

ON THE EFFECT OF SIMULTANEOUS TACTUAL-VISUAL STIMULATION IN RELATION TO THE INTERPRETATION OF SPEECH*

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[An earlier published reference by the author to the research and its results as described below has led the distinguished Professor David Katz, of Rostock, Germany, to direct an independent investigation of the same nature as that discussed in the following pages. Under date of November 24, 1929, he wrote to the author saying that one of his pupils, "Herr Thiel, has found that in the instruction of the deaf a very much better result is obtained if the *feel* of the spoken word is communicated to the lip-reader by the use of special vibrators." This is confirmation of the conclusions that follow.—R. H. G.]

Psychologists and many other scientific folk are aware, at least in a general way, that this Laboratory has, for several years, been engaged in experiments with the sense of touch. Through the organs of this sense, observers are detecting and distinguishing various rates, intensities and complexes of vibration in a solid body. In a larger way, the first question of the Laboratory is: How far can one go toward learning to identify tones, vocal elements, words and sentences by means alone of the tactual impressions that are occasioned by their vibrational characters in our laboratory situation? The second question is: Can the tactual experience of speech be profitably employed to supplement the eye of the deaf, e. g., and to aid them in interpreting spoken language?

The experiments from which we obtained the data reported here were made on December 8th, 9th, 14th, 16th and 17th, 1925; on January 14th, 17th and 26th, 1926; on May 6th and 17th, 1926; on January 2nd, 17th and 18th, 1928; and on December 9th, 1928.

Prior to these experiments, the subjects had participated in laboratory experiments with tactual stimuli during an aggregate number of hours that varied with the individuals. The median is 78.5 hours.

INSTRUMENTATION

The instrumentation employed in this enterprise is designed, of course, to transmit sound. A telephone-like apparatus is used to carry stimuli from the source of energy (e. g., a speaker's vocal

* The research reported here was done under the auspices of the Carnegie Institution of Washington, in the Vibro-Tactile Laboratory.

apparatus) to a receiver that the subject or observer holds in his fingers. This receiver vibrates in unison with the speaker's voice and the subject feels the voice. At the other end of the system is a microphone at the mouth of the speaker or against his cheek or larynx. Between the microphone and the receiver are a six volt A battery, a 120 volt B battery and three tube amplifier. We use six or eight receivers simultaneously. Each of them (in the form of apparatus we have used exclusively in the course of experiments reported here) is a device operated by a single magnet. It has a diaphragm whose natural frequency is 800 d. v.

The entire system we call the "Teletactor." It has been designed and contributed for our use by Bell Telephone Laboratories of New York City.

TACTUAL STIMULATION AS AN AID TO INTERPRETATION

In this paper, we have assumed, in particular, the task of answering the second question above: does the feel of speech in the fingers, simultaneous with the vision of speech as the lip-reader sees it upon a speaker's face, facilitate one's interpretation. Certain data that have been accumulated in this laboratory, even without further to-do, indirectly support an affirmative hypothesis.

INDIRECT DATA

Data obtained both before and since our experiments on dual tactual-visual stimulation were made, throw a good deal of light upon the question re the discriminations that the sense of touch may be expected to make toward the interpretation of isolated words and sentences. They have already been published, in part at least, and are mentioned, therefore, but briefly here.

1. Vibrational frequencies, at least as high as 2600 d. v. a second, can be detected by the tactile organs.
2. After appropriate training, subjects are able to recognize at least ten vowel and diphthongal elements by their tactual qualities with a good degree of accuracy.
3. Likewise, they detect and distinguish at least ten consonantal and semi-vowel elements.
4. They are able to identify at least 120 sentences by their patterns as felt. This has been accomplished to from 60% to 100% of accuracy in 36 Laboratory sessions of 45 minutes each. (*Pattern* is a term that means a complex of at least accent, emphasis, rhythm, variations of pitch and tempo or speed.)

5. An analysis of 10,140 judgments indicates that one may be expected to detect and locate accent by touch alone in bi-syllabic compounds in over 90% of instances. The stimuli, in this connection, were constructed from thirteen vowel qualities combined with *l* and *s* to make as many nonsense syllables. Each syllable was combined with every other to make bi-syllabic nonsense compounds. These compounds were the stimuli and they were accented now on one syllable and now on the other in unknown order. The subject had to report on whether accent was upon the first or the second syllable.

6. Experiments with 103 unselected groups of homophenes, aggregating 307 words (these are words that look alike on the face of a speaker, and that cannot be distinguished by the lip-reader when they stand alone), show conclusively that our subjects are able to discriminate by touch among the members of all these groups but eight, and to make their discriminations with an accuracy ranging from *fair* to *perfect*. This means that touch contributes data for judgment, in this situation at least, that vision cannot furnish. An analysis of data indicates that the criteria are most probably, in many cases, the feel of final consonants; in others, initial consonants; in others, vowels. In other cases, all these qualities combined contribute a quatum that makes for recognition.

7. A deaf lip-reader, rated as "fair," locates accent by lip-reading little better than by chance, notwithstanding that she has been interpreting speech by this means for twenty years. She has been training in the Vibro-Tactile Laboratory, to the present date (December, 1928), no more than fifteen hours and she locates accent by means of the teletactor, when the speaker's face is hidden, in upwards of 80% of instances. She makes such a record as this even when the pronouncer of the words is one who knows nothing of the purpose of the experiment, and who cannot, therefore, be suspected of unconsciously "throwing" the result in the direction of his preconceived notion. The pronouncer is blind-folded so that he cannot, in either the lip-reading or the touch-reading series, see the subject's face when she is about to make a verbal report. It is impossible for him to guide her by an involuntary sign when he sees her about to make a right or a wrong report. Moreover, the pronouncer does not even know when the subject is attempting to read his face and is out of contact with the teletactor, and when she is feeling the pronunciation of suc-

cessive stimuli, but is prevented, by means of a screen from seeing his face.

