TECHNICAL REPORT - SDC 411-1-8

SOME EFFECTS OF THE COMMON COLD UPON SPEECH

(Psychological Studies of Training Techniques)

Kenyon College
Gambier, Ohio

SDC Human Engineering Project 20-K-2
Contract N7onr-411, T.O. I
Project Designation NR-782-004

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August 12, 1949

Introduction

Frequently heard are remarks which imply that when we have a cold our speech sounds "different." This commonly alleged difference has evidently been so generally accepted that scientific investigators have not been stimulated to evaluate it; at least, a search through the literature by the author revealed few observations other than what might be furnished by any man on the street. It was felt that some attempt should be made to obtain more definite information about the influence a cold might have upon speaking not only because of the frequency of opportunities that any such relationship has to exert itself but also because information concerning it might add to our understanding of other voice problems. By way of initiating such an attempt, a number of victims of coryza were found, and several possible effects of that condition upon their speaking were studied. The purpose of this paper is to report findings of that study.

Specific questions posed for investigation were the following: 1) To what extent does having a cold affect a speaker's intelligibility or vocal quality? 2) If a cold modifies speech, does the effect vary with different acoustical conditions under which the listeners respond? 3) Does nasal spraying with a vasoconstricting agent influence the relationships implied by

the preceding questions? (4) Are such relationships associated with medical symptoms which characterize a cold or with phonemes which require nasal emission of sounds?

Procedure

Twenty-four subjects (Ss) were selected from a group of aviation cadets and enlisted men at the U.S. Naval Air Station, Pensacola, Fla. Everyone in the group had been referred by physicians in the station dispensary after having been diagnosed there as having a cold. No one referred in a febrile condition or with sinusitis, tonsillitis, laryngitis, bronchitis, or otitis media was used in the investigation. Nor was anyone used if his audiogram showed a hearing loss greater than 20 db for any frequency between 256 c. and 8192 c. or an average loss greater than 10 db. In other words, the Ss were troubled primarily by simple coryza uncomplicated by symptoms other than acute rhinitis and/or nasopharyngitis.

The procedure followed for each S involved obtaining an evaluation of the severity of his coryzal symptoms,*

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* The writer is grateful to Lt.(j.g.) Calvin J. Curts (MC), USN, for furnishing these evaluations.

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a test of his auditory acuity, and two high-fidelity

phonograph records of his speech. The first record represented the S's reading of a 24-word intelligibility-test list[1] before he had received any treatment for his cold; the second record, his reading of a comparable list five minutes after a nasal spray of neosynephrine hydrochloride (.25% sol.) had been administered by a physician. The S was then sent back to the dispensary for further treatment. In a week or ten days, after a second medical examination indicated that his coryzal symptoms had disappeared, he returned to the laboratory and a third record was made, representing his reading of a list in his normal voice. The S was then dismissed.

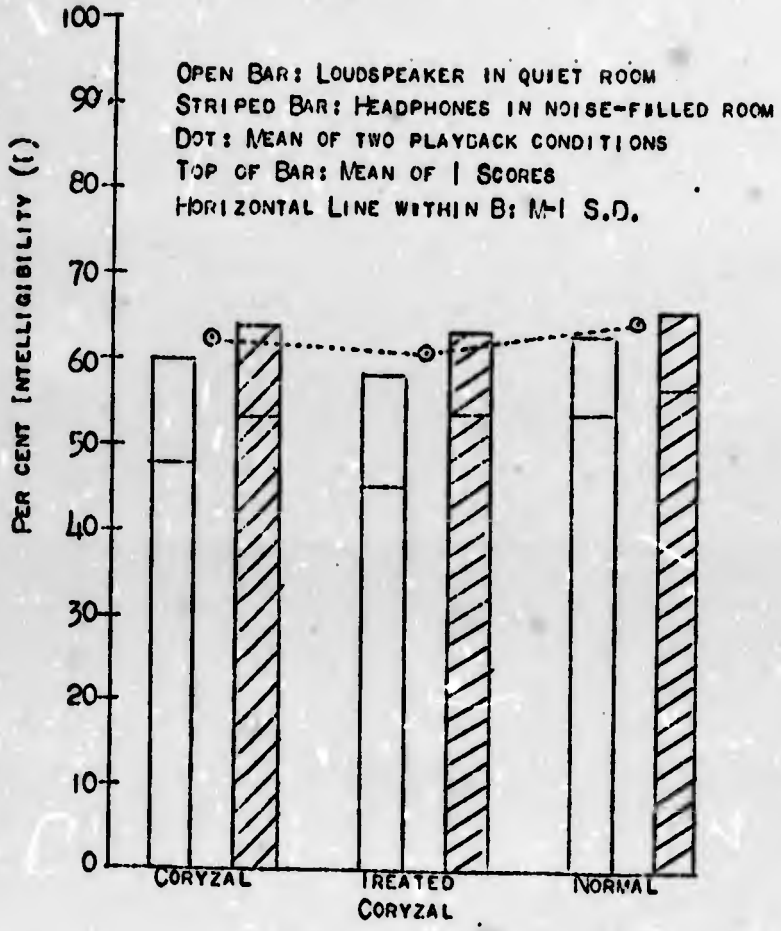
The remainder of the experimental procedure consisted of getting reactions of listeners to various aspects of the recorded utterances played back under various conditions. Details of the several types of listener-response will be given with the presentation of the results.

