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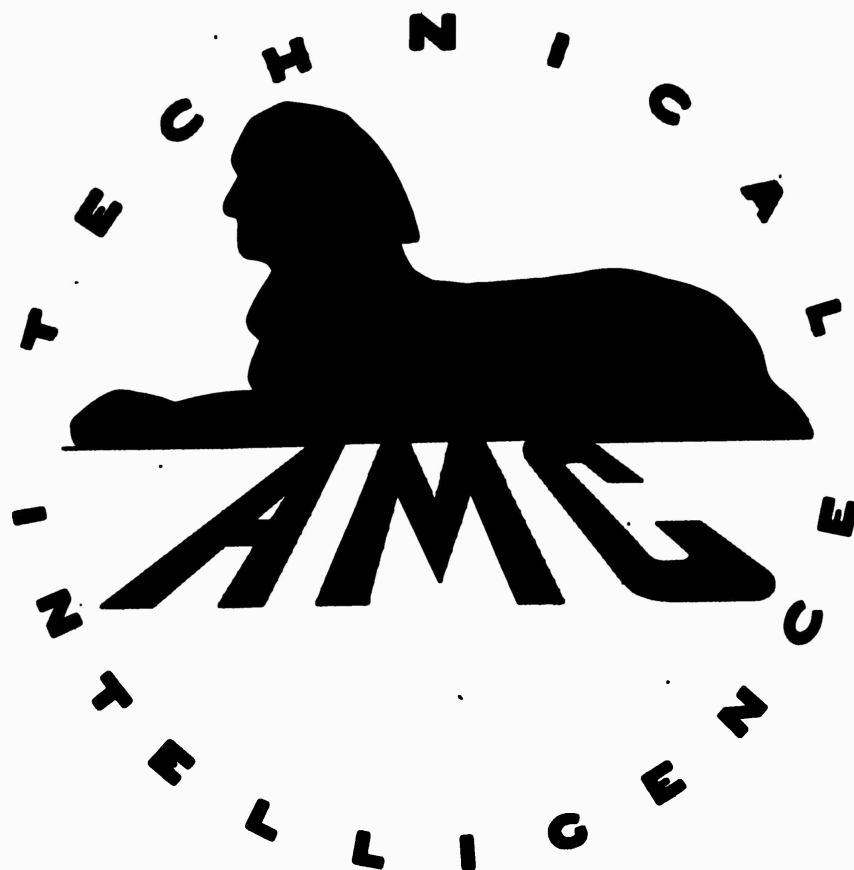
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Applied Psychology Panel, NDRC
Project SC-67: VOICE COMMUNICATION

Report No. 18, August 20, 1945

TRAINING STUDIES IN VOICE COMMUNICATION:
III. EFFECTS OF TRAINING IN ARTICULATION

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THE PSYCHOLOGICAL CORPORATION
New York, New York
George K. Bennett, Contractor's Technical Representative
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Summary

Four experiments designed to investigate effects of training in pronunciation or articulation are presented.*

Results indicate that training to pronounce accurately and clearly produces increased intelligibility.

Instruction to stress final consonants resulted in increased intelligibility when the T-17 (hand held) microphone was used, but not when T-30 (throat) or ANB-M-C1 (mask) microphone were used.

No gains in intelligibility were shown as a result of instruction to stress sibilant sounds.

Training for one hour in clear pronunciation affected a subsequent intelligibility test, not only in the scores obtained by the speakers, but in the degree to which words were articulated, as determined by judges who heard phonograph recordings of tests given before and after training. Loudness of speech signal was not changed by this training.

*These experiments were performed in part at Voice Communication Laboratory, Waco AAF and in part at Goodfellow AAF in conjunction with the ground school course in voice communication, Major H. D. Ransier, Director, and Lt. R. P. Stewart, instructor in charge.

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EFFECTS OF TRAINING IN ARTICULATION

I. Introduction

Since the difference between one word and another is often a difference of a single sound, it is obvious that slovenly pronunciation of words may result in lowered intelligibility. The crucial question for Army Air Forces voice communication training, however, is whether a relatively small amount of training directed at improving articulatory practices is effective in improving intelligibility in noise.

The effects of three types of training, each of which was directed toward clear pronunciation, are shown in four experiments presented in the following sections. The types of instruction given were:

1. Instruction to stress final consonants.
2. Instruction to stress sibilant sounds (s, z, sh, zh, ch, j).
3. Instruction in precise articulation of words.
(Lecture and practice in quiet.)
4. Instruction in precise articulation of words.
(Lecture, practice in noise, demonstration record.)

In the first two experiments reported emphasis was put upon the manner in which individual sounds were to be made, in one case sounds were singled out for attention; in the other, attention was paid to the last sound in each word. The last two experiments deal with attempts to get the student to pay attention to pronunciation generally, no attempt being made to stress any particular sound.