In fact, the pronouncer knows only that he is to say "loosloos" or "dubdub" repeatedly, accenting now the first syllable and now the second, according as the director of the experiment (behind the subject and out of her sight) may indicate.

Success at locating accent by touch is a reminder of Dr. Knudsen's saying that the tactual organs can discriminate intensities of vibration as nicely as the ear.¹

Further experiments are in progress to compare the vision of a speaking face (lip-reading) with the feel of speech as means of learning to recognize sentences by their patterns as wholes; to compare hearing with feeling in the same relation; to compare vision with feeling for detecting and locating each element of pattern aside from accent.

8. The use of the teletactor alone is superior to lip-reading alone as means of becoming acquainted with the number of syllables being spoken. This comparative study has been made in relation only to deaf cases and the reactions to each one have proved the point. Eighty sentences have been employed for the purpose. They were all outside the lists that were requisitioned in relation to other experiments that are under discussion in this paper. The figures in this connection are quoted below:

Subject	Rank as Lip-Reader	Detection via Lip-R.	Detection via Teletactor
1	Mediocre	24%	40.7%
2	Mediocre	25%	46%
3	Good	35%	60%

DIRECT EVIDENCE

The foregoing paragraphs 5, 6, 7, and 8 contain indirect evidence for the hypothesis that dual (tactual and visual) stimulation from spoken language may be expected to guarantee more successful interpretation of speech than visual stimulation alone (straight lip-reading). Exclusive of these data, the material referred to in paragraphs 1 to 5, inclusive, has been collected for the purpose of discovering what are some of the things that tactual organs can do in the way of receiving forms of spoken language, irrespective of the means by which they can be best received.

¹ For more details of data summarized above see:
Jour. Frank. Inst. Vol. 204, No. 3, Sept., 1927, pp. 329-358.
Arch. of Otolaryngology, Vol. 4, Sept., 1926, pp. 228-239.
Jour. Abn. Psy. and Soc. Psy. Vol. XXII, No. 1, Apr.-June, 1927, pp. 33-39.
Jour. of Gen. Psych. Vol. II, Nos. 2 and 3, 1929, pp. 212-228.
 Also: Knudsen: "Hearing" with the Sense of Touch.
Jour. Gen. Psy., Vol. I, No. 2, Apr. 1928, pp. 320-352.

What is the direct evidence? Deaf subjects in our Laboratory are enabled to see the face of a speaker and, simultaneously, through the Teletactor system, to feel his words in their finger tips. Do they interpret speech in this dual stimulation situation any better than they can as unaided lip-readers? Briefly, the answer is affirmative, as the indirect evidence suggests it may be. This conclusion is based upon the Laboratory's experience, as has already been stated, with 22 deaf subjects. The median time they had spent in the Laboratory at work, prior to participation in the tests on which this paper is based, was 78.5 hours. Their Laboratory exercises were directed toward training them *to be attentive to tactual stimuli* from the human voice that is made to produce vibration in the diaphragm of the Teletactor system; to distinguish and memorize vowel qualities by their feel; to distinguish and memorize the patterns of English sentences. Their training was about equally divided among these types of exercises.

In all, a total of 124 records were obtained from the 22 subjects. Eighty records were from six observers; the remaining 44 from sixteen observers. Of the 124 records, 108 were confirmatory of the hypothesis: i. e., they indicate a more successful interpretation of speech under conditions of dual (tactual-visual) stimulation than in the straight lip-reading situation.

SUBJECTS

The chronological age of observers in these experiments ranges from six to thirty-five years; median, 23 years. In scholastic status, 17 range from the very beginning of elementary school study to the senior year in college—equivalent, approximately, to the sophomore year in a standard college. One of the remaining five subjects was an instructor in a college for the deaf. Three others had graduated from a school or college for the deaf several years prior to the first of these experiments. The remaining one, six years old, had never been in school.

Their residuum of hearing ranged all the way from 0-0 (0 in each ear) to 60%-70%. The median residuum of hearing in the more defective of our 22 pairs of ears is between 10 and 20%; of the less defective, between 25% and 30%. No one of these could get any help from an acousticon. Eleven are described as congenitally deaf. Of the remainder, all but two are reported as having been deafened in early childhood. These two attended schools for hearing children until they were in their early teens. It is, of

course, impossible now to say whether they were able to hear speech in the course of their last years in the standard school.

Owing to lack of means for making a satisfactory measure of accuracy in lip-reading, we are able to do no more than rank these cases themselves from *no lip-reading ability* to *superior ability*. There is one case at the lower extreme and two at the upper. One of the *superior* ones, for several years, held a situation among hearing co-workers in one of the Government offices in Washington. We think she is entitled to be described as *the superior* of the whole group in this one respect. At the other extreme was a six-year-old case who had no school history. The other cases should all be ranked from *very poor* to *good* lip-readers. Going among them, day after day, one would doubtless get the impression that the median ability of the group is *mediocre*, although their school records indicate a higher rating.

STIMULI

The stimuli that were selected for use in these tests are of two sorts: *words isolated from sentence structures*, and *sentences*. Of the isolated words, there were 200. It is important to observe that they were all monosyllables. Of sentences, there were 116. They contain 1,026 words; 20 trisyllabic; 81 bisyllabic and 925 (over 90%) monosyllabic words. Furthermore, 89 sentences contained 10 syllables each; six contained 11; 19 contained 9 syllables each; one, 12 and one, 8 syllables. It is important, as we shall see later, to observe these facts.

