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PERCEPTION OF DICHOTICALLY PRESENTED WORDS
ARRANGED IN FOUR CONTEXTS.

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ARRANGED IN FOUR CONTEXTS

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the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

by
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## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>VITA</td>
<td>ii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vi</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>I INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Purpose</td>
<td>7</td>
</tr>
<tr>
<td>The Hypotheses</td>
<td>8</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>9</td>
</tr>
<tr>
<td>Organization of the Report</td>
<td>11</td>
</tr>
<tr>
<td>II A REVIEW OF RELATED LITERATURE</td>
<td>12</td>
</tr>
<tr>
<td>Research on Perception of Diotic Speech</td>
<td>12</td>
</tr>
<tr>
<td>Studies of Speech Perception in Multi-channel Listening Situations</td>
<td>19</td>
</tr>
<tr>
<td>Research Involving Dichotic Presentation of Verbal Stimuli</td>
<td>23</td>
</tr>
<tr>
<td>Research on Speech Perception Which Relates to a Statistical Theory of Communication</td>
<td>38</td>
</tr>
<tr>
<td>III PROCEDURES AND INSTRUMENTATION</td>
<td>45</td>
</tr>
<tr>
<td>The Stimulus Material</td>
<td>46</td>
</tr>
<tr>
<td>Organization of the Stimuli</td>
<td>48</td>
</tr>
<tr>
<td>Recording Instrumentation and Procedure</td>
<td>49</td>
</tr>
<tr>
<td>Procedure for Processing Tape Recorded Stimuli</td>
<td>51</td>
</tr>
<tr>
<td>The Speakers</td>
<td>57</td>
</tr>
<tr>
<td>The Listeners</td>
<td>58</td>
</tr>
<tr>
<td>Instrumentation and Procedure for the Presentation of Test Stimuli and Recording Listeners' Responses</td>
<td>60</td>
</tr>
<tr>
<td>Instructions to Listeners</td>
<td>61</td>
</tr>
<tr>
<td>Treatment of the Data</td>
<td>63</td>
</tr>
</tbody>
</table>

III
TABLE OF CONTENTS (cont.)

The Hypotheses.............................................65
Statistical Treatment of the Data.......................65
Summary of Procedures and Instrumentation.............68

IV RESULTS AND DISCUSSION...............................70

Word-Repetition Scores as a Function of Inter-
Stimulus Word Arrangement...............................70
Listeners' Word-Repetition Scores for the
First and Second 140 Pairs of Stimuli
Heard.......................................................73
Differences in Word-Repetition Scores for
Stimuli Heard in the Right and in the
Left Ear.....................................................77
Discussion of Results......................................77
Summary of Results and Discussion......................88

V SUMMARY AND CONCLUSIONS.............................90

Conclusions..................................................93

APPENDIXES

A STIMULI CONSTRUCTED AND USED BY MARKS AND MILLER..94
B PAIRS OF STIMULI..........................................96
C INSTRUCTIONS TO LISTENERS............................114

REFERENCES................................................115
LIST OF TABLES

Table | page |
-----|------|
1. Summary of an analysis of variance for 24 listeners who heard four classes of stimuli | 71 |
2. Mean word-repetition scores of 24 listeners for four classes of stimuli | 72 |
3. Results of "critical difference" tests between mean word-repetition scores of 24 listeners on four classes of stimuli | 74 |
4. Summary of an analysis of variance for two groups of 12 listeners who heard 280 stimuli in different orders | 75 |
5. Mean word-repetition scores for two groups of listeners who heard 280 pairs of stimuli in a different order | 76 |
6. t-tests for related means between mean word-repetition scores for stimuli heard in the right and left ear | 78 |
7. Summary of an analysis of variance for 24 listeners who heard three types of pairs of stimuli | 83 |
8. Mean percentage word-repetition scores for 24 listeners for three types of pairs of stimuli | 85 |
9. Critical difference tests between mean percentage of word-repetition scores for three types of pairs of stimuli | 86 |
10. Number of stimuli of each class in each of the types of pairs of stimuli | 87 |
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Schematic diagram of equipment used to record the stimuli</td>
<td>50</td>
</tr>
<tr>
<td>2.</td>
<td>Schematic diagram of equipment used to alter the temporal relation between stimuli of each pair</td>
<td>53</td>
</tr>
<tr>
<td>3.</td>
<td>Schematic diagram of equipment used to filter and add noise to the tape recorded stimuli</td>
<td>56</td>
</tr>
<tr>
<td>4.</td>
<td>Schematic diagram of equipment used to compare relative intensity levels between stimuli of each pair</td>
<td>58</td>
</tr>
<tr>
<td>5.</td>
<td>Schematic diagram of equipment used to monitor the intensity levels of the tape recorded stimuli and to present the tape recorded stimuli to listeners</td>
<td>62</td>
</tr>
</tbody>
</table>
CHAPTER I
INTRODUCTION

The perception of speech is facilitated by two ears which jointly serve as an input. Unilaterally deaf individuals function nearly as well as normal hearing persons. Unilateral deafness does make sound localization a very difficult task. The ability to localize sound is dependent upon the semi-independent function of the ears in perceiving intensity and phase differences in the speech signal between ears. Each of the ears receives the signal, it may differ slightly between ears in intensity or time of arrival, yet the signal is perceived as being singular. This condition in which both ears receive identical, or nearly identical, signals was termed diotic stimulation by Stumpf.¹

also initiated the use of the term dichotic stimulation according to Boring.\textsuperscript{2} Dichotic stimulation refers to simultaneous stimulation of the two ears with different stimuli. Boring credits Weber with the first recorded observation of dichotic stimulation. In 1846, Weber wrote "...when two watches are placed near an observer, one on each side of the head, they can both be heard simultaneously."\textsuperscript{3}


Speech perception is negatively affected when two speech signals are received simultaneously, one in each ear. This is very evident to a person who is listening to a telephone conversation with one ear while at the same time trying to perceive a message from a person who
is near. The listener experiences great difficulty in receiving both conversations at once. In like manner, air traffic controllers who routinely monitor incoming messages through a single earphone, while the uncovered ear is used to listen to messages from other members of the traffic control team in the immediate environment, fail to perceive simultaneous messages in their entirety. The controllers have an advantage which the telephone speaker lacks. The vocabulary used in air traffic control is somewhat standard, predictable, and small. The person who is listening to a telephone conversation with one ear and another conversation with the other ear does not have the benefit of a restricted vocabulary with words arranged in a highly predictable verbal context. In terms of statistical communication theory, the messages received by the controller contain less information per word than do the messages received by the person using the telephone. In this sense the word information is used to mean amount of uncertainty or unexpectedness. Words which are not easily predicted to be in a given verbal context contain more information than words which are readily predicted.\textsuperscript{4} This is further

clarified in Chapter II of this report.

The intelligibility of a word is dependent, in part, on the length of the word. The longer the word, the higher is the intelligibility.\(^5\)

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The effect of vocabulary size and the resulting number of alternative choices on the perception of spoken words in different levels of masking noise was demonstrated by Miller, Heise and Lichten. Listeners were more accurate in identifying words from a small known vocabulary than from a large known vocabulary in all levels of masking noise. Words from small vocabularies are more predictable than words from larger vocabularies.\(^6\)

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The results of the above study are in keeping with a generalization by Black: "...the more likely an event of
oral language, the more readily it is perceived.\textsuperscript{7}

\begin{itemize}
\item The users of a given language learn the rules by which it is constructed. For example, a native speaker might say "two boys," but hardly would say "two boy." This, because the speaker has learned a syntactic rule pertaining to the formation of a class of noun-plural words. A native speaker might say "a pretty flower," but probably would not say "pretty a flower" which would not be in keeping with semantic rules of English. The speaker's knowledge of the semantic and syntactic rules of his native language enable him to construct a phrase or sentence which is meaningful to another person who is facile in the use of the same language.

Miller discusses three types of rules which apply to language usage. They are \textit{semantic rules} and \textit{syntactic rules} as mentioned above, and \textit{pragmatic rules}. Pragmatic rules "$...govern the relations between symbols and the user of the symbols."\textsuperscript{8} Only semantic rules
\end{itemize}
and syntactic rules are integrally related to the present research.

Knowledge of the rules by which language is constructed enables a listener to predict, to some extent, words in a sentence or phrase on the basis of preceding words. This is to say that the rules of language contribute to its redundancy. This concept is discussed in Chapter I I of this report.

The use of a word in a sentence or a phrase is constrained, to some extent, by its syntactic and semantic relationship to preceding words. This fact raises questions about the effects of various types of word milieu on speech perception. Miller and Isard have demonstrated the effects of semantic and syntactic constraint on the perception of words in a noise environment.
One of the purposes of the present research was to determine the perceptual effects of dichotic presentation of words in various verbal contexts.

**Purpose**

The purpose of the research under discussion was to investigate the effect of four different verbal contexts on the perception of dichotically presented words. The stimuli were those used by Marks and Miller and consisted of 50 words arranged to form 40 five-word stimuli. The five-word stimuli were arranged in four verbal contexts: (1) Context A, which Marks and Miller termed "sentences," had conventional syntactic and semantic constraint; (2) Context B, "semantically anomalous" sentences which had syntactic structure identical to Context A stimuli; (3) Context C, stimuli termed "anagram strings" by Marks and Miller consisted of sentences of Context A with the word order somewhat scrambled resulting in an agrammatical series of words with semantic components identical to sentences of...
Context A; (4) Context D, stimuli termed "word lists" by Marks and Miller which were formed by scrambling anomalous sentences. The word lists possess neither the syntactic structure nor the semantic components of the original sentences. Examples of the stimuli are:

- Context A - Furry wildcats fight furious battles.
- Context B - Furry jewelers create distressed stains.
- Context C - Furry fight furious wildcats battles.
- Context D - Furry create distressed jewelers stains.

The stimulus material is more completely described in Chapter III, and the stimuli as they were used by Marks and Miller are found in Appendix A.

The Hypotheses

The following hypotheses were tested.

1. There is no difference in listeners' perception of dichotically presented words when the words are in the four verbal contexts, A, B, C, and D.

2. There is no difference in listeners' perception of words, in the four verbal contexts, between the first and the second half of the total of the dichotic pairs of stimuli.

3. There is no difference in listeners' perception of words in verbal contexts A, B, C, and D between those stimuli heard in the left ear and those heard in the right.
Definition of Terms

For the purposes of this report, the following definitions are applicable.

**Context A Stimuli**  Context A Stimuli are five-word sentences having conventional semantic and syntactic constraint.

**Context B Stimuli**  Context B Stimuli are five-word sentences having syntactic structure which is identical to that of Context A Stimuli. Context B Stimuli are semantically anomalous.

**Context C Stimuli**  Context C Stimuli are five-word strings formed by rearranging the words of Context A Stimuli. Conventional syntactic structure is absent in Stimuli of Context C.

**Context D Stimuli**  Context D Stimuli are strings of words formed by scrambling the word order of Context B Stimuli. Stimuli of this context have neither the syntactic structure nor the semantic components of Context A Stimuli.

**Dichotic Stimulation**  Dichotic stimulation is the simultaneous stimulation of the two ears by different stimuli. (This definition and the following one of diotic stimulation are based on Stumpf's definitions.)
Diotic Stimulation  Diotic stimulation is the simultaneous stimulation of the two ears by the same stimulus.

Time of Onset  Time of onset is used to describe the time, relative to a reference time, at which the first sound waves of the first word of a stimulus are perceived on an oscilloscope.

Verbal Context  "The verbal context of any particular verbal unit is made up of the communicative acts that surround it." 12 In the present report, verbal contexts

A, B, C, and D correspond to the "types of stimuli constructed by Marks and Miller. The "types" are (1) sentences, (2) anomalous sentences, (3) anagram strings, and (4) word lists. 13

12 George A. Miller, op. cit., p.81.

Word-Repetition Score  The word-repetition score is a measure which indicates the number of words correctly perceived and repeated by a listener from a five-word stimulus.

Organization of the Report

The report is divided into five chapters. Chapter I includes the introduction and purpose of the study, the hypotheses to be tested and definitions of terms used. Chapter II contains a review of related literature. Chapter III is a description of the experiment, including the stimulus material, speakers, listeners, data recording and processing and instrumentation. In Chapter IV, there is a presentation and discussion of the results of the experiment. The final chapter consists of the summary and conclusions of the research.
CHAPTER II
A REVIEW OF RELATED LITERATURE

Many research reports dealing with dichotic listening, selective attention to verbal stimuli and speech perception have been published. Some of these researches are reviewed in the present chapter although they are not directly related to the topic of the present report. These researches are cited because they represent different methodologies and present various concepts which serve as "background" for the rationale and design of the present research.

