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THE RELATION OF TONGUE MOVEMENTS TO INTERNAL SPEECH

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Since the discussion by Bain in 1879, the problem of the actual relation of 'internal speech' to verbal mechanisms has been of interest to psychologists, and has led to rather extensive discussion. Earlier writers are difficult to interpret as to their point of view concerning the function of overt movements. Bain ('79) made the statement that 'thinking is restrained speaking or acting.' He also says, "When we recall the impressions of a word or sentence, if we do not speak it out, we feel the twitter of the organs (vocal)" In the same year Ribot ('79) advanced a similar theory, "When man reads silently each visual perception is accompanied by suppressed articulation." He is of the opinion that all the psychical processes terminate in movement of some sort or other, but he does not particularly stress internal speech nor insist that it is necessary for all thinking. Most of the older theories of inner speech are characterized by the absence of any attempt to relate it to motor phenomena. Those of Egger ('81) and Ballet ('86) are the most conspicuous in this group. To these writers inner speech seems to be something intangible, something psychic, which they cannot explain, so they attempt to settle the controversy by calling that something inner speech. They do not wish to imply that inner speech is thinking, but that it is merely the vehicle of thought, or the outer garment in which thought makes its appearance. Inner speech does not enter in until a thought

is almost completely formed; therefore in thinking of something new and difficult the lapse of time between the genesis of thought and inner speech is long, while in thinking of something familiar thought and inner speech are almost simultaneous. Both Ballet and Egger rely mainly upon their own introspection in drawing their conclusions.

Stricker ('80) came to the conclusion that we could not have an idea of the sound 'B' without feeling some muscular movement. He also relied upon the introspective method, but did not restrict it to his own introspections. His method was to ask 100 persons whether when thinking or reciting silently a poem, they spoke to themselves. All answered 'yes.' Paulhan ('86) objected to Stricker's conclusion, since he maintained that he could have an image of a vowel while pronouncing aloud another vowel. He has no objection to considering thought an inner language, but he does not believe this language can be reduced to words or images of words. It is not clear what he does mean by 'inner language.'

These writers have pointed out the possible significance of actual vocal movements in thought, or in so-called internal speech, but have not stated very clearly the extent to which they believed them to play an essential part in internal speech.

Watson ('14) was the first to maintain the identity of thought and language activity. He states that no one has successfully connected thought with the rest of the process of integration, that investigators have for the most part assumed that, "it is something, no one knows quite what, that can go on in the absence apparently of all muscular activity." He states further, "we will suppose that future analysis will enable us ultimately to show that every word, syllable, and letter, whether spoken or thought, produces a characteristic form of response. . . ."

Throughout this discussion Watson uses thought as synonymous with the internal speech or imagery of earlier writers. This fact led to some confusion in the British Symposium ('11), when thinking was interpreted, particularly by Smith and Pear, as meaning the adaptive reactions of

the organism, whether involving verbal formulations or not. Watson restricts his identification of thinking and language mechanisms to verbal or symbolic formulation of ideas, rather than to mechanisms of reasoning or general adaptive reactions. To this extent the criticisms urged against him in the Symposium were aside from the point.¹

Since the rôle of motor organs in internal speech is a problem which can be attacked experimentally, we must appeal to the actual analysis of movements to settle it. Certain experimental work has been attempted.

As early as 1895 Hansen and Lehman found that when a person concentrated greatly upon a word or number an unintentional whispering nearly always occurred, which could actually be heard by an observer. In other words, articulation accompanied all concentrated thought. These same investigators in another experiment on thought transference ('96) found some indication of the fact that the thought of one person could be interpreted by another by means of observable articulatory movements made during the thinking.

Curtis ('99) worked on the movements of the larynx. He placed a tambour on the larynx, while the subject recited or whispered familiar verses, or read to himself from a book. Out of 40 curves on 20 subjects, 18 showed clearly marked automatic movements of the larynx in some or all of the tracings, 11 showed smaller but still distinguishable variations, the remaining 11 showed hardly any difference between 'normals' and other curves. Out of 20 subjects 15 showed movements, and 5 none at all, not even in whispering.