Both isolated words and sentences were selected from a well known manual for lip-readers, with a view to having all sorts and degrees of lip-readers' problems represented in our lists.

METHOD

The method, in general, consisted in presenting isolated spoken words, visually, in a series and obtaining the subjects' interpretation. (Straight-lip-reading.) The same spoken words were presented, in a distinct series, tactually and visually, *simultaneously*. (Lip-touch-reading.)

In more detail: from the list of 200 monosyllabic isolated words, the experimenter ordinarily selected 100, (for one test only 50). These were taken from all parts of the total list. For another test, the remaining 100 were taken. A short series of ten words were given for straight lip-reading, followed by a short series of ten for lip-touch-reading, and so on until words in the

list had been given for both dual (visual-tactual) stimulation and single visual stimulation. Never were *identical* short lists of ten given in immediate succession. That is if *a, b, c, d*, etc. are in a given short list for straight lip-reading, the immediately following short list for lip-touch-reading might contain *a, x, c, y*, etc. But, as has already been stated, every member of the total list was ultimately given in both ways.

In like manner, selections were made from the 116 sentences that have already been referred to. In a given test, 58, 30, 28, or 10 sentence stimuli were presented. These groups contained an aggregate of 507 to 529, 266 to 277, 241 to 252, and 114 words, respectively. The *modus operandi* was altogether the same, whether words or sentences were being employed as stimuli.

In no instance did the subjects receive any aid whatever excepting from the moving face of the experimenter and the vibration of the receiver. None of the stimuli, furthermore, was ever used for any purpose in this Laboratory, excepting incidentally, outside the experiments we are discussing here.

Scoring in the case of word lists was made, of course, on the basis of the number of words recognized by the two methods, respectively. In the case of sentence lists, scoring was done on this basis, also, and, in addition, on the basis of whole sentences literally reported. Further comment relating to scoring reports on sentence stimuli will occur on a later page.

Certain records were obtained by the co-operation of a stranger to our cases and to the whole Laboratory situation—Miss Josephine Timberlake. She came into the Laboratory and pronounced the stimuli (sentences) without a prepossession that results like those already obtained must be forthcoming. Her work may be described as a control test.

In the dual stimulation series, the subjects held the receiver of the teletactor system in their fingers and the experimenter held the microphone at the side of his face. In this situation, the subjects can see the speaking face and, at the same time, feel the spoken words and sentences against their fingers. It should be remembered, too, that in the straight lip-reading series, the experimenter always held the microphone in this position, also, so that in all experiments (dual stimulation and single visual stimulation) his face was equally visible.

In both series, too, the current was on so that the teletactor was being actuated by the experimenter's voice. In the single,

visual stimulation series, however, the receiver was not in the subject's fingers. It was lying upon a table, diaphragm upward at the elbow of the observer. Thus, if there was any possibility that an observer with a remnant of hearing could obtain an occasional helpful auditory cue in one series, he should have the same advantage in the other. In fact, he would have a greater advantage from such a source in the straight-lip-reading series; for the receiver was not damped in this situation by contact with the subject's finger. It was, therefore, more audible, to the experimenter at least, than in the dual stimulation series.

RESULTS AND DISCUSSION

Isolated Words as Stimuli. The main results of this experiment are set out in the tables below. In the interest of economy of space, absolute scores in lip-reading and lip-touch-reading are omitted, except in Table III. There are included in Table I only the *ratios* of scores obtained under conditions of dual (tactual-visual) stimulation (Lip-Touch-Reading scores) to those that were made under single (visual) stimulation (Lip-Reading scores). The stimuli in this case were drawn from our list of 200 monosyllabic words already referred to. Sixteen of these ratios were obtained when 50 words were being employed as stimuli; 31 when 100 were being employed, and one ratio was derived from the use of 132 words.

TABLE I.
RATIOS OF SCORES FROM DUAL STIMULATION TO SCORES FROM SINGLE
STIMULATION WHEN THE STIMULI ARE SPOKEN ISOLATED
MONOSYLLABIC WORDS.

1.—1.87	17.—1.01	33.—1.03
2.—1.53	18.—1.33	34.—1.21
3.—1.35	19.—1.25	35.—1.12
4.—1.15	20.—1.07	36.—2.04
5.—1.17	21.—1.43	37.—1.1
6.—1.35	22.—1.29	38.—1.21
7.—2.27	23.—1.44	39.—1.3
8.—1.29	24.—1.81	40.—1.25
9.—1.79	25.—1.56	41.—2.5
10.—1.19	26.—1.49	42.—1.0
11.—1.94	27.—1.48	43.—1.3
12.—1.13	28.—1.49	44.—5.0
13.—0.81	29.—1.87	45.—3.0
14.—1.19	30.—1.06	46.—0.88
15.—1.43	31.—1.07	47.—1.3
16.—1.04	32.—1.35	48.—1.1

Median ratio 1.3.

Median Absolute Scores: Lip-Reading, 29; Lip-Touch-Reading, 40.

Those who are predisposed toward statistical research may inquire, at the outset, (apropos of the records above and similar ones to follow) about group average ratios, mean variations, probable errors, correlations with one thing and another, and the like. This is no place for such activity, for the reason that we *are not dealing here with comparable units*. The description of our subjects or observers on a preceding page makes the last statement sufficiently emphatic. Observers differ widely among themselves in respect to degree of deafness; age of onset of deafness; chronological age; school history; lip-reading ability; temperament and, in all probability, in natural intelligence. Our observers are a group only in the sense that they are together in the Laboratory. In view of their manifold differences, the only comparison we are justified in making is between a given observer's record as a lip-reader and the same person's record in the dual stimulation situation—lip-touch-reading.