The review of research is organized under the following categories: (1) research involving diotic presentation of speech stimuli, (2) research on speech perception in multi-channel listening situations, (3) research involving dichotic presentation of verbal stimuli, and (4) research on speech perception which relates to a statistical theory of communication.

Research on Perception of Diotic Speech

A practical problem encountered in many communication situations involves understanding a speaker against
background of one or several irrelevant messages. It becomes obvious in a party situation that speech can serve to mask speech. Miller demonstrated that speech is slightly less effective than white noise in masking speech.  


Perception of diotic speech messages is affected by factors other than masking. Dirks and Bower reported the results of several experiments designed to test the effect of semantic context or "meaning" of a competing speech message on the identification of "synthetic sentences" which were third order approximations to "real sentences." The synthetic sentences were not "meaningful" as a result of the means by which they were constructed. Competing messages comprised of prose read by the same speaker were mixed with the synthetic messages. Listeners attempted to recognize the synthetic sentences in the presence of the prose in a second condition, in the presence of the prose played backward. By playing the prose backward all semantic content was destroyed while the frequency spectrum of the prose
was maintained. Listener performance under the two conditions was not significantly different at any message-to-competing-message intensity ratio. Dirks and Bower interpreted this finding as supportive of studies which demonstrate that the masking efficiency of speech on speech is due to the spectral characteristics of the speech rather than semantic properties. A serendipitous finding led Dirks and Bower to construct a follow-up experiment. When the primary and forward prose competing messages were at the same intensity, listeners experienced difficulty in separating the two messages. This difficulty was not experienced when the same prose played in reverse served as the competing message. This unexpected result led to a second experiment in which Latin prose was substituted for the English prose. Results were identical to the first experiment in that Latin prose played forward interfered more than Latin prose played backward, with the perception of synthetic sentences. This result was interpreted as an indication that differences in temporal pattern created by reversing the competing message provided cues which are useful in separating a primary from a competing message. It was concluded that semantic factors have no measurable effect on listeners' ability to keep diotic messages separate in the auditory system. 15
Other studies of speech perception in diotic listening situations have been conducted by Cherry. Cherry lists several factors which enable a person to recognize what one person is saying while others are speaking at the same time. The factors as stated by Cherry are:

(a) The voices come from different directions.
(b) Lip-reading, gestures and the like.
(c) Different speaking voices, mean pitches, mean speeds, male and female, and so forth.
(d) Accents differing.
(e) Transition-probabilities (subject matter, voice dynamics, syntax...)

Cherry noted that all of the above factors except the last (e) may be eliminated by recording two messages on the same magnetic tape. Under this condition, the messages remain separable as shown by numerous reports.
Cherry postulated that listeners are able to discriminate between diotic messages on the basis of a knowledge of the statistics of language. He termed the separation of messages "statistical separation." To demonstrate statistical separation of messages experimentally, Cherry used one speaker who recorded two prose speeches simultaneously on magnetic tape. Listeners experienced little difficulty in separating the messages after hearing them an unlimited number of times. Errors which did occur were "probably" in accord with the statistics of language. Cherry conducted a second experiment which differed only in the stimulus material used. Cliches were used in place of the prose. Listeners were not efficient in separating the cliches. This finding was attributed to the fact that it was more difficult to make use of transition probabilities between words and phrases for the cliches than for the prose.17

17 Ibid., pp.975-977.

Effects of time of occurrence of extraneous messages on the perception of primary messages in a diotic listening situation were studied by Peters. He used multiple-choice
Intelligibility test words and monosyllabic words as primary messages. The competing or "extraneous messages" were comprised of other monosyllabic words or in the case of the multiple-choice intelligibility words, extraneous messages were words similar in phonetic content to the primary message, words unrelated to the primary message, nonsense words, flight phrases, and babel. Extraneous messages either immediately preceded or followed primary messages. Peters' data indicated that nearly all of the extraneous stimuli had a detrimental effect on the perception of primary words. Extraneous messages which followed primary messages had a larger detrimental effect on perception than did extraneous messages which preceded primary messages. 18


Data obtained by Dirks and Bower and by Peters have at least one factor in common. The results of both researches indicated that when the primary and extraneous message have a similar temporal pattern, perception of the primary message is reduced. The above
studies illustrate that message reception in a diotic listening situation is impaired by factors which include peripheral masking and temporal and phonetic similarity between the primary and irrelevant message.

Broadbent constructed two experiments to test the importance of central, as opposed to peripheral, auditory processes in the perception of diotic speech messages. In the first experiment, two groups of listeners heard questions presented diotically. The first group was instructed by a "visual indicator" to listen to and answer one or the other of the two simultaneous questions. The nature of the visual indicator was not reported. The other group was not instructed to listen to a particular voice, only to answer one of the two questions. Listeners who were instructed to answer the question asked by a particular voice did so more efficiently than those listeners who were instructed to answer one of the questions without regard to a particular voice. In a second experiment, Broadbent eliminated the effects of peripheral masking by "stretching out the questions." This was done by splicing the tape recorded signals. For example, the two questions, "is it raining today?" and "are they going outside?" would be heard as "is are it they raining going today outside." Two groups of listeners heard the stimuli
under conditions identical to those of the first experiment. The results of the second experiment were similar to the results of the first. Listeners who were instructed to answer questions asked by a particular voice responded more efficiently than listeners who were merely instructed to answer one of the two diotic questions. On the basis of these two researches, Broadbent concluded that the difficulty in the perception of competing messages "...is clearly one within the central nervous system."19


Studies of Speech Perception in Multi-channel Listening Situations

Perception of one of several simultaneous signals requires that the signal be kept separate from the competing signals in the auditory system. Several properties of messages have been shown to serve as cues which aid the listener in keeping them separate in multi-channel listening situations. Among the factors which aid the listener to perceive one of several messages
are differences in spatial location of the message sources and differences in the frequency spectra of the messages.

Spieth, Curtis, and Webster studied multi-channel listening under several conditions. They tested listener recognition of a verbal message in the presence of two similar messages. In one condition the message to be repeated was mixed with the other messages and was put through a single loudspeaker. In a second condition, each of the messages was heard from a separate loudspeaker. The third and fourth conditions were identical to the first and second conditions, respectively, except that each of the three messages had different spectral characteristics as a result of band-pass filtering. Results of the experiment indicated that spatial separation of the three messages (obtained by using three speakers) enabled listeners to recognize a given message more effectively than when all messages came from a single speaker. Difference in spectrum between the messages was an aid to message recognition in the single speaker and multi-speaker conditions. 20

Webster and Thompson also found spatial separation of the message source to be useful in separating one message from several. They used six messages, each message coming from a separate speaker. This arrangement yielded higher listener efficiency in listening to a single message than when all were heard from one speaker. In addition, Webster and Thompson used a "pull down" arrangement which enabled the listener to monitor any one of the six messages through a single speaker which was located closer to the listener's ears. This provision was clearly effective in improving listener efficiency in responding to one message at a time.

Webster and Thompson list differences in voice quality, density of the message, and intensity, as cues which might be used to keep messages separate.  


Broadbent presented pairs of short verbal messages simultaneously through two loudspeakers with one message at a time coming from each of the loudspeakers. The listeners were to respond to only one of the questions heard. Spatial separation of the loudspeakers was
shown to improve listener efficiency in replying to the questions. In a second condition, the questions were stereophonically presented through the separated speakers. In this condition, both messages were put through both speakers with one message delayed two milliseconds in one speaker and the other message delayed the same amount of time in the other speaker. The stereophonic separation of messages resulted in higher efficiency in replying to one of the questions than was found without stereophonic separation of messages.\footnote{22}{Donald E. Broadbent, "The Role of Auditory Localization in Attention and Memory Span," \textit{Journal of Experimental Psychology}, LXVII (1954), 191-196.}

Diotic, multi-channel, and dichotic listening situations result in perceptual problems which are quite similar in many respects. Dichotic presentation of stimuli results in some perceptual effects which are not found in diotic and multi-channel listening situations. Literature dealing with dichotic listening is reviewed in the following section.
Research Involving Dichotic Presentation of Verbal Stimuli

Listeners are able to attend selectively to one of two dichotically presented messages effectively as has been shown experimentally by Cherry. He presented different speeches to each of the listeners' ears through earphones. Listeners were asked to "shadow" one of the speeches, that is, repeat the speech while hearing it. Listeners found the task to be "surprisingly easy." In another experiment, the two speeches both started in English. As the listener shadowed the message from one ear the message in the other, or "rejected," ear was changed to German. Listeners were found to be unaware of the change in language in the rejected ear. Further experiments of the same type were devised to determine what factors of the "rejected message" are recognized. It was determined that a change from male to female voice and a change from voice to 400 Hz pure tone were nearly always noted by the listener. A change from speech to reversed speech was identified as "having something queer about it" by only a few of the listeners.\(^{23}\)

\(^{23}\)E. Colin Cherry, op. cit., p.978.
Broadbent proposed a "filter mechanism" to explain the ability to attend to one dichotic message while disregarding the message in the opposite ear. He viewed the human nervous system as a single communication channel having limited capacity. Input to the channel would be selected or "filtered" on the basis of physical features including intensity, pitch, and spatial localization. Incoming information may be held in a storage mechanism "on the order of seconds" to be passed through the communication channel when the filter mechanism selects the class of events to which it belongs.24


Several dichotic listening studies have indicated a possible fault in Broadbent's "filter hypothesis." Gray and Wedderburn presented dichotic verbal stimuli which were meaningless if the listener repeated stimuli presented only to one ear. However, the stimuli formed a meaningful sequence of words if words and syllables were selected alternately from each ear. Listeners reported the meaningful sequence of words rather than the series of words and syllables presented to one ear or the other.25 The findings of Gray and Wedderburn
are incongruous with Broadbent's "filter hypothesis" which states that the filtering mechanism operates after analysis of general characteristics of sounds such as their location, frequency, and intensity, and rejects irrelevant messages before words and meaning are identified. It would seem that the listeners in the Gray and Wedderburn study were able to select from the words and syllables which were received at each ear on the basis of meaning.

Triesman used a modification of an unconventional methodology developed by Cherry in a study of the monitoring and storage of irrelevant messages. The technique consisted of presenting identical messages to both ears with one of the messages delayed a variable amount of time. The method required listeners to listen to and repeat the message in one ear and to disregard the message in the other. The time differential between
messages was gradually reduced until listeners spontaneously noted that the messages were identical. Triesman attempted to obtain an indication of the approximate delay time between related dichotic messages which was necessary for detection of similarities between the two messages. The listener's task was, as in Cherry's experiment, to shadow one message while ignoring the message in the contralateral ear. The measure used in Triesman's experiment was the delay time between messages at which listeners spontaneously noted some similarity between the dichotic messages. Several types of irrelevant messages, that is, messages to be ignored, were used. They were: (a) identical messages, (b) identical messages with different speakers, (c) meaning and voice the same, with language of the two messages different (French and English), and (d) identical messages both played backward. Triesman found that listeners were able to note the similarity of the two messages while shadowing one of the messages even when the messages were spoken by different speakers and also when the messages were in different languages. Triesman concluded that "...the comparison between messages must be made at a central level, and required the identification of words and meaning rather than a simple analysis of the sounds, since S's noticed the identity of the messages even when they were spoken
by different speakers or in different languages. \(^{27}\)

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Another study which is incongruous with Broadbent's filter theory and suggests that the content of both dichotic messages is analyzed prior to acceptance of one and rejection of the other was conducted by Moray. He presented dichotic verbal messages to listeners who were instructed to listen with either their left or right ear. The listener's name was recorded among the words which were presented to the ear contralateral to the ear to which the listener was instructed to attend. Moray found that some of the listeners switched attention to the message which included their name at the time that the name was presented. \(^{28}\)

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In explaining the tendency of listeners to switch attention from a "relevant" to an "irrelevant" stimulus,
Triesman credits two properties of the stimulus as causes of the phenomenon. "The two important factors seem to be subjective 'importance' and high probability or relevance to what is being attended to."  

Deutch and Deutch state that "...review of the behavioral evidence leads us to the probable conclusion that a message will reach the same perceptual and discriminatory mechanisms whether attention is paid to it or not; and such information is then grouped or segregated by these mechanisms."  

