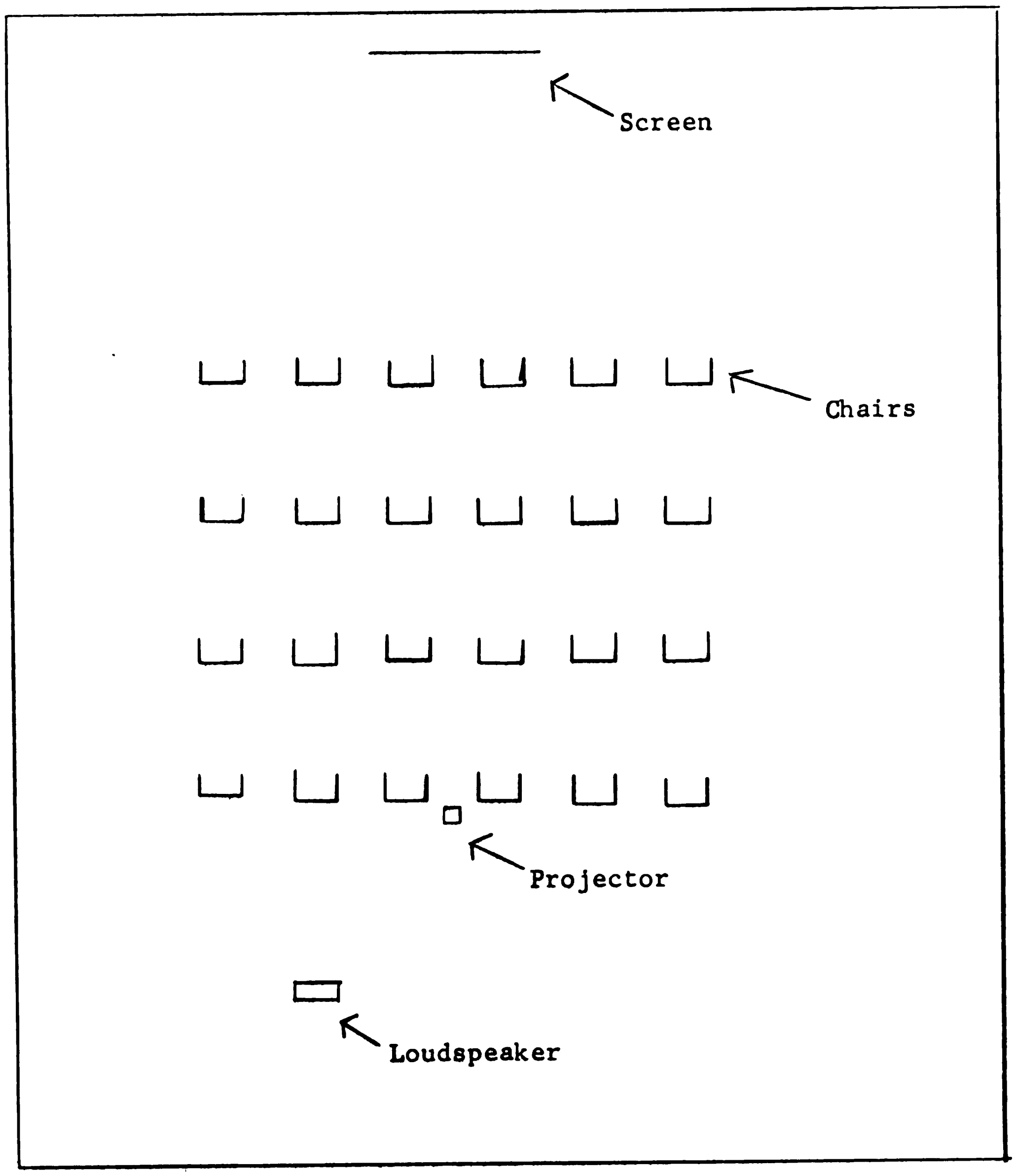
With the projector located 16 feet, 4 inches from the screen, the image of each speaker was approximately life size.

The stem components of the stimulus words were played from a tape recorder and auxiliary loudspeaker located four feet to the rear of the last row of seats. A diagram of the viewing arrangement is shown in Figure 1.

Presentation of Stimuli

The experimental procedure for this study involved showing four silent films of each of four speakers uttering seventy-six monosyllabic words. Before the showing of each word to be lipread, the stem of the word with the consonant omitted was heard by the subject. Also the possible printed forms of each stem were included on each subject's answer sheet, and the subjects were asked to preview the printed forms of the stems before viewing the speaker saying the entire word--consonant plus stem. Therefore, the stem of each word was always known.

Each filmed speaker spoke the same words in a different random order. Four groups (twenty subjects each) viewed all four speakers, but the speakers were shown to each group in a different order: Group I viewed speakers one and two in the first session and speakers three and four in the second session. Group II saw speakers two and



Scale ¼" = 1'0"

Fig. 1.--Physical Arrangement for Viewing

three in the first session and speakers four and one in the second session. Group III saw speakers three and four in the first session and speakers one and two in the second session. Group IV saw speakers four and one in the first session and speakers two and three in the second session.

The order of the viewing of the speakers was counter-balanced in this manner so that the differences of identification due to the speakers might be examined with variance due to the order of the speakers controlled.

At the beginning of the first viewing session each subject was provided with an instruction sheet and two response forms, one for each speaker seen during that session. The following instructions were read aloud to the subjects by the experimenter while the subjects read the instructions silently from their own instruction sheets:

> You are going to view a speaker on film saying a number of single-syllable words consisting of a consonant or blend of consonants, a vowel, and then a consonant. Examples of the words you might see are LIGHT, VASE, JEEP, etc. Before you see each word you will hear a tape recording of the word with the beginning sound omitted, and you will also see on your answer sheet a listing of possible printed forms which the word-stem you are to hear might take. For each word you are asked to listen to the stem on the tape recording and note the printed stems appropriate to the item number on your answer sheet. You will then view the entire word spoken by the filmed speaker and are asked to identify the word from what you have heard and seen. Next add the beginning sound to the appropriate printed stem on the answer sheet to form the word you have identified. <u>Always</u> <u>make</u> <u>a</u> <u>response</u>. If you are not certain what the word is, <u>guess</u>, no matter how far-fetched the guess may seem to you.
>
> Note the item on your answer sheet labeled EXAMPLE. Suppose the word <u>jeep</u> were to be shown; you would first hear the stem, __eep, then you would glance at your answer sheet and note the possible printed forms as illustrated by the example on your answer sheet. Next you would view the filmed speaker saying

the word jeep; and finally you would write the letter j before the stem _eep on your answer sheet. Do this now.

After each word is shown, the projector will be stopped so that you may write your response. Remember, always make a response. Guess if you must. Are there any questions?

You will now view a speaker saying five words similar to those you will see during this project. It is not necessary that you write these practice words; merely watch and try to identify them.

EXAMPLE

__eap

__eep

__epe

__iep

The experimenter then presented five practice words, first giving the stem aloud and then saying the entire practice word silently.

The stimulus material was presented to the subjects according to the following pattern: (1) The number and stem of the appropriate stimulus word was heard from the tape recorder when the tape was set in motion by a foot-pedal control; (2) the subjects previewed the printed stem forms; (3) the projector was started and the filmed speaker uttered the appropriate word; (4) the projector was stopped and approximately five seconds were allowed for the subjects to record their responses. This pattern was repeated for each word.

The same procedure was followed for the second viewing session except that the instructions were not repeated. Each group was merely told that they would hear and see other stimuli of the same nature as those seen previously. No information was given as to whether they were different words or the same words.

Derivation of Parameter Values[1]

Frequency of Stimulus Words

In this study the index of the frequency of each stimulus word was its frequency of occurrence in the Lorge magazine count.[2] The magazine count is used rather than the more general counts of Thorndike because frequency of occurrence of the words is always numerically indicated in the magazine count; whereas in the general count, highly frequent words are indicated only by "M"; consequently, if these counts were used, no precise quantitative differentiation among frequent words could be made.

When homonyms occurred, the frequencies of occurrence of the homonyms were added together and the total used as the frequency index of the stimulus word.

The actual frequencies were transformed to common logarithms, since previous studies have shown that the relationship of word frequency to perception is best shown when such a transformation is carried out.[3,4,5]

Number of Possible Alternative Rhyme Words

The number of rhyming words that can be derived from each stimulus stem was determined from an actual count using Moser's

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[1]These values are shown in Appendix A.

[2]Thorndike and Lorge, op. cit.

[3]Howes and Solomon, op. cit., pp. 401-410.

[4]King-Ellison and Jenkins, op. cit., pp. 700-703.

[5]Riegel and Riegel, op. cit., pp. 157-170.

tabulation of monosyllablic words by sound ending.[1] Only those words listed in Thorndike's general count were counted as alternatives.[2]

The Relative Frequency of the Alternative Rhyme Words

The relative frequency of the alternative rhyme words was obtained by calculating the ratio of the mean frequency of the five alternative rhyme words having the highest frequency count, to the frequency of the appropriate stimulus word. Only the five alternative words of highest frequency were used, because it was observed from the results of the study that the majority of the confusions of each stimulus word were distributed among five alternative words or less. Therefore, if frequency of the rhyming alternatives is a factor that influences the occurrence of the confusions of the stimulus word, and the confusions are limited to five words or less, then it is logical to expect that the alternative rhyming words most prominently affecting the identification of the initial consonsants are the alternatives of highest frequency, and are limited to five or less. Consequently, the best index of this influence was considered to be one which was limited to the five most frequent rhyming alternatives. In cases where five alternatives did not exist, the mean of the number that did exist was employed.

As in the case of the frequency of the stimulus words, the mean frequencies of the occurrence of the alternative rhyme words were transformed to common logarithms.

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[1] Henry M. Moser, One-Syllable Words--Revised and Arranged by Ending Sounds, RF Project 882, Technical Report 52 (Columbus, Ohio: The Ohio State University Research Foundation, 1960).

[2] Thorndike and Lorge, op. cit.

CHAPTER IV

ANALYSIS AND DISCUSSION

From the responses of the subjects to the stimulus words, error scores in the identification of the initial consonant of each stimulus word were determined. Each error score was made up of the number of errors of identification made by eighty subjects in their responses to each stimulus word spoken by four speakers. Hence, each error score was obtained from a total of 320 responses to each stimulus word. The error scores for each stimulus word, according to consonant category, are presented in the tables of Appendix A. Other parameter values, whose relationships to the error scores are examined in this study, are also presented in Appendix A.

The data tabulated were used to test the hypotheses formulated in this investigation.

