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# Armed Services Technical Information Agency

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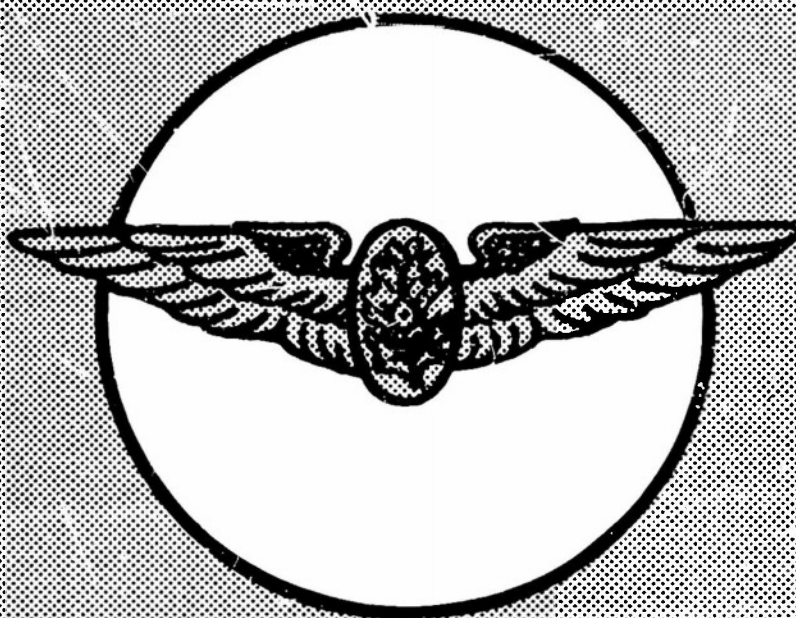
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THE EFFECT OF ACOUSTIC ENVIRONMENT  
UPON SPEAKER INTELLIGIBILITY

PROJECT NUMBER NM 001 064.01.26



# RESEARCH REPORT

OF THE

**U. S. NAVAL SCHOOL OF AVIATION MEDICINE**

NAVAL AIR STATION

PENSACOLA FLORIDA

U. S. Naval School of Aviation Medicine, Pensacola, Florida

30 August 1954

Joint Report NM 001 064.01.26

"THE EFFECT OF ACOUSTIC ENVIRONMENT UPON SPEAKER INTELLIGIBILITY"

Robert W. Peters, The Ohio State University and Acoustic Laboratory, and The U. S. Naval School of Aviation Medicine, Pensacola, Florida

5 pp. 2 tables 1 figure UNCLASSIFIED

Speakers read lists from multiple-choice intelligibility tests while simultaneously hearing one of six acoustic signals. The six types of interfering acoustic signals presented to the subjects were selected to represent types of material which would be in the listening environment of speakers in various military communication situations. Mean intelligibility values for the speakers reading under the different acoustic circumstances were determined from listener responses to the reading of the lists. The results of the experiment indicated that speakers were significantly more intelligible when the distractions which they were hearing while reading were either nonsense words or words similar to those being read than they were when words heard simultaneously were the same words or meaningful words unrelated to those being read.

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JOINT PROJECT REPORT NO. 26

The Ohio State University Research Foundation  
Columbus, Ohio, under Contract N6ONR 22525,  
Office of Naval Research Project Designation No. NR 145-993

and

U. S. Naval School of Aviation Medicine  
The Bureau of Medicine and Surgery Project NM 001 064.01.26

THE EFFECT OF ACOUSTIC ENVIRONMENT UPON SPEAKER INTELLIGIBILITY

Report by

Robert W. Peters

Approved by

John W. Black  
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and

Captain Ashton Graybiel, MC, USN  
Director of Research  
U. S. Naval School of Aviation Medicine

Released by

Captain Julius C. Early, MC, USN  
Commanding Officer

30 August 1954

## SUMMARY

Intelligibility values were obtained for 36 speakers who read lists from multiple-choice intelligibility tests (7) under conditions of simultaneously hearing various acoustic signals. The signals were selected to represent conditions which might confront a speaker operating in a number of circumstances, especially in military establishments where voice messages are frequently transmitted in the presence of other signals and noise. The six groups of acoustic signals which were presented to the speakers consisted of: (a) the same words as the speaker was reading, (b) similar words which could be confused with the words the speaker was reading, (c) unrelated words which would not easily be confused with those the speaker was reading, (d) nonsense words with the same temporal patterning as those the speaker was reading, (e) meaningful "flight-patter" phrases, and (f) babel which was prepared by overlapping a number of "flight-patter" phrases on a single recording.