It seems likely that Broadbent's filter theory is in need of slight revision if it is to explain some of the above cited research results. Specifically, "statistical separation" must include separation of simultaneous messages on the basis of linguistic meaning as well as on the basis of frequency, intensity,
duration, etc. of the message. Broadbent's filter theory has been valuable in inspiring research.

The remaining studies reviewed in this section of the report were designed to investigate asymmetry in function between ears under conditions of dichotic stimulation. Kimura presented dichotic digits to listeners who had a lesion affecting the left temporal lobe and to listeners who had lesions in other portions of the brain. She found all groups to be more accurate in reporting materials presented to the right ear.\footnote{Doreen Kimura, "Some Effects of Temporal-Lobe Damage on Auditory Perception," \textit{Canadian Journal of Psychology}, XV (1961), 156-165.}

Kimura also found that unilateral temporal lobectomy impaired the recognition of digits arriving at the ear contralateral to the brain tissue excision. Before and after the operations, the performance of patients with lesions of the left temporal lobe was inferior to that of patients with lesions of the right temporal lobe in recalling digits.\footnote{Doreen Kimura, "Cerebral Dominance and the Perception of Verbal Stimuli," \textit{Canadian Journal of Psychology}, XV (1961), 166-171.}
Kimura's finding of right ear superiority in dichotic listening situations (mentioned above) was further investigated by Inglis and Bryden. Both authors investigated the possibility that the listeners were merely reporting the message from the right ear first. It has been shown by Broadbent that listeners report more accurately the dichotic message which they report first. A probable explanation for this phenomenon is that the message which is reported second is forgotten to a greater extent than is the message reported first.

Bryden eliminated the variable of number of times the right and left ear messages were reported first.

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by instructing listeners to report the message from one ear first and then the message from the other ear first in an alternating fashion. The supposition was that a difference between right ear and left ear recall scores could be attributed to a "...true perceptual difference" between ears. Bryden concluded that right ear superiority for verbal dichotic material exists even when order of report is controlled.\footnote{M.P. Bryden, \textit{op. cit.}, pp.104-105.}

Kimura investigated right-left differences in the perception of dichotic melodies using a recognition task. Listeners heard two melodies, one in each ear, and then selected the melodies from among four melodies played binaurally. Listeners indicated the melodies heard by saying, for example, first and fourth or any combination of melodies which they recognized. Kimura's data indicated a significant left ear superiority for recognition of dichotic melodies. She concluded that the left-ear superiority for music was analogous to the right ear superiority for speech. Kimura proposed that the left-right asymmetries in the perception of dichotically presented speech and music are indicative
of an asymmetry of function in the cerebral hemispheres.\textsuperscript{37}


Broadbent and Gregory noted that \textit{recall} of dichotically presented speech was better for the right ear as shown by Bryden while \textit{recognition} of dichotically presented music was better for the left ear as demonstrated by Kimura. To test the possibility that the difference in testing techniques was responsible for the reported asymmetries, Broadbent and Gregory tested for recognition of dichotically presented digits. It was found that recognition scores were significantly higher for the right ear.\textsuperscript{38}


To test the hypothesis that there is no right-left ear difference in the perception of monaurally presented verbal stimuli, Dirks constructed an experiment
using filtered monosyllabic words. The words were presented to listeners monaurally, dichotically with listeners instructed to repeat the words heard in one or the other ear, and dichotically with listeners instructed to repeat the words heard in both ears. Right- and left-ear intelligibility scores for monaurally presented words were not significantly different. Significantly higher right-ear intelligibility scores were obtained when subjects were instructed to repeat the words from both ears. No significant difference between right- and left-ear scores was found when subjects were instructed to report the words heard in one or the other ear while disregarding the dichotic message in the contralateral ear.  


In a later study, Kimura used conditions similar to the conditions used by Dirks (as described above). However, when Kimura's listeners were asked to report the message in the right ear only, or the left ear only, a significantly higher score was obtained for the right ear. This finding supports Kimura's supposition that
hearing different stimuli at the two ears appears to be a necessary condition for obtaining asymmetrical recall scores between ears, while reporting the stimuli from both ears is not.  

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In an attempt to provide information about differences between right- and left-handed persons on dichotic listening tasks, Curry conducted an experiment using right- and left-handed listeners on two verbal tasks and one non-verbal task. The verbal listening tasks were of two kinds. One was comprised of meaningful words and the other of nonsense syllables. The non-verbal task was comprised of familiar environmental sounds. Curry found that right- and left-handed listeners obtained significantly higher recall scores for the right ear on both of the verbal tasks. This finding seems to indicate that the right-left difference in the perception of dichotic stimuli was unaffected by semantic factors. The left ear scores were higher for both groups of listeners on the non-verbal dichotic listening task.
In a similar experiment, Curry and Rutherford presented three types of dichotic verbal materials to right-handed and left-handed listeners. The stimuli were (1) semantically meaningful words having a high frequency of occurrence, (2) functional words which serve a non-semantic, syntactic role in language, and (3) non-meaningful nonsense syllables. Of the three types of dichotic stimuli, function words were most successfully repeated following dichotic stimulation and nonsense syllables were least successfully repeated. Difference scores between the right and left ears for left-handed subjects were smaller than those for right-handed subjects. No significant difference between right-ear and left-ear scores was found when the stimuli were comprised of function words. The authors suggested that verbal materials most easily recognized and recalled may produce smaller differences between right-ear and left-ear scores under dichotic stimulation.
Asymmetry in auditory perception was investigated by Brunt and Geotzinger using three tests which are potentially useful as clinical tools to assess integrity of the central auditory nervous system. The tests were (1) Kimura's dichotic digits; (2) two filtered lists of monosyllabic words arranged for dichotic presentation by Dirks; and, (3) Katz's Staggered Spondaic Word Test. The first and second tests use dichotically presented stimuli. The third test is not truly dichotic. It is described as follows:

The Katz test consists of 40 test items, each of which incorporates two spondees. They are arranged so each ear is exposed to both non-competing and competing conditions. For example, the right ear might receive the word "up-stairs" and the left, the word "down-town." However, "up" would arrive alone at the right ear (Right Non-Competing condition) with "stair" and "down" simultaneously and respectively presented to the right (Right Competing) and left (Left Competing) ears. "Town" would then be heard alone in the left ear. (Left Non-Competing condition). To avoid ear order effects the lead ear is alternately the right or left.
Brunt and Geotzinger used normal hearing subjects. A right ear dominance effect was demonstrated for the Kimura test comprised of dichotic digits and the Katz Staggered Spondaic Word Test. No significant difference in perception between right and left ears was demonstrated with Dirks' filtered dichotically presented monosyllabic words. The authors suggested that demonstration of ear dominance is test dependent.

Literature dealing with perception of dichotic stimuli is diverse in scope as shown by the review in this section of Chapter II. The research methodology has differed from study-to-study. Most importantly, the objectives of the various researches cited have been different. Some tentative generalizations might be formulated. With regard to methodology; there is no difference in listeners' perception of verbal stimuli when they must recall, as opposed to recognize, the stimuli. The same generalization might be made for musical dichotic stimuli.

Listener perception of dichotic verbal stimuli
presented to the ear contralateral to the ear used to perceive a message is limited. Only "highly meaningful" and "relevant" words are perceived. Perception of dichotic verbal stimuli seems to be unaffected by the semantic content of competing stimuli. A final tentative generalization might be that Broadbent's filter theory is applicable in most dichotic listening situations where verbal stimuli are used. The theory does not explain listeners perception of "irrelevant" messages in certain instances.

The following section of this chapter deals with research on perception of speech in non-dichotic situations. It is included as background information for the present study.

**Research on Speech Perception Which Relates to a Statistical Theory of Communication**

Speech perception has been studied by scientists in the fields of psychology, speech science, engineering, linguistics, physiology and many other fields. Each discipline contributes to the body of information related to speech perception. However, the contributions of each discipline must necessarily be constrained by the limitations in the scope of that discipline. Theories of speech perception differ, in part, due
to the discipline of the respective theorists. On this basis, it is not surprising that some of the theories of speech perception are seemingly complimentary rather than contradictory.

Statistical communication theory is an outgrowth of the technological gains in telecommunications systems. It was originated by Hartley, an engineer, to aid in determining the capacity of telecommunication systems. Hartley defined information as "the successive selection of signs or words from a given list, rejecting all 'meaning' as merely a subjective factor." Although


this definition of information proved to be useful in telecommunication measurements, it was not applied, by Hartley, to voice communication. Shannon and Weaver stated that a mathematical or statistical theory of communication could be applied to the measurement of semantic content of a message. 45

To measure semantic content of a message, the term information was defined as the amount of one's freedom of choice or uncertainty in selecting a message. The unit of information is a binary digit or "bit." which is designated as $H$. Information is the number of yes-no decisions which are to be made. Bits of information might be computed using the formula $H = \log_2 N$ where $N$ is equal to the number of equally available alternative choices.  


A slightly different definition of information was proposed by Garner:

Information is something we get when some person or machine tells us something we didn't know before... Thus information occurs only if there exists some a priori (sic) uncertainty, and the amount of information is determined by the amount of the uncertainty ---or, more exactly, it is determined by the amount by which the uncertainty has been reduced.  

Garner used the same means of computing information as did Shannon, only the nomenclature was changed. Garner defined information as $U = \log_2 K$ where $U$ equals uncertainty and $K$ is equal to the possible number of equally likely outcomes or the number of categories. The use of the base 2 for the logarithm of the number of categories is merely a convention used to establish a constant unit of measurement.

As applied to the communication of verbal messages, the amount of information per word is reduced by redundancy.

If the successive units in a message are related, if the probability of a unit depends upon the units that precede it, these relations reduce the amount of information that a single unit can carry. When any restricting relations of this sort exist, it means that the same amount of information could be coded more rapidly in a language that had the same number of independent alternatives. In a sense, therefore, contextual dependencies mean that a message source is repeating itself.48


Redundancy is built into languages in diverse ways including prosodic features, semantic features and
syntactic features. No general laws exist for the construction of redundancy in languages. Listeners profit from redundancy in that it enables them to "fill in" missing words on the basis of knowledge of the statistics of language called a "store of verbal habits" by Cherry.

Two attributes of English which aid listeners to perceive it are semantic redundancy and syntactic redundancy. Due to the redundant construction of language, a word is more easily perceived if it is contextually constrained, that is, dictated by semantic and syntactic rules which are based on the words which surround the word to be perceived. Semantic and syntactic rules thus increase or decrease the probability of a given word occurring in a given context.

Broadbent notes that "the probability of a word being heard correctly varies with the probability of that word occurring in a particular situation. A

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49 E. Colin Cherry, op. cit., pp. 119-121.

50 Donald E. Broadbent, op. cit., p. 13.
more probable word carries less information and has a higher probability of being heard correctly than a less probable word. This fact was demonstrated experimentally by Miller, Heise, and Lichten. In an attempt to estimate the importance of the size of an intelligibility test vocabulary listeners were acquainted with vocabularies of 2, 4, 8, 16, 32, 256, or an unlimited vocabulary. The results of the experiment indicated that as the size of the test vocabulary increases, it is necessary to provide a more favorable signal-to-noise ratio in order to maintain a given level of accuracy in repeating the words. Words in sentences were found to be significantly more intelligible than the same words in isolation if the signal-to-noise ratio was the same.51


This chapter included a review of literature in the areas of diotic, multi-channel and dichotic listening and a brief review of some basic tenets of a statistical theory of communication. In the following chapter
is a description of the procedures and instrumentation which were used in the research under discussion.
CHAPTER III
PROCEDURES AND INSTRUMENTATION

Researches involving dichotic listening have used various kinds of stimuli including pure tones, clicks, random noise, and filtered and unfiltered speech and music. The tasks of listeners have also been varied. Some of the tasks have been (1) to listen to stimuli in one or the other ear exclusively; (2) to listen alternately to the stimuli in one and then the other ear; and, (3) to listen to both stimuli.

Upon hearing the stimuli, subjects have been asked (1) to determine which stimulus of a pair was perceived first; (2) to recall the verbal stimulus and reproduce it, sometimes in writing; (3) to reproduce the verbal stimulus as it is heard in a continuous passage; and, (4) to identify the stimulus after hearing it a second time.