No characteristic of the data in the foregoing table can be attributed to aid that the teletactor affords toward making one acquainted with the number of syllables being spoken, because all the stimuli are monosyllabic.

The figures indicate, on the whole, a considerable advantage for dual over single stimulation. The words were interpreted less successfully by straight Lip-Reading than by Lip-Touch-Reading. The median advantage is 30%. There are nine of the 48 cases in which the ratio is under 1.1. Three of these nine records were made by one of the nineteen who participated in this experiment as subjects. This was a young woman 18 years of age who appeared for six experiments of the nature we are describing on December 8th, 9th, 14th, 16th, 17th, 1925, and on May 17, 1926. On her other three appearances, dual stimulation gave her an advantage of 19%, 33% and 43%, respectively. Prior to the first of these six experiments in which she participated, she had worked in the Laboratory as a subject during an aggregate of 138 hours.

The remaining six ratios that are under 1.1 in this list were obtained, no two of them, from the same subject. Their aggregate time in the laboratory, prior to their taking part in these experiments, was 3, 4, 7, 14 and 33 hours, respectively.

Thirty-nine of the 48 ratios in the above table are within five points (a point is 0.1) above and five below the median advantage for dual stimulation that lies, as already stated, at 30%. The median number of aggregate hours of prior Laboratory work, in

these instances, is 76. So far as our present background of experience is indicative, not many fewer than this number of hours of appropriate training can be relied upon to support our general findings.

Sentences as Stimuli; Scores Based Upon Words Recognized.
The following Table II contains data that correspond exactly with those in I. Whole sentences, however drawn from the list of 116 already described, were employed as stimuli. The scorings from which the ratios in this table have been derived were based upon the absolute number of words that were recognized by Lip-Touch-Reading and by Lip-Reading respectively.

TABLE II.

RATIOS OF SCORES FROM DUAL STIMULATION TO SCORES FROM SINGLE STIMULATION WHEN THE STIMULI ARE SPOKEN SENTENCES.
SCORING BASED UPON RECOGNITION OF WORDS.

1.—0.9*	14.—0.9	27.—1.1
2.—0.97	15.—1.1	28.—0.89
3.—0.8	16.—1.8*	29.—1.3
4.—2.2	17.—1.6	30.—1.3
5.—1.2	18.—1.5	31.—1.3
6.—1.3	19.—1.5	32.—1.3
7.—1.3	20.—1.5	33.—1.1
8.—1.4	21.—1.8	34.—1.1
9.—1.2	22.—1.05	35.—1.1
10.—1.1*	23.—0.99	36.—1.2
11.—1.7*	24.—1.0	37.—2.8
12.—1.2	25.—1.1	38.—1.7
13.—1.1	26.—1.1	

Median ratio 1.2.

Median Absolute scores: Lip-Reading, 52; Lip-Touch-Reading, 67.
Grand Total, scoring on Words, Table I and Table II, 86.

In each of two of the 38 experiments from which the data of this table were obtained, the sentence stimuli included 87 words; each of nine, 114 words; in each of five, 252 words; in each of nine, 277 words, and in of the remaining thirteen, 529 words. It has already been pointed out that just above 90% of all these words are monosyllabic; 7.8% of all are bisyllabic and slightly over 2% are trisyllabic.

This table indicates also a considerable advantage for dual over single stimulation. The median advantage is 20%, contrasted

* Ratios marked by an asterisk are between absolute values obtained in the control test, already referred to, that was made by a stranger to the subjects, Miss Josephine Timberlake of the Volta Bureau, Washington, D. C.

with 30% indicated in Table I. The absolute scores, both for Lip-Reading and Lip-Touch-Reading are considerably higher in relation to words that are comprised in sentences than to isolated words. The median values are given in Tables I and II. The higher scores in this case were anticipated at the outset because a sentence affords a helpful context that is wholly lacking in the word standing alone.

The tendency of the context factor should be in the direction of lifting up the ratios also in Table II. But this tendency is doubtless counteracted by the higher absolute scores themselves. For obviously, as the room for improvement in interpretation by the more successful of the methods is narrowed, the *relative* rate of improvement by the less successful method is accelerated, and the gap between the corresponding scores tends to become closed.

Of the ratios in this table, eight are below 1.1. Six of these low records were made by two of the eighteen subjects who lent a hand in this portion of the work. It should be said that one of the six ratios is 1.05. The remainder are 1.0, 0.99, 0.9, 0.9, 0.97 and 0.8. The subject who made three of the nine records below 1.1, in relation to isolated words, is responsible for three entries in Table II, as follows: 1.1, 1.2 and 1.7.

A subject who contributed three of the seven low ratios in the above table (1.05, 0.99 and 1.0) gave us the following ratios in Table I: 1.06, 1.07, 1.35, 1.03, 1.21 and 1.12. At the time these experiments were made, her Laboratory practice had aggregated only 12 to 16 hours. Among all the 35 deaf persons the Laboratory has dealt with in all its relations in the course of the last four years, this one is superior as a Lip-Reader. In her case, when sentences and continued discourse (as opposed to isolated words) are being employed to detect her interpretative ability, there is probably no tool that can importantly supplement her visual perception of a speaking face.