Analysis and Discussion: Basic Hypothesis

The basic hypothesis was stated as follows:

> If the stem of a monosyllabic word is known and the initial consonant is unknown, the correct or incorrect identification of the initial consonant by lipreading is influenced by the linguistic characteristics of the known stem.

If the basic hypothesis is true then significant differences among the error scores of the words in each consonant category should exist and may be attributed to the influence of the stems, since other factors that might influence the identification of the initial consonants were controlled. Tests of the significance of the differences among the error scores for the words within each consonant category were carried out using an analysis of variance technique. Lindquist's "Type VI" analysis of variance design was used as the statistical model.[1] This design is a three-dimensional model that permits the examination of the significance of the differences of error scores due to different speakers and differences of error scores due to the order-group effect[2] in addition to an examination of the significance of the differences of error scores among the same initial consonants united with different stems.

This design also provides for the special case in which two of the main effects are replicated for all subjects, but a third effect is not replicated for all subjects. That this was the situation in the present study will be recognized when it is recalled that all subjects viewed all of the words spoken by all of the speakers, but that all of the subjects did not view all of the speakers in all of the four different orders of presentation. Thus the order effect was not replicated.

The results of the analysis of variance for each separate consonsant category are presented in Tables 3 through 9. These results show that for all consonant categories the differences among the error

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[1]E. F. Lindquist, Design and Analysis of Experiments in Psychology and Education (Boston: Houghton Mifflin Company, 1956), pp. 292-297.

[2]The effects of using four different groups and the effects of different orders of viewing the speakers cannot be separated since each different group viewed a different order of speakers; consequently these effects are treated as the single order-group source of variance.

TABLE 3

SUMMARY OF THE ANALYSIS OF VARIANCE OF DIFFERENCES IN ERRORS OF IDENTIFICATION OF THE INITIAL CONSONANT [f] UNITED WITH DIFFERENT STEMS

Source	df	ss	ms	F	$F_{.05}$	$F_{.01}$
Stem (St)	10	2.564	0.256	5.12	1.85	2.37
Speaker (Sp)	3	0.040	.013	0.34	2.65	3.88
Order-Group (O)	3	0.433	.144	1.36	2.74	4.08
St x Sp	30	1.460	.049	1.63	1.46	1.69
St x O	30	2.117	.071	1.42	1.49	1.74
Sp x O	9	0.335	.037	0.97	1.92	2.50
St x Sp x O	90	2.840	.032	1.07	1.28	1.41
Error (b)	76	8.066	.106			
$Error_1$ (w)	760	37.909	.050			
$Error_2$ (w)	228	8.625	.038			
$Error_3$ (w)	2280	68.200	.030			
Total	3519	132.589				

NOTE: Tests of significance were made as follows: St and St x O against $error_1$ (w), Sp and Sp x O against $error_2$ (w), St x Sp and St x Sp x O against $error_3$ (w), and O against error (b .

TABLE 4

SUMMARY OF THE ANALYSIS OF VARIANCE OF DIFFERENCES IN ERRORS OF IDENTIFICATION OF THE INITIAL CONSONANT [k] UNITED WITH DIFFERENT STEMS

Source	df	ss	ms	F	$F_{.05}$	$F_{.01}$
Stem (St)	11	147.237	13.385	53.76	1.80	1.76
Speaker (Sp)	3	27.030	9.010	37.36	2.65	3.88
Order-Group (O)	3	1.847	0.615	0.41	2.74	4.08
St x Sp	33	21.617	0.656	4.86	1.46	1.69
St x O	33	9.100	0.276	1.11	1.47	1.71
Sp x O	9	12.946	1.438	5.97	1.92	2.50
St x Sp x O	99	20.695	0.209	1.55	1.24	1.36
Error (b)	76	113.267	1.490			
$Error_1$ (w)	836	208.020	0.249			
$Error_2$ (w)	228	54.878	0.241			
$Error_3$ (w)	2508	337.584	0.135			
Total	3839	954.227				

NOTE: Tests of significance were made as follows: St and St x O against $error_1$ (w), Sp and Sp x O against $error_2$ (w), St x Sp and St x Sp x O against $error_3$ (w), and O against error (b).

TABLE 5

SUMMARY OF THE ANALYSIS OF VARIANCE OF DIFFERENCES IN ERRORS OF IDENTIFICATION OF THE INITIAL CONSONANT [p] UNITED WITH DIFFERENT STEMS

Source	df	ss	ms	F	$F_{.05}$	$F_{.01}$
Stem (St)	11	182.128	16.557	63.68	1.80	1.76
Speaker (Sp)	3	7.465	2.488	17.65	2.65	3.88
Order-Group (O)	3	14.409	4.803	3.54	2.74	4.08
St x Sp	33	10.519	0.319	2.90	1.46	1.69
St x O	33	15.725	0.477	1.83	1.47	1.71
Sp x O	9	8.079	0.898	6.37	1.92	2.50
St x Sp x O	99	16.374	0.165	1.50	1.24	1.36
Error (b)	76	102.886	1.354			
$Error_1$ (w)	836	217.251	0.260			
$Error_2$ (w)	228	32.227	0.141			
$Error_3$ (w)	2508	275.586	0.110			
Total	3839	882.650				

NOTE: Tests of significance were made as follows: St and St x O against $error_1$ (w), Sp and Sp x O against $error_2$ (w), St x Sp and St x Sp x O against $error_3$ (w), and O against error (b).

TABLE 6

SUMMARY OF THE ANALYSIS OF VARIANCE OF DIFFERENCES IN ERRORS OF IDENTIFICATION OF THE INITIAL CONSONANT [r] UNITED WITH DIFFERENT STEMS

Source	df	ss	ms	F	$F_{.05}$	$F_{.01}$
Stem (St)	15	141.525	9.434	48.13	1.70	2.09
Speaker (Sp)	3	68.877	22.959	65.22	2.65	3.88
Order-Group (O)	3	1.952	0.650	0.22	2.74	4.08
St x Sp	45	29.045	0.645	5.20	1.40	1.59
St x O	45	7.920	0.176	0.90	1.41	1.61
Sp x O	9	10.527	1.170	3.32	1.92	2.50
St x Sp x O	135	23.564	0.175	1.41	1.24	1.36
Error (b)	76	230.048	3.027			
$Error_1$ (w)	1140	223.164	0.196			
$Error_2$ (w)	228	80.143	0.352			
$Error_3$ (w)	3420	425.593	0.124			
Total	5119	1242.358				

NOTE: Tests of significance were made as follows: St and St x O against $error_1$ (w), Sp and Sp x O against $error_2$ (w), St x Sp and St x Sp x O against $error_3$ (w), and O against error (b).

TABLE 7

SUMMARY OF THE ANALYSIS OF VARIANCE OF DIFFERENCES IN ERRORS OF IDENTIFICATION OF THE INITIAL CONSONANT [ʃ] UNITED WITH DIFFERENT STEMS

Source	df	ss	ms	F	$F_{.05}$	$F_{.01}$
Stem (St)	8	81.599	10.200	44.54	1.96	2.55
Speaker (Sp)	3	3.174	1.057	7.83	2.65	3.88
Order-Group (O)	3	7.663	2.554	1.66	2.74	4.08
St x Sp	24	2.976	0.124	1.51	1.52	1.79
St x O	24	11.938	0.497	2.17	1.54	1.84
Sp x O	9	5.240	0.582	4.31	1.92	2.50
St x Sp x O	72	8.310	0.115	1.40	1.28	1.41
Error (b)	76	116.602	1.534			
$Error_1$ (w)	608	139.298	0.229			
$Error_2$ (w)	228	30.808	0.135			
$Error_3$ (w)	1824	148.992	0.082			
Total	2879	556.600				

NOTE: Tests of significance were made as follows: St and St x O against $error_1$ (w), Sp and Sp x O against $error_2$ (w), St x Sp and St x Sp x O against $error_3$ (w), and O against error (b).

TABLE 8

SUMMARY OF THE ANALYSIS OF VARIANCE OF DIFFERENCES IN ERRORS OF IDENTIFICATION OF THE INITIAL CONSONANT [t] UNITED WITH DIFFERENT STEMS

Source	df	ss	ms	F	$F_{.05}$	$F_{.01}$
Stem (St)	10	63.747	6.375	23.44	1.85	2.37
Speaker (Sp)	3	8.630	2.877	12.45	2.65	3.88
Order-Group (O)	3	13.924	4.641	4.84	2.74	4.08
St x Sp	30	13.960	0.465	3.27	1.46	1.69
St x O	30	11.867	0.396	1.46	1.49	1.74
Sp x O	9	22.982	2.554	11.06	1.92	2.50
St x Sp x O	90	16.290	0.181	1.27	1.23	1.41
Error (b)	76	72.876	0.959			
$Error_1$ (w)	760	206.386	0.272			
$Error_2$ (w)	228	52.591	0.231			
$Error_3$ (w)	2280	324.296	0.142			
Total	3519	807.550				

NOTE: Tests of significance were made as follows: St and St x O against $error_1$ (w), Sp and Sp x O against $error_2$ (w), St x Sp and St x Sp x O against $error_3$ (w), and O against error (b).

TABLE 9

SUMMARY OF THE ANALYSIS OF VARIANCE OF DIFFERENCES IN ERRORS OF IDENTIFICATION OF THE INITIAL CONSONANT [ə] UNITED WITH DIFFERENT STEMS

Source	df	ss	ms	F	$F_{.05}$	$F_{.01}$
Stem (St)	4	5.584	1.396	19.66	2.41	3.41
Speaker (Sp)	3	0.527	0.176	2.38	2.65	3.88
Order-Group (O)	3	0.942	0.314	0.61	2.74	4.08
St x Sp	12	5.951	0.421	7.14	1.76	2.20
St x O	12	1.261	0.105	1.48	1.80	2.28
Sp x O	9	1.666	0.185	2.50	1.92	2.50
St x Sp x O	36	6.244	0.173	2.93	1.47	1.71
Error (b)	76	39.234	0.516			
$Error_1$ (w)	304	21.455	0.071			
$Error_2$ (w)	228	16.759	0.074			
$Error_3$ (w)	912	54.005	0.059			
Total	1599	152.728				

NOTE: Tests of significance were made as follows: St and St x O against $error_1$ (w), Sp and Sp x O against $error_2$ (w), St x Sp and St x Sp x O against $error_3$ (w), and O against error (b).

scores for the same initial consonants united with different stems are significant beyond the .01 level.

The total errors associated with each of the four speakers were significantly different beyond the .01 level in five cases, but were non-significant at the .05 level for the [f] and [θ] categories. The order-group effect was found to be significant beyond the .05 level only in the cases of the [p] and [t] categories.