Criterion measures of relative speaker intelligibility under the various signal conditions were obtained from a total of 481 listeners in 36 panels. A single speaker was heard by two panels simultaneously. The voice signal to one panel was subjected to limiting to maintain relatively constant signal level, while the signal to the other panels was fed directly from the speaker to the listeners, allowing speaker voice-level changes to be transmitted to the listeners. The listeners responded to the reading of the intelligibility lists under the condition of 114 db of simulated propeller-type aircraft noise. The results indicated that the speaker's intelligibility was influenced by the type of signal concurrently heard while he read test material. Under both listening conditions, i.e., with the sound pressure level of the speaker's voice signal modified and not modified by limiting, the intelligibility of the speakers was significantly higher under the conditions of simultaneously hearing nonsense words or words similar to those they were reading than it was under the conditions of hearing other types of material.

## INTRODUCTION

In many communication systems the speaker operates in the presence of a wide variety of acoustic signals. This is especially true in aircraft control towers and other similar situations where a number of voice messages are being received and transmitted simultaneously. The results of previous experimentation have indicated that the speaker responds to his immediate acoustic environment. Speakers tend to raise their voice-level as the level of pure-tone and noise stimuli which they are hearing is increased (1, 3, 4). Also there is a tendency for speakers to imitate the precision of heard stimuli in their vocal responses (2). These findings suggest that the intelligibility of the speaker may be influenced by the signals present in his auditory environment. This study was concerned with the effect of various acoustic signals upon the intelligibility of speakers while simultaneously reading

aloud and hearing the acoustic signals. The hypothesis under test was, there is no difference in speaker intelligibility when speakers read while simultaneously hearing one of six different types of acoustic signals.

#### PROCEDURE

Thirty-six speakers read 12 speaker lists from either Form A or B of the multiple-choice intelligibility tests (7). Each speaker read two lists while simultaneously hearing one of six types of acoustic signals. These signals were selected to represent conditions under which speakers in a wide variety of situations would be operating, and consisted of the same words the speaker was reading, words similar to those the speaker was reading, unrelated words that would not be likely to be confused with those the speaker was reading, nonsense words which were a backward reproduction of the same words the speaker was reading, meaningful five-syllable "flight-patter" phrases (9), and babel which was composed of overlapping "flight-patter" phrases.

Preparation of the acoustic signal stimuli was facilitated by use of lists from alternate forms of the multiple-choice intelligibility test. The words similar to those which the speaker was reading were composed of lists from Forms A-1 and B-1 (8). These words appear on the same answer form as the ones the speaker was reading, for the reason that they have been demonstrated to be frequently misunderstood for the words of the speaker's lists. The unrelated words were taken from Form C of the multiple-choice test (5). They are entirely different from the ones of Forms A and B, but are of similar length and are presented in similar groupings. The stimulus material for the acoustic signals was recorded on disks by a single voice. The disk recording of the material permitted randomization of the order of presentation of the acoustic signal conditions to the speaker.

The speakers read the intelligibility lists while seated in a small sound-treated room. The source pick-up for their voice was a condenser microphone boom-mounted adjacent to the corner of the mouth. The acoustic signals were presented to the speakers through a PDR-8 headset at a level of approximately 80 db (re .0002 dyne/cm<sup>2</sup>). These signals were all presented in the same temporal pattern with the same identifying carrier numbers as the material which the speaker was reading. The speaker was instructed to read at his normal level and to attempt to read in unison with the recorded material he was hearing. A three-second beep consisting of a 1000-cycle tone preceded each acoustic signal and provided the subject with an auditory cue to prepare to read the next portion of the intelligibility list. Each subject read a practice list while hearing concurrent acoustic signals before reading the actual test material.

Two panels of listeners in another sound-treated room responded to the speaker's reading of the intelligibility lists by marking answer sheets for Forms A and B of the multiple-choice intelligibility tests (7). The speaker's voice signal to one panel was subjected to limiting to maintain a relatively constant signal level irrespective of the speaker's change in level under the experimental conditions, while the signal fed to the

listeners in the other panel allowed the speaker's changes in sound pressure level to be transmitted. The listeners in both panels heard the speaker's voice through PDR-3 headsets at a level of approximately 95 db (re .0002 dyne/cm<sup>2</sup>) in the presence of 114 db of simulated propeller-type aircraft noise present free field in the testing room.

The speakers read two intelligibility lists under each condition of hearing simultaneous acoustic signals. The mean intelligibility value for each speaker on two lists was used as the basic score in the analysis of the data. The statistical treatment of the data was by double-classification analysis of variance. A separate analysis was performed relative to each listening condition, that is, with the speaker's voice signal modified or unmodified by a limiter in the circuit.