Courten ('02) placed a rubber bulb on the tongue, connected with a recording tambour. Otherwise his method was similar to that of Curtis. He found that the amount of movement differed with the individual and also with the

¹ Owing to this confusion in terminology I shall use the term *internal speech* for the as yet obscure processes which are involved in the verbal formulation of thought, without prejudicing the case as to whether this internal speech is to be regarded as a succession of kinesthetic images or of actual overt movements. I shall use the term *implicit speech* for the actual slight muscular contractions which have been considered by Watson and others to constitute internal speech; and the term *overt speech* for voluntarily articulated language.

matter read or thought about, and the degree of attention. No record was taken which did not show some movement.

Wyczoikowski ('13) placed the tongue in a flattened glass cup connected with a recording tambour, while the subject thought of a familiar verse, the words 'experimental psychology' or listened to spoken words. Her conclusion was that every thought produced some movement of the tongue.

Pintner ('13) tested the degree to which the process of articulation could be eliminated in silent reading without lessening the degree of comprehension and rate of reading. His method was to have the subject read over certain selected passages of prose, while inhibiting articulatory movements. The inhibitory process was repeating *la, la, la*, or reciting numerals. His conclusions are:

1. Articulation during the reading process is a habit not necessary.
2. Practice in reading without articulation can make such reading as good as the ordinary.
3. Practice in reading without articulation tends to aid ordinary reading.

Reed ('16) experimented upon tongue movements. He placed in the subject's mouth a sensitive rubber bag, attached to a wooden framework placed between the teeth. This was connected with a tambour by means of a glass tube. The tambour was connected with a lever, which recorded movements on a kymograph drum. His stimuli were: silent reading, whispering, writing abstracts of newspaper clippings, mental multiplication, and the like. His results show in several cases definite tongue movements during silent reading comparable to those made during the whispering of the same material. He concludes that thinking is definitely a process of tongue movements for some subjects, but that this is an individual trait rather than a universal one.

Clark ('22) secured records of both laryngeal and tongue movements simultaneously, placing a tambour on the larynx and a rubber bulb on the tongue, while the subject was given a problem to solve. The results on tongue movements show the occasional presence of inner speech in each reaction; and

laryngeal movements were occasionally recorded when the tongue was especially active. She concludes that while inner speech plays an important part in thought, the greater part of thinking is carried on without it.

Most of these studies are open to three main objections:

1. *The type of apparatus used*: in practically all of the former experiments the rubber bulb type of apparatus was used to record tongue movements. Such apparatus can not possibly record tongue movements only, for any slight change in air pressure due to respiration, swallowing movements, and the like, would cause deflation of the rubber bulb, even though they were not great enough to bring about any movement of the tongue. This constitutes a constant error which is present during thinking and whispering alike. Its influence is possibly of sufficient magnitude to give a false appearance of similarity to curves of tongue or laryngeal movement.

2. *Interpretation of results*: It has been the common practice for investigators to interpret any movements of the tongue whatever as an indication of internal speech. The quantitative study made in this experiment (see results) shows this to be a fallacy.

3. *Suggestibility*: In all mechanical recording of movement the attachment of the apparatus, and the resultant discomfort tend to direct the subject's attention to the tongue and thus may tend to suggest movements. Subsequent taking of introspections may have a similar effect unless carefully controlled. In this respect Reed's technique seems especially open to criticism. As part of his experimental procedure, the subject was questioned, after each situation, as to whether or not he used inner speech during that situation. These introspective results were summarized and compared with the actual graphic records for the corresponding situations. This comparison reveals the following: 60 per cent. of the time there was absolute agreement between the subject's awareness of inner speech and the indication of it on the graphic records; 31 per cent. of the time the subject was not quite sure whether he used implicit movements or not, nor did the graphic records indicate it clearly; and only 9 per cent.

of the time was there disagreement between the introspective and graphic results. This very close agreement (91 per cent.) between the subject's awareness of the presence or absence of implicit movements and the objective results, seems to indicate that the functioning of the tongue as a mechanism for thinking is not a normal one, but an artificial one forced for the purpose of the experiment. Furthermore suggestible subjects, by way of this technique, would have their attention attracted to the tongue more than normally, and increased movement would follow.

In a more recent development of the theory, sketched by Watson in the British Symposium, a further problem was brought forth. That is, the possibility of the implicit activity shifting from one language mechanism to another. If the results of our experiments are to be valid, this shift must be controlled. However in the experiments cited above, little has been done to control this; and where it has been controlled to some extent, as in Pintner's work, the results have not been sufficiently analyzed.