For the purpose of the present research, listeners were instructed to attend to the verbal stimuli in both ears and to say aloud afterward as many words as possible from both of the stimuli of each pair after they heard the stimuli.
The Stimulus Material

Verbal stimuli which were constructed and used by Marks and Miller were utilized in the present research. The verbal stimuli (1) had an equal number of words; (2) were so constructed as to provide variation in the context in which individual words were located; and, (3) consisted of a small vocabulary. It was decided to use stimuli constructed by Marks and Miller even though the stimuli were constructed for a purpose other than dichotic presentation. Marks and Miller describe the construction of the five-word stimuli as follows:

Five normal sentences of five words each with identical syntactical structures (adjective-plural noun-verb-adjective-plural noun) were constructed. From these original sentences five more sentences were derived by taking the first word from the first sentence, the second from the second and so on. The syntactic structure of these derivative sentences remained identical to that of the normal sentences, but, because of the word substitutions, the derivative sentences were semantically anomalous.

In addition, two other types of strings of words were derived. The first, which we shall call anagram strings, was constructed by taking each of the normal sentences and scrambling the word order, each sentence being scrambled somewhat differently in order to avoid the possibility of S's noticing any pattern, with care being taken that none of the scrambled sentences was grammatical. Thus nothing was done to the semantic components of these sentences,
but the normal syntactic structure was
destroyed. Finally, strings of words we
shall call word lists were similarly
formed by scrambling the word order of the
anomalous sentences. The word lists
preserved neither the syntactic structure
nor the semantic components of the original
sentences.52

52 Lawrence E. Marks and George A. Miller, "The
Role of Semantic and Syntactic Constraints in the
Memorization of English Sentences," Journal of Verbal
Learning and Verbal Behavior, 11(1964), 1-12.

The stimuli constructed by Marks and Miller are
reproduced in Appendix A. The pairs of stimuli used
in the present study are included in Appendix B.

In the interest of brevity, the stimuli which
Marks and Miller termed sentences will be termed
Context A Stimuli for the purposes of the present study.
Examples of Context A Stimuli are as follows:

Furry wildcats fight furious battles.
Respectable jewelers give accurate appraisals.

In like manner, anomalous sentences are termed Context
B Stimuli. Examples are:

Furry jewelers create distressed stains.
Respectable cigarettes save greasy battles.

Anagram strings are termed Context C Stimuli. Examples of
Context C Stimuli are:

Furry fight furious wildcats battles.
Jewelers respectable appraisals accurate give.
The stimuli which Marks and Miller called word lists will be designated as Context D Stimuli. Some examples are:

Furry create distressed jewelers stains.
Cigarettes respectable battles greasy save.

The organization of the stimuli is described in the following section.

Organization of the Stimuli

The five-word stimuli were arranged in pairs such that the stimuli of each context were paired an equal number of times with stimuli of each of the other contexts and stimuli having the same context. No stimulus was paired with itself. The 280 pairs of stimuli were recorded on two 140-item tapes. Each tape contained 70 stimuli of each Context A, B, C, and D. Of the total of 280 pairs of stimuli, 40 pairs had all words in common between pairs with the words arranged in different sequential order. Eighty pairs of stimuli had one word in common. The remainder of the stimuli (160 pairs) had no word in common between stimuli. The pairs of stimuli were arranged in a manner which prohibited a given stimulus from occurring in two successive pairs of stimuli. Five speakers were rotated in a 1, 2, 3, 4, 5 order throughout the 280 pairs of stimuli. Both of the five-word stimuli which formed a
given pair of stimuli was spoken by the same speaker. The manner in which the pairs of stimuli were recorded is explained in the following section.

Recording Instrumentation and Procedure

All stimuli were recorded on Scotch brand, number 111, magnetic tape moving at 7\(\frac{1}{2}\) inches per second on a Magnecord Model 1022 dual-channel tape recorder. Input was from an Altec 525-A power supply fed by an Altec 21-D condensor type microphone located approximately 10 inches in front of the speakers' lips. Speakers were seated, one at a time, in an Industrial Acoustics Company Model 400-A sound-treated booth. They practiced reading the stimuli several times while monitoring the intensity of their voices on a VU meter. The speakers attempted to "peak" the VU meter at zero while saying the stimuli. Eight five-word stimuli were recorded at thirty-second intervals on one channel of the tape recorder. The tape was then re-wound and the cognate stimuli were recorded at thirty-second intervals on the second channel of the tape recorder. This process was then repeated for succeeding groups of 8 pairs of stimuli. A diagram representing the recording equipment is in Figure 1.
Figure 1. Schematic diagram of equipment used to record the stimuli.
To achieve close correspondence between the time of onset of the stimuli recorded on Channel One and the cognate stimuli recorded on Channel Two of the tape recorder, the thirty-second intervals were marked on the tape at corresponding distances. By viewing the thirty-second interval markers on the tape, the experimenter was able to signal the appropriate time-intervals to the speaker. The speakers wore an insert microphone by which they could hear the signal given by the experimenter who was located outside of the booth. After each of the five speakers had recorded 56 pairs of stimuli, each pair of stimuli was spliced to form a "tape-loop" for further processing.

Procedure for Processing Tape Recorded Stimuli

After each of the pairs of stimuli had been recorded on magnetic tape which was subsequently spliced to form "tape-loops", with one pair of stimuli recorded on each tape loop, it was possible to alter the intensity relationship and the relative time of onset of the stimuli. Both stimuli of a pair were made as nearly equal in intensity and as nearly simultaneous in time of onset as possible. Difference in time of onset between dichotic messages presumably results in listeners
attending to the message which is heard first if the two are nearly equal in intensity.\textsuperscript{53}


The equipment used in these procedures is diagrammed in Figure 2. Each successive tape-loop was placed on a Magnecord Model 1022 dual-channel tape recorder which was in the "play" mode of operation. The output of each of the channels of the tape recorder was monitored, simultaneously, on a Tektronix 502-A dual-trace persistence oscilloscope set to trigger and record automatically at a voltage level corresponding to a level slightly higher than the voltage equivalent of the noise on the tape loop. The noise was caused by the irregularity in the tape at the point of the splice. The initial portions of the first words of the pair of stimuli recorded on the two channels were compared visually, on the oscilloscope, to determine which channel carried the stimulus that was leading in time of onset. This stimulus was fed to one channel of a second magnecord Model 1022 tape recorder. A custom
Figure 2. Schematic diagram of equipment used to alter the temporal relation between stimuli of each pair.
designed and fabricated audio-delay unit was in the line. The stimulus which lagged in time of onset was fed directly to the remaining channel input of the second tape recorder. Both stimuli were visually monitored on a Tektronix 502-A dual-trace persistence oscilloscope prior to being recorded on the second tape recorder. By adjusting the delay time which was introduced into one of the channels by the audio delay unit, it was possible to re-record the stimuli on the second tape recorder with the time of onset of both stimuli nearly simultaneous. The relative intensity levels of the stimuli were adjusted using the "record intensity" controls of the second tape recorder. The intensity of each stimulus was adjusted such that the most intense portion of the stimulus "peaked" at zero on the VU meter.

The pairs of stimuli were recorded with an interval of 12 seconds between the final word of one pair of stimuli and the onset of the first word of the next pair. No attempt was made to match the duration of the stimuli which were paired.

Difference in frequency spectrum between dichotic messages has been shown by Egan, Carterette, and Thwing, and Spieth, Curtis, and Webster to provide a cue by which a listener may more easily attend to
one message to the exclusion of the other.\textsuperscript{54, 55} To reduce the inter-channel difference in spectra, the stimuli on both channels were filtered using Allison 2-AR and 2-B variable high- and low-pass filters connected in series in each channel. The "roll-off" characteristics of the filter systems was approximately 60 dB per octave. The filters were adjusted to pass frequencies above 210 Hz and below 4800 Hz.

To reduce further spectral differences between channels, speech frequency random noise produced by a Grason-Stadler Model 901B Noise Generator was mixed with the filtered stimuli at a 20 dB signal-to-noise ratio. The filtered stimuli with -20dB noise were then re-recorded on a Magnecord Model 1022 tape recorder with attention to maintaining the intensity relationship between channels. Equipment used in the above procedures is diagrammed in Figure 3.


\textsuperscript{55} W. Spieth, J.F. Curtis, and J.C. Webster, "Responding to One of Two Simultaneous Messages," The Journal of the Acoustical Society of America, XXVI (1954), 391-396.
Figure 3. Schematic diagram of equipment used to filter and add noise to the tape recorded stimuli.
Since speech fluctuates continually in intensity it would be impossible to obtain dichotic verbal stimuli which are equally intense throughout their duration. In order to match the intensity of the dichotic verbal stimuli as nearly as possible the most intense sound of each stimulus was used as a measure relative to the intensity of a 1000 Hz tone. The stimuli were recorded, one channel at a time, on a General Radio Company Model 1521-B graphic level recorder as diagrammed in Figure 4.

The difference between the most intense portion of each of the 560 stimuli and the 1000 Hz tone was measured. The mean value for 280 of the stimuli on one of the channels was -3.9 dB re the 1000 Hz pure tone. The mean difference between the points of highest intensity of the corresponding 280 pairs of stimuli and the 1000 Hz tone was -0.4 dB. There was a mean difference between the tape recorded stimuli on the two channels of approximately 0.5 dB as computed by this method.

The Speakers

The dichotic verbal stimuli were spoken by two female and three male college graduates. All speakers
Figure 4. Schematic diagram of equipment used to compare relative intensity levels between stimuli of each pair.
were free from clinically significant speech defects and all were judged to have general American dialectal patterns.

The Listeners

Twenty-four female college students served as listeners. All had minimum pure tone hearing sensitivity thresholds "better" than 20 dB (ISO) at 500, 1000, 2000, and 4000 Hz. Pure tone audiometric thresholds were no more than 5 dB different between ears at any frequency. All listeners scored at least 86 percent on the Rush Hughes recordings of the Harvard Psycho-acoustic Laboratory Test (PB-50), lists 7 and 8, presented at a comfortable listening level. 56

56 Rush Hughes, Central Institute for the Deaf Auditory Test (PB-50), Lists 7 and 8, Technisonic Studios, 1201 Brentwood Blvd., Richmond Heights, Missouri, 63117.

Persons who were ambidextrous, or stated a present or previous preference for the use of their left hand in the activities of holding a spoon or fork, throwing a ball, or holding a writing instrument, were
excluded from participation in this study as listeners. Also excluded were persons with clinically significant speech defects.

Instrumentation and Procedure for the Presentation of Test Stimuli and Recording Listeners' Responses

Twenty-four listeners individually heard tape recorded dichotic stimuli while seated in a small non-commercial sound treated room. The stimuli were recorded on two tapes. Each tape had 140 pairs of stimuli, and each lasted approximately 42 minutes. Listeners heard only 140 pairs of stimuli on any one day.

The stimuli were presented through matched telephonics Corporation TDH-39 earphones which were wired for dichotic presentation. The earphones were set in MX/41 AR cushions. Each of the earphones was connected to one channel output of a Magnecord Model 1022 dual-channel tape recorder-reproducer.

A calibration tone of 1000 Hz preceded the recorded stimuli on each of the magnetic tapes. The tape recorder output was adjusted to the setting at which the calibration tone reached 80 dB re .0002 dyne per square centimeter. An Allison Model 300 Audiometer Calibration Unit with a 3 cubic centimeter
A coupler was used to measure the intensity of the 1000 Hz tone. The mean of the intensity levels of the most intense portion of each of the stimuli was approximately -4 dB re the intensity of the 1000 Hz tone as explained in the section of this chapter, "Procedures for the Processing of Tape Recorded Stimuli." The Equipment used for the presentation of the stimuli is diagrammed in Figure 5.

Possible effects of inequalities in channel characteristics were counterbalanced by reversing the earphones for each successive listener. In addition, the earphones were reversed between the presentation of the first 140 stimuli and presentation of the second 140 stimuli of each listener.

Twelve of the 24 listeners heard the tapes in a 1-2 order. More specifically, this group heard stimuli numbered 1 through 140 before they heard stimuli numbered 141-280. The remaining 12 listeners heard the stimuli in a 2-1, or reverse, order.

**Instructions to Listeners**

Listeners were instructed as follows:

You will hear five words in one ear at the same time that you hear five words in the other ear. You will hear
Figure 5. Schematic diagram of equipment used to monitor the intensity levels of the tape recorded stimuli and to present the tape recorded stimuli to listeners.
a total of ten words for each trial. As soon as you have heard the ten words repeat as many of them as possible into the microphone. If a word is heard more than once repeat it as many times as you have heard it. Listen very carefully.

Treatment of the Data

The recorded verbal responses of listeners were transcribed into typewritten transcriptions against the tape-recorded responses to ensure that the transcriptions were accurate.