Significant interaction effects were also shown by the analyses. Stem-speaker interaction, significant beyond the .01 level, was found for all consonant categories except the [ʃ] category; the stem-order interaction was significant beyond the .01 level in the case of the [p] and [ʃ] categories; speaker-order interaction was significant beyond the .01 level in all cases except the [f] category; and the stem-speaker-order interaction was significant in four cases beyond the .01 level, significant beyond the .05 level in the case of the [ʃ] category, and nearly significant at the .05 level in the case of the [t] category.

Although other effects were examined by the analyses of variance utilized in this part of the present investigation, of primary concern is the stem effect, which indicates support or lack of support for the basic hypothesis. As was pointed out, the differences in recognition among words due to the stem effects were significant beyond the .01 level in all cases. However, these findings are complicated by the existence of significant interaction of the stem effect with other main effects.

The most prominent interaction is that of the stems with the speakers. This means that although the stems of the words within a consonant category do influence the accuracy of identification of the same initial consonant, the magnitude of the influence is not the same for all speakers; i.e., the influence of the stem is, to a degree, dependent on the speaker.

The stem-order interaction was shown to be significant in only two cases, and hence cannot be considered as a prominent complicating factor; however, the stem-speaker-order interaction was significant in six cases and nearly so in another. This suggests a three-way interdependence of effects which further confounds any conclusions that one might wish to make regarding the stem effect.

Nevertheless, the magnitude of the F-ratios calculated for the stem effects is important. In every case they are extremely high in relation to the F-value necessary for significance. Consequently, it is thought likely that although the magnitude of differences due to the stem effect may vary significantly in relation to other effects, the influence of the stem effect is so prominent that it may be considered to be significant in spite of its dependence on other effects. For example the stem influence may be at a maximum for speaker number one and at a minimum for speaker number four, but it is likely that even the influence of the stem effect at its minimum is sufficient to cause significant differences in the accuracy of identification of the same initial consonant united with different stems.

Therefore, because of the magnitude of the F-ratios shown for the stem effects the acceptance of the basic hypothesis seems justified.

The acceptance of this hypothesis suggests the generalization that in considering the lipreadability of English sounds, the influence of the expectancy created by perceived fragments of the accompanying sounds must be considered in addition to the visibility of a particular sound. This would seem to have important implications for the selection of materials for lipreading research and teaching.

It is interesting to note that the stems were shown to influence the accuracy of perception of highly visible sounds such as [f] and [p] as well as such visually obscure sounds as [k] and [t] . This indicates that the influence of probability and expectancy is a strong one and can affect even that which is clearly perceived.

In addition to considering the quantitative aspects of the error scores, it is of interest to consider the nature of the errors made by the subjects in attempting to identify the initial consonants of the stimulus words. The detailed picture of the confusions in identification that occurred are presented in the tables of Appendix B. Certain tendencies will be noted that may be of significance. A wide range of differences in the percentage of correct responses among the consonant categories will be noted. The percentage of correct identifications extended from 96 per cent for the [f] category to 26 per cent for the [ʃ] category.

This wide range of differences of percentages of correct responses among categories is not surprising since differences in the visibility of the consonants can be expected to play a part. However, in certain specific cases the percentages of correct responses were not in line with what one would expect. The extremely low percentage of correct responses (26 per cent) in the case of the [ʃ] category seems ususual, since this sound is usually shown to be moderately visible. And the relatively high percentage of correct responses (65 per cent) in the case of the [t] category also seems a bit unusual since this sound is usually ranked low in relation to visibility.[1,2]

That factors other than visibility may have been operating to determine percentages of correct responses is given additional support by the fact that correlations of percentages of correct responses for the seven consonants used in this study with the visibility ratings determined by O'Neill[3] and by Woodward and Barber[4] were only .26 and .63 respectively. This inconsistency is perhaps accounted for by the nature of the stimulus words used in this study and the influence of knowing the stems of the stimulus words.

The types of the confusion in identification within each category also seems to be meaningful. The most frequently confused sounds for each of the consonant categories were as follows: [v] for [f] ; [t, h, l] for [k] ; [b, m] for [p]; [w, dr, tr] for [r]; [tʃ , dʒ] for [ʃ]; [d, s] for [t]; and [t] (only .035 per cent) for [θ] . It will be noted that in all cases, except for the case of the [θ], the confusions accounting for the greatest number of errors involve sounds that are similar in visual configuration to the sounds used in the stimulus words. This suggests the influence on the error score of the

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[1] O'Neill, op. cit., p. 433.

[2] Woodward and Barber, op. cit., p. 45. [3] O'Neill, loc. cit.

[4] Woodward and Barber, loc. cit.

confusability relationship of various English consonants. This factor is discussed later in this chapter.

Analysis and Discussion: Corollary Hypotheses

The corollary hypotheses were stated as follows:

> Hypothesis A. Errors in identification of initial consonants of monosyllables occur in inverse proportion to the frequency of occurrence of the word formed by the union of an initial consonant and a given stem.
>
> Hypothesis B. The frequency of errors in the identification of an initial consonant united with different stems differs in proportion to the number of alternative rhyming words that may be formed from a given stem.
>
> Hypothesis C. The frequency of errors in the identification of an initial consonant united with different stems varies proportionately with the relative frequency of occurrence of the alternative rhyming words that may be derived from a given stem.

In order to examine the validity of these hypotheses, simple and multiple coefficients of correlation were obtained. In each case the criterion variable involved in the correlation consisted of the error scores of the stimulus words. The three experimental variables consisted of (1) the number of alternative rhyme words corresponding to each stimulus word, (2) the log frequency of each stimulus word, and (3) the log of the ratio of the mean frequency of the five most frequent alternative rhyme words to the frequency of each stimulus word.

Correlations were determined for each consonant category. The results of the correlation analysis are presented in Tables 10 through 16.

Corollary Hypothesis A

In the case of corollary hypothesis A, the relationship of the frequency of the alternative words to the number of errors of identification of the initial consonant in each consonant category was examined.

TABLE 10

SUMMARY OF THE CORRELATION ANALYSIS FOR THE STIMULUS WORDS WITH [f] AS THE INITIAL CONSONANT

Variables		Product-Moment Correlations: Number of Rhyming Alternatives	Product-Moment Correlations: Frequency of Stimulus Words	Product-Moment Correlations: Ratio of Frequency of Alternatives to Frequency of Stimulus word	Multiple Correlation
Error Score		.55	-.20	.22	.57
Number of Rhyming Alternatives			-.49	.58	
Frequency of Stimulus Word				-.87	
Tests of Significance of Correlations Involving Error Scores	Degrees of Freedom	1/9	1/9	1/9	3/7
	F-ratio	4.00	0.38	0.46	1.13
	F-value .05 Level	5.12	5.12	5.12	4.35

TABLE 11

SUMMARY OF THE CORRELATION ANALYSIS FOR THE STIMULUS WORDS WITH [k] AS THE INITIAL CONSONANT

Variables		Product-Moment Correlations: Number of Rhyming Alternatives	Product-Moment Correlations: Frequency of Stimulus Words	Product-Moment Correlations: Ratio of Frequency of Alternatives to Frequency of Stimulus Word	Multiple Correlation
Error Score		.42	-.38	.18	.67
Number of Rhyming Alternatives			-.08	.43	
Frequency of Stimulus Word				-.71	
Tests of Significance of Correlations Involving Error Scores	Degrees of Freedom	1 / 10	1 / 10	1 / 10	3 / 8
	F-ratio	2.14	1.69	0.34	2.14
	F-value .05 level	4.96	4.96	4.96	4.07

TABLE 12

SUMMARY OF THE CORRELATION ANALYSIS FOR THE STIMULUS WORDS WITH [p] AS THE INITIAL CONSONANT

Varibles		Product-Moment Correlations: Number of Rhyming Alternatives	Product-Moment Correlations: Frequency of Stimulus Words	Product-Moment Correlations: Ratio of Frequency of Alternatives to Frequency of Stimulus Word	Multiple Correlation
Error Score		.57	-.33	.40	.57
Number of Rhyming Alternatives			-.57	.73	
Frequency of Stimulus Word				-.75	
Tests of Significance of Correlations Involving Error Scores	Degrees of Freedom	1 / 10	1 / 10	1 / 10	3 / 8
	F-ratio	4.81	1.24	1.88	1.31
	F-value .05 Level	4.75	4.75	4.75	4.07

TABLE 13

SUMMARY OF THE CORRELATION ANALYSIS FOR THE STIMULUS WORDS WITH [r] AS THE INITIAL CONSONANT

Variables		Product-Moment Correlations: Number of Rhyming Alternatives	Product-Moment Correlations: Frequency of Stimulus Words	Product-Moment Correlations: Ratio of Frequency of Alternatives to Frequency of Stimulus Word	Multiple Correlation
Error Score		.59	-.42	.62	.69
Number of Rhyming Alternatives			-.22	.55	
Frequency of Stimulus Word				-.65	
Tests of Significance of Correlations Involving Error Scores	Degrees of Freedom	1/14	1/14	1/14	3/12
	F-ratio	7.72	3.01	8.96	3.81
	F-value .05 Level	4.60	4.60	4.60	3.49

TABLE 14

SUMMARY OF THE CORRELATION ANALYSIS FOR THE STIMULUS WORDS WITH [ʃ] AS THE INITIAL CONSONANT

Variables		Product-Moment Correlations			Multiple Correlation
		Number of Rhyming Alternatives	Frequency of Stimulus Words	Ratio of Frequency of Alternatives to Frequency of Stimulus Word	
Error Score		-.03	-.02	.13	.44
Number of Rhyming Alternatives			.65	-.54	
Frequency of Stimulus Word				-.96	
Tests of Significance of Correlations Involving Error Scores	Degrees of Freedom	1/7	1/7	1/7	3/5
	F-ratio	0.006	0.003	0.12	0.42
	F-value .05 Level	5.59	5.59	5.59	5.41

TABLE 15

SUMMARY OF THE CORRELATION ANALYSIS FOR THE STIMULUS WORDS WITH [t] AS THE INITIAL CONSONANT

Variables		Product-Moment Correlations: Number of Rhyming Alternatives	Product-Moment Correlations: Frequency of Stimulus Words	Product-Moment Correlations: Ratio of Frequency of Alternatives to Frequency of Stimulus Word	Multiple Correlation
Error Score		.72	.04	.68	.87
Number of Rhyming Alternatives			.55	.42	
Frequency of Stimulus Word				-.18	
Tests of Significance of Correlations Involving Error Scores	Degrees of Freedom	1/9	1/9	1/9	3/7
	F-ratio	9.92	0.01	7.78	8.25
	F-value .05 Level	5.12	5.12	5.12	4.35

TABLE 16

SUMMARY OF THE CORRELATION ANALYSIS FOR THE STIMULUS WORDS WITH [θ] AS THE INITIAL CONSONANT

Variables		Product-Moment Correlations: Number of Rhyming Alternatives	Product-Moment Correlations: Frequency of Stimulus Words	Product-Moment Correlations: Ratio of Frequency of Alternatives to Frequency of Stimulus Word	Multiple Correlation
Error Score		.12	-.19	.35	.96
Number of Rhyming Alternatives			-.64	.72	
Frequency of Stimulus Word				-.98	
Tests of Significance of Correlations Involving Error Scores	Degrees of Freedom	1 / 3	1 / 3	1 / 3	3 / 1
	F-ratio	0.04	0.11	0.42	3.82
	F-value .05 Level	10.13	10.13	10.13	2.16

When the relationship is expressed as a product-moment correlation coefficient and its statistical significance tested, the results show the correlation to be non-significant at the .05 level for all of the consonant categories. Low magnitude negative correlations are shown for the [f], [k], [p], and [r] categories, which are in line with the hypothesis that postulates that the number of errors are inversely proportionate to the frequency of the stimulus words; however, the magnitude of the correlations are so slight that hypothesis A cannot be accepted on the basis of these results.