Consequently this earlier experimental work must be regarded as inconclusive, and the problem is still unsettled as to whether internal and implicit speech ought to be looked upon as identical; or whether internal speech ought to be regarded as representing some form of wholly central neural activity not dependent upon implicit speech.

The experiments reported in this study were designed to test the following:

1. Do movements of the tongue occur constantly or with any significant frequency during internal speech?
2. Are the movements which occur identical in their form to those of the corresponding overt speech?
3. If so, are they an essential element of internal speech or only an incidental consequence of it?
4. If they do not occur regularly, what is the significance of the occasional movements which have been reported?

APPARATUS

The apparatus used for recording tongue movements in this experiment was devised by Dr. K. S. Lashley, and is a modification of Sommer's 'Movement analyzer.'¹ This apparatus is shown in diagram form in Fig. 1. *A*, *B*, and *C* are upright supports in which the recording levers are mounted. A small metal suction cup *i* is attached to the tongue. This cup is attached to a lever system at *g* by means of a fine wire *h*, which passes between the teeth. Tongue movements in a vertical plane are communicated to the lower writing point *f* by means of the bell cranks *a* and *b*. Horizontal movements of the tongue are communicated through levers *a*, *c*, and *d*

FIG. 1. Diagram of instrument used to record movements of the tongue, $\times 1/2$. *ABC*, rigid frame supported in adjustable clamp by the rod, *BD*. *i*, metal suction cup for attachment to tongue. *a*, aluminum bar, attached to suction cup by the aluminum wire, *h*, adjustable by the set screw, *g*, and transmitting movements through the links and bell-cranks, *b*, *c*, *d*, and *e*, to the writing points. The writing points are adjustable horizontally by thumb screws, *m*, acting against light bronze springs.

to the bell crank *e* which carries the upper writing point. The writing points *e* and *f* are arranged so as to record on smoked paper.²

The upper recording point magnifies the movements approximately 3.5 times, and the lower recording point

¹ I wish to acknowledge my indebtedness to Dr. K. S. Lashley for the suggestion of the problem, construction of the apparatus, and for his direction and supervision of the work throughout.

² Extension arms *k* and *k'* were designed as rests for the teeth but were not used in this experiment.

magnifies approximately 4.5 times. Therefore an actual tongue movement of one fourth or one fifth of a millimeter can easily be recorded and measured on the curve.

The particular advantage of this apparatus is the fact that it is not sensitive to the influence of respiration and of swallowing movements except when these directly affect the tongue. It also simplifies the records by separating the vertical and horizontal movements into two distinct curves. This permits of more ready identification.

A long-paper-kymograph which advanced the smoked paper nine mm. per second was used. It provided continuous records for about 15 minutes. The time was recorded in seconds with a Jacquet timer. A cardboard screen was placed in front of the subject's eyes, in order that any factor of suggestion from watching the movements of the levers and the tracings made on the drum might be eliminated. To minimize head movements, the subject's head was strapped into a head rest, which was free from any chin or laryngeal obstruction. A telegraph key connected with a signal magnet provided the subject with a means of indicating on the kymograph record, the beginning of each new repetition of a task. During the major part of the experiment tracings of thoracic respiration were taken by means of a Sommer pneumograph.

METHOD

The following experimental procedure was used. The subject was seated on a revolving stool, his head strapped securely in the head rest, and the suction cup attached to his tongue. Then adjustments were made so that all levers tracing upon the drum were parallel, the tips of all forming a vertical straight line upon the drum. Thus the curved tracings could be referred to a constant base line and so compared for duration. With only the fine wire serving as a connection between the suction cup on the tongue and the rest of the apparatus, it was not necessary for the subject to keep his mouth open more than a few millimeters. Of course, his lower jaw must be relaxed and his teeth apart, in order

not to interfere with correct tracings of movements, but aside from this the situation was a close approximation to normal and not necessarily uncomfortable. Even whispering was possible without a great deal of interference by the apparatus, except when forming the dental sounds.

Complete instructions were given to the subject verbally, before the kymograph was set running, and immediately preceding each new task. The subject was instructed to press a telegraph key at each repetition of the task.

Five different groups of tasks were used, one at each sitting of the subject. Each group was selected for the purpose of solving a definite problem.