II. Instruction to Emphasize Final Consonants

Twelve lists, each made up of 24 one-syllable words, were assembled. Words were chosen so that each list contained at least once in the final position each consonant sound that commonly is so used in the English language. Twelve groups of 18-20 AAF student pilots spoke and listened to the words. Six-eight from each group served as readers, the remaining 12-14 as listeners. Readers and listeners were surrounded by 100-110 db aircraft-type noise.

Each speaker read two lists of words over an inter phone network, one in his normal manner, and one with added stress on final consonants.

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A schedule of reading was followed in which, among 4 repetitions of the procedure, each list was read twice normally and twice with stressed final consonants. In one instance the stressed reading of a list occurred first, in the other, the normal. Speakers watched a VU meter connected across the interphone headset circuit, and produced each word at a loudness level of -2 VU, where 0 VU = 4.2 volts.

This procedure, with four readings of each list, was repeated with three groups of subjects, one each with readers using ANB-M-C1 microphones in 7-10-R oxygen masks, T-17 (hand held) microphones, and T-30 (throat) microphones.

Intelligibility values were computed so that the value obtained by speakers pronouncing normally could be compared with that when lists were read with special stress on final consonants. Due to absences, the counterbalancing for order of stressed and non-stressed readings was not complete. Analysis showed, however, that this was not a serious defect, since there was negligible variance due to order of stressed-normal readings.

Table I

Intelligibility of One-Syllable Words Read Normally and With Special Stress on Final Consonants

<u>Microphone</u>	<u>N</u>	<u>Normal Mean</u>	<u>Stressed Mean</u>	<u>Difference Stressed-Normal</u>	<u>S.D. Within Groups</u>	<u>"t"</u>
T-17	30	50.5	56.5	6.0	10.2	4.26
T-30	32	39.2	40.9	0.7	9.9	0.50
ANB-M-C1	27	56.2	52.9	-3.3	11.2	1.61

"t's" from distributions of differences.

"t" (1%) for 30 d.f. = 2.75.

"t" (5%) for 30 d.f. = 2.04.

A significant improvement was made by stressing final consonants in the case of the T-17 microphone (Table I). The mean gain and loss for the other two microphones were within the amount expected by chance.

III. Training to Stress Sibilant Sounds

Some sounds have been shown to be factors in the low intelligibility values of words containing them.* For example sibilant sounds are among the most difficult to understand in nonsense-syllable articulation tests. To find whether the detrimental effects of these sounds could be overcome in voice communication through training,

*Phonetic Characteristics of Words as Related to Their Intelligibility in Aircraft-Cockpit Noise. OSRD Report 4681. Restricted.

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speakers were tested, trained and re-tested for intelligibility.* Fifty-eight AAF student pilots, who had previously served as subjects in an experiment in voice communication, were given an intelligibility test, using the T-17 microphone. Twenty-nine were then given 2 half-hour periods of lecture and practice in quiet on stressing sibilant sounds. At the end of the second training session, both groups were given a final intelligibility test.

Table II

Initial and Final Intelligibility Scores of Control Subjects and Subjects Trained in Stressing Sibilant Sounds

<u>Group</u>	<u>Initial Mean</u>	<u>Final Mean</u>
Experimental(N=29)	54.2	53.9
Control(N=29)	51.7	54.8

Weighted Ave. S. D. within groups = 10.9.

Since the trained subjects (Table II) lost in performance, it is evident that the training to stress sibilant sounds was not effective. It is probable that the strong sibilant articulation resulted in distortion of word patterns, making words less, instead of more, intelligible.

IV. Instruction in Precise Articulation (in quiet)

To study the effect of instruction in precise articulation of words upon intelligibility, 58 AAF student pilots were given 2A-word write-down intelligibility test in 100-110 db aircraft-type noise. Thirty of the men then received two half-hour periods of training (lecture and practice in quiet) in precise articulation of words. The training periods were on successive days. At the end of the second training period, both trained and untrained (control) subjects were re-tested. All subjects used the T-17 microphone in tests.

Table III

Initial and Final Intelligibility Scores of Control Subjects and Subjects Trained in Precise Articulation

<u>Group</u>	<u>Initial Mean</u>	<u>Final Mean</u>	<u>"t"</u>
Experimental (N=28)	56.0	60.14	6.90
Control (N=30)	57.0	57.5	

"t" from distribution of differences.

"t" (1%) for 27 d.f. = 2.77.

Weighted Ave. S.D. within groups = 10.3.

*Intelligibility Measurement: Techniques and Procedures Used by the Voice Communication Laboratory. OSD Report 3748 Restricted.

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The experimental groups (Table III) gained by a significant amount; the control group made no significant gain in performance. It is evident that the training given the experimental group was effective.