Results

Intelligibility

Mean percentage-intelligibility scores representing six combinations of experimental conditions and the standard deviations of their six distributions are represented in Fig. 1. The three records of each S were each presented to two panels of 9-11 listeners. One panel, seated in a large classroom, identified a S's

FIGURE 1



MEANS AND STANDARD DEVIATIONS OF SIX DISTRIBUTIONS, EACH OF WHICH CONSISTED OF INTELLIGIBILITY SCORES OF 24 S·S FOR ONE OF THREE RECORDING CONDITIONS AND ONE OF TWO PLAYBACK CONDITIONS.

words as they were transmitted at a rather low level through a high-fidelity loudspeaker 20 feet away. Speaker-intelligibility means derived from such identifications are represented by the open bars in the figure. Another panel, seated in a smaller room saturated with airplane-type noise (105 db above threshold), identified the same S's words as they were transmitted through headphones characterized by high-frequency attenuation. Means derived from such identifications are represented by the striped bars. The first pair of bars represent the first recording condition, i.e., coryzal speech; the second pair represent treated-coryzal speech; the third pair, the third recording condition, normal speech.

The fact that the open bars in the figure are all slightly shorter than the striped ones need cause no concern since it was not the purpose of the experiment to compare the intelligibility associated with the two playback conditions. The question of interest concerning playback conditions was whether or not their effects influenced the intelligibility of one recording condition more than another. An analysis of the variance, summarized in Table I, indicated that there was no such differential effect and that, consequently, the intelligibility associated with any one of the three recording

Table I

Analysis of variance for speech intelligibility scores.

Source of variation	D.F.	Variance estimate
Recordings (r)	2	159.92
Playbacks (p)	1	556.17
Subjects (s)	23	232.14
Interaction rp	2	11.11
" rs	46	38.42
" ps	23	280.19
" rps	46	78.87
	143	

conditions might be represented by a single mean.* The

* $V_{rp} < V_{rps}$

mean intelligibility for the coryzal speech, represented by the first encircled dot in the figure, was 62.02 (S.D., 9.93); for the treated-coryzal (second dot), 60.83 (S.D.,8.19); for the normal (third dot), 64.42 (S.D., 7.20). Fisherian analysis, summarized in Table II, indicated that these amounts were probably not random variations of a single population value. Although it did not appear improbable that coryzal and treated-coryzal intelligibility are the same, it would seem that

Table II

F and t evaluations of differences between means based on combined intelligibility scores (loudspeaker-quiet plus headphones-noise) for three recordings: 1) coryzal, 2) treated-coryzal and, 3) normal. (N = 24)

$V_r/V_{rs} = 159.92/38.42 = 4.163$ $(P < .05)$
$M_3 - M_1/S.E._{diff.} = 2.40/2.218 = 1.080$ $(P < .30)$
$M_3 - M_2/S.E._{diff.} = 3.59/1.683 = 2.129$ $(P < .05)$
$M_1 - M_2/S.E._{diff.} = 1.19/1.946 = 0.674$ $(P < .60)$

there might be a difference between the latter of these and the intelligibility of normal speech. It should be noted, however, that the obtained difference was not highly significant.*

* Since the second recording of each S was made within several minutes of the first, it is possible that there was an adaptation effect which diminished the variation among the means.