## RESULTS

A summary of the results of the analyses of variance relative to speakers reading under the conditions of various acoustic signals is shown in Table 1. The variance attributable to acoustic signal conditions exceeded the five per cent level of confidence in the instance in which the speaker's voice signal was subjected to limiting, and exceeded the one per cent level of confidence in the instance in which the speaker's voice signal was not modified by the equipment.

The mean intelligibility values of speakers for both listening conditions are shown in Table 2. With the speaker's voice level not modified, speakers were more intelligible, at the five per cent level of confidence or better, under the conditions of hearing nonsense words or similar words while reading than they were while under the conditions of hearing the same or unrelated words simultaneously with the reading of intelligibility lists. The speakers were also significantly more intelligible when reading under conditions of hearing "flight-patter" phrases and babel than they were while under the conditions of hearing the same words.

Similar results were found in speaker intelligibility values when the voice level of the speaker's voice fed to the listeners was modified by limiting. Mean intelligibility was significantly higher under the conditions of hearing "flight-patter" phrases and nonsense words while reading than it was under the conditions of hearing the same or unrelated words. Further, speakers were more intelligible at the five per cent level of confidence or better when hearing similar words than they were under the conditions of hearing the same or unrelated words while speaking.

Mean intelligibility curves for speakers reading while hearing the various signals are portrayed graphically in Figure 1. It may be noted that the same mean intelligibility patterns occur for both panel listening conditions. The higher scores which accompanied the voice signals that were subjected to limiting may be due to a combination of factors:

(a) a lower average free-field level of noise existed at the ears of these listeners due to their position in relation to the source of noise in the testing room, and (b) the action of the limiter maintained a higher signal level at the headsets than was maintained by the individual speaker. The difference between the two sets of scores, however, is not important to the results of the present experiment.

## DISCUSSION AND CONCLUSION

The hypothesis of no difference in speaker intelligibility with speakers reading while hearing various acoustic signals simultaneously and in the same temporal pattern as the material being read may be rejected on the basis of the preceding results. When speaking concurrently with heard acoustic signals, speakers tend to be more intelligible when the acoustic signals are nonsense or words similar to those being read than they are when the signals are the same or unrelated words. The similarity of results found with the speaker's voice signal modified by limiting and not modified before being heard by the listeners suggests that the effect of hearing simultaneous acoustic signals upon the intelligibility of the speaker is relatively independent of fluctuations in sound pressure level of response occasioned by the presence of the signals.

The finding of lowered intelligibility when the speaker was hearing the same words as he was reading suggests that the acoustic signal in this instance could be raising the perceived side-tone level, thus causing sound pressure level of response and precision of articulation on the part of the speaker to be lowered.

Results of previous studies have indicated that speakers respond to signals present in their acoustic environment by adjusting their sound pressure level of response and precision of articulation to match the heard stimuli. These findings suggested the experiments described here, wherein speaker intelligibility was studied relative to the type of acoustic signal heard by the speaker while he was reading. The acoustic signals were selected to represent a variety of conditions under which speakers in communication systems would be likely to operate. The acoustic signals were presented simultaneously with the material the speaker was reading and were in the same temporal pattern. Under these restrictions of the experiment, the mean intelligibility of the speakers was found to differ significantly under the conditions of various acoustic signals. Speakers were more intelligible while they were simultaneously hearing nonsense words and similar words than they were while hearing the same words or words unrelated to those words which they were reading.

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Table 1. A summary of analyses of variance relative to speaker intelligibility for speakers reading under six conditions of acoustic signals.

| Source of Variation | df  | Voice signal to<br>listeners controlled | Voice signal to listen-<br>ers not controlled. |
|---------------------|-----|-----------------------------------------|------------------------------------------------|
| Signal conditions   | 5   | 120 <sup>**</sup>                       | 221 <sup>*</sup>                               |
| Speakers            | 35  | 391 <sup>*</sup>                        | 1008 <sup>*</sup>                              |
| Remainder           | 175 | 37                                      | 4                                              |

\*F > 1 per cent level of confidence

\*\*F > 5 per cent level of confidence

Table 2. Mean intelligibility values for speakers reading multiple-choice intelligibility lists under six conditions of acoustic signals.

| <u>Acoustic signal</u>                                                 | Same<br>Words | Similar<br>Words | Neutral<br>Words | Nonsense<br>Words | Flight<br>Patter | Babel |
|------------------------------------------------------------------------|---------------|------------------|------------------|-------------------|------------------|-------|
| Scores % <sup>*</sup><br>Voice level of<br>speakers<br>controlled      | 67.00         | 69.25            | 66.61            | 71.50             | 69.97            | 68.25 |
| Scores % <sup>**</sup><br>Voice level of<br>speakers not<br>controlled | 61.16         | 65.00            | 62.16            | 68.22             | 64.61            | 64.86 |

\*Any difference between two means of 3.66 significant at the 1 per cent level of confidence, any difference of 2.80 significant at the 5 per cent level of confidence.