In most experiments involving an intelligibility test and re-test, a slight gain is registered by a control group, even though no intervening training has taken place. The failure of this control group to gain in score is probably due to the fact that neither it nor the experimental group was completely naive at the beginning of the experiment. Both had served for several days as listeners in another experiment, and had taken an intelligibility test before the initial test given at the outset of the present experiment. These circumstances probably stabilized the scores of both groups to some extent, making it more difficult to produce a significant gain in either.

V. Instruction in Precise Articulation (in noise)

Thirty-seven AAF cadets in pre-pilot training were tested for intelligibility, trained for one class hour in clear pronunciation of words, and re-tested. Thirty-eight cadets were tested and re-tested without intervening training, as a control group.

The multiple-choice intelligibility test was used, Form A in initial tests, and Form B in final tests. In addition, each cadet read a list of 12 one-syllable words in both initial and final testing sessions. The 12-word lists were of selected "difficult" words, and were written down by the listeners as they were spoken. All of them contained one or more of the sounds ait, fox or thin, and all were of low intelligibility. Tests were administered in 100-105 db aircraft-type noise. Instead of the usual situation in which each man serves both as speaker and listener, listening was done by special panels of AAF cadets.

To provide a measure of the incidental effect of training in pronunciation upon loudness of speech signal, monitors read VU meters connected across the headphone circuits, noting the peak loudness for each word. Phonograph recordings (CGS) were made of initial and final tests for as many speakers as equipment would allow.

Training given in articulation covered one 55-minute class period on the day between initial and final tests. The outline of the training hour follows:

1. An instruction period on the need for clear articulation when speaking in noise (5 minutes).
2. Examples of words containing sounds of low intelligibility value (3 minutes).

3. Drill with word lists. Words had been selected for low intelligibility. In 100-102 db airplane-type noise, each reader read a word over the interphone system. Another subject called the word back. If the word was incorrectly received, the speaker pronounced the word again. If the monitor perceived inadequate articulation, he gave a corrected pattern for the faulty words spoken. Each speaker read 12 different words (37 minutes).
4. Speakers listened to a demonstration recording, "Articulation," through their headsets (6 minutes).
5. Drill with interphone messages. Each speaker read an interphone message in noise, and a listener answered a question of fact about the content. The monitor criticized unclear speech (5 minutes).

Throughout the teaching session, all criticisms were directed toward clearness of speech and articulation of sounds. No mention was made of rate of speaking, loudness, or rhythm.

Data available from initial and final testing periods were:

1. Initial and final scores on equivalent forms of the multiple-choice intelligibility test.
2. Initial and final intelligibility scores on 12-word lists of low intelligibility, where each man read the same words in initial and final tests.
3. VU meter readings for each word in all tests ($\frac{1}{2}$ VU = 4.2 volts).
4. Phonograph recordings of intelligibility tests for approximately 1/4 of the speakers' initial and final tests.

The trained group made significant gains in performance on both the multiple-choice test and the lists of difficult words (Table IV). The control group showed no improvement on the multiple-choice test. However, it did improve significantly on the difficult words. The gain of the control group on the difficult words was almost equal to that of the trained group. Since the same tests were used in initial and final difficult word tests, the gain in both groups was probably due to increased speaker-listener familiarity with the items. The fact that the trained group made a gain on the multiple-choice test, while the control group did not, indicates that the training did produce better intelligibility on words in general.

All single-word VU readings for a speaker were averaged, and the average treated as his initial or final VU level. Comparison

Table IV
Intelligibility of Trained and Control Speakers

a. Multiple-Choice Test

	Initial		Final		Difference	
	Mean	S. D.	Mean	S. D.	$M_2 - M_1$	"t"
Trained Group (N=37)	58.8	8.6	66.2	7.8	7.4	3.77
Control Group (N=38)	63.4	8.7	64.1	7.4	.7	.80

b. Difficult-Words Test

	Initial		Final		Difference	
	Mean	S. D.	Mean	S. D.	$M_2 - M_1$	"t"
Trained Group (N=37)	50.2	11.3	48.3	10.2	8.1	4.39
Control Group (N=38)	38.8	12.8	45.0	9.7	6.1	3.30

"t's" from distributions of differences.
"t" (1%) for 36 d.f. = 2.75.

Correlations, initial vs. final scores
were as follows:

trained, multiple choice, r, -.01;
control, multiple choice, r, .38;
trained, difficult words, r, .49;
control, difficult words, r, .60.

of initial and final Mean VO readings (Table V) shows that neither training in articulation nor the experience of taking a test had any significant effect upon overall strength of signal.

Table V

Group	Effect of Training in Articulation on Strength of Signal				Difference	"t"
	VU Initial		VU Final			
	Mean	S.D.	Mean	S.D.		
Trained (N=37)	-2.4	2.9	-2.0	2.7	.4	.66
Control (N=38)	-2.2	3.2	-2.3	3.1	-.1	.50

"t's" from distributions of differences.