Corollary Hypothesis B

Corollary hypothesis B was concerned with the question of whether the accuracy of the identification of the initial consonants in the experimental task has a significant relationship to the number of alternative rhyming words associated with the stem of the stimulus words. This hypothesis suggests that the greater the number of rhyming alternatives associated with a stimulus word, the greater will be the number of errors in the identification of the initial consonant of the stimulus word.

The correlations of the error scores to the number of alternative rhyme words are shown in Tables 10 through 16. An examination of the product-moment correlation coefficients reveals that low magnitude correlations exist for all consonant categories except those of [ʃ] and [θ].

The correlation coefficients of .57 for the [p] category, .59 for the [r] category, and .72 for the [t] category are significant at the

.05 level. Thus there would seem to be some statistical support for hypothesis B, since three of the seven categories showed significant correlations. However, it is not possible to accept this hypothesis as generally correct since no statistically significant correlations were found in the majority of the consonant categories.

Corollary Hypothesis C

The last of the corollary hypotheses involves the relationship of the error scores to the relative frequency of the alternative rhyme words. The latter is expressed by the ratio of the mean of the five most frequent rhyme words to the frequency of the corresponding stimulus word. It can be seen by consulting Tables 10 through 16 that the correlations of the two variables included in hypothesis C are significant only in the case of the [r] and [t] consonant categories. The [f], [k], [p], [ʃ], and [θ] categories show slight positive correlations which are in the right direction for the support of hypothesis C, but actually these correlations must be considered negligible. Therefore, as was the case in the test of hypothesis B, the statistical results do not justify the general acceptance of hypothesis C.

Intercorrelation of the Experimental Variables

It will be noted from the tables that there are some fairly consistent intercorrelations among the experimental variables. This is especially true of the relationship between frequency of the stimulus words and the ratio of the mean frequency of the alternative rhyme words. This is understandable in view of the fact that the latter variable is derived as a ratio to the former. That they are, however, somewhat independent in their relationship to the criterion variable is demonstrated by the fact that the ratio shows somewhat higher correlations with the criterion variable than does the frequency of occurrence of the stimulus words alone.

In the case of the relationship of number of alternatives to the relative frequency of the alternatives and the relationship of this latter parameter to the frequency of the stimulus words, the correlations are not of extreme magnitude, but must be acknowledged as indications that the variables used in this study are not entirely independent of each other.

Multiple Correlations

In addition to the product-moment correlations involving the criterion variable and each separate experimental variable, a multiple correlation was calculated using the three experimental variables. This made it possible to examine the contingency that although the simple correlations of the experimental variables to the criterion variable were not high, the correlation involving the experimental variables in combination would be of significant magnitude. Again the results are shown in Tables 10 to 16.

It can be seen that the multiple correlations range from .44 to .96, but that the correlations are significant only for the [r] [t] and [θ] categories. Thus the postulation that the combined influence of the variables examined might be of significance does not have sufficient statistical support.

Further Considerations of the Corollary Hypotheses

Although it was not possible statistically to accept the corollary hypotheses formulated in this investigation as generally valid, certain trends are shown by the data which are worth consideration. Definite (significant in three cases) correlations between error score and number of rhyming alternatives were shown in the case of five of the seven consonant categories. The consistency of these correlations would seem to give some support to the postulation that accuracy of identification of the initial consonants was influenced by the number of alternative rhyme words associated with the stimulus words. The evidence seems at least sufficient to merit the consideration of the possibility of such an influence in future research. And where lipreading ease or difficulty is being considered in the selection of sounds or words for either research or pedagogy, the evidence suggests that the most careful selection should give attention to the number of alternative sounds or words that might be hypothesized by a lipreader in attempting to identify the correct sound or word.

In the case of corollary hypothesis C which considered the influence of the relative frequency of the rhyming alternative words, the fact that the correlations were significant in two cases should be recognized. Though significant correlations in only two of seven cases is not sufficient statistical basis for accepting hypothesis C as being generally valid, the possibility of its being valid in specific cases should not be ignored. The existence of significant correlations for two consonant categories, but not for the others, suggests just such a possibility.

Thus again the findings in regard to hypothesis C may be of value to the careful researcher or educator concerned with the area of lip-reading.

The low and neglibible correlations shown in the test of corollary hypothesis A are somewhat surprising in view of the findings that the frequency of occurrence of stimulus words does influence the recognition thresholds of printed words presented tachistoscopically and spoken words presented in masking noise.[1] However a number of possible explanations for this discrepancy can be suggested.

One possible reason emerges from the fact that the frequency intervals among stimulus words in studies such as those of Howes,[2] Howes and Solomen,[3] and McGinnies, Comer and Lacey[4] were carefully controlled. For example, in the latter study words were selected which approximated the word frequency categories of 10, 100, 200, 300, and 400 per million.[5] However, in the present study it was not possible to maintain such regular word frequency intervals. For example in the case of the p consonant category, frequency of occurrence of all stimulus words did not exceed 121 per 4½ million and ranged irregularly down to one occurrence per 4½ million. This narrow range and the irregular word frequency intervals may not have shown the effect of word frequency because in some cases there was insufficient difference in frequency

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[1]Studies dealing with the effect of word frequency on perception are reviewed in Chapter II, pages 45 through 56.

[2]Howes, op. cit., pp. 296-305.

[3]Howes and Solomon, op. cit., pp. 401-410.

[4]McGinnies, Comer, and Lacy, op. cit., pp. 65-69. [5]Ibid., p. 66.

of occurrence of the words. For instance "punch" and "pulse" had the same frequency of occurrence, and "putt" and "pub" differed only by three.

However, a more likely explanation, for the lack of any tangible word frequency effect in the present study arises from the nature of the experimental task. In this investigation the subjects were given the auditory stem of the stimulus word and were asked to hypothesize the initial consonant from the evidence of the known auditory stem and evidence supplied by lipreading the initial consonant. On the other hand, the previously cited studies of the effect of word frequency on word perception used the technique of obtaining thresholds of recognition.

In the threshold studies the subjects were engaged in making a number of hypotheses based on fragmentary perception of words, and the experimenters were concerned with the number of hypotheses necessary to attain accuracy, rather than the nature of the hypotheses. However, in the tachistoscopic threshold study of McGinnies, Comer and Lacy, the nature of the incorrect responses (hypotheses) of the subjects was examined in addition to obtaining thresholds. From this examination an important clue to the significant difference of the experimental task of the present experiment from the tasks involved in the word recognition threshold studies was obtained. It was found that the response hypotheses of the subjects tended to be related to the visible structure of the stimulus word.[1] Words chosen as responses were found to be similar to the stimulus word in letter

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[1] *Ibid.*, p. 68.

configuration, etc. Thus it can be said that the alternatives from which hypotheses were made were reduced to those with similar structures. However, the perceived fragments of the structure of the stimulus words apparently were sufficiently ambiguous that more than one hypothesis had to be made before the recognition threshold was achieved. It is suggested that this ambiguity of perceived structure in the threshold studies prevented immediate identification and permitted word frequency effect to operate by making some words more prominent in a subject's response repertoire, and thus contributing to lower thresholds for such words.

It is further suggested that if structural ambiguity were reduced to a large degree, that the influence of structural characteristics might be so prominent as to obscure the effect of the frequency of occurrence of the stimulus words.

It is postulated that this was the case in the current experiment. In this study the subject always had a knowledge of the auditory structure of the stem of each stimulus word; hence the auditory structure of any response hypothesis was to a large degree predetermined. Possible Hypotheses were limited to the rhyming alternatives--a function of stem structure. Thus the influence of auditory structure in identifying the initial consonants of the stimulus words was made prominent by the knowledge of the stems.

Moreover, evidence affecting the response hypotheses in the present study could also be obtained from lipreading the initial consonants; thus the visible nature of the initial sound configurations constituted another structural influence on the accuracy of the response hypothesis.

With the auditory structure of the stem known, the task of the subjects became one of discriminating among the words suggested by the stem on the basis of lipreading the initial consonant of the stimulus word.

It is suggested that successful discrimination depended to a large degree on the nature of the initial consonants of the rhyming alternatives as well as on the visibility of the initial consonant of the stimulus word. It is likely that discrimination was, at least in part, a function of the degree to which the initial consonants of the alternatives suggested by a given stem could be confused as the initial consonant of the stimulus word. For example, if among the alternative rhyming words there were those whose initial consonants were highly similar to that of the stimulus word, then less accuracy of identification might be expected. To further illustrate, it might be anticipated that if there were words beginning with [w] among the rhyming alternative words for a stimulus word beginning with [r], that more errors in the identification of [r] would occur because of the degree of similarity of the visual configuration of [w] to that of [r]. And indeed it will be seen by consulting Table 27 of Appendix B that [r] was misidentified as [w] a large number of times (the substitution of [w] accounted for 1400 errors, or 27.34 per cent of the total responses). Consequently the confusability of the alternatives may be considered as a factor which may have had a great deal of effect on the accuracy of identifying the initial consonants of the stimulus word.

At this point one might be caused to think that the important factor for success in the experimental task involved in this study was related primarily to the discriminability of the initial consonants of the stimulus word and hence the basic hypothesis concerning the influence of the stem is not sound. However, it must be kept in mind that it is postulated that the confusions that occurred in the task of discrimination were determined by the initial consonants of the alternative words that existed as possible hypotheses, and these were restricted, by a knowledge of the stem, to words that rhyme with the stem. Consequently "confusability" was controlled to a large degree by the nature of the stem.