Examination of the intelligibility indices of each S separately revealed information not made obvious by consideration of only the group averages. Although the average intelligibility obtained for the coryzal speech condition was slightly higher than that obtained for the treated-coryzal recordings, 13 speakers had better intelligibility after receiving the nasal spray than before, while 11 were less intelligible. And, although

the mean for the coryzal speech was lower than that for the normal, 14 speakers were more intelligible when they had a cold than when they were well, while only 10 were less intelligible. In an attempt to find explanation for these discrepancies, the direction of change shown by each speaker in his intelligibility was compared to the amount and type of each of four medical symptoms. There seemed to be little relationship between direction of shift in intelligibility, from that of coryzal speech to that of either treated-coryzal or normal, and extent of nasal inflemation, nasal edema, or nasopharyngeal inflamation. (cf. Table III.) Possibly it is noteworthy that, although marked nasal discharge was observed in nearly half of the subjects whose shift in intelligibility from the coryzal to the treated-coryzal condition followed the direction of the averages, only three of the subjects whose shifts were in the opposite direction displayed the same effect while 10 revealed little or no nasal discharge. Similarly, although considerable nasal discharge characterized half of the subjects whose coryzal intelligibility was--as in the case of the means--lower than their normal intelligibility, of those whose differences between coryzal and normal intelligibility departed from the pattern of the means, only three presented marked nasal discharge while 11 presented relatively little. Neither of these

Table III

Distribution of speakers according to direction of change in intelligibility and according to extent of each of four coryzal symptoms during cold. (Marked, +. Slight or negative, 0)

	Nasal Inflam.		Nasal Edema		Nasal Discharge		Pharyng. Inflam.	
	+	0	+	0	+	0	+	0
A.								
Coryzal vs. Treated-Coryzal								
$I_C > I_T$	4	7	6	5	5	6	6	5
$I_C < I_T$	5	8	7	6	3	10	7	6
B.								
Coryzal vs. Normal								
$I_C > I_N$	6	8	8	6	3	11	7	7
$I_C < I_N$	3	7	5	5	5	5	6	4

discrepancies, however, was great enough to produce a chi-square which accompanies the commonly accepted level of significance *

* Chi-squares were 1.34 (P = .25), for the first discrepancy mentioned, and 2.16 (P = .15) for the second.

There are at large a number of individuals who, upon meeting someone displaying obvious coryzal symptoms, seem unable to resist remarking in an unnatural voice,

"Goodess be! You got a cold id your doze." The implication of such a cliché--*viz.*, that sounds requiring nasal emission are altered by a cold--suggested the possibility that any influence of coryza on intelligibility may be greater for words which include nasal sounds than for other words. In order to evaluate this possibility, each of the three lists recorded by each of the 24 S's was considered as consisting of two sub-lists: one made up of words containing one or more of the three nasal phonemes ([m], [n] , [ŋ]), the other made up of words containing only phonemes ordinarily uttered with velopharyngeal closure.* For each subject, the listener-

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* Nasal-including words constituted about 35 percent of the total in most of the lists used.