The measure used was the number of words correctly repeated per stimulus. This measure will be designated the word-repetition score. Words were not counted as correct if they did not occur in the stimulus item to be repeated even though the word may have been heard in a previous stimulus.

The responses of the listeners to the 40 pairs of stimuli which had all words in common between stimuli, but in different sequential order, were scored in accordance with the following arbitrary rules:

1. If the word order of the listener's response was identical to one or the other stimulus of the pair, that stimulus was scored as having been correctly repeated.
2. If the word order of the listener's verbal response did not correspond to the word order of either of the stimuli, but the words of the response did correspond to the words of the stimuli, than the number of correctly repeated words was divided by 2 and that number used as the number of words correctly repeated for each of the stimuli.

Listener's responses to the 80 pairs of stimuli which had one word in common between stimuli were scored using the following arbitrary rules:

1. If the word which was common to both stimuli of the pair was correctly repeated two times by the listener, it was scored as a correct repetition for each of the stimuli.

2. If the common word between stimuli was repeated only once, and it corresponded in word order to one or the other of the pair of stimuli, it was scored as a correct repetition within the stimulus to which it corresponded.

3. If the word which was common to both of the stimuli of the pair was repeated only once by the listener in a word order which did not correspond to either of the stimuli of the pair, the word was scored as one-half of one correctly repeated word for each of the stimuli.
After determining the number of words of each of the five-word stimuli correctly repeated, it was possible to analyze statistically the data and to test the hypotheses which are stated in the next section.

The Hypotheses

1. There is no difference in listeners' word-repetition scores for dichotically presented stimuli arranged in Contexts A, B, C, and D.

2. There is no difference in listeners' word-repetition scores between the first half and second half of the total of the dichotic pairs of stimuli.

3. There is no difference in listeners' word-repetition scores, for stimuli of the Contexts A, B, C, and D, between those heard in the left ear and those heard in the right ear.

Statistical Treatment of the Data

A treatments-by-subjects analysis of variance\(^{57}\)

was used to test the first hypothesis. The measure used in this analysis was the mean number of correctly repeated words of each of the listeners for all of the stimuli within each of the four Contexts A, B, C, and D. The treatments-by-subjects analysis of variance was used to test for a difference between the mean word-repetition scores obtained by all listeners for words arranged in each of the four Contexts. A test for difference between individual pairs of treatment means (critical difference test)\(^{58}\) was used to determine which of the mean scores were significantly different.

\(^{58}\)Ibid., p.166.

Lindquist's mixed design, Type \(^{59}\) was used to test the second hypothesis. The measure used in this analysis was the mean number of correctly repeated words of all four contexts in the first half and second half of the experimental test by one group of listeners who heard the first and then the second

\(^{59}\)Ibid., p.267.
half of the test and a second group of listeners who heard the halves of the experimental test in the reverse order.

The third hypothesis was tested using the t-test for related measures. The measure was the mean number of correctly repeated words per five-word stimulus of each of Contexts A, B, C, and D, heard in the left and in the right ear.

As a result of the method used to construct the five-word stimuli, and due to a limited vocabulary, some of the pairs of stimuli had words in common. Forty pairs of stimuli had all words in common. For example:

\begin{quote}
Furry wildcats fight furious battles.
Furry fight furious wildcats battles.
\end{quote}

Eighty of the pairs of stimuli had one word in common between stimuli as shown in the following example.

\begin{quote}
Bouquets pink odors fragrant emit.
Accidents pink storms sleeping cause.
\end{quote}

The remaining 160 pairs of stimuli had no words in common between stimuli.
To test for a difference in perception as a function of the number of words in common between stimuli, a treatments-by-subjects analysis of variance was used. The mean percentage of the number of correctly repeated words of each of the listeners for each of the three conditions, (five, one, or no words in common between stimuli), was used as the measure. Mean percentage scores were used because the number of stimuli for the three conditions was unequal. "Critical difference" tests were used to determine whether the differences between the means of the scores were significant.

Summary of Procedures and Instrumentation

Five hundred sixty five-word stimuli of four contexts differing in inter-stimulus word arrangement, were arranged to yield 280 pairs of stimuli. Stimuli of each context were paired with stimuli of each of the other contexts and of the same context. The stimuli were spoken by five persons and each of the stimuli
of each pair was recorded on one or the other of the channels of a dual-channel tape recorder. The tape recorded stimuli were then processed to achieve a closer correspondence between the time of onset and between relative intensity levels of each of the stimuli of each pair. Twenty-four female college students listened to the pairs of stimuli and responded by repeating as many of the words of the dichotically presented pairs of stimuli as they were able. The listeners' responses were tape recorded and copied on a typewriter. Analyses of variance, "critical difference" tests, and a t-test for related means were used to test the hypotheses. The results of these tests are included in the following chapter.
CHAPTER IV
RESULTS AND DISCUSSION

Three experimental hypotheses were tested statistically as described in Chapter III of this report. The results of the statistical tests are found in the present chapter along with a discussion of these results.

Word-Repetition Scores as a Function of Inter-Stimulus Word Arrangement

A treatments-by-subjects analysis of variance was used to test the first hypothesis: there is no difference between listeners' mean word-repetition scores for stimuli in Contexts A, B, C, and D (which differed in inter-stimulus word arrangement). A summary of this analysis is included in Table 1. Mean word-repetition scores were significantly different between stimuli beyond the .01 level of confidence and the null hypothesis was rejected.

The mean word-repetition scores for stimuli in each context are included in Table 2. Highest mean scores were obtained on Context A Stimuli. Mean word-repetition scores, in descending order of magnitude,
TABLE 1.--Analysis of variance summary table for 24 listeners on four independent variables: Contexts A, B, C, and D stimuli. The dependent variable was mean number of words correctly repeated from stimuli of each of the contexts.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listeners</td>
<td>23</td>
<td>12.01</td>
<td>.52</td>
<td>---</td>
</tr>
<tr>
<td>Contexts</td>
<td>3</td>
<td>11.55</td>
<td>3.85</td>
<td>128.33*</td>
</tr>
<tr>
<td>Remainder</td>
<td>69</td>
<td>2.05</td>
<td>.03</td>
<td>---</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>25.61</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

*Sig. at .01 level
TABLE 2.--Mean word-repetition scores for each of 24 listeners for each of the 140 items of each of the four contexts of stimuli, A, B, C and D, and the mean word-repetition for all of the 24 listeners on stimuli of Contexts A, B, C, and D.

<table>
<thead>
<tr>
<th>Listener</th>
<th>Context A</th>
<th>Context B</th>
<th>Context C</th>
<th>Context D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.7</td>
<td>2.8</td>
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<td>1.9</td>
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<td>2.0</td>
<td>1.8</td>
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<td>2.4</td>
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<td>2.5</td>
<td>2.9</td>
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<td>2.7</td>
<td>3.0</td>
<td>2.6</td>
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<tr>
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<td>2.9</td>
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<td>2.1</td>
<td>1.9</td>
<td>1.7</td>
</tr>
<tr>
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<td>3.0</td>
<td>2.5</td>
</tr>
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<td>12</td>
<td>3.3</td>
<td>2.7</td>
<td>2.7</td>
<td>2.3</td>
</tr>
<tr>
<td>13</td>
<td>3.2</td>
<td>2.4</td>
<td>2.4</td>
<td>2.1</td>
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<td>14</td>
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<td>2.1</td>
<td>1.6</td>
</tr>
<tr>
<td>15</td>
<td>2.9</td>
<td>2.3</td>
<td>2.4</td>
<td>2.2</td>
</tr>
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<td>16</td>
<td>3.3</td>
<td>2.3</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
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<td>3.1</td>
<td>2.5</td>
<td>2.1</td>
<td>2.4</td>
</tr>
<tr>
<td>18</td>
<td>3.4</td>
<td>2.4</td>
<td>2.5</td>
<td>2.1</td>
</tr>
<tr>
<td>19</td>
<td>4.0</td>
<td>3.1</td>
<td>3.5</td>
<td>2.6</td>
</tr>
<tr>
<td>20</td>
<td>3.3</td>
<td>2.6</td>
<td>2.7</td>
<td>2.5</td>
</tr>
<tr>
<td>21</td>
<td>3.7</td>
<td>3.0</td>
<td>3.2</td>
<td>2.7</td>
</tr>
<tr>
<td>22</td>
<td>3.5</td>
<td>2.5</td>
<td>3.0</td>
<td>2.5</td>
</tr>
<tr>
<td>23</td>
<td>2.7</td>
<td>1.8</td>
<td>1.8</td>
<td>1.4</td>
</tr>
<tr>
<td>24</td>
<td>2.9</td>
<td>2.2</td>
<td>2.1</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Mean | 3.1 | 2.5 | 2.5 | 2.2 |
were smaller for stimuli in Contexts B, C, and D. The difference between the mean word-repetition score of all subjects for Context B Stimuli and Context C Stimuli was not statistically significant. Differences which were significant beyond the .01 level of confidence were obtained between the mean of listeners' word-repetition scores for all other combinations of stimulus contexts as tested by "critical difference" tests. These tests are included in Table 3.

Listeners' Word-Repetition Scores for the First and Second 140 Pairs of Stimuli Heard

The second hypothesis: there is no difference in listeners mean word-repetition scores between the first and second 140 pairs of stimuli, was tested using a Type I Analysis of Variance. A Summary of the analysis is found in Table 4. This analysis was done to determine whether listeners perceived dichotic stimuli more efficiently as a function of familiarity with the task. The second hypothesis was rejected at the .01 level of confidence. The mean word-repetition scores for the first and second 140 items heard are presented in Table 5.
TABLE 3.--Results of "critical difference" tests between the mean of 24 listeners' word repetition scores on 70 stimuli of each of four contexts of stimuli; A, B, C and D. The datum within each of the cells of the matrix is the difference between the mean word-repetition of scores for the contexts of data in the row and column which intersect at the point of the datum.

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>.68*</td>
<td>.62*</td>
<td>.95*</td>
</tr>
<tr>
<td>B</td>
<td>---</td>
<td>.06</td>
<td>.27*</td>
</tr>
<tr>
<td>C</td>
<td>---</td>
<td>---</td>
<td>.33*</td>
</tr>
</tbody>
</table>

*Sig. at .01 level
TABLE 4.—Summary of an analysis of variance for two groups of 12 listeners. Each group heard both halves of a total of 280 pairs of stimuli, but in a different order. Group 1 heard the first and then the second half of the total number of stimuli. Group 2 heard the halves in reverse order. The dependent variable was mean word-repetition score.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>23</td>
<td>23</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Conditions</td>
<td>1</td>
<td>0</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Remainder Between</td>
<td>22</td>
<td>23</td>
<td>1.07</td>
<td>---</td>
</tr>
<tr>
<td>Within Subjects</td>
<td>24</td>
<td>12</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Trials</td>
<td>1</td>
<td>0</td>
<td>.64</td>
<td>4.00</td>
</tr>
<tr>
<td>Trials X Conditions</td>
<td>1</td>
<td>8</td>
<td>8.20</td>
<td>51.26*</td>
</tr>
<tr>
<td>Remainder Within</td>
<td>22</td>
<td>3</td>
<td>.16</td>
<td>---</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>35</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

*Sig. beyond .01 level.
TABLE 5.--Mean word-repetition scores for two groups of 12 listeners who heard 280 pairs of stimuli in a different order. Group 1 heard pairs of stimuli 141-280. Group 2 heard the stimuli in reverse order.

<table>
<thead>
<tr>
<th></th>
<th>Pairs of Stimuli 1-140</th>
<th>Pairs of Stimuli 141-280</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>4.65</td>
<td>5.66</td>
</tr>
<tr>
<td>Group 2</td>
<td>5.45</td>
<td>4.85</td>
</tr>
</tbody>
</table>
Differences in Word-Repetition Scores for Stimuli Heard in the Right and in the Left Ear

The data were analyzed to determine whether listeners obtained higher mean word-repetition scores from the four classes of stimuli repeated from the left or from the right ears. Means of the word-repetition scores for stimuli in each of the four contexts repeated from the left and from the right ears were compared using t-tests for related means. The results of the t-tests are presented in Table 6. The mean word-repetition scores for stimuli in each of the four contexts were significantly higher, beyond the .01 level of confidence, when the stimuli were repeated from the right, as opposed to the left, ear. This finding was not unexpected in view of the results of previous research cited in Chapter II. The following section is devoted to a discussion of the above results followed by a summary of this chapter.