In fact more than one aspect of the nature of the alternatives determined by a given stem may have been operating to produce confusion of identification; i.e., confusability may have been determined by the number of confusable rhyme words which must be discriminated, and it may have been determined by the degree of confusability that might be found to exist among the alternatives.

In addition it is possible that word frequency could still be found to have exerted a significant influence, not through the stimulus word, but through its influence on the confusable rhyme words. It would seem reasonable to expect a rhyming alternative that is characterized by both confusability and high frequency of occurrence to be very prominent as a response hypothesis; and consequently, that this prominence would promote inaccuracy in the identification of the initial consonant of the stimulus word. Thus it would seem possible that the accuracy of identification of initial consonants may, in part, have an inverse relationship to the frequency of occurrence of the confusable rhyming alternatives.

Basically, then, the implication of the foregoing discussion is that the experimental task in this study was of such a nature that the word frequency effect of the stimulus word was obscurred because of the influence of the confusability characteristics of rhyming alternatives--and the characteristics of the alternatives were, in turn, determined by the nature of the auditory structure of the stems.

The question now arises as to which type of experimental technique--obtaining recognition thresholds or determining the accuracy of initial hypotheses--best reflects influences on perception that occur in actual communication. It seems correct to suppose that the technique most resembling actual communication would have the soundest implications for the real verbal communication experience. Therefore, that method which is concerned with the nature rather than the number of hypotheses would seem to carry the most valid implications, since in face-to-face communication it is the nature (accuracy) of hypotheses that is most significant rather than the number of hypotheses. As mentioned earlier the threshold studies cited were concerned with the number of hypotheses necessary to attain accuracy; therefore the findings derived from this technique would seem to be rather tenuous in their implications as to what takes place in verbal communication--this would include the implications as to the significance of word frequency.

The lack of support for the corollary hypotheses should not be interpreted as weakening the validity of the basic hypothesis. That influences related to the characteristics of the stem affect the identification of the initial consonants is still evident, and the implication is still sound that where attention is given to the lipreadability of sounds and words in lipreading research and training, factors in addition to the visibility of the language units must be considered. The complete nature of these factors remains to be determined, but the importance of the alternative response hypotheses that may be derived from the fragmentary perception of word structure has been suggested. It has been further suggested that the number, nature, and frequency of occurrence of the "confusable" alternatives may play an extremely important role in the identification by lipreading of the components of words. Future research should be directed toward an investigation of these influences.

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

Summary

In lipreading research and training, the assumption is often made that the lipreadability of a language unit is almost exclusively a function of its visibility. The purpose of this study was to investigate other influences which affect the accuracy with which language units are identified.

Basic Hypothesis

This investigation has been limited to an examination of factors that affect the identification, by lipreading, of initial consonants of monosyllabic words. The basic hypothesis considered was that different vowel-consonant endings (stems) would affect differently the accuracy of visual identification of the same initial consonants if the endings were known by the subjects.

The influence of the known stems on the identification of seven consonants was studied. These consonants were [f, k, p, r, ʃ, t, θ]. For each consonant, a set of stimulus words was developed which differed only as to final sound. Thus seven sets of stimulus words were developed with constant vowel environments for each of the initial consonants within a set. The number of stimulus words associated with

each consonant ranged from five to sixteen; the total list of stimulus words was made up of seventy-six monosyllables.

Four speakers were filmed uttering the stimulus words in random order. Each of the four speakers were then presented for viewing to each of four groups of twenty subjects. Before each stimulus word was seen by the subjects, they heard the stem (vowel plus final consonant) of the word spoken and were also able to read from their response sheet the various printed forms the auditory stem might take. Thus the stem of each stimulus word was always known. However, the subjects were required to identify the initial consonant of each stimulus word by lipreading.

Error scores in the identification of the initial consonants of each of the stimulus words within a consonant category were determined from the responses of the subjects. Analyses of variance were then made to determine the statistical significance of the differences among the error scores for each of the words within each separate consonant category.

It was found that the differences in the accuracy of identification of the same initial consonant united with different stems was statistically significant beyond the .01 level for all seven consonant categories. However, stem-speaker and stem-speaker-order interaction affects were found to be statistically significant in most cases, which would seem to make conclusions about the stem effect tenuous. Nevertheless, the magnitude of the F-ratios for the stem effects were so large in comparison to the F-statistic necessary for significance that acceptance of the basic hypothesis was thought to be justified in spite of the interaction effects.

Corollary Hypotheses

On the basis of the assumption that the basic hypothesis was valid, additional hypotheses were made as to what particular characteristics of the stems of the stimulus words would show relationships to the differences among the error scores in the identification of the initial consonants within a consonant category.

It was hypothesized that (1) the number of errors of identification would be an inverse function of the frequency of occurrence of the stimulus word formed by an initial consonant and a given stem--the more frequent the stimulus word, the fewer the errors; (2) the number of errors of identification would be directly related to the number of rhyming alternative words which might be hypothesized as a response in the identification of an initial consonant--the greater the number of alternatives, the greater the number of errors; and (3) the number of errors would be a correlate of the relative frequency of the alternative rhyme words as determined by the ratio of the mean frequency of the five most frequent rhyming alternatives to the frequency of the stimulus word, i.e., if the mean frequency of the alternatives was proportionately greater than the frequency of the stimulus word, more errors would occur.

It was found that there was no significant relationship between the frequency of occurrence of stimulus words and accuracy of identification of initial consonants. This was thought to be surprising in view of previous findings that word frequency was an important factor in determining tachistoscopic word recognition thresholds and in determining signal-to-noise thresholds for spoken words. However, the explanation was offered that the word frequency effect was obscured by a stronger determinant of accuracy of identification which was not examined in the present study. It was suggested that this determinant was related to the confusability characteristics of the alternative rhyme words suggested by the stems; i.e., when words exist among the alternatives that have initial consonants that are easily confused with the initial consonant of the stimulus word, more errors in identification are made because of this confusability factor.

Some support was found for the hypothesis that accuracy of identification was related to the number of rhyming alternatives suggested by the known stem of a stimulus word. In three of the seven consonant categories significant product-moment correlation coefficients were found to exist. However, this is not sufficient justification for accepting this hypothesis as being generally valid.

Statistical tests of the hypothesis concerned with the relationship of the relative frequency of the rhyming alternatives to differences in accuracy of identification of the same initial consonant revealed a similar situation. Significant correlations were found for two of the seven consonant categories. Again this is insufficient evidence to merit the general acceptance of the hypothesis. But the possibility that the hypothesis may be valid in some cases though not in others seems justified.

Conclusions

On the basis of the statistical analysis of the results obtained in this investigation, the following conclusions appear to be warranted:

Basic Hypothesis

The degree of accuracy of identification by lipreading of the same initial consonant united with different -VC stems is influenced by the linguistic characteristics of the stem, if the stem is known but the initial consonant is unknown. However, the magnitude of the influence is not the same for all speakers.

This conclusion implies that perceived word fragments may influence the accuracy of identification of English sounds by lipreading and that such influence should be considered by teachers and researchers concerned with lipreading.

Corollary Hypotheses

1. Accuracy of identification of an initial consonant by lipreading is not influenced by the frequency of occurrence of the word formed by the union of that initial consonant and a known -VC stem.

2. In some cases the accuracy of identification of an initial consonant by lipreading is inversely related to the number of alternative rhyme words suggested by a known -VC stem; however, this relationship cannot be generalized to all cases.

3. Accuracy of identification of an initial consonant by lipreading has an inverse relationship in some cases to the relative frequency of the alternative rhyme words suggested by the known stems; but this relationship cannot be concluded to exist in all cases.

The implications of these findinns suggest that, when influences on the identification of English sounds in lipreading are exerted by perceived fragments of the stimulus, these influences are derived primarily from the nature of the alternatives suggested by the perceived fragments.

Implications for Future Research

This study represents a beginning in the investigation of some of the more obscure, but nevertheless important, aspects of the language code that influence lipreading. Numerous possibilities for future research remain. Some of the questions suggested by the present study that remain unanswered are listed as follows:

1. What are the confusability relationships of the various English sounds in lipreading?

2. What is the relationship of the number of confusable alternative rhyme words, the degree of confusability of the rhyme words, and the frequency of occurrence of the confusable rhyme words to accuracy of identification by lipreading of initial consonants united with known -VC stems?

3. Would a greater correlation between accuracy of visual identification of English sounds and frequency of occurrence of stimulus words be shown if a frequency count other than the Lorge magazine count were used, or if combined counts, such as the Lorge magazine count and the Thorndike juvenile count, were used as the criterion of word frequency?

4. How is the accuracy of visual identification of an initial consonant influenced by a knowledge of word fragments other than the stem?

5. What is the nature of the influence of known word fragments on the identification of English sounds in positions other than the initial position?

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APPENDICES

APPENDIX A

TABLES OF ERROR SCORES AND PARAMETER INDICES FOR EACH STIMULUS WORD

TABLE 17

SUMMARY OF ERROR SCORES AND PARAMETER INDICES FOR STIMULUS WORDS WITH [f] AS THE INITIAL CONSONANT

Stimulus Word	Error Score	Frequency of Occurrence of Stimulus Word*	Log Frequency of Occurrence of Stimulus Word	Number of Rhyming Words	Average Frequency of Five Most Frequent Rhyming Words	Ratio of the Mean Frequency of Rhymes to Frequency of Stimulus Word	Log Ratio of Mean Frequency of Rhymes to Frequency of Stimulus Word
Face	14	3902	3.591	14	1202.20	0.30	-1.489
Fade	9	108	2.033	37	2152.40	19.95	1.300
Fail	17	620	2.792	31	414.00	0.70	-1.825
Faint	6	312	2.494	5	263.60	0.86	-1.927
Faith	0	459	2.661	1	51.00	0.11	-1.046
Fake	4	53	1.724	19	2875.80	53.70	1.730
Fame	20	107	2.029	13	1931.00	1.80	1.257
Fate	10	257	2.410	27	2245.80	8.73	0.941
Fay	14	0	0.000	36	7282.20	7278.00	3.862
Feign	33	40	1.602	39	654.40	16.37	1.214
Phase	15	91	1.959	41	3064.00	33.65	1.527
Mean	12.91	540.81	2.118	23.91	2011.43	674.01	0.504
Median	14.00	108.00	2.033	27.00	1931.00	8.73	1.257
Std. Dev.	8.92	1206.57	0.900	14.22	2798.47	2194.34	1.828

*All word frequencies indicate occurrence per 4.5 million words of the Lorge magazine count as listed in Edward L. Thorndike and Irving Lorge, The Teacher's Word Book of 30,000 Words (New York: Bureau of Publications, Teachers College, Columbia University, 1959).