The problems presented themselves as follows:

1. It was found desirable to determine the similarity between movements in the repetition of the same internal speech, and to compare these with the corresponding movements in overt speech. For the identification and analysis of similar movements a simple task was required. Groups I. and II. were selected for this purpose. In group I. each task was thought slowly and repeated several times (except parts 3 and 4). In group II. each task was whispered and then thought (except part 3), repeating the process several times.

2. It was also desirable to make the determination of movements with more difficult material. Groups III. and IV. were chosen for this purpose. In group III. a very difficult passage in Polish was whispered and thought alternately. In group IV. a short newspaper clipping was written rapidly from dictation, read silently, and read in a whisper.

3. Lastly, it was of interest to determine the effect of distraction and emotional disturbance on movements. Also it was desirable to eliminate to some extent the possibility of shift of internal speech to laryngeal, manual, and respiratory mechanisms. This led to the introduction of singing a constant tone, tapping with the fingers, and the taking of respiration records. As a basis for this study the tasks of group V. were used. In group V. the same tasks were repeated with and without distraction.

As the problem developed, the amount of movement irrespective of its pattern seemed significant. So controls were introduced, in which the subjects were instructed to inhibit internal speech, close the eyes, and try to sleep. These situations are designated as 'blanks' throughout.

A detailed statement of the separate tasks (material to be repeated in internal or overt speech) in each group follows: the nonsense material was presented visually, to be read and pronounced in internal speech.

Group I:

1. 'Experimental psychology.'
2. 'Shave a cedar shingle thin.'
3. Mental multiplication—'25 x 23.'
4. Mental multiplication—'69 x 72.'
5. 'Duka rima rinka ro.'
6. 'Bonim bokie salib so.'
7. 'Experimental psychology.'
8. Blank.

Group II:

1. 'Individual differences.'
2. 'If she sells sea shells by the seashore, why can't he sell sea shells by the seashore.'
3. Mental addition of 12 three place numbers.
4. Blank.
5. 'Raemenpuimembimer.'
6. 'Sam lip rascal nes lo tod.'
7. 'Entac riplam in sel rich.'
8. 'Jack and Jill went up the hill.'
9. 'Experimental psychology.'

Group III:

1. "Palacy! Kasciuszko i pulaski walczyli zu walnosc Polski i innych narodow! dd'zmy wich slady! Hej na boj z wrogum odwucznyim Polski i walmas ci!"

Group IV:

1. A short newspaper clipping.

Group V:

1. Thinking 'experimental psychology' while constantly singing 'ah,' and tapping the table with the fingers.
2. Thinking 'experimental psychology' without any distraction.
3. Reciting silently the multiplication table of 7's or 9's from 1 to 14 while singing 'ah,' and tapping.
4. Reciting the multiplication table of 7's or 9's from 1 to 14 without any distraction.
5. Reciting silently the entire alphabet as rapidly as possible.
6. Multiplying mentally a two place number by a two place number, while the experimenter rasps irregularly with a coarse file upon a piece of metal clamped to a table (suggested by Landis ('24)).
7. Blank.

Controls.—As the experiment progressed, there was some indication that tongue movements may be produced as a result of several different sorts of reactions, such as breathing, swallowing, excessive salivation, tongue tremor, and increased nervous tension. The first of these is common to all situations, but since all conclusions are based on relative amounts of movement, this becomes negligible. The swallowing was taken care of by careful watching of the subject, so that whenever this occurred, with its characteristic mark on the curve, the record was discounted in computing results. When excessive salivation occurred, and this was present in only a very few subjects, the subject was permitted to swallow and the situation was repeated, the first results being thrown out.

The amount of movement due to tongue tremor was measured by control tests referred to already as 'blanks.' Despite the fact that a few subjects reported having difficulty in keeping their 'thoughts blank,' there is a high degree of uniformity of the results obtained on the different subjects, and the average amount of movement during these various blank situations is lower than that of the average in any other situation.

The amount of movement due to variations in nervous tension is measured quantitatively by repeating the same and similar stimuli under conditions with and without increased nervous tension.¹

Subjects: Eighteen subjects were used in this experiment, 14 of whom were faculty members or graduate students in the department of psychology. Three undergraduate students and one ten-year-old boy were also used. The boy could be secured for one sitting only, but his results are very similar to the rest obtained, so they are included here.