Discussion of Results

Listeners' mean word-repetition scores were significantly different for stimuli arranged in the four contexts. Listeners obtained the highest mean word-repetition score for Context A Stimuli (sentences)
TABLE 6.--Four t-tests for related means between mean word-repetition scores of 24 listeners for stimuli heard in the right and the left ear, for stimuli in Contexts A, B, C, and D.

<table>
<thead>
<tr>
<th>Types of Stimuli</th>
<th>Mean Score Right Ear</th>
<th>Mean Score Left Ear</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.45</td>
<td>2.81</td>
<td>10.51*</td>
</tr>
<tr>
<td>B</td>
<td>2.74</td>
<td>2.16</td>
<td>9.91*</td>
</tr>
<tr>
<td>C</td>
<td>2.80</td>
<td>2.22</td>
<td>10.09*</td>
</tr>
<tr>
<td>D</td>
<td>2.48</td>
<td>1.88</td>
<td>10.98*</td>
</tr>
</tbody>
</table>

*Sig. beyond the .01 level.
and the lowest mean word-repetition score for Context D Stimuli ("word lists"). The reason or reasons for this difference are not clear. The following possibilities might be considered.

1. Sentences are more intelligible than word lists when both are presented dichotically. This possibility is consistent with the findings of Miller and Isard that the intelligibility of "strings of English words" depends, at least partially, on their conformity to linguistic rules which are known by the listener. Although Miller and Isard used binaural stimulus presentation, it seems likely that their findings might be generalized to dichotic stimulus presentation as well.

2. It is possible that listeners selectively attend to sentences more often than to word lists when both are presented dichotically.

3. It is possible that sentences are committed to memory more easily and/or persist in memory for a longer period of time than do word lists when both are

dichotically presented. These possibilities are in agreement with the findings of Marks and Miller who used the same stimuli as the ones used in the present study but presented the stimuli binaurally as opposed to dichotically.63


4. Any of the above possibilities, singularly, or in combination, might be true.

The present research was not designed to test the above possible reasons for the significant difference between the mean word-repetition scores for stimuli arranged in Contexts A and D.

The difference between the mean word-repetition scores for Context B and Context C Stimuli did not reach statistical significance. The mean word-repetition scores for both Context B and Context C Stimuli (which had "semantic and syntactic" rules disrupted, respectively)

64 Ibid., p. 20.
yielded lower mean word-repetition scores than Context A Stimuli (sentences having normal semantic and syntactic constraint\textsuperscript{65}) and higher mean word-repetition scores than Context D Stimuli (which violated both semantic and syntactic rules.)

The finding that the listeners obtained higher mean word-repetition scores on the second 140 pairs of stimuli than on the first 140 pairs of stimuli was not unexpected. The learning effect was probable in view of the fact that all stimuli were constructed from a vocabulary of 50 words. Despite the high degree of familiarity of the listeners developed for the task and the stimulus words, the difference between the mean word-repetition scores of the first 140 pairs and second 140 pairs of stimuli was small, on the order of one word. It seems probable that the statement; "the final act of recognition can only be performed on one message at a time,"\textsuperscript{66} is accurate in the case of

\textsuperscript{65}Ibid., p.1.

the present findings.

Right ear superiority in dichotic listening situations has been shown repeatedly by previous research discussed in the second chapter of this report. The present research indicated right ear superiority for stimuli of all contexts. This result is in keeping with the finding of Curry that the functional left-right ear difference under dichotic stimulation appears to be relatively unaffected by semantic factors.67


As a result of the method used to construct the stimuli and to arrange them into pairs, there were inevitably words in common between stimuli of some of the pairs. Because of this circumstance, it was possible to construct and test the following hypothesis: there is no difference between listeners' word-repetition scores when they listen to pairs of stimuli which have all words in common but in different sequential order, one word in common, and no words in common. A treatments-by-subjects analysis of variance is included in Table 7. A significant difference, beyond the .01 level of confidence,
TABLE 7.--Analysis of variance summary table for 24 listeners on three independent variables: one, all, or no words in common between stimuli which comprise a dichotic pair. The dependent variable was mean percentage of words correctly repeated.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listeners</td>
<td>23</td>
<td>4727.</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Type of Stimulus Pairs</td>
<td>2</td>
<td>2180.</td>
<td>1090.28</td>
<td>38.46*</td>
</tr>
<tr>
<td>Remainder</td>
<td>46</td>
<td>1303.</td>
<td>28.34</td>
<td>---</td>
</tr>
<tr>
<td>Total</td>
<td>71</td>
<td>8211.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Sig. at .01 level.
was obtained between the mean percentage of listeners' word-repetition scores for the three types of pairs of stimuli. The hypothesis was rejected. "Critical difference" tests between the individual mean percentages of word-repetition scores for each of the three types of pairs of stimuli yielded a significant difference at the .01 level of confidence, between all combinations of the mean percentage scores. The means of the percentages of listeners' word-repetition scores and the results of the "critical difference" tests between these means is included in Tables 8 and 9, respectively.

Pairs of stimuli which had no words in common between stimuli; pairs of stimuli which had one word in common between stimuli; and, pairs of stimuli which had all words in common between stimuli, yielded significantly different mean percentage word-repetition scores. Listeners obtained the highest mean percentage word-repetition score on pairs of stimuli which had no words in common between stimuli and the lowest mean percentage word-repetition score on pairs of stimuli which had one word in common between stimuli. Significant differences were found between the mean percentage of word-repetition scores of the three types of stimulus pairs. Table 10 shows the number of stimuli of each of the Contexts A, B, C, and D which comprised the three
TABLE 8.—Mean percentage word-repetition scores of 24 listeners repeating words from three types of pairs of stimuli. The types of pairs of stimuli differed in the number of words in common between stimuli of each pair; one, all (5), or none, represented by the letters x, y, and z, respectively, at the top of each column. The mean percentage for each is shown at the bottom of the columns.

<table>
<thead>
<tr>
<th>Listener</th>
<th>x</th>
<th>y</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>57.1%</td>
<td>56.0%</td>
<td>76.1%</td>
</tr>
<tr>
<td>2</td>
<td>48.8</td>
<td>49.2</td>
<td>63.3</td>
</tr>
<tr>
<td>3</td>
<td>45.8</td>
<td>54.2</td>
<td>53.4</td>
</tr>
<tr>
<td>4</td>
<td>43.8</td>
<td>46.8</td>
<td>56.0</td>
</tr>
<tr>
<td>5</td>
<td>46.5</td>
<td>51.7</td>
<td>62.0</td>
</tr>
<tr>
<td>6</td>
<td>49.4</td>
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<td>51.3</td>
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<td>9</td>
<td>57.3</td>
<td>79.3</td>
<td>73.3</td>
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<td>10</td>
<td>39.5</td>
<td>48.5</td>
<td>51.6</td>
</tr>
<tr>
<td>11</td>
<td>52.2</td>
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<td>41.3</td>
<td>49.3</td>
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<td>59.8</td>
</tr>
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<td>16</td>
<td>51.6</td>
<td>49.0</td>
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<tr>
<td>18</td>
<td>55.2</td>
<td>50.2</td>
<td>68.6</td>
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<td>19</td>
<td>67.8</td>
<td>75.7</td>
<td>81.3</td>
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<tr>
<td>20</td>
<td>59.7</td>
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<td>21</td>
<td>64.7</td>
<td>68.0</td>
<td>80.9</td>
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<td>60.7</td>
<td>55.2</td>
<td>76.1</td>
</tr>
<tr>
<td>23</td>
<td>36.2</td>
<td>41.1</td>
<td>50.8</td>
</tr>
<tr>
<td>24</td>
<td>46.7</td>
<td>48.0</td>
<td>57.8</td>
</tr>
</tbody>
</table>

Total mean Percentage

51.7%  58.0%  65.2%
TABLE 9.--"Critical difference" tests between the mean percentage of word-repetition scores for three types of pairs of stimuli; those pairs having one word in common, all words in common, and no word in common, between the stimuli of a pair. The three types of pairs of stimuli are represented by the letters \( x \), \( y \), and \( z \), respectively. The datum in each cell of the matrix is the difference between the mean percentage of word-repetition scores of the types of pairs of stimuli located in the column and row which intersect at the point of the datum.

<table>
<thead>
<tr>
<th></th>
<th>( x )</th>
<th>( y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>6.3%*</td>
<td>---</td>
</tr>
<tr>
<td>( z )</td>
<td>13.5%*</td>
<td>7.2%*</td>
</tr>
</tbody>
</table>

*Significantly different at the .01 level with 4.3% needed.
TABLE 10.—Number of stimuli of each context in each of the types of pairs of stimuli.

<table>
<thead>
<tr>
<th>Types of Pairs of Stimuli</th>
<th>All words in common between stimuli</th>
<th>One word in common between stimuli</th>
<th>No word in common between stimuli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context A</td>
<td>40</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Context B</td>
<td>40</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Context C</td>
<td>0</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>Context D</td>
<td>0</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>160</td>
<td>320</td>
</tr>
</tbody>
</table>
types of stimulus pairs.

The next, and last, section of this chapter is a summary of the results. The summary is followed by the final chapter which is a summary of the research report and conclusions thereof.

**Summary of Results and Discussion**

Word-repetition scores were tabulated for 24 listeners who heard 560 five-word stimuli which they were to repeat. The 560 stimuli comprised 280 pairs of stimuli which were presented dichotically. The 560 stimuli were of four Contexts A, B, C, and D. There were an equal number of stimuli (140) in each context.

Listeners; mean word-repetition scores were found to improve between the first and second 140 pairs of stimuli heard.

A significant difference between mean word-repetition scores for stimuli heard in the left ear and stimuli heard in the right ear was obtained. Each of the four contexts of stimuli presented to the right ears of subjects yielded significantly higher mean word-repetition scores than those scores for the same contexts of stimuli presented to the left ear.

The 280 pairs of stimuli were of three types:
(1) those having no words in common between the stimuli of a pair, (2) pairs of stimuli having one word in common, and (3) pairs of stimuli having all words in common between each of the stimuli of the pair with words in different sequential order between stimuli.

A significant difference was found between listeners' mean word-repetition scores for the stimuli in the four contexts. Context A Stimuli (sentences) yielded the highest mean word-repetition scores and Context D Stimuli (word lists) yielded the lowest mean word-repetition scores. The mean word-repetition scores for Contexts B and C Stimuli were not significantly different. The mean word-repetition scores for both C and D Stimuli were significantly lower and higher than mean word-repetition scores for Context A and D Stimuli, respectively.
CHAPTER V
SUMMARY AND CONCLUSIONS

The primary goal of the present investigation was to determine whether context affects the efficiency with which listeners are able to perceive dichotically presented words. Twenty-four listeners heard 280 pairs of dichotic stimuli spoken by five speakers. The stimuli were arranged in four contexts. They were obtained from a research report by Marks and Miller who termed the "types" of stimuli "sentences," "anamalous sentences," "anagram strings," and "word lists." 68 The stimuli were arranged in pairs such that stimuli of each context were paired with stimuli of each of the other contexts and its own context.

Upon hearing the dichotic pairs of stimuli listeners repeated as many as possible of the words heard in both

---

ears. The listeners' oral responses were recorded and later typewritten. The number of words repeated of each of the five-word stimuli was used as a measure and called the word-repetition score.

It was found that words from the context of a sentence were repeated most often and words from the context of a word list were repeated least often. No significant difference was found between the number of times that listeners repeated words in the contexts of anomalous sentences and anagram strings. Words in the contexts anomalous sentences and anagram strings were repeated significantly more often than words in the context of word lists and significantly less often than words in the context of sentences.

It was found that listeners were able to repeat a significantly greater number of dichotically presented words on the second 140 pairs of stimuli than on the first 140 pairs of stimuli heard. The significant difference would be expected on the basis of learning. Listeners became better acquainted with the task and with individual words which comprised the stimuli. It would seem that this finding is in agreement with Broadbent's conclusions on the effects of practice in receiving simultaneous stimuli. His conclusions are:
...it (practice) makes performance less dependent on incoming information and it increases the possibility of receiving information for one task during the intervals between the arrival of information for the other. But there is no sign in existing data of any improvement in dealing with excessive amounts of information arriving truly simultaneously. 69


Listeners repeated words presented to the right ear significantly more often than words presented to the left ear. This result was obtained for all words irrespective of the context in which they were arranged.