TABLE 18

SUMMARY OF ERROR SCORES AND PARAMETER INDICES FOR STIMULUS WORDS WITH [k] AS THE INITIAL CONSONANT

Stimulus Word	Error Score	Frequency of Occurrence of Stimulus Word	Log Frequency of Occurrence of Stimulus Word	Number of Rhyming Words	Average Frequency of Five Most Frequent Rhyming Words	Ratio of the Mean Frequency of Rhymes to Frequency of Stimulus Word	Log Ratio of Mean Frequency of Rhymes to Frequency of Stimulus Word
Calm	74	267	2.427	6	3393.20	12.71	1.104
Car	81	2218	2.346	12	609.00	2.75	0.439
Card	195	491	2.691	13	732.00	1.49	0.174
Cart	240	68	1.833	9	1293.80	19.01	1.279
Carve	80	82	1.914	1	181.00	2.21	0.344
Cob	167	10	1.000	11	579.20	57.94	1.763
Cock	268	63	1.799	17	482.80	7.67	0.885
Cod	210	39	1.591	14	350.80	9.00	0.954
Cog	238	13	1.114	7	206.80	15.92	1.202
Cop	176	112	2.049	17	917.20	8.17	0.913
Cost	164	903	2.956	6	435.40	0.50	-1.683
Cot	176	87	1.940	22	8165.20	93.76	1.972
Mean	172.42	362.75	1.972	11.25	1445.53	19.22	0.779
Median	171.50	84.50	1.887	10.50	670.50	7.92	0.899
Std. Dev.	65.11	612.75	0.581	5.85	2188.76	26.95	0.940

TABLE 19

SUMMARY OF ERROR SCORES AND PARAMETER INDICES FOR STIMULUS WORDS WITH [p] AS THE INITIAL CONSONANT

Stimulus Word	Error Score	Frequency of Occurrence of Stimulus Word	Log Frequency of Occurrence of Stimulus Word	Number of Rhyming Words	Average Frequency of Five Most Frequent Rhyming Words	Ratio of the Mean Frequency of Rhymes to Frequency of Stimulus Word	Log Ratio of Mean Frequency of Rhymes to Frequency of Stimulus Word
Pub	82	28	1.447	12	660.06	23.07	1.363
Puff	72	121	2.083	12	223.20	1.85	0.266
Puck	161	6	0.778	9	186.86	31.12	1.493
Pug	205	3	0.477	15	141.80	47.32	1.675
Pulp	19	51	1.708	1	91.00	1.78	0.251
Pulse	01	78	1.892	0	0.00	0.80	-1.892
Pump	157	111	2.045	12	184.20	1.66	0.220
Pun	111	1	0.000	17	4565.60	4571.00	3.660
Punch	220	78	1.892	5	148.40	1.91	0.279
Punk	154	19	1.279	11	116.40	6.12	0.787
Pup	34	62	1.792	2	669.00	10.79	1.033
Putt	158	31	1.491	14	7545.40	243.80	2.387
Mean	114.50	49.08	1.407	9.17	1210.99	411.70	0.960
Median	132.00	41.00	1.641	12.00	185.53	8.44	1.198
Std. Dev.	72.68	39.60	0.663	5.77	2259.15	1255.76	1.363

TABLE 20

SUMMARY OF ERROR SCORES AND PARAMETER INDICES FOR STIMULUS WORDS WITH [r] AS THE INITIAL CONSONANT

Stimulus Word	Error Score	Frequency of Occurrence of Stimulus Word	Log Frequency of Occurrence of Stimulus Word	Number of Rhyming Words	Average Frequency of Five Most Frequent Rhyming Words	Ratio of the Mean Frequency of Rhymes to Frequency of Stimulus Word	Log Ratio of Mean Frequency of Rhymes to Frequency of Stimulus Word
Rear	208	251	2.400	35	2941.00	11.72	1.069
Rib	132	85	1.929	5	28.80	0.30	-1.518
Rich	219	656	2.817	8	2334.80	3.56	0.551
Rick	243	32	1.505	19	594.00	18.58	1.269
Rid	151	143	2.155	8	1432.80	10.02	1.001
Ridge	40	111	2.045	2	234.50	2.13	0.329
Rift	212	10	1.000	9	354.40	35.40	1.549
Rig	211	26	1.415	10	440.40	16.94	1.229
Rill	274	4	0.602	24	3.49	769.10	2.886
Rim	228	48	1.681	16	3928.00	81.85	1.913
Ring	184	622	2.794	15	1755.40	2.82	0.450
Rinse	145	63	1.799	17	478.00	7.59	0.880
Rip	193	93	1.968	20	694.60	7.48	0.874
Risk	158	272	2.435	6	78.00	0.30	-1.457
Wrist	175	170	2.230	12	803.60	4.73	0.675
Writ	224	4	0.602	20	833.40	208.40	2.319
Mean	187.31	161.87	1.836	14.13	1058.44	73.77	0.876
Median	200.50	89.00	1.949	13.50	818.20	9.63	0.940
Std. Dev.	54.86	196.95	0.680	8.40	1104.68	186.56	1.148

TABLE 21

SUMMARY OF ERROR SCORES AND PARAMETER INDICES FOR STIMULUS WORDS WITH[ʃ]AS THE INITIAL CONSONANT

Stimulus Word	Error Score	Frequency of Occurrence of Stimulus Word	Log Frequency of Occurrence of Stimulus Word	Number of Rhyming Words	Average Frequency of Five Most Frequent Rhyming Words	Ratio of the Mean Frequency of Rhymes to Frequency of Stimulus Word	Log Ratio of Mean Frequency of Rhymes to Frequency of Stimulus Word
She	222	31087	4.493	30	23283.80	0.80	-1.874
Sheaf	289	30	1.477	8	265.00	8.83	0.946
Sheath	200	12	1.079	3	143.33	11.94	1.077
Sheave	273	3	0.477	8	519.00	173.00	2.238
Sheen	213	13	1.114	19	1244.40	9.57	0.981
Sheep	285	86	1.935	13	819.20	9.51	0.978
Sheet	282	338	2.530	25	1008.80	2.98	0.474
Shiek	250	12	1.079	26	853.00	71.12	1.852
Shield	112	44	1.643	16	416.40	9.48	0.977
Mean	236.22	3513.89	1.759	16.44	3172.54	32.94	0.850
Median	273.00	30.00	1.643	16.00	819.20	9.57	0.978
Std. Dev.	57.32	9749.89	1.182	9.29	7118.43	53.46	1.151

TABLE 22

SUMMARY OF ERROR SCORES AND PARAMETER INDICES FOR STIMULUS WORDS WITH [t] AS THE INITIAL CONSONANT

Stimulus Word	Error Score	Frequency of Occurrence of Stimulus Word	Log Frequency of Occurrence of Stimulus Word	Number of Rhyming Words	Average Frequency of Five Most Frequent Rhyming Words	Ratio of the Mean Frequency of Rhymes to Frequency of Stimulus Word	Log Ratio of Mean Frequency of Rhymes to Frequency of Stimulus Word
Tare	175	919	2.963	38	6878.00	7.48	0.874
Ted	191	92	1.964	25	4432.80	48.19	1.683
Tell	86	3800	3.580	17	1650.80	0.04	-1.638
Tempt	93	94	1.973	0	0.00	0.09	-1.973
Ten	85	1260	3.100	14	5797.20	4.60	0.663
Tend	139	201	2.303	10	864.60	4.30	0.634
Tense	117	125	2.097	7	367.20	2.93	0.468
Tent	129	145	2.161	15	1752.20	12.11	1.083
Tenth	22	69	1.839	0	0.00	0.07	-1.839
Test	110	415	2.618	19	1252.60	3.02	0.480
Text	100	41	1.613	2	2321.00	56.62	1.753
Mean	113.36	651.00	2.383	13.36	2301.54	12.67	0.199
Median	110.00	145.00	2.161	14.00	1650.80	4.30	0.634
Std. Dev.	46.09	1065.29	0.609	11.53	2254.91	26.61	1.366

TABLE 23

SUMMARY OF ERROR SCORES AND PARAMETER INDICES FOR STIMULUS WORDS WITH [θ] AS THE INITIAL CONSONANT

Stimulus Word	Error Score	Frequency of Occurrence of Stimulus Word	Log Frequency of Occurrence of Stimulus Word	Number of Rhyming Words	Average Frequency of Five Most Frequent Rhyming Words	Ratio of the Mean Frequency of Rhymes to Frequency of Stimulus Word	Log Ratio of Mean Frequency of Rhymes to Frequency of Stimulus Word
Thaw	15	18	1.255	17	817.00	45.39	1.657
Thong	53	20	1.301	7	1495.20	74.88	1.874
Thor	44	0	0.000	33	12115.60	12115.60	4.083
Thorn	15	28	1.447	11	258.00	9.23	0.965
Thought	32	3990	3.601	11	640.00	0.16	-1.205
Mean	31.80	811.20	1.521	15.80	3065.15	2457.05	1.475
Median	32.00	20.00	1.301	11.00	817.00	74.88	1.657
Std. Dev.	17.05	1784.24	1.300	10.26	5479.99	5427.20	1.800

APPENDIX B

TABULATION OF THE RESPONSES OF THE SUBJECTS IN ATTEMPTING TO IDENTIFY THE INITIAL CONSONANT OF THE STIMULUS WORDS IN EACH CONSONANT CATEGORY

TABLE 24

TABULATION OF RESPONSES RESULTING FROM ATTEMPTS TO IDENTIFY THE INITIAL CONSONANT [f] *

Initial Sound Indicated	Stimulus Words							
	Face	Fade	Fail	Faint	Faith	Fake	Fame	Fate
b			1			2		5
bl							1	
d								
f	306	311	303	314	320	316	300	310
fl						1	14	
fr		1						1
h				1				
k			1				1	
kl								
m								1
n								
p	1	2	9	4				1
r		1	1					
s		1						
sw		2						
t	1		2				2	1
tr								
ð								
v	12		2					
w								1

*Discrepancies between the total number of responses listed for each stimulus word in the tables and the total number of possible responses (320) is due to the fact that omissions and ambiguous responses are not included.