THE RELATION OF PATTERN OF MOVEMENT TO INTERNAL SPEECH

The primary interest of the problem lies in the possible identity of implicit movements and inner speech, or 'thought' as used by Watson ('11). If the theory of implicit speech is true, and if the tongue plays an important part in it, we should find some similarity between the movements of the tongue which appear in overt speech and in implicit speech during the repetition of simple words or phrases.

To test this, first, a comparison was made of actual whispering movements with the movements occurring during a repetition of the whispered phrases in internal speech. The results of group II. were analyzed to determine the number of peaks, depressions, and changes in directions of movement for each curve obtained during overt speech (whispering) and the corresponding ones obtained during internal speech. The material of group II. consists mainly of short phrases (see page 10), making a word for word analysis and comparison fairly simple. 131 pairs of curves (one for whispering and one for internal speech) for these tasks were compared. They were considered similar when any possible similarity between them could be noted; such as having the same number of major changes in direction, and

¹ The term 'nervous tension' is used, for lack of a better expression, to characterize the conditions of increased excitability which seem to appear after innervation of an organ, during emotional disturbance, or excessive effort. Physiologically the condition is probably one of facilitation of final common paths through irradiation. (Adrian '23, Head '23, Myers '23, and Pieron '23.)

the same number of major peaks and depressions, ignoring all the lesser peaks. Fig. 2 shows the most similar of the records obtained. The results of this analysis are shown in Table I. Of ten subjects, only three show any similarity at all between pattern of tongue movement in internal speech and in whispering, and these three show similarity in only a small per cent. of cases. The other 7 subjects show in 100

FIG. 2. Tracings of curves from subject B, alternate whispering and silent thinking of the phrase, "Jack and Jill went up the hill." These are among the most nearly alike of the curves included as 'similar' in Table I. Upper line, respiration; middle line, horizontal movements; lower line, vertical movements. The lower case letters indicate corresponding points on the curves; O, overt whispering; I, internal speech.

per cent. of cases no relationship whatsoever. Averaging the results of all the subjects together, we find that 4.4 per cent. of the total cases show some similarities, as against 95.6 per cent. which show no similarities at all between pattern of movement in thinking as compared with whispering.

But possibly the implicit processes are so abbreviated, short-circuited and economized, to use Watson's terminology, that they would be unrecognizable when compared with the explicit processes. For this reason the tongue movement

TABLE I
COMPARISON OF PATTERN OF TONGUE MOVEMENTS DURING WHISPERING WITH
PATTERN OF MOVEMENTS DURING INTERNAL SPEECH

Subject	Similar		Dissimilar	
	No. of Pairs of Curves	%	No. of Pairs of Curves	%
K.....	2	28.6	5	71.5
D.....	0	0.0	14	100.0
H.....	0	0.0	14	100.0
M.....	0	0.0	12	100.0
L.....	0	0.0	14	100.0
A.....	2	15.4	11	84.6
G.....	0	0.0	16	100.0
N.....	0	0.0	15	100.0
D.....	0	0.0	14	100.0
B.....	2	16.7	10	83.3
Totals.....	6	4.4	125	95.6

curves on the successive repetitions in internal speech of the same words and phrases were compared. The results grouped under three headings, identical, similar, and dissimilar are shown in Table II. Fig. 3 shows the types of curves listed

TABLE II
COMPARISON OF TONGUE MOVEMENTS DURING REPETITION OF THE SAME TASKS IN
INTERNAL SPEECH

Subject	Identical		Similar		Dissimilar	
	No.	%	No. of Pairs of Curves	%	No. of Pairs of Curves	%
K.....	0	0.0	2	28.6	5	71.4
D.....	0	0.0	1	7.1	13	92.9
B.....	0	0.0	4	33.3	8	66.6
H.....	0	0.0	0	0.0	14	100.0
M.....	0	0.0	2	16.7	10	83.3
D.....	0	0.0	0	0.0	14	100.0
L.....	0	0.0	0	0.0	14	100.0
A.....	0	0.0	2	15.4	11	84.7
G.....	0	0.0	2	12.5	14	87.5
N.....	0	0.0	4	26.6	11	73.4
Totals..	0	0.0	17	13.0	114	87.0

as similar. When repeating the same tasks, not a single internal speech curve is identical in pattern with any other internal speech curve. Of the total cases for all subjects,

13 per cent. show some similarity, ranging by subjects from 0.0 to 33.3 per cent. similarity, whereas 87 per cent. show no possible pattern relationship. Similarity reaches a considerable proportion only in the case of subjects 'K,' 'B,' and 'N.' Subjects 'K' and 'B' have already shown some indications of similarity between patterns of movements in internal speech and in whispering, so it is not very surprising to find that their internal speech curves occasionally correspond to each other.