As a consequence of the manner in which the stimuli were constructed and paired, the pairs of stimuli were of three types: (1) those having one word in common between stimuli; (2) those having all words in common between stimuli of a pair, but with the words in different orders; and, (3) those having no word in common between the stimuli of a pair. Listeners repeated the highest number of words when the stimuli of a pair had no words in common and the lowest number of words when the stimuli of a pair had all words in common.
Conclusions

On the basis of this research, several conclusions seem to be justified. The results suggest that listener perception of dichotic verbal stimuli is affected by semantic and syntactic constraint of the stimuli. This conclusion was previously stated by Marks and Miller for binaurally presented verbal stimuli.\footnote{Lawrence E. Marks and George A. Miller, \textit{loc. cit.}} Dichotically presented words are more efficiently repeated from the right ear than from the left ear irrespective of the context in which the words are situated.
APPENDIX A

STIMULI CONSTRUCTED AND USED BY MARKS AND MILLER

Sentences
(set one)
Rapid flashes augur violent storms.
Pink bouquets emit fragrant odors.
Fatal accidents deter careful drivers.
Melting snows cause sudden floods.
Noisy parties wake sleeping neighbors.

(set two)
Furry wildcats fight furious battles.
Respectable jewelers give accurate appraisals.
Lighted cigarettes create smokey fumes.
Gallant gentlemen save distressed damsels.
Soapy detergents dissolve greasy stains.

Anomalous Strings
(set one)
Rapid bouquets deter sudden neighbors.
Pink accidents cause sleeping storms.
Fatal snows wake violent odors.
Melting parties augur fragrant drivers.
Noisy flashes emit careful floods.

(set two)
Furry jewelers create distressed stains.
Respectable cigarettes save greasy battles.
Lighted gentlemen dissolve furious appraisals.
Gallant detergents fight accurate fumes.
Soapy wildcats give smokey damsels.
**Anagram Strings**

(set one)

Rapid augur violent flashes storms.
Bouquets pink odors fragrant emit.
Deter drivers accidents fatal careful.
Sudden melting cause floods snows.
Neighbors sleeping noisy wake parties.

(set two)

Furry fight furious wildcats battles.
Jewelers respectable appraisals accurate give.
Create fumes cigarettes lighted smokey.
Distressed gallant save damsels gentlemen.
Strains greasy soapy dissolve detergents.

**Word Lists**

(set one)

Rapid deter sudden bouquets neighbors.
Accidents pink storms sleeping cause.
Wake odors snows fatal violent.
Floods careful noisy emit flashes.
Fragrant melting augur drivers parties.

(set two)

Furry create distressed jewelers stains.
Cigarettes respectable battles greasy save.
Dissolve appraisals gentlemen lighted furious.
Accurate gallant fight fumes detergents.
Damsels smokey soapy give wildcats.
APPENDIX B
PAIRS OF STIMULI
1-140

Item


2. Pink accidents cause sleeping storms. Respectable jewelers give accurate appraisals.


7. Cigarettes respectable battles greasy save. Accidents pink storms sleeping cause.


13. Create fumes cigarettes lighted smokey. 
Deter drivers accidents fatal careful.

14. Fragrant melting augur drivers parties. 
Distressed gallant save damsels gentlemen.

15. Damsels smokey soapy give wildcats. 
Floods careful noisy emit flashes.

Furry jewelers create distressed stains.

17. Respectable jewelers give accurate appraisals. 
Pink bouquets emit fragrant odors.

18. Fatal snows wake violent odors. 
Lighted cigarettes create smokey fumes.

19. Gallant detergents fight accurate fumes. 
Melting parties augur fragrant drivers.

Soapy wildcats give smokey damsels.

21. Furry fight furious wildcat battles. 
Rapid augur violent flashes storms.

22. Accidents pink storms sleeping cause. 
Jewelers respectable appraisals accurate give.

23. Dissolve appraisals gentlemen lighted furious. 
Wake odors snows fatal violent.

24. Melting snows cause sudden floods. 
Accurate gallant fight fumes detergents.

25. Soapy detergents dissolve greasy stains. 
Noisy parties wake sleeping neighbors.

Furry fight furious wildcats battles.

27. Respectable cigarettes save greasy battles. 
Pink accidents cause sleeping storms.

28. Deter drivers accidents fatal careful. 
Lighted gentlemen dissolve furious appraisals.

29. Distressed gallant save damsels gentlemen. 
Sudden melting cause floods snows.
30. Floods careful noisy emit flashes.  
   Stains greasy soapy dissolve detergents.

31. Furry create distressed jewelers stains.  
   Rapid deter sudden bouquets neighbors.

32. Pink bouquets emit fragrant odors.  
   Cigarettes respectable battles greasy save.

33. Lighted cigarettes create smokey fumes.  
   Fatal accidents deter careful drivers.

34. Melting parties augur fragrant drivers.  
   Gallant gentlemen save distressed damsels.

35. Soapy wildcats give smokey damsels.  
   Noisy flashes emit cardful floods.

36. Rapid flashes augur violent storms.  
   Furry create distressed jewelers stains.

37. Jewelers respectable appraisals accurate give.  
   Bouquets pink odors fragrant emit.

38. Wake odors snows fatal violent.  
   Create fumes cigarettes lighted smokey.

39. Accurate gallant fight fumes detergents.  
   Fragrant melting augur drivers parties.

40. Noisy parties wake sleeping neighbors.  
   Damsels smokey soapy give wildcats.

41. Rapid flashes augur violent storms.  
   Rapid deter sudden bouquets neighbors.

42. Respectable jewelers give accurate appraisals.  
   Cigarettes respectable battles greasy save.

43. Fatal snows wake violent odors.  
   Fatal accidents deter careful drivers.

44. Gallant detergents fight accurate fumes.  
   Gallant gentlemen save distressed damsels.

45. Neighbors sleeping noisy wake parties.  
   Noisy flashes emit careful floods.

46. Furry wildcats fight furious battles.  
   Furry create distressed jewelers stains.
47. Accidents pink storms sleeping cause. Bouquets pink odors fragrant emit.
49. Melting snows cause sudden floods. Fragrant melting augur drivers parties.
50. Soapy detergents dissolve greasy stains. Damsels smokey soapy give wildcats.
52. Respectable cigarettes save greasy battles. Respectable jewelers give accurate appraisals.
53. Deter drivers accidents fatal careful. Fatal snows wake violent odors.
56. Furry jewelers create distressed stains. Furry wildcats fight furious battles.
57. Pink bouquets emit fragrant odors. Accidents pink storms sleeping cause.
58. Lighted cigarettes create smokey fumes. Dissolve appraisals gentlemen lighted furious.
60. Smokey wildcats give soapy damsels. Soapy detergents dissolve greasy stains.
63. Wake odors snows fatal violent. Deter drivers accidents fatal careful.
64. Accurate gallant fight fumes detergents. 
   Distressed gallant save damsels gentlemen.

65. Noisy parties wake sleeping neighbors. 
   Floods careful noisy emit flashes.

66. Furry fight furious wildcats battles. 
   Furry jewelers create distressed stains.

67. Pink accidents cause sleeping storms. 
   Pink bouquets emit fragrant odors.

68. Lighted gentlemen dissolve furious appraisals. 
   Lighted cigarettes create smokey fumes.

69. Sudden melting cause floods snows. 
   Melting parties augur fragrant drivers.

70. Stains greasy soapy dissolve detergents. 
   Soapy wildcats give smokey damsels.

71. Rapid deter sudden bouquets neighbors. 
   Rapid augur violent flashes storms.

72. Cigarettes respectable battles greasy save. 
   Jewelers respectable appraisals accurate give.

73. Fatal accidents deter careful drivers. 
   Wake odors snows fatal violent.

74. Gallant gentlemen save distressed damsels. 
   Accurate gallant fight fumes detergents.

75. Noisy flashes emit careful floods. 
   Noisy parties wake sleeping neighbors.

76. Furry create distressed jewelers stains. 
   Furry fight furious wildcats battles.

77. Bouquets pink odors fragrant emit. 
   Pink accidents cause sleeping storms.

78. Create fumes cigarettes lighted smokey. 
   Lighted gentlemen dissolve furious appraisals.

79. Fragrant melting augur drivers parties. 
   Sudden melting cause floods snows.

80. Damsels smokey soapy give wildcats. 
   Stains greasy soapy dissolve detergents.
81. Rapid flashes augur violent storms.  
    Furry jewelers create distressed stains.
82. Respectable jewelers give accurate appraisals.  
    Bouquets pink odors fragrant emit.
83. Fatal snows wake violent odors.  
    Create fumes cigarettes lighted smokey.
84. Gallant detergents fight accurate fumes.  
    Fragrant melting augur drivers parties.
85. Neighbors sleeping noisy wake parties.  
    Damsels smokey soapy give wildcats.
86. Furry fight furious wildcats battles.  
    Rapid flashes augur violent storms.
87. Accidents pink storms sleeping cause.  
    Respectable jewelers give accurate appraisals.
88. Dissolve appraisals gentlemen lighted furious.  
    Fatal snows wake violent odors.
89. Melting snows cause sudden floods.  
    Gallant detergents fight accurate fumes.
90. Soapy detergents dissolve greasy stains.  
    Neighbors sleeping noisy wake parties.
91. Rapid bouquets deter sudden neighbors.  
    Furry fight furious wildcats battles.
92. Respectable cigarettes save greasy battles.  
    Accidents pink storms sleeping cause.
93. Deter drivers accidents fatal careful.  
    Dissolve appraisals gentlemen lighted furious.
94. Distressed gallant save damsels gentlemen.  
    Melting snows cause sudden floods.
95. Floods careful noisy emit flashes.  
    Soapy detergents dissolve greasy stains.
96. Rapid bouquets deter sudden neighbors.  
    Furry create distressed jewelers stains.
97. Pink bouquets emit fragrant odors.  
    Respectable cigarettes save greasy battles.
98. Lighted cigarettes create smokey fumes. Deter drivers accidents fatal careful.


100. Soapy wildcats give smokey damsels. Floods careful noisy emit flashes.


103. Wake odors snows fatal violent. Lighted cigarettes create smokey fumes.

104. Accurate gallant fight fumes detergents. Melting parties augur fragrant drivers.

105. Noisy parties wake sleeping neighbors. Soapy wildcats give smokey damsels.


108. Lighted gentlemen dissolve furious appraisals. Wake odors snows fatal violent.

109. Sudden melting cause floods snows. Accurate gallant fight fumes detergents.


112. Cigarettes respectable battles greasy save. Pink accidents cause sleeping storms.

113. Fatal accidents deter careful drivers. Lighted gentlemen dissolve furious appraisals.

114. Gallant gentlemen save distressed damsels. Sudden melting cause floods snows.
115. Noisy flashes emit careful floods.  
   Stains greasy soapy dissolve detergents.
116. Furry jewelers create distressed stains.  
   Rapid deter sudden bouquets neighbors.
117. Bouquets pink odors fragrant emit.  
   Cigarettes respectable battles greasy save.
118. Create fumes cigarettes lighted smokey.  
   Fatal accidents deter careful drivers.
119. Fragrant melting augur drivers parties.  
   Gallant gentlemen save distressed damsels.
120. Damsels smokey soapy give wildcats.  
   Noisy flashes emit careful floods.
121. Rapid flashes augur violent storms.  
   Rapid bouquets deter sudden neighbors.
122. Respectable jewelers give accurate appraisals.  
   Respectable cigarettes save greasy battles.
123. Fatal snows wake violent odors.  
   Deter drivers accidents fatal careful.
124. Gallant detergents fight accurate fumes.  
   Distressed gallant save damsels gentlemen.
125. Neighbors sleeping noisy wake parties.  
   Floods careful noisy emit flashes.
126. Furry fight furious wildcats battles.  
   Furry create distressed jewelers stains.
127. Accidents pink storms sleeping cuase.  
   Pink bouquets emit fragrant odors.
128. Dissolve appraisals gentlemen lighted furious.  
   Lighted cigarettes create smokey fumes.
129. Melting snows cause sudden floods.  
   Melting parties augur fragrant drivers.
130. Soapy detergents dissolve greasy stains.  
   Soapy wildcats give smokey damsels.
131. Rapid bouquets deter sudden neighbors.  
   Rapid augur violent flashes storms.
132. Respectable cigarettes save greasy battles.
   Jewelers respectable appraisals accurate give.

133. Deter drivers accidents fatal careful.
   Wake odors snows fatal violent.

134. Distressed gallant save damsels gentlemen.
   Accurate gallant fight fumes detergents.

135. Floods careful noisy emit flashes.
   Noisy parties wake sleeping neighbors.

136. Furry create distressed jewelers stains.
   Furry wildcats fight furious battles.

137. Pink bouquets emit fragrant odors.
   Pink accidents cause sleeping storms.

138. Lighted cigarettes create smokey fumes.
   Lighted gentlemen dissolve furious appraisals.

139. Melting parties augur fragrant drivers.
   Sudden melting cause floods snows.

140. Soapy wildcats give smokey damsels.
   Stains greasy soapy dissolve detergents.
141. Rapid flashes augur violent storms.
Furry fight furious wildcats battles.