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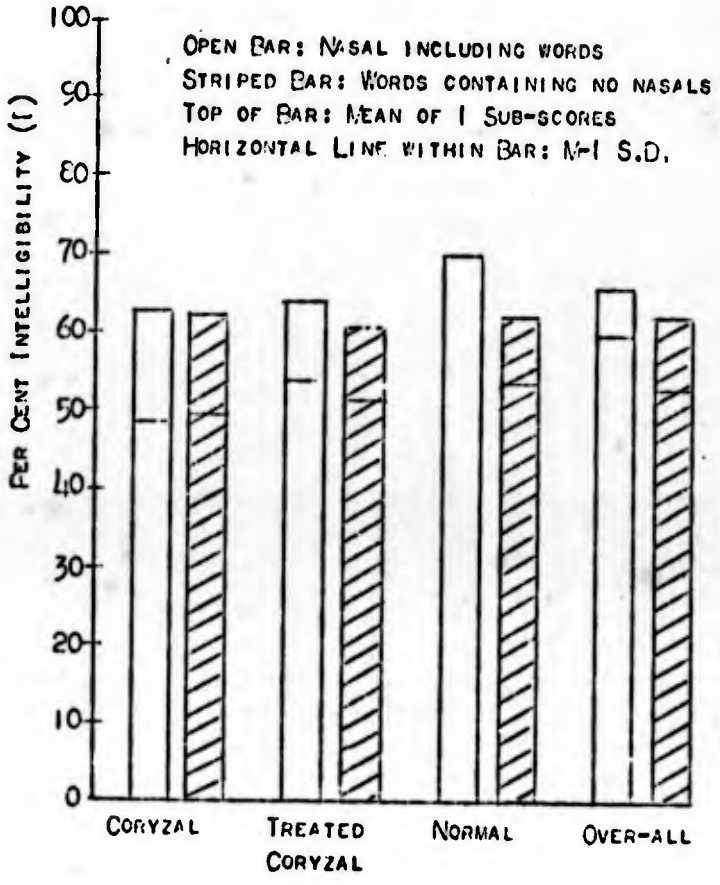
identifications of the two playback conditions were combined, and two sub-scores--one for each sub-list--were computed for each of the three recording conditions.

Means and the standard deviations for the six distributions of sub-scores are represented in Fig. 2; the distributions of over-all sub-scores, each of which was a S's average for all three recording conditions, are similarly represented for the two word-types. Under all three conditions of speaking, the average subject was more intelligible when he read nasal-including words than when he read other words; the difference was considerably

FIGURE 2



MEANS AND STANDARD DEVIATIONS OF SIX DISTRIBUTIONS, EACH OF WHICH CONSISTED OF INTELLIGIBILITY SUB-SCORES OF 24 S S FOR ONE OF THREE RECORDING CONDITIONS AND ONE OF TWO WORD TYPES; AND OF TWO DISTRIBUTIONS, EACH OF WHICH CONSISTED OF OVER-ALL SUB-SCORES OF 24 S S FOR ON WORD-TYPE.

Table IV

Analysis of variance for speech intelligibility subscores represented in Fig. 2.

Source of variation	D.F.	Variance estimate
Recordings (r)	2	218.75
Word-types (w)	1	580.00
Subjects (s)	23	213.67
Interaction rw	2	172.30
" rs	46	99.84
" ws	23	65.02
" rws	46	97.82
	143	

greater, however, when he did not have a cold. This variation in amount of difference, judging from the statistical analysis which is summarized in Table IV, might not be representative of the populations sampled.*

* $V_{rw}/V_{rws} = 1.77.$ $(P > .05)$

Indeed, all such differences may be negligible.**

** $V_r/V_{rs} = 2.19.$ $(P > .05)$

Although it was not the purpose of the investigation to evaluate the influence of phonetic content upon speech intelligibility, it may be of interest to point

out that the over-all average intelligibility of the nasal-including words (65.24) was significantly greater than that of the other words (61.24).* This difference

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* $V_w/V_{ws} = 8.92$. ($P < .01$)