TABLE 24--Continued

Initial Sound Indicated	Stimulus Words			TOTAL	Per Cent of Total Response
	Feign	Fay	Phase		
b				8	0.22
bl				1	0.02
d			1	1	0.02
f	287	306	305	3376	95.96
fl		1		16	0.45
fr				2	0.05
h				1	0.02
k		1		3	0.08
kl		1		1	0.02
m			2	3	0.08
n		1		1	0.02
p	4	3	2	26	0.73
r				2	0.05
s				1	0.02
sw				2	0.05
t			1	7	0.19
tr			1	1	0.02
ɚ		1		1	0.02
v	27	3	8	52	1.47
w		1		2	0.05

TABLE 25

TABULATION OF RESPONSES RESULTING FROM ATTEMPTS TO IDENTIFY THE INITIAL CONSONANT [k]

Initial Sound Indicated	Stimulus Words						
	Calm	Car	Card	Cart	Carve	Cob	Cock
b	10	1				2	6
bl						1	
d	1		1	33	2	6	19
dʒ		1	7		1	10	1
f		2		1	1		
fl							
fr							
g		1	9		1	4	4
gl						1	
h	8	10	61	106	14	13	24
j			6				
k	246	239	125	80	240	153	52
kl	2			2	1	7	52
kr							
l	4	9	61	30	23	38	31
m					3	1	1
n	2	2			2	9	2
p	9		1	1			1
pl							
r						3	3
s				1	2	1	5
sk			2				
sl						1	
st		3		4	18		3
ʃ							1
t	33	51	44	46	10	41	104
tl							
θ							
tʃ			2	10	1		5
v							
w	1						1
z							

TABLE 25--Continued

Initial Sound Indicated	Stimulus Words					TOTAL	Per Cent of Total Responses
	Cod	Cog	Cop	Cost	Cot		
b	1	3			2	25	0.65
bl						1	0.02
d	4	58	1	1	6	132	3.43
dʒ		1			6	27	0.70
f						4	0.10
fl			1			1	0.02
fr				1		1	0.02
g	35	4	1		13	72	1.87
gl						1	0.02
h	12	53	29	2	24	375	9.76
j						40	1.04
k	110	82	143	156	142	1768	46.04
kl	42	13	11		4	134	3.48
kr				3		3	0.07
l	26	37	5	94	8	366	9.53
m			1			6	0.15
n	2	1	1		2	23	0.57
p	1		4	1		18	0.46
pl		1				1	0.02
r	1		1			8	0.20
s	5	2	1		1	18	0.46
sk						2	0.05
sl						1	0.02
st			4			32	0.83
ʃ	3				1	5	0.13
t	69	62	112	62	70	704	18.33
tl	1					1	0.02
θ					1	1	0.02
tʃ		1				19	0.49
v			1			1	0.02
w						2	0.05
z	1					1	0.02

TABLE 26

TABULATION OF RESPONSES RESULTING FROM ATTEMPTS TO IDENTIFY THE INITIAL CONSONANT [p]

Initial Sound Indicated	Stimulus Words						
	Pub	Puck	Puff	Pug	Pulp	Pulse	Pump
ə br							
ə p							
b	67	68	54	132	8		139
bl		1	1				
br							
d		1					
dʒ				1			
f							1
fl			1				
g					5		
h	3						1
k	1						
kl	1	1					
l		2					1
m	2	44	11	66	3	1	6
ml		2					
p	238	159	248	115	301	319	163
pl		40		4	3		5
r	3		3	2			2
t	4		2				
θ							2
w							

TABLE 26--Continued

Initial Sound Indicated	Stimulus Words					TOTAL	Per Cent of Total Responses
	Pun	Punch	Punk	Pup	Putt		
ɜbr				2		2	0.05
əp	8					8	0.20
b	91	165	132	17	121	994	25.88
bl				1		3	0.07
br		9				9	0.23
d						1	0.02
dʒ			1			2	0.05
f	3			1		5	0.13
fl						1	0.02
g						5	0.13
h			2		1	7	0.18
k				7		8	0.20
kl						2	0.05
l		4		1		8	0.20
m	6	42	17	3	33	234	6.09
ml						2	0.05
p	209	100	166	286	162	2366	61.61
pl			2			54	1.40
r	1				2	13	0.33
t				1		7	0.18
θ						2	0.05
w	2					2	0.05

TABLE 27

TABULATION OF RESPONSES RESULTING FROM ATTEMPTS
TO IDENTIFY THE INITIAL CONSONANT [r]

Initial Sound Indicated	Stimulus Words								
	Rear	Rib	Rich	Rick	Rid	Ridge	Rift	Rig	Rill
b		3	2	1	3	2			
br					1	5			
d	13	1	17		7		2	6	1
dr	20	9	1	9	13	8	77	9	34
dʒ	1	1			1			3	
f	7	1	5					2	1
fl									
fr									
g	4				1		4	1	
gl		2							
go									
gr					10		1		2
h	1		1	1					
j	3								
k	1			1	3				1
kl	1			1					
kr		41	1	3	2	1			
kw	27	8	1	35	10				13
l		3	1	1	6		13		1
m						3			
n		1							
p			1	4				1	
pr				1					

TABLE 27--Continued

Initial Sound Indicated	Stimulus Words							TOTAL	Per Cent of Total Responses
	Rim	Ring	Rinse	Rip	Risk	Wrist	Writ		
b		1						12	0.23
br		1			2			9	0.17
d	5	4			26	1	3	86	1.67
dr	11	9	2	28	2	1	9	242	4.72
dʒ	2	3		4				15	0.29
f			1		3	1		21	0.41
fl		1			1			2	0.03
fr		1			2			3	0.05
g		1					2	13	0.25
gl								2	0.03
go		2						2	0.03
gr	6	1		8		3	8	39	0.76
h	9			2				14	0.27
j			3					6	0.11
k			1	1			3	11	0.21
kl								2	0.03
kr	1	1		1				51	0.99
kw	1		5	2		1	17	120	2.34
l			1	2		5	2	35	0.68
m						3		6	0.11
n			1					2	0.03
p	1		1			3		11	0.21
pr			3					4	

TABLE 27--Continued

Initial Sound Indicated	Stimulus Words								
	Rear	Rib	Rich	Rick	Rid	Ridge	Rift	Rig	Rill
r	112	189	101	77	156	280	108	111	46
s	1	1		3	3		2	1	
skr		1							
sl									
spr									
skw		1			1				
st			4						
str									
sw	2	1	2				10	2	2
ʃ	1						3	1	
ʃr							2		
t	8	2	5	2	3		1	1	6
tr	4	7	3	63	13	2	1	41	8
tw			16		3	1		10	4
θ				4					
θr							8		10
tʃ	3		2	2					
w	98	35	111	110	50	16	55	117	190
hw	7	12	43	1	6		32	14	
z									

TABLE 27--Continued

Initial Sound Indicated	Stimulus Words: Rim	Ring	Rinse	Rip	Risk	Wrist	Writ	TOTAL	Per Cent of Total Responses
r	83	135	174	125	162	144	96	2099	40.99
s		8	5	1			2	27	0.52
skr								1	0.01
sl		1						1	0.01
spr		1						1	0.01
skw								2	0.03
st								4	0.07
str		1						1	0.01
sw	8	3					1	31	0.60
ʃ							2	7	0.13
ʃr	1							3	0.05
t		4	2	2	3	1	1	41	0.80
tr	32	7	3	39	3	13	11	250	4.88
tw	1		1		3	26	10	75	1.46
θ		7						11	0.21
θr								18	0.35
tʃ		7		2				16	0.31
w	36	114	108	29	88	84	139	1400	27.34
hw	71		7	68	24	20	13	318	6.21
z		1						1	0.01

TABLE 28

TABULATION OF RESPONSES RESULTING FROM ATTEMPTS TO IDENTIFY THE INITIAL CONSONANT [ʃ]

Initial Sound Indicated	Stimulus Words				
	She	Sheaf	Sheath	Sheave	Sheen
ɚk				1	
ətʃ				33	
b		1			1
d	1	1			
dʒ	108	6	6	14	149
f					
fr	1				
gl				1	
gr		3		1	1
h	1		3	3	
j					
k	4	6	5	7	3
kl	1				1
kr					
l		7		17	2
m					
p				3	1
r		1	4	1	
s	32	3	6	10	26
skw					
sl			2	10	
sp					
st				3	
sw					
ʃ	98	31	120	47	112
t	18	1	114		3
tr	2				
θ		6		1	
tʃ	52	248	51	139	20
v					
w					

TABLE 28--Continued

Initial Sound Indicated	Stimulus Words: Sheep	Sheet	Shiek	Shield	TOTAL	Per Cent of Total Responses
ək					1	0.03
ətʃ					38	1.31
b		2			4	0.13
d					2	0.06
dʒ	179	4	6	4	476	16.52
f				2	2	0.06
fr					1	0.03
gl					1	0.03
gr					5	0.17
h	2	2		1	12	0.41
j	1			25	26	0.90
k					25	0.86
kl					2	0.06
kr		1	1		2	0.06
l		2			28	0.97
m		5	3		8	0.27
p			2	1	7	0.24
r					6	0.20
s	4	11	21	48	161	5.59
skw				1	1	0.03
sl	4				16	0.55
sp			1		1	0.03
st	1				4	0.13
sw	1	1			2	0.06
ʃ	35	39	70	208	760	26.38
t		2	8		146	5.06
tr		2			4	0.13
θ					7	0.24
tʃ	87	245	203	15	1060	36.80
v	1		1	2	4	0.13
w			2		2	0.06

TABLE 29

TABULATION OF RESPONSES RESULTING FROM ATTEMPTS TO IDENTIFY THE INITIAL CONSONANT [t]

Initial Sound Indicated	Stimulus Words					
	Tare	Ted	Tell	Tempt	Ten	Tend
æbs						
əh		1				
ət				10		
b		2	2			2
bl						
d	45	83	10	1	27	2
dr				2		
dʒ			4	1	6	1
ɛgz				18		
f		2	5		1	2
fr		1				
h	5	21	3	3	3	
k	24	9	6	33	5	6
kl				1		
l	5	16	7	3	3	49
m					1	1
n	3		5			1
p	1		1		1	
pr						
r	1	2				
s	5	37	36	15	26	68
sɛv						
sl		4				
st	38	9	1	3	1	
sw			2			
ʃ	4					
t	145	129	234	227	235	181
tr						2
θ						
ð	13				10	
tʃ	31		1			1
v				2	1	
w			2			
z					1	