"t" (5%) for 36 d.f. = 1.04.

From CCS recordings of 12 of the trained group, re-recordings of the lists of difficult words were made in such a manner that initial and final speaking of each word by the same speaker were paired. Position in the pair (initial - final) was determined from a table of random numbers. Volume level of recording was equalized for each pair by monitoring its peak-level on a cathode-ray oscilloscope connected across the output of the recording amplifier. The re-recording was done from 2 turntables, each system used alternately for reproducing an initial test. These pairs of records of the same word, spoken before and after training, were played to a panel of 9 persons, 4 of whom were specialists in speech. All were given the instruction to designate the A or B member of a pair of words as articulated with most precision. Judgment was not to be on correctness of pronunciation or probable intelligibility, but on degree of formation of sounds. Judges were provided with lists of the words heard, so that intelligibility would not necessarily be a factor in their judgments. A judgment was required for each pair. Table VI presents the number and proportion of correct judgments for each of 9 judges, with χ^2 (chi square) to show the probability of such a departure from chance expectancy. It may be seen that all judges were able to detect the effect of training upon articulation to a significant degree.

Table VI

Proportion of Words Spoken after Training Judged More Articulated Than the Same Words Spoken Before Training.

Judge	1*	2	3	4	5	6	7	8	9
N Correct Judgments	62	65	67	64	68	65	62	60	60
N Incorrect Judgments	14	26	27	30	26	29	32	34	34
% Correct Judgments	79%	77%	71%	68%	72%	69%	66%	64%	64%
χ^2	27.0	13.8	17.0	12.3	18.8	13.8	9.6	7.2	7.2

χ^2 (1%) for 1 d.f. is 6.64

*This judge missed 16 judgments, being called out during the judging session.

Although the 12 speakers taken as a group were judged to be changed by articulation training, some speakers did not change to a discernible degree. To show this, the proportion of "after training" words judged more articulated by the whole judging panel for each speaker was computed (Table VII). Some men made great changes due to training. For others, no discernible effect on articulation appears.

Table VII

Proportion of Words Spoken with Greater
Articulation* after Training, for 12 Speakers

Speaker	1	2	2	4	5	6	7	8	9	10	11	12
Percent of words more articulated after training	94	88	88	85	83	81	79	56	49	46	46	39

*Degree of articulation is determined by composite score of a panel of 9 judges listening to 7-8 pairs of words per speaker.

VI. Summary and Interpretation

Three of the four experiments reported in this study showed significant effects of training in precise articulation upon intelligibility. The effects were shown with word intelligibility tests involving a wide variety of speech sounds. All involved the T-17 (hand held) microphone. The only experiment in which other microphones were used failed to show any effect of training in pronunciation with the T-30 (throat) or ANB-M-C1 (mask) microphone. Training in this experiment, however, only involved stressing final consonants, so that no general conclusion is possible regarding the effect of training in clear speech with respect to the T-30 or ANB-M-C1 microphone.

Gains in intelligibility were not due to increased loudness of speech signal which might have accompanied more careful articulation. In one experiment, (stressing final consonants) loudness was controlled by the reader, who watched a VU meter as he spoke; in another, loudness readings were compared before and after training in clear pronunciation. No appreciable change in loudness occurred.

Where phonograph records of speech before and after training were available, judges were able to pick out the speech of trained speakers by the degree to which they articulated test words.

Two experiments afforded an opportunity to measure the effect of training upon sounds associated with low intelligibility. In one, training in stressing sibilant sounds was given. In another, general training in clear pronunciation was given, and a special test of

one-syllable words containing the g (git), f (fox), and th (thin) was given before and after training. Trained subjects gained no more than untrained subjects in either experiment. These results indicate that training for good articulatory patterns is likely to improve intelligibility, and is superior to training which attempts to improve the pronunciation of difficult sounds.

In two cases where general patterns of clear speech were taught, the one involving instruction in noise was the more effective. Too many conditions were different in the experiments to attribute the greater gain to the presence of noise, but the presumption is that noise used during training was helpful.

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ABSTRACT:

Since the difference between one word and another is often the difference of a single sound, it is obvious that slovenly pronunciation of words may result in lowered intelligibility. Four experiments designed to investigate effects of training in pronunciation and articulation are discussed. Results indicate that training to pronounce accurately and clearly produces increased intelligibility. Instructions to stress final consonants resulted in increased intelligibility when the T-17 hand held microphone was used, but not when the T-30 (throat) or ANB-M-C1 (mask) microphones were used. No gains in intelligibility were shown as a result of instruction to stress sibilant sounds. Loudness of speech signal was not changed by this training.

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