The other subject who contributed three of the seven low figures in Table II is a lackadaisical fellow of good natural capacities who has very poor lip-reading ability. In our tests employing isolated words, his ratios were 1.15, 1.17, 1.35, 1.35, 1.53 and 1.87. Prior to the earliest test, he had had Laboratory training aggregating 130 hours.

Of the 38 records in this table, 36 are within the limits of five points above and five below the median of 1.3, which suggests a median advantage of Lip-Touch-Reading over Lip-Reading, of

30%. The median number of corresponding aggregate hours of training, prior to the earliest of these dual stimulation experiments, is 86. This figure may be misleading when compared with the corresponding median in relation to Table I, which is 76. This difference between the two, however, is not quite so much as it appears to be, for the reason that the aggregate number of Laboratory hours spent by our subjects, prior to our use of sentences as stimuli, includes all the time that they spent with dual stimulation by isolated words. This time alone amounts to from one to six hours. In a few instances, moreover, other Laboratory practice intervened between the two sets of experiments.

INSTRUCTIONS TO SUBJECTS

The instructions given to subjects, when sentences were about to be pronounced as stimuli, were complicated. They were required:

1. To write down, if possible, the whole sentence as soon as they should feel it and see it upon the experimenter's face.
2. If they were unable to do this, they were instructed to make a dash on their pads for every syllable in the sentence.
3. Any word that they might recognize, they were to write in its proper place among the dashes.

Obviously these instructions demand a much more complicated reaction than is required in the isolated word situation in which the subject wrote a single word or a dash. In the whole sentence situation, the subjects were under the necessity of attending to several things: the sentence as a whole; each word individually and finally, the number of words in each sentence, so that he should be able to "dash it" in the event of his being able to report only a part of it or none of it. The situation is further complicated by the fact that if a subject has recognized but two words, for instance in a five word sentence—the second and the fourth—he must try to place the words in their proper places: that is, between the first and the third dashes, and between the third and fifth dashes, respectively. The division of attention that all this entails might be expected to produce erratic behavior in both the Lip-Reading and the Lip-Touch-Reading series. As a matter of fact, it seems not to have done so. For, as has been stated already in Table II, 36 of the 38

ratios (over 94%) are within a range of five points on each side of the median. Whereas, in Table I, 39 of the 48 ratios (just above 81%) are within the same range.

Sentences as Stimuli; Scoring Based Upon the Number of Sentences Literally Reported. Reactions in the sentence stimuli situation were scored, not only upon the basis of the number of words they recognized, but upon the number of sentences they interpreted. In this connection, a rigid criterion was arbitrarily adopted. Every word must be recognized and written in its proper place. A single transposition of words, or an omission, automatically threw out a whole sentence as incorrect. It is not surprising, therefore, that scores on this basis are lower and more erratic than those based upon the number of words recognized.

There were thirteen reports on 58 sentences aggregating 529 words; eight on 30 sentences aggregating 266 words; six on 28 sentences, 241 words, and eleven on 10 sentences, 114 words.

Table III indicates there were two instances in which subjects registered zero in both Lip-Reading and Lip-Touch-Reading. One of these subjects recognized 15 and 28 words by Lip-Reading and Lip-Touch-Reading, respectively, and the other 20 and 32. Neither of them reported a literally correct sentence. But for transpositions, one of them would have scored *two* and *three* sentences, and the other *three* and *five* by the two methods, respectively. It is highly probable that they understood these sentences perfectly. There may be many other cases among the 38 represented in the table in which subjects grasped more sentences than their credit indicates. On the other hand, there is no denying the fact that what has sometimes been a correctly interpreted sentence may be, for the subject, merely a string of words—at the moment of writing them, at least. Furthermore, it is probable that there were instances in which the recognition by Lip-Touch-Reading of but one word more than by Lip-Reading may have turned the scale for that method of interpretation. The facts might have been established by requiring a pantomime in connection with each report. There was no recourse to such a measure. The figures in Table III represent both absolute values and ratios, not ratios alone as in the preceding tables.

TABLE III—REPORTS ON THE BASIS OF LIP-READING AND LIP-TOUCH-READING, RESPECTIVELY, WHEN THE STIMULI ARE SPOKEN SENTENCES.

Scores Based on Number of Sentences Literally Reported.

	Number of sentences	Correct By L. R.	Correct by L. T. R.	Ratios
1.....	58	3	2	0.6
2.....	58	1	3	3.0
3.....	58	13	19	1.46
4.....	58	3	16	5.3
5.....	58	2	19	9.5
6.....	58	5	20	4.0
7.....	58	32	48	1.5
8.....	58	13	30	2.3
9.....	58	9	29	3.2
10.....	58	7	6	0.0
11.....	58	31	33	1.06
12.....	58	13	16	1.2
13.....	58	5	12	2.4
14.....	30	3	6	2.0
15.....	30	3	3	1.0
16.....	30	13	15	1.15
17.....	30	6	20	3.3
18.....	30	5	21	4.2
19.....	30	5	22	4.4
20.....	30	25	26	1.04
21.....	30	5	6	1.2
22.....	28	1	2	2.0
23.....	28	3	5	1.66
24.....	28	3	9	3.0
25.....	28	14	19	1.35
26.....	28	2	5	2.5
27.....	28	2	1	0.5
28.....	10	9*	6*	0.66
29.....	10	0*	4*	
30.....	10	3*	4*	1.3
31.....	10	0*	1*	
32.....	10	2*	4*	2.0
33.....	10	1	3	3.0
34.....	10	2	4	2.0
35.....	10	2	3	1.5
36.....	10	1	3	2.0
37.....	10	0	0	0.0
38.....	10	0	0	0.0

Median ratio, 2.0.