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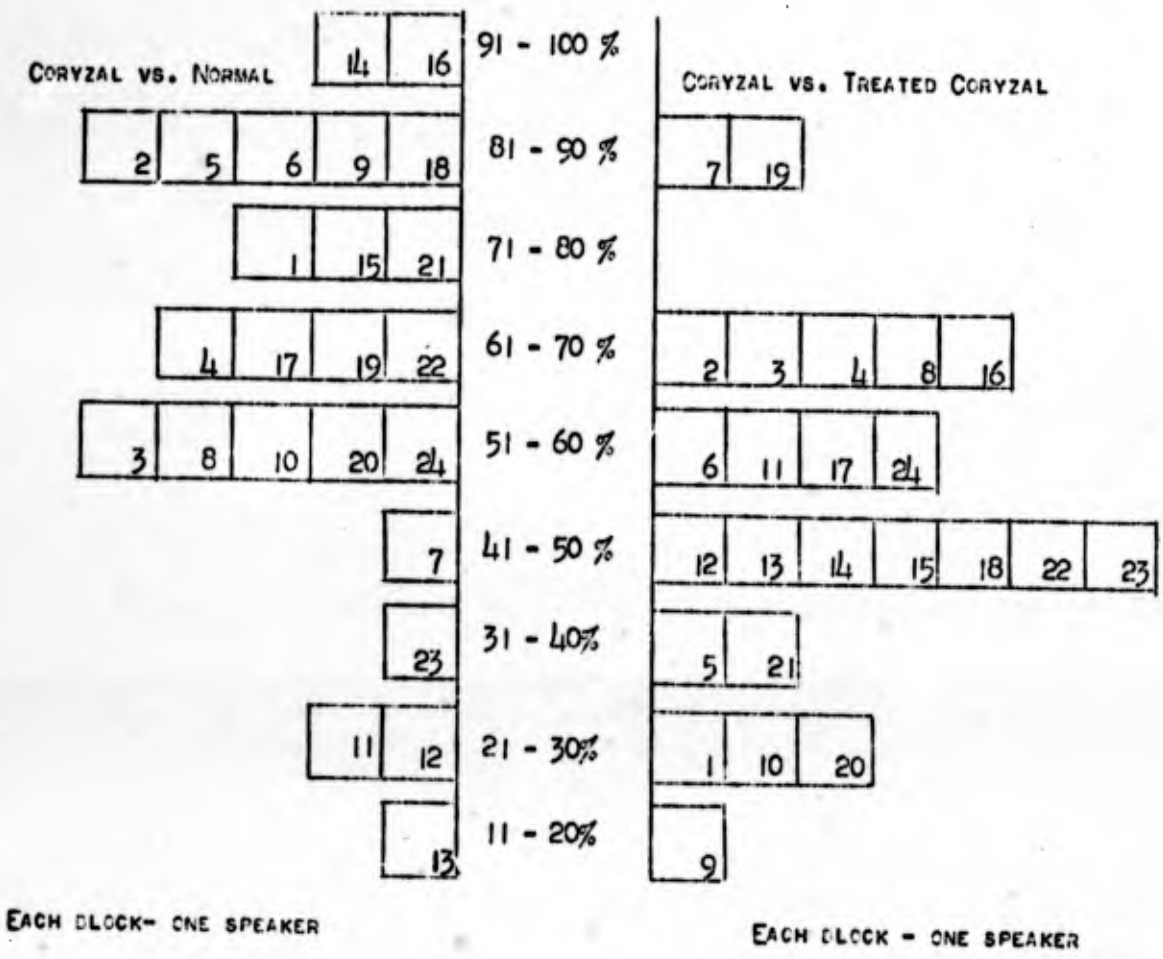
is made all the more interesting by the fact that it contradicts findings of Mason, who reported means for words containing [m] and [n] that were significantly smaller than means for other words.[2]

Recognizability

Another aspect of speech, other than intelligibility, for which listeners furnished data was recognizability of quality. From the original recordings two dubs were made, each containing a pair of three-word samples for each of the 24 Ss. The first dub consisted of words from the "coryzal" recordings paired against words from the "normal" recordings in random order. The second dub consisted of words from the "coryzal" records paired against words from the "treated-coryzal." Both dubs were played to 72 listeners who had been instructed to identify, guessing if necessary, the coryzal utterance of each pair. The results are summarized in Fig. 3.

The coryzal utterances of most of the speakers were distinctive enough, compared to normal speech, that they were correctly identified by a majority of the listeners. The coryzal words of five of the subjects, however, sounded more normal to most of the listeners

FIGURE 3



DISTRIBUTION OF 24 SPEAKERS ACCORDING TO PERCENTAGE OF 72 LISTENERS DISTINGUISHING CORYZAL SPEECH FROM 1.) NORMAL SPEECH AND FROM 2.) TREATED CORYZAL SPEECH. (INDIVIDUAL SUBJECTS ARE IDENTIFIED BY THE NUMBERS INSIDE THE SQUARES.)

than did the samples furnished by those subjects after their colds had disappeared. Indeed, in the case of one speaker, four-fifths of the listeners labeled the normal utterance as coryzal. On the other hand, over 90 per cent of the listeners were right in their judgments concerning the speech samples of two of the speakers. The average pair of utterances was correctly judged by about two-thirds of the listeners.