TABLE 29--Continued

Initial Sound Indicated	Stimulus Words: Tense	Tent	Tenth	Test	Text	TOTAL	Per Cent of Total Response
æbs				2		2	0.05
əh						1	0.02
ɝt						10	0.28
b		3		3		12	0.34
bl				1		1	0.05
d	53	21	1	2	2	247	7.01
dr						2	0.05
d		4		17		33	1.05
ɛgz						18	0.51
f	3					13	0.36
fr						1	0.05
h	7				11	53	1.50
k	1	10	1	1		96	2.72
kl	1	1	1			4	0.11
l	5	23	2	6	5	124	3.52
m						2	0.05
n				16	47	72	2.04
p		1		2		6	0.17
pr				1		1	0.07
r		3		3		9	0.25
s	38	59	2	9	27	322	9.14
sɛv			1			1	0.02
sl						4	0.11
st						52	1.47
sw						2	0.05
ʃ				1		5	0.14
t	204	192	297	210	220	2274	64.60
tr			1			3	0.08
θ	6					6	0.17
ɝ			4	1		28	0.79
tʃ				12	1	46	1.30
v					6	9	0.25
w		2				4	0.11
z				28		29	0.82

TABLE 30

TABULATION OF RESPONSES RESULTING FROM ATTEMPTS TO IDENTIFY THE INITIAL CONSONANT [θ]

Initial Sound Indicated	Stimulus Words: Thaw	Thong	Thor	Thorn	Thought	TOTAL	Per Cent of Total Responses
ɑ			1			1	0.06
d		1	1			2	0.12
f	3	3	6		7	19	1.18
fl	1		1			2	0.12
g		2				2	0.12
h			2	1		3	0.18
k	1	1	7	2	5	16	1.00
kl	1					1	0.06
l	1	11	1	1		14	0.87
m				2		2	0.12
p	1					1	0.06
r		6				6	0.37
s	1	4	4			9	0.56
str		1				1	0.06
t	6	11	13	8	18	56	3.50
tr		1				1	0.06
θ	305	267	276	305	288	1441	90.06
θr		10				10	0.62
tʃ			1			1	0.06
w		1		1	1	3	0.18

APPENDIX C

STIMULUS LISTS USED BY THE FOUR SPEAKERS

STIMULUS LIST NUMBER ONE

1.	pub	20.	rinse	39.	tare	58.	fay
2.	rift	21.	cop	40.	thaw	59.	rill
3.	sheave	22.	tense	41.	thor	60.	tent
4.	faint	23.	ring	42.	pulp	61.	sheet
5.	rib	24.	fate	43.	feign	62.	cob
6.	cog	25.	pug	44.	shiek	63.	ridge
7.	test	26.	tenth	45.	tell	64.	phase
8.	cost	27.	cart	46.	pulse	65.	thorn
9.	puff	28.	puck	47.	cod	66.	pup
10.	rim	29.	wrist	48.	fame	67.	ted
11.	card	30.	tend	49.	carve	68.	rick
12.	rid	31.	writ	50.	pump	69.	punk
13.	car	32.	putt	51.	risk	70.	face
14.	sheen	33.	rear	52.	sheaf	71.	fail
15.	rig	34.	text	53.	pun	72.	sheep
16.	fade	35.	tempt	54.	sheath	73.	rich
17.	fake	36.	she	55.	ten	74.	calm
18.	thong	37.	faith	56.	punch	75.	thought
19.	shield	38.	rip	57.	cock	76.	cot

STIMULUS LIST NUMBER TWO

1. tent
2. cost
3. tea
4. tenth
5. thaw
6. pup
7. rift
8. cart
9. sheaf
10. faint
11. card
12. carve
13. sheep
14. punk
15. sheave
16. tare
17. rim
18. rill
19. ring
20. punch
21. pump
22. pun
23. faith
24. cod
25. fake
26. thought
27. shield
28. car
29. tell
30. puff
31. rid
32. thorn
33. thor
34 fate
35. cop
36. ted
37. sheet
38. fame
39. fame
40. phase
41. rick
42. pub
43. writ
44. tense
45. rib
46. test
47. cot
48. pub
49. fay
50. feign
51. ridge
52. cob
53. pulse
54. tent
55. tend
56. shiek
57. cog
58. text
59. thong
60. she
61. pulp
62. putt
63. cock
64. fail
65. rear
66. rip
67. risk
68. rick
69. calm
70. rig
71. puck
72. tempt
73. face
74. wrist
75. rinse
76. sheath

STIMULUS LIST NUMBER THREE

1. cart
2. rill
3. sheave
4. putt
5. thought
6. sheen
7. card
8. tare
9. fake
10. fate
11. tent
12. tenth
13. phase
14. thor
15. cop
16. tell
17. tense
18. pup
19. rinse
20. sheaf
21. fame
22. faith
23. pug
24. punk
25. faint
26. ring
27. thorn
28. cob
29. sheet
30. rick
31. pun
32. cod
33. cog
34. ted
35. cost
36. thong
37. puff
38. rid
39. pulse
40. rift
41. she
42. punch
43. pulp
44. test
45. carve
46. shield
47. car
48. fay
49. sheep
50. feign
51. fail
52. rear
53. risk
54. thaw
55. fade
56. pub
57. sheath
58. rig
59. shiek
60. text
61. cock
62. rim
63. ridge
64. rib
65. rip
66. tempt
67. puck
68. cot
69. tend
70. calm
71. face
72. writ
73. wrist
74. rich
75. pump
76. ten

STIMULUS LIST NUMBER FOUR

1. sheave
2. cart
3. tenth
4. fame
5. ring
6. pup
7. faint
8. thought
9. tare
10. ted
11. thorn
12. pump
13. tense
14. punch
15. card
16. faith
17. pug
18. fate
19. rill
20. puff
21. sheep
22. sheen
23. pulse
24. fade
25. shield
26. rear
27. ten
28. pub
29. rick
30. cop
31. car
32. cod
33. tell
34. tent
35. rim
36. thaw
37. shiek
38. phase
39. feign
40. rinse
41. test
42. pun
43. cost
44. text
45. tend
46. rip
47. rid
48. rib
49. fail
50. rig
51. sheath
52. fake
53. thong
54. cock
55. risk
56. ridge
57. putt
58. fay
59. tempt
60. calm
61. rich
62. sheet
63. she
64. face
65. rift
66. cot
67. wrist
68. writ
69. pulp
70. thor
71. puck
72. sheaf
73. cog
74. carve
75. cob
76. punk

APPENDIX D

SAMPLE INSTRUCTION SHEET
AND RESPONSE FORM

SAMPLE INSTRUCTION SHEET AND RESPONSE FORM

NAME______________________ AGE____ SEX: M - F CLASS_____ SEAT NO.__

INSTRUCTIONS

You are going to view a speaker on film saying a number of single-syllable words consisting of a consonant or blend of consonants, a vowel, and then a consonant. Examples of the words you might see are LIGHT, VASE, JEEP, etc. Before you see each word you will hear a tape recording of the word with the beginning sound omitted, and you will also see on your answer sheet a listing of possible printed forms which the word-stem you are to hear might take. For each word you are asked to listen to the stem on the tape recording and note the printed stems appropriate to the item number on your answer sheet. You will then view the entire word spoken by the filmed speaker and are asked to identify the word from what you have heard and seen. Next add the beginning sound to the appropriate printed stem on the answer sheet to form the word you have identified. Always make a response. If you are not certain what the word is, guess, no matter how far-fetched the guess may seem to you.

Note the item on your answer sheet labeled EXAMPLE. Suppose the word jeep were to be shown; you would first hear the stem __eep, then you would glance at your answer sheet and note the possible printed forms as illustrated by the EXAMPLE on your answer sheet. Next you would view the filmed speaker saying the word jeep; and finally you would write the letter J before the stem _ EEP on your answer sheet. Do this now.

After each word is shown, the projector will be stopped so that you may write your response. Remember, always make a response. Guess if you must. Are there any questions?

You will now view a speaker saying five words similar to those you will see during this project. It is not necessary that you write these practice words; merely watch and try to identify them.

EXAMPLE

__EAP
__EEP
__EPE
__IEP

1. __art
__eart

2. __if
__ill
__ille

3. __eave
__eve
__ieve
__ive

4. __at
__ut
__utt

5. __aught
__aut
__ot
__ought

6. __can
__eanne
__een
__ene
__ien

7. __ard
__arred
__aurd

8. __air
__are
__arer
__ayer
__ear
__ere
__earer
__eir
__ierre

9. __ache
__ake
__eak

10. __aight
__ait
__ate
__eat
__eight
__ete

11. __ent

12. __enth

13. __aise
__aize
__ase
__ayes
__ays
__aze
___eas
__eighs
__eys

14. __awer
__oar
__oer
__ohr
__oor
__or
__ore
__orps
__our
__ourer

15. __ap
__op

16. __el
__ell
__elle

17. __ence
__ense

18. __up

19. __ince
__inse

20. __eaf
__eef
__ief

21. __aim
__ame

22. __aith

23. __ug

24. __unc
__unk

25. __aint
__eint

26. __ing

27. __arn
__orn
__orne
__ourne

28. __ob
__uab

29. __eat
__eet
__ete
__ite

30. __ic
__ick
__ique

31. __an
__on
__one
__un

32. __ ad
__aaed
__ahed
__od
__odd

33. __aag
__ague
__ag
__og
__ogg

34. __ead
__ed
__edd

35. __ast
__ossed
__ost

36. __ong

37. __ough
__uff

38. __id

39. __ulse

40. __iffed
__ift

41. __ay
__e
__ea
__ee
__ey
__i
__eigh
__ix

42. __unch

43. __ulp

44. ___east
___essed
___est

45. ___arv
___arve

46. ___ealed
___eald
___eeled
___ield

47. ___aar
___ar
___are
___arr
___our

48. ___a
___ae
___ay
___aye
___ea
___ei
___eigh
___ey

49. ___eap
___eep

50. ___ain
___ane
___ayne
___egn
___eign
___ein
___eine

51. ___ael
___ail
___aille
___aie

52. ___ear
___eer
___eir
___ere
___ier
___ierre

53. ___isc
___isk
___isque

54. ___a
___au
___aw
___awe

55. ___ade
___aid
___aide
___ayed
___ede
___eighed
___eyed

56. ___ub

57. ___eath
___eeth
___eith

58. ___ig

59. ___eak
___eek
___eke
___ic
___iek
___ique

60. ___exed
___ext

61. ___ach
___oc
___och
___ock
___oque

62. ___im
___imb
___ym
___ymn

63. ___idge

64. ___ib

65. ___ip
___ippe
___yp

66. ___eampt

67. ___uck

68. ___acht
___at
___att
___ot

69. ___end
___ende
___enned
___iend

70. ___alm
___om
___omb
___uam

71. ___ace
___aice
___ase
___ass

72. ___it
___itt

73. ___issed
___ist

74. ___ich
___iche
___itch

75. ___ump

76. ___en