Median absolute scores.

Lip-reading, 3.

Lip-touch-reading, 6.

The grand total of records in Tables I, II and III is 124. Of these, 108 are positively in favor of Lip-Touch-Reading.

* The digits marked by an asterisk indicate scores obtained from the control test in which Miss Josephine Timberlake of the Volta Bureau, Washington, D. C., acted as experimenter.

An inspection of the foregoing table will show that there are only nine ratios below 1.1. Whether we include or exclude the two cases in which no score was made by either Lip-Reading or Lip-Touch-Reading, the median ratio is 2.0. It will be recalled that the median ratios computed from Tables I and II are, in each case, 1.3. The records in Table III are comparatively erratic, due to causes that have been discussed herein. Only ten of the 38 ratios lie within the range of five points on each side of the median. This is slightly above 26% of the total as compared with the corresponding 81% and 94% in Tables I and II, respectively. The median aggregate number of Laboratory hours corresponding to these records is 86. Fifteen ratios are below 1.5. The corresponding median hours is 43. The twenty-three remaining ratios are above 2.5. The median number of hours in the Laboratory, corresponding to these ratios, is 110.

Owing to the almost uniform syllabic composition of the sentence stimuli that were employed in this section of the work, there is no more than a negligible chance that counting the syllables could give a subject the slightest clue to the sentence that was being spoken.

The data presented, to this point, clearly indicates an advantage for Lip-Touch-Reading over Lip-Reading. But why? Does the tactual stimulation contribute in its own right or otherwise?

TACTUAL STIMULI AS MERE DISTRACTION

The question above will be at least partially answered by a discussion of the following query. Does the tactual stimulation reenforce visual stimulation in the process of interpretation merely because it is an accessory and distracting factor? Some people declare that they can study in the midst of slight confusion more successfully than in a quiet place. But the question, as bearing upon the present work, implies a bare guess without a particle of foundation. The Laboratory has made preliminary experiments that have been aimed at the question. The *modus operandi* was as follows:

An experimenter (in this case a Professor of Spoken English in Smith College who was visiting the Laboratory) pronounced a list of sentences for the purpose of determining the accuracy of a deaf subject at "straight" lip-reading. There were 50 sentences in all, divided into five short series of ten each. When the first short series had been pronounced, a second was presented, but

with a difference: in this case, the subject held in her fingers the receiver of the teletactor system, and a second experimenter, out of sight at the microphone, pronounced other sentences. Thus, while the subject was observing the face of the first experimenter and was attempting to lip-read, she was receiving tactual impressions of the second experimenter's sentences. By vision and by touch, respectively, she was simultaneously receiving two sets of sentence stimuli that were different and unrelated to each other. If tactual stimuli, merely *as distraction*, are positively effective in relation to interpretation, the subject should have made a better record in those alternate short series in which she was impressed by simultaneous visual and tactual stimuli, than in the other series in which she was observing the speaking face of the first experimenter, but was receiving no tactual stimulation. But the results were actually the reverse. She made a better record without the distraction of tactual stimulation, as Table IV indicates.

TABLE IV—RECORDS WITH TACTUAL DISTRACTION AND WITHOUT IT.

A. 100 sentences as stimuli containing 795 monosyllables, 69 bisyllables and 17 trisyllables.

	Prof. A experimenter	Miss L experimenter
With distraction.....	34%	32%
Without distraction.....	35%	41%

B. Recognition of words in above sentences.

	Prof. A experimenter	Miss L experimenter
With distraction.....	41%	30%
Without distraction.....	49%	47%

The subject whose reactions furnished these results was finally tested to obtain her record as a straight lip-reader and as a lip-touch-reader, with the following results:

100 isolated words—Lip-Reading, 39%. Lip-Touch-Reading, 51%. Ratio, 1.3.

436 words in 50 sentences—Lip-Reading, 48%. Lip-Touch-Reading, 61%. Ratio, 1.27.

Up to this time, the subject had spent an aggregate of 30 hours in the Laboratory. Each successive Laboratory period had been divided approximately as follows: Instruction in enunciation, 10-15 min.; drill on the patterns of sentences as felt, 15-20 min. The balance of the hour was spent on continued discourse: reading aloud in unison with the experimenter's voice as felt. She is a very intelligent person of about 25 years of age. Her facility in general conversation would probably rank her as a *very good* lip-reader, although the test figures above mean less than that. There are records of two audiometric tests in her case. One makes her residuum of hearing 50% in each ear. The other makes it 40% in one ear and 45% in the other. The condition is described as congenital.

It may be good, as David Harum said, for a dog to have a few fleas—because of their mission as distractors from the idea of being a dog. But there is no evidence, in these preliminary figures, that tactual stimuli in our Laboratory situation perform an analogously useful distracting function for the deaf lip-reader. Further work on this topic is in progress; and it should be said, in this connection, that to the present, we have no evidence upon the distraction hypothesis contrary to what is suggested by the figures above.

On the other hand, the work on homophenous words already referred to and our experiments at comparing vision alone with touch alone as means for locating accent, (see above) afford indubitable proof that the tactual sense, in its own right, does make some positive contributions toward interpretation that eyes alone cannot make.