Evidently identifying speech samples uttered by cold-sufferers before and after vasoconstriction is a more difficult task than distinguishing between coryzal and normal speech. The coryzal utterances of only 11 Ss were, when presented along with words representing the treated-coryzal condition, recognized as such by 50 per cent or more of the judges. The coryzal words of the other 13 speakers were mistaken for treated-coryzal utterances by a majority of the listeners. In only two cases was coryzal speech correctly identified by more than 70 per cent of the listeners. The average pair was judged correctly by the same proportion of listeners as judged it incorrectly.

Although the coryzal speech of a speaker might be recognized by a large number of listeners comparing it with normal speech, it might be recognized by but a few listeners comparing it with treated-coryzal speech. Subject No.1, for example, had 70 per cent of the listeners

correctly identify his coryzal speech when it was contrasted with his normal speech; whereas, only 30 per cent correctly distinguished it from his treated-coryzal speech. The correlation coefficient obtained in an effort to describe the relationship between the number of listeners who responded correctly in the 'coryzal vs. normal' comparison and the number who responded correctly in the 'coryzal vs. treated-coryzal' comparison was insignificantly larger than zero. (r = .048)*

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* Of possible interest here is the fact that the number of paired speech samples correctly judged by a listener in one comparison was not a good indication of the number he might judge right in the other comparison. (r = —.061)

In the hope that the variation among the 24 Ss with respect to recognizability of coryzal speech might be better understood, the data presented above were compared with the medical findings. Results are summarized in Table V. Of particular concern were those Ss whose coryzal utterances were mistaken for their normal or treated-coryzal speech samples by more than 50 per cent of the listeners. Of the 13 whose coryzal and treated-coryzal utterances were confused by a majority of the listeners, marked nasal discharge had been observed in only three. Chi-square tests, however, indicated that, any apparent association between this--or between severity of any of the the three intra-nasal symptoms--and

Table V

Distribution of speakers according to relative incidence of right and wrong quality recognitions and according to extent of four coryzal symptoms during cold. (Marked, +. Slight or negative, 0)

	Nasal Inflam.		Nasal Edema		Nasal Discharge		Pharyng. Inflam.	
	+	0	+	0	+	0	+	0
A. Coryzal vs. Treated-coryzal								
R>W	3	8	5	6	5	6	8	3
R<W	6	7	8	5	3	10	5	8
B. Coryzal vs. Normal								
R>W	8	11	10	9	6	13	9	10
R<W	1	4	3	2	2	3	4	1

proportion of correct identifications of coryzal speech might easily be explained as a function of sampling error. Possibly more significant is the fact that eight of the 13 speakers mentioned above were found to have relatively little nasopharyngeal inflamation; whereas, all but three of the remaining 11 Ss were found to have a considerable amount.* Interestingly enough, of the

* Chi-square = 2.82. (P = .09)

five speakers whose coryzal words were distinguished from their normal utterances by only a minority of the listeners, marked nasopharyngeal inflammation was noted in all but one; however, this condition was observed in slightly less than half of those whose coryzal speech was evidently more distinctive.*

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* Chi-square = 1.69. (P = .19)

Although no attempt was made to determine all the phonetic components of the utterances used in the two quality comparisons, the incidence of three normally nasal sounds ([m], [n], and [ŋ]) was noted for each of the four samples which represented each S. These data combined with the determination of which Ss had coryzal speech mistaken for either treated-coryzal or normal speech by a majority of the listeners made possible the compilation of Table VI. In twelve of 'coryzal vs. treated' pairs, the coryzal contained more nasal sounds than did the treated-coryzal utterance; in the other twelve pairs the latter contained an equal or greater number of nasal sounds than did the coryzal. Both groups included about the same number of pairs which were misidentified by 50 per cent or more of the listeners. In the other comparison, the coryzal member of thirteen pairs of utterances contained more nasals than did the

Table VI

Distribution of speakers according to relative incidence of right and wrong identifications of coryzal speech and according to relative occurrence of nasal phonemes in the speech samples.