\*\*Any difference between two means of 3.99 significant at the 1 per cent level of confidence, any difference of 3.03 significant at the 5 per cent level of confidence.

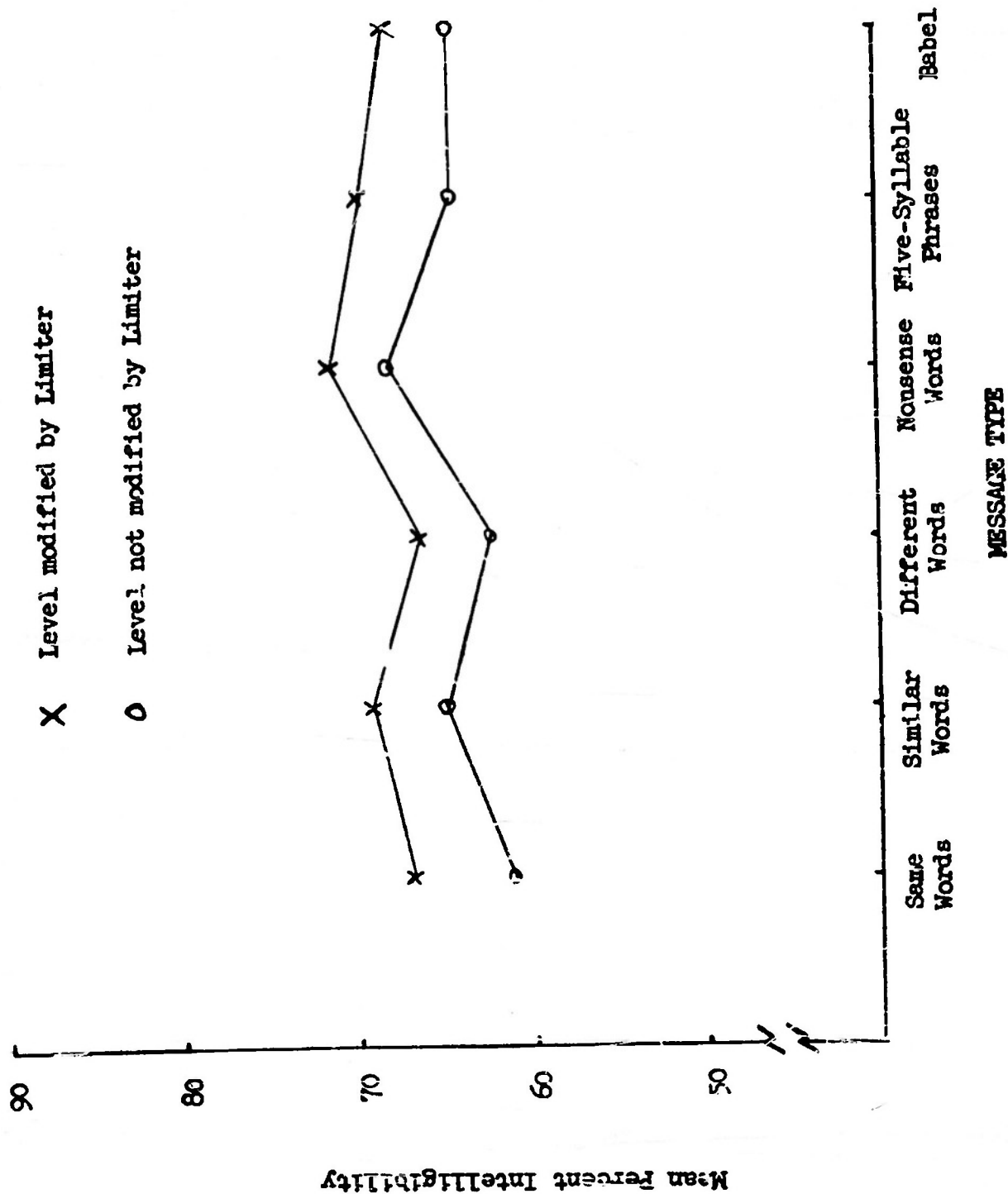


FIGURE 1. Mean Speaker Intelligibility Under Six Acoustic Signal Conditions.

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