AN IMPORTANT QUESTION

It is only when one is in contact with the teletactor that one enjoys a profit from having trained in its use? At present, we have no direct answer to this question. No such answer to the query can be had till a considerable number of subjects shall have been harnessed to the teletactor continuously during several years in succession, while, at the same time, they are having conventional instruction in lip-reading, and until they shall have been compared at the beginning and at the end of the period with a comparable group who have, all the while, had parallel conventional instruction in lip-reading. Even so, iron clad conditions for such a test would be very difficult to obtain and experimenters

would undoubtedly have to rely, to a great degree, upon the testimony of intelligent deaf folk who have trained for a long time in the use of the teletactor.

A priori a positive hypothesis in this relation is not unbelievable. At any rate, there is probably no normally hearing person but who believes that his acquaintance with even the conventional lilt, movement or pattern of speech helps him to get the meaning of spoken language. One of our difficulties with foreign speech, in addition to our scanty vocabulary, is just our unfamiliarity with its pattern, which normally cooperates with other spoken language factors to convey meaning. What we call "acquaintanceship with pattern" is probably, in its last analysis, a very great complex of incipient motor reactions that have been conditioned to auditory symbols, and, incidentally, to printed symbols on the pages of our books also. Now we have fully enough demonstrated that this "acquaintanceship" is made by our deaf cases through the sense of touch and the hypothesis is that the corresponding "incipient motor reactions" may be conditioned to visual symbols on the speaking face. When then the lip-reader catches facial signs of meanings, a host of meaningful conditioned motor reactions that correspond to his laboratory acquired tactual patterns, come to his aid.

But this is not the only way to answer the question. In the Laboratory, we have demonstrated (in re recognition of words) a median superiority of lip-touch-reading over lip-reading of 30%. In respect to the recognition of whole sentences, the median superiority runs to 100%. Let us assume, if you please, that in the schoolroom, this superiority will be reduced two-thirds. Even so, the expedient of lip-touch-reading will greatly speed up the processes of learning and, consequently, the range of information, because the pupils can the better understand what is being said to them. Only this, therefore, remains to be observed: the broader and fuller one's information, the greater one's facility at jumping at meanings when signs are caught upon the face of a speaker. Thus the effect of laboratory or school training may carry over to a situation in which the lip-reader is not in contact with the teletactor.

In concluding our remarks upon this point, it is worth keeping in mind that there is a distinct possibility that an easily portable teletactor may sometime be constructed so that, wherever a lip-reader may be, he may have the direct advantage of its use.

SUMMARY AND CONCLUSION

1. When deaf subjects feel speech in their fingers through the teletactor and, at the same time, see it upon the face of a speaker, the combined tactual-visual impression enables them to interpret speech more fully and accurately than does the visual impression alone, as in straight lip-reading.

2. The median advantage (48 cases) afforded by the combined stimulation over visual stimulation alone is 30%, when the stimuli are isolated monosyllabic words and scoring is made on the basis of the number of words correctly reported by the subject.

3. When whole sentences are presented as stimuli and scoring is upon the basis of the number of words correctly reported, the median advantage (38 cases) is 30%.

4. When whole sentences are stimuli and scoring is upon the basis of the number of whole sentences literally reported, without even the transposition of words, the median advantage of combined stimulation (38 cases) is 100%.

5. The advantage of dual stimulation over single visual stimulation does not appear to be due merely to a distracting effect of dual stimulation.

6. It is impossible that the advantage is due, in our situation, in any degree whatever, to the fact that the teletactor enables the subject to count the number of syllables being spoken, for, in the isolated word tests, all words were monosyllabic and over 90% of the 1,026 words in our sentence stimuli were of one syllable. Moreover, over 71% of the sentences contained 10 syllables each, over 16% have nine syllables each, and over 5% contain eleven each. The remainder are of eight and twelve syllables each.

7. Other studies have shown that the deaf are able to count syllables more accurately by touch than by lip-reading; that they may be expected to locate accent to an accuracy of more than 90%, and that they locate it more accurately by touch alone than by lip-reading alone. A study of reactions to 103 groups of homophenous words, furthermore, has shown deaf subjects to be much more accurate in discriminating homophenes by touch alone, than by lip-reading alone.

SUPPLEMENT

A. List of words from which stimuli were selected for comparing efficiency in Lip-Reading with efficiency in Lip-Touch-Reading.

foam	farm	bear	share
harm	bee	pie	pear
see	sew	bathe	bar
bow	by	let	lathe
my	me	ham	bet
be	came	reap	ram
rain	race	rail	heap
case	rope	hose	hail
hope	hill	bay	rose
rill	me	ream	ray
fee	far	rice	beam
mar	hole	mock	mice
coal	call	cave	rock
hall	day	rook	rave
whey	why	sharp	cook
die	cave	keep	carp
gave	gape	coke	sheep
cape	beef	palm	poke
reef	rake	pool	calm
bake	bow	cone	cool
how	hay	fir	pone
boy	who	same	sir
shoe	shop	joy	fame
hop	shy	tam	toy
home	pair	pie	jam
thy	thine	chill	jest
line	knead	queer	quill
read	real	lice	cheer
kneel	lark	vile	vice
shark	shame	go	lisle
lame	hair	same	so
rare	row	get	game
hoe	pipe	lay	let
ripe	reach	that	gay
peach	ride	kiss	cat
tide	to	thin	this
rue	moon	pen	pin
June	Jew	door	then
mew	new	bet	bore
chew	chum	wave	debt
numb	mouth	roar	rave
south	soap	way	wore
mope	sight	rife	ray
might	mop	white	wife
sop	you	rye	right
hew	hard	heap	why
yard	yell	rate	reap
sell	set	ship	hate
yet	jar	lie	lip
lie	test	tar	shy

B. List of sentences from which selections were made to serve as stimuli. Some indication of the pattern of the sentences

as spoken is afforded by various signs. Hyphens indicate quickly spoken words. Primary and secondary emphasis are indicated by " and ' respectively.