	A. Coryzal vs. Treated-coryzal		B. Coryzal vs. Normal	
	$N_C > N_T$	$N_C \leq N_T$	$N_C > N_N$	$N_C \leq N_N$
R > W	5	6	11	8
R < W	7	6	2	3

normal sample; in the other eleven pairs the latter contained an equal or greater number of such sounds compared to the coryzal. The five pairs which were misidentified by a majority of the listeners were as evenly divided between the two groups as their odd number could allow. These distributions obviously furnish no basis for associating coryzal speech which is indistinguishable from other kinds of speech with the relative number of nasal sounds it may contain.

As was stated earlier, the coryzal sample of all but five speakers was distinguished from its normally spoken counterpart by at least half of 72 listeners. In the case of any pair of utterances it is possible, in view of the listeners' knowledge of the two conditions which the pair represented, that many of the correct judgments resulted from a decision on the part of many

listeners that the utterance which sounded the less 'natural' must be coryzal speech even though it might not sound similar to other utterances judged as coryzal on the same basis. In other words, it is possible that the coryzal utterances had nothing more in common than abnormality and that the abnormality of each such utterance might have been a unique characteristic. On the other hand it is possible that those utterances which were classified as coryzal by most of the judges all had in common one or more acoustical properties. This latter possibility led to the carrying out of another experiment.

Four distorted dubs were made of the 'coryzal vs. normal' recording, which could reproduce all frequencies between 50 c. and 8000 c. with good fidelity. Each dub was made by recording the output of an adjustable low-pass filter set* to which was fed the output of a phono-

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* Type Ra - 243, Electrical Research Products, Inc.

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graph playing the high-fidelity version. For one dub the filter set was adjusted to attenu te sharply all frequencies above 4400 c.; for another, all frequencies above 3000 c.; for another, all above 2200 c.; and for the fourth, all above 1000 c. Thus, counting the one from which the others were made, there became available five recorded versions of coryzal utterances paired against normal utterances, the versions all alike except for

width of frequency range. Forty midshipmen, none of whom were among the listeners previously used, were called upon to listen to the five records and to identify the coryzal samples as had the 72 listeners mentioned above. The forty were divided into panels of eight. One panel heard one record, then another panel heard a different record, etc., until finally--at the end of 25 listening sessions--all five panels had responded to all five records but in different sequence. At least 30 minutes separated any two sets of responses by a single panel.

The number of recognitions of coryzal speech was determined for each recorded representation of each speaker. From those data four 2 x 2 contingency tables were prepared for each speaker, each table showing the number of correct and incorrect responses to both the full-range and one of the distorted representations of that speaker. The discrepancy in each table between the ratio of right to wrong responses accompanying one record and the comparable ratio accompanying the other record was evaluated by means of a chi-square test. The results of the 72 evaluations thus made are summarized in Table VII. A glance at the table will reveal that cutting off the upper frequencies--whether at 4400 c. or at 1000 c. or at a point in between--of both a coryzal and a normal utterance is not likely to increase the difficulty of

Table VII

Distribution of Ss according to level of significance accompanying Chi-square tests of the shift found for each S in the number of his listeners who correctly differentiated between his coryzal and his normal speech when the basis of differentiation shifted from relatively full-range phonograph records to records sharply attenuated in all harmonics above 4400, 3000, 2200, or 1000 cycles/sec. (N = 24)

	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00
4400c.	0	5	2	0	2	1	3	6	1	4
3000c.	0	1	2	1	2	6	3	6	0	3
2200c.	2	0	5	2	1	0	4	5	0	5
1000c.	1	3	2	1	3	6	1	2	1	4

identifying the samples. In the case of only one speaker could it be said with confidence at the 5 per cent level that listeners responded differently to two records of different frequency ranges.