These results seem to prove that movements of the tongue are not an essential element in internal speech. For if they were, we should expect to find records of movements showing

FIG. 3. Tracings of successive curves of subject N repeating 'Individual differences' in internal speech. The specimens are the most nearly identical of those called similar in Table II. The letters mark corresponding points of the curves. Upper line horizontal, lower vertical movements.

constant patterns during successive repetitions of the same task. Even if internal speech is an abbreviated form of overt speech, there is no reason to believe that a different abbreviation would be used at each repetition of the same task during the sitting.

To make sure that the apparatus was capable of recording the movements, had they occurred, a similar study was made of the records for the successive repetitions in whispering of the same words and phrases. These results are shown in Table III. Typical curves for whispering are shown in Fig. 4.

Out of the total cases for all subjects, 25.2 per cent. are identical, 64.2 per cent. similar, and only in 10.6 per cent. of the cases is there no pattern relationship. This makes a total of 89 per cent. clearly showing pattern relationship.

The 10.6 per cent. not showing pattern relationship can be explained by the fact that the subjects were not always equally conscientious about following instructions, and would sometimes slur over the words. This is sufficient evidence to enable one to say with certainty that the apparatus can record such movements when they occur.

TABLE III

COMPARISON OF TONGUE MOVEMENTS DURING REPEATED WHISPERING OF THE SAME TASKS

Subject	Identical		Similar		Dissimilar	
	No.	%	No. of Pairs of Curves	%	No. of Pairs of Curves	%
K.....	2	28.6	5	71.4	0	0.0
D.....	2	14.3	10	71.4	2	14.3
B.....	4	33.3	8	66.6	0	0.0
H.....	6	42.8	7	50.0	1	7.2
M.....	3	25.0	9	75.0	0	0.0
D.....	0	0.0	14	100.0	0	0.0
L.....	0	0.0	13	93.0	1	7.0
A.....	2	15.4	5	38.5	6	46.2
G.....	7	43.8	8	50.0	1	6.2
N.....	7	46.7	5	33.3	3	20.0
Totals..	33	25.2	84	64.2	14	10.6

It has been suggested (Watson '19) that a shift can take place in the internal speech mechanism which is functional at any one instant. Therefore, since the tongue is encumbered with apparatus the process of internal speech might slip from this motor region to another. To control this possibility the following experiments were undertaken. The subject was asked to think 'experimental psychology' repeatedly, while singing 'ah' and tapping on the table with the finger tips (parts 1 and 3 of group V. situations). This must rule out, to a great extent, the larynx and the fingers as mechanisms for implicit language. Of course it does not exhaust the range of motor organs which might conceivably function in implicit speech, but it does rule out the more probable ones (the chief gestural mechanisms). If these organs had been functioning, their elimination should throw the activity back to the tongue, and we should expect to

find that the tongue movements in internal speech, during this situation at least, bear some resemblance to movements in overt speech or a greater resemblance to each other. The curves resulting from this experiment show no closer relationship to whispering curves than do those obtained when these controls are not operating.

FIG. 4. Tracings of successive curves of subject N for overt whispering of 'individual differences' as an illustration of curves judged identical in Table III. The letters indicate corresponding points in the curve. Upper line horizontal, lower vertical movements.

If it is difficult to accept the statement that singing 'ah' rules out the larynx as a mechanism for internal speech, perhaps further evidence will help to substantiate the conclusion drawn. The larynx is capable of movement as a whole, and also the relation of its parts can be changed to bring about a change in tension of the vocal cords. But the only effects of the movements in overt speech are changes in the pitch and timbre of the voice. Therefore, if the larynx is functional during internal speech, any significant muscular contractions in it must be accompanied by changes in the

pitch of the voice. Any activity should therefore be recognized by a change in the pitch while singing 'ah,' but no such changes in pitch were noted during the experiment.

Furthermore, should the muscles of the thorax and diaphragm serve as a basis for implicit language, the respiration records must show some significant movements other than those produced by normal breathing. The respiration records obtained however showed no significant deviation from normal.