They both' seem to-be so" far" away.
 They may' be on-the-same"- ship" with you.
 They are on"-the"-way" to-the shoe' shop.
 They say the ship is safe' in-the-bay".

I will show'-you the-palm" by-and-by.
 I bought five' pies' at-the-shop" for you.
 I shall-buy both-the-pipe' and-the fife'.
 I will go now' to-pay for-the-farm".

Why do-you-go-to-the-cave' with them?
 Will you give-me-a-cup-of coffee?
 Will you' go to-the-game with-the boy?
 Will you show me the-way" to-the cave"?

I' believe they will refuse" to-remain.
 Why' do-you-wish to remain" on the-ship?
 Do you' remember what became" of-them?
 You must' remember to-make-a report.

We shall be so' ha'ppy to have you come.
 I wish you would' help-me move the palm.
 They may all' remain with-you for-an hour.
 I heard about it before" they-came home'.

I" have not written to-him' for some time".
 You will hurt your eyes' if-you read" so-much.
 That' is not the-right way" to-the river.
 They have raised the rent' of-the house today".

I wish" you would'-read the rest" of-it now.
 Where" did-you-buy the nice rug' for-your-room?
 I hope'-it won't rain" before-we-get-home".
 It is a long" way" to-the rain' bow's end.

I cannot remember how' many" there were.
 Are you quite' sure that-this-is-the-right" car"?
 You-will hear from-me' before very long.
 I am sure" that-it-was more' than-an-hour.

They will surely' be quite through by-that'' time.
How far is it from there'' to-the-long'-pier?
I shall-go more frequently' from now'' on.
Did-you make' this frame or did-you buy'' it?

Will-you please' buy a-loaf-of-bread for me?
She wore-a large brown' hat with-a broad'' brim.
That is too high priced for my' pocketbook.
Bring me' the-book after you have read-it.

I am quite' sure there-were-a-great'' many more.
We-have-been-out there a great' many' times'.
She spends a-great'' deal' of-her-time reading.
Can-you'-tell-me' now where the grape'-fruit grows?

Bring me' the-book after you have-read-it.
The bird is-on-the-branch of the fruit' tree.
I-was surprised' to-see-them on Friday''.
The-boys have all been fishing' in-the-brook.

The farmer has raised-a-fine' crop-of-grain.
She-was very' cross when I criticized her work.
They live in-the-brown' house across the-way.
There were-a-great' many nice grapes on our'' vine.

Have you ever seen-a-field of flax' in-bloom?
Will-you-please' help me to plant the rose''-bush?
You are much' too slow to-finish'-in-time.
Will you take-a sleigh'-ride with-me-today?

I saw-a fleet of ships' in-the-harbor.
Do you prefer the-black' or the-brown'' frame?
Are you' going to-take-a-part in-the-play?
Myrtle wore her new blue hat' to-the-play.

What-is-the-price'' of-the black' broad-cloth cloak?
Will-you-buy a globe' for me when-you go?
He can' not see-to-read' without his glasses.
There is-a hall' clock in-the other room.

He-lost his glasses' on-the-way to-the-club.
Please' show-me the-short'' way to-the-club-house.
Can-you-tell-me at-what-time the bank' closes?
Did-you-speak to-the-clerk' about the-gloves?

If possible' let-me-know tomorrow".
I am afraid he knows nothing' about" it.
We-have-had no' news since last" November".
They-will-arrive here' on November ninth".

Do you' know the-number of-their new" room"?
You will need more new clothes' if-you-go south".
Give-me-the note' that-he-brought-you tonight.
Did-you-notice the name' on-the-note book?

Do you know the-name-of-the inn' in Lynn"?
Buy-the-pin in-Japan" or in-Berlin".
Yes' you-may-keep whichever one you please.
Nothing can-be-done now' about the-name".

If I were in-your' place I-should-go now".
Then come to us tomorrow' if-you-can.
Is this the-best' way to-the-road-side Inn?
Shall-we-go-to San Francisco today'?

Can-you-play-a tone' on-the-piano?
The-house-and-barn belong to-my father'.
I found the-pine cone in-the-near-by woods'.
I prefer' to-go in-the-afternoon".

What kind-of-grain' do-they-raise on their" farm?
Do-you-know how much he paid' for-his-cane"?
If I had known'-of it I should-have-gone".
Do you insist' that-I-must-go-alone"?

I mean to-go-down town' this-after-noon.
I mean to-ask'-her if-she-has-seen-them.
We-should-be-much pleased' to-have-you join" us.
Do-you-think he-can-earn' as-much-as that?

Did-you-affix your' name" to-the-paper?
There-was-no sign' of-rain when we" left home.
You-must return' the-book" this afternoon.
He-did-not-learn his lesson well' today".

She is sure' that-she-lost-it on-the-way".
He-lost-it last time he visited' here.
It-was week before last' when he-was-there.
It-was half-past four' when-they arrived here".

This-is-the-worst storm' we-have-had" here.
The-crew' was saved when-the-ship sank today".
Have-you-seen-the raft' float on-the-river"?
I wish we-had-saved" some-of-the-fruit.

My brother's' name was last" on-the-ship-list.
Who-is-going east' with-you this summer?
The-boys" are playing out-in-the hay" loft.
She slipped on-the-floor" and broke her left wrist'.

The-list-must-be ready' by next Monday".
It-will-be best" to-go on-the-fast train.
I wrapper-the-book in heavy brown paper'.
It must-be-done' by Monday afternoon".