These data do not imply that the coryzal utterances do not have some common acoustical characteristic by which they could be differentiated from normal speech. It is possible that differences might have been obtained had records been dubbed which altered the spectra of samples below 1000 c. This possibility seems all the more tenable when one considers the results obtained by Kelly[3] when he analyzed the energy distribution of vowels uttered by a speaker whose nasal resonance had been eliminated by nasopharyngeal packing.

Relationship between Intelligibility and Recognizability.

In the preceding sections of this paper it has been reported that a large proportion of the Ss, upon catching a cold, acquired a different sort of vocal quality and almost as many of them became less intelligible. In view of these findings it seemed reasonable to hypothesize that the greater the proportion of listeners who could distinguish between a sample of a man's coryzal speech and one of his normal speech, the more sizeable would be the difference between his coryzal and normal intelligibility scores. In order to test this hypothesis, a difference based upon the subtraction of the coryzal intelligibility score from the normal score was determined for each S, and the differences thus obtained were correlated with the corresponding proportions of correct recognitions obtained from the 'coryzal vs. normal' quality comparison. The correlation coefficient thus obtained was —.34, an amount somewhat less than is generally regarded as significant.*

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* Values of r required for significance at the 1% and 5% levels are, respectively, .515 and .404.

An hypothesis similar to that stated in the preceding paragraph but pertaining to the difference between coryzal and treated-coryzal intelligibility and to recognizability of coryzal speech when contrasted with treated-coryzal

was also evaluated. The resulting correlation coefficient was .10, a negligible amount.

Although neither of the correlation coefficients was of significant magnitude, their signs give them some interest. It will be recalled that the mean coryzal intelligibility score was somewhat smaller than the mean normal score; it would seem reasonable to assume, therefore, that any effect of a cold upon intelligibility would be an adverse one. In view of this consideration and the fact that the differences which constituted one set of values in the first correlation mentioned above were obtained by subtracting the coryzal from the normal score, it would seem that the coefficient should have been a positive one rather than the negative one that was obtained. A similar line of reasoning would suggest that the other coefficient should have been negative rather than positive.

Conclusions

1. Whether their words are transmitted to listeners through earphones in a very noisy room or through a loudspeaker in a quieter place, a group of men with coryza will vary considerably with respect to direction and amount of change that administration of a vasoconstricting nasal spray will produce in the intelligibility of their speech.

2. Their average intelligibility, however, after such treatment, will probably be lower than a comparable average representing their normal speech, provided that no more than about a third of their words contain sounds ordinarily requiring nasal emission.

3. Prominence of any symptom in the nose of nasopharynx of a man with a cold will tell little of what temporary vasoconstriction or complete recovery would do to the intelligibility of his speech.

4. Coryzal utterances of most men can be distinguished from their normal utterances by a majority of untrained listeners; however, the coryzal speech of some men is rather misleading.

5. When presented with a number of pairs of speech samples, a majority of listeners--although aware that one of each pair was spoken by a man with a cold shortly after his nasal passages had been sprayed and that one had been spoken before such treatment--are likely to be wrong in at least half of their attempts to identify coryzal speech.

6. Although a man's coryzal utterances might be recognized by a large proportion of listeners comparing it with his normal speech, it might be recognized by relatively few listeners comparing it with something he said shortly after his nose had been sprayed.

7. Conspicuousness of any intranasal condition such as inflamation, edema or discharge is not an indicator of the proportion of listeners who will be able to distinguish a man's coryzal speech from utterances he might make after he is given a vasoconstricting nasal spray or from those he might make after his cold disappears.

8. There may be some relationship between distinctiveness of coryzal vocal quality and extent of nasopharyngeal inflamation.

9. There is no relationship between the incidence of nasally emitted phonemes ([m], [n], [ŋ]) in coryzal speech and its distinguishability from the other kinds of speech previously mentioned.

10. Attenuation of harmonics above 1000 c. in a sample of coryzal speech is not likely to alter the proportion of listeners who could distinguish it from a comparable sample of normal speech.

11. There may be little or no relationship between the amount of influence catching a cold might have upon a man's normal intelligibility and the distinctiveness of his coryzal speech.

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