142. Respectable jewelers give accurate appraisals.
Accidents pink storms sleeping cause.

143. Fatal snows wake violent odors.
Dissolve appraisals gentlemen lighted furious.

144. Gallant detergents fight accurate fumes.
Melting snows cause sudden floods.

145. Neighbors sleeping noisy wake parties.
Soapy detergents dissolve greasy stains.

146. Furry wildcats fight furious battles.
Rapid deters sudden bouquets neighbors.

147. Accidents pink storms sleeping cause.
Respectable cigarettes save greasy battles.

148. Dissolve appraisals gentlemen lighted furious.
Deter drivers accidents fatal careful.

149. Melting snows cause sudden floods.
Distressed gallant save damsels gentlemen.

150. Soapy detergents dissolve greasy stains.
Floods careful noisy emit flashes.

151. Rapid bouquets deters sudden neighbors.
Furry create distressed jewelers stains.

152. Respectable cigarettes save greasy battles.
Pink bouquets emit fragrant odors.

153. Deter drivers accidents fatal careful.
Lighted cigarettes create smokey fumes.

154. Distressed gallant save damsels gentlemen.
Melting parties augur fragrant drivers.

155. Soapy wildcats give smokey damsels.
Floods careful noisy emit flashes.
156. Furry jewelers create distressed stains.  
Rapid flashes augur violent storms.  

157. Pink bouquets emit fragrant odors.  
Jewelers respectable appraisals accurate give.  

158. Lighted cigarettes create smokey fumes.  
Wake odors snows fatal violent.  

159. Melting parties augur fragrant drivers.  
Accurate gallant fight fumes detergents.  

160. Soapy wildcats give smokey damsels.  
Noisy parties wake sleeping neighbors.  

161. Rapid augur violent flashes storms.  
Furry wildcats fight furious battles.  

162. Jewelers respectable appraisals accurate give.  
Pink accidents cause sleeping neighbors.  

163. Wake odors snows fatal violent.  
Lighted gentlemen dissolve furious appraisals.  

164. Accurate gallant fight fumes detergents.  
Sudden melting cause floods snows.  

165. Noisy parties wake sleeping neighbors.  
Stains greasy soapy dissolve detergents.  

166. Furry fight furious wildcats battles.  
Rapid bouquets deter sudden neighbors.  

167. Pink accidents cause sleeping storms.  
Cigarettes respectable battles greasy save.  

168. Lighted gentlemen dissolve furious appraisals.  
Fatal accidents deter careful drivers.  

169. Sudden melting cause floods snows.  
Gallant gentlemen save distressed damsels.  

170. Stains greasy soapy dissolve detergents.  
Noisy flashes emit careful floods.  

171. Rapid deter sudden bouquets neighbors.  
Furry jewelers create distressed stains.  

172. Cigarettes respectable battles greasy save.  
Bouquets pink odors fragrant emit.
175. Noisy flashes emit careful floods. Damsels smokey soapy give wildcats.
179. Fragrant melting augur drivers parties. Gallant detergents fight accurate fumes.
183. Fatal snows wake violent odors. Wake odors snows fatal violent.
186. Furry wildcats fight furious battles. Furry fight furious wildcats battles.
188. Dissolve appraisals gentlemen lighted furious. Lighted gentlemen dissolve furious appraisals.
189. Melting snows cause sudden floods. Sudden melting cause floods snows.
190. Soapy detergents dissolve greasy stains.  
    Stains greasy soapy dissolve detergents.

191. Rapid bouquets deter sudden neighbors.  
    Rapid deter sudden bouquets neighbors.

192. Respectable cigarettes save greasy battles.  
    Cigarettes respectable battles greasy save.

193. Deter drivers accidents fatal careful.  
    Fatal accidents deter careful drivers.

194. Distressed gallant save damsels gentlemen.  
    Gallant gentlemen save distressed damsels.

195. Floods careful noisy emit flashes.  
    Noisy flashes emit careful floods.

196. Furry jewelers create distressed stains.  
    Furry create distressed jewelers stains.

197. Pink bouquets emit fragrant odors.  
    Bouquets pink odors fragrant emit.

198. Lighted cigarettes create smokey fumes.  
    Create fumes cigarettes lighted smokey.

199. Melting parties augur fragrant drivers.  
    Fragrant melting augur drivers parties.

200. Soapy wildcats give smokey damsels.  
    Damsels smokey soapy give wildcats.

201. Rapid augur violent flashes storms.  
    Rapid flashes augur violent storms.

    Respectable jewelers give accurate appraisals.

203. Wake odors snows fatal violent.  
    Fatal snows wake violent odors.

204. Accurate gallant fight fumes detergents.  
    Gallant detergents fight accurate fumes.

205. Noisy parties wake sleeping neighbors.  
    Neighbors sleeping noisy wake parties.

206. Furry fight furious wildcats battles.  
    Furry wildcats fight furious battles.
207. Pink accidents cause sleeping storms.
    Accidents pink storms sleeping cause.

208. Lighted gentlemen dissolve furious appraisals.
    Dissolve appraisals gentlemen lighted furious.

209. Sudden melting cause floods snows.
    Melting snows cause sudden floods.

210. Stains greasy soapy dissolve detergemts.
    Soapy detergents dissolve greasy stains.

211. Rapid deter sudden bouquets neighbors.
    Rapid bouquets deter sudden neighbors.

212. Cigarettes respectable battles greasy save.
    Respectable cigarettes save greasy battles.

213. Fatal accidents deter careful drivers.
    Deter drivers accidents fatal careful.

214. Gallant gentlemen save distressed damsels.
    Distressed gallant save damsels gentlemen.

    Floods careful noisy emit flashes.

216. Furry create distressed jewelers stains.
    Furry jewelers create distressed stains.

217. Bouquets pink odors fragrant emit.
    Pink bouquets emit fragrant odors.

218. Create fumes cigarettes lighted smokey.
    Lighted cigarettes create smokey fumes.

219. Fragrant melting augur drivers parties.
    Melting parties augur fragrant drivers.

220. Damsels smokey soapy give wildcats.
    Soapy wildcats give smokey damsels.

221. Rapid flashes augur violent storms.
    Furry wildcats fight furious battles.

222. Respectable jewelers give accurate appraisals.
    Pink accidents cause sleeping storms.

223. Fatal snows wake violent odors.
    Lighted gentlemen dissolve furious appraisals.
224. Gallant detergents fight accurate fumes.
   Sudden melting cause floods snows.

225. Neighbors sleeping noisy wake parties.
   Stains greasy soapy dissolve detergents.

226. Furry fight furious wildcats battles.
   Rapid deter sudden bouquets neighbors.

227. Accidents pink storms sleeping cause.
   Cigarettes respectable battles greasy save.

228. Dissolve appraisals gentlemen lighted furious.
   Fatal accidents deter careful drivers.

229. Melting snows cause sudden floods.
   Gallant gentlemen save distressed damsels.

230. Soapy detergents dissolve greasy stains.
   Noisy flashes emit careful floods.

231. Rapid bouquets deter sudden neighbors.
   Furry jewelers create distressed stains.

232. Respectable cigarettes save greasy battles.
   Bouquets pink odors fragrant emit.

233. Deter drivers accidents fatal careful.
   Create fumes cigarettes lighted smokey.

234. Distressed gallant save damsels gentlemen.
   Fragrant melting augur drivers parties.

235. Floods careful noisy emit flashes.
   Damsels smokey soapy give wildcats.

236. Furry create distressed jewelers stains.
   Rapid flashes augur violent storms.

237. Pink bouquets emit fragrant odors.
   Respectable jewelers give accurate appraisals.

238. Lighted cigarettes create smokey fumes.
   Fatal snores wake violent odors.

239. Melting parties augur fragrant drivers.
   Gallant detergents fight accurate fumes.

240. Soapy wildcats give smokey damsels.
   Neighbors sleeping noisy wake parties.
241. Rapid augur violent flashes storms.  
   Furry fight furious wildcats battles.

242. Jewelers respectable appraisals accurate give.  
   Accidents pink storms sleeping cause.

243. Wake odors snows fatal violent.  
   Dissolve appraisals gentlemen lighted furious.

244. Accurate gallant fight fumes detergents.  
   Melting snows cause sudden floods.

245. Noisy parties wake sleeping neighbors.  
   Soapy detergents dissolve greasy stains.

246. Furry wildcats fight furious battles.  
   Rapid bouquets deter sudden neighbors.

247. Pink accidents cause sleeping storms.  
   Respectable cigarettes save greasy battles.

248. Lighted gentlemen dissolve furious appraisals.  
   Deter drivers accidents fatal careful.

249. Sudden melting cause floods snows.  
   Distressed gallant save damsels gentlemen.

250. Stains greasy soapy dissolve detergents.  
   Floods careful noisy emit flashes.

251. Rapid deter sudden bouquets neighbors.  
   Furry create distressed jewelers stains.

252. Cigarettes respectable battles greasy save.  
   Pink bouquets emit fragrant odors.

253. Fatal accidents deter careful drivers.  
   Lighted cigarettes create smokey fumes.

254. Gallant gentlemen save distressed damsels.  
   Melting parties augur fragrant drivers.

255. Noisy flashes emit careful floods.  
   Soapy wildcats give smokey damsels.

256. Furry jewelers create distressed stains.  
   Rapid augur violent flashes storms.

257. Bouquets pink odors fragrant emit.  
   Jewelers respectable appraisals accurate give.
258. Create fumes cigarettes lighted smokey. 
   Wake odors snows fatal violent.

259. Fragrant melting augur drivers parties. 
   Accurate gallant fight fumes detergents.

260. Damsels smokey soapy give wildcats. 
   Noisy parties wake sleeping neighbors.

261. Rapid augur violent flashes storms. 
   Rapid deter sudden bouquets neighbors.

262. Jewelers respectable appraisals accurate give. 
   Cigarettes respectable battles greasy save.

263. Wake odors snows fatal violent. 
   Fatal accidents deter careful drivers.

264. Accurate gallant fight fumes detergents. 
   Gallant gentlemen save distressed damsels.

265. Noisy parties wake sleeping neighbors. 
   Noisy flashes emit careful floods.

266. Furry wildcats fight furious battles. 
   Furry jewelers create distressed stains.

267. Pink accidents cause sleeping storms. 
   Bouquets pink odors fragrant emit.

268. Lighted gentlemen dissolve furious appraisals. 
   Create fumes cigarettes lighted smokey.

269. Sudden melting cause floods snows. 
   Fragrant melting augur drivers parties.

270. Stains greasy soapy dissolve detergents. 
   Damsels smokey soapy give wildcats.

   Rapid flashes augur violent storms.

272. Cigarettes respectable battles greasy save. 
   Respectable jewelers give accurate appraisals.

273. Fatal accidents deter careful drivers. 
   Fatal snows wake violent odors.

274. Gallant gentlemen save distressed damsels. 
   Gallant detergents fight accurate fumes.
275. Noisy flashes emit careful floods.
    Neighbors sleeping noisy wake parties.

276. Furry jewelers create distressed stains.
    Furry fight furious wildcats battles.

277. Bouquets pink odors fragrant emit.
    Accidents pink storms sleeping cause.

278. Create fumes cigarettes lighted smokey.
    Dissolve appraisals gentlemen lighted furious.

279. Fragrant melting augur drivers parties.
    Melting snows cause sudden floods.

280. Damsels smokey soapy give wildcats.
    Soapy detergents dissolve greasy stains.
INSTRUCTIONS TO LISTENERS

You will hear five words in one ear at the same time that you hear five words in the other ear. You will hear a total of ten words for each trial. As soon as you have heard the ten words repeat as many of them as possible into the microphone. If a word is heard more than once repeat it as many times as you have heard it. Listen very carefully.
REFERENCES


Hughes, Rush. Central Institute for the Deaf Auditory Test (PB-50), Lists 7 and 8, Technisonic Studios, 1201 Brentwood Blvd., Richmond Heights, Missouri, 63117.


Peters, Robert W. "Competing Messages: The Effect of Interfering Messages Upon the Reception of Primary Messages," United States Naval School of Aviation Medical Research Report, 1954, Project Number N.M. 001 064 01.27.