All of the records show that there is no correlation between the pattern of movements of the tongue in successive repetitions of the same words or phrases; and that this can not be interpreted by the assumption that internal speech is carried on by manual, laryngeal, or respiratory mechanisms.

The possibility still remains however, that movements are inhibited by attention to the apparatus. To direct the attention elsewhere, more difficult problems were introduced, such as writing from dictation, reading Polish, and solving problems under severe distractions. The results of these experiments show movements in varying amounts, but not even here is there any indication of pattern relationship.

THE RELATION OF AMOUNT OF MOVEMENT TO INTERNAL SPEECH

Despite the lack of qualitative similarity, the records show continuous irregular movements of the tongue, varying in amount in different situations. What can be the significance of these increases in movement? If the increases were directly related to internal speech, they should show greater qualitative similarity under the conditions which produce them. Since they do not show this, they must be due to something else.

Possibly the increase is due to something in the way of differences in nervous tension. It was hoped that some light could be thrown on this problem by a study of the after effects of innervation of the tongue, by the introduction of several distractions which required an effort to carry on the problem, or by the introduction of emotional disturbances.

The following method was used in analyzing the data for this study. The actual amount of movement for each repetition of each task was measured in centimeters with a chartometer.¹

Since the duration of the tasks and of internal speech varies, it becomes necessary to express the amount of movement as a ratio of extent to duration. To obtain these ratios the total amount of movement for each repetition of a task was divided by the straight line distance on the record between the beginning and end of the task. The averages of these ratios at each sitting for each subject for each task appear in the Appendix in Tables IX. to XIII. inclusive.²

Turning to a comparison of the amount of tongue movement during internal speech following whispering (situations of group II.) with the amount of movement during internal speech not preceded by whispering (situations of group I.), the averages for about five hundred ratios of both upper and lower curves show:

Averages for Group II.....	1.8 and 1.7
Averages for Group I.....	1.2 and 1.2
Difference.....	.6 and .5

Table IV. *A*³ shows that 83.4 per cent. and 88.4 per cent. of the ratios of group II. are above the corresponding averages of group I. Table IV. *B* shows that 88 per cent. and 96 per cent. of the cases of group I. are below the averages of group II. This indicates that there is a very significant difference

¹ The wheel of this chartometer had been cut to about one third of normal size to facilitate the accurate measurement of very acute angles and minute peaks and depressions. The instrument was then recalibrated.

² The ratios in Table XIII. are the only exception to this system of recording results. Here the same tasks were repeated in the same ten subjects on a number of different days: five of them underwent the same experiment on six different days, and the figures appearing for them in the table are averages of six performances; the other five went through the experiment only twice, and the figures appearing for them in the table are averages of two performances. This was done as a check to determine the constancy of response to the same situations, from day to day. Since the subjects showed relatively the same results from one day to the next (although absolutely there were some differences) it was not considered necessary to make further repetitions.

³ Percentages were used in the determination of the significance of the difference between two averages rather than the P.E.D. Since these data are made up of averages of averages, the computation of P.E.'s would be very time consuming and would not add greatly to the significance of the results.

between the amounts of movement under these two conditions. We therefore conclude that when nervous tension is increased as by whispering prior to internal speaking, tongue movements occur more readily than they do when this tension is lacking.

TABLE IV. *A*

COMPARISON OF THE AMOUNT OF MOVEMENT DURING INTERNAL SPEECH FOLLOWING OVERT SPEECH, WITH THE AMOUNT DURING INTERNAL REPETITIONS OF THE SAME TASKS WITHOUT PRECEDING OVERT SPEECH

The comparison is made in terms of the percentage of cases in the first category which equaled or exceeded and the percentage which fell below the average of all cases in the second category. This same method of comparison is followed in Tables IV. *B* to VIII. inclusive.

Upper Curve				Lower Curve			
Above Average		Below Average		Above Average		Below Average	
No.	%	No.	%	No.	%	No.	%
25	83.4	5	16.6	23	88.4	3	11.6

TABLE IV. *B*

COMPARISON OF THE AMOUNT OF MOVEMENT WITHOUT INCREASED TENSION WITH THE AMOUNT OF MOVEMENT WITH INCREASED TENSION

Upper Curve				Lower Curve			
Above Average		Below Average		Above Average		Below Average	
No.	%	No.	%	No.	%	No.	%
6	12.0	44	88.0	2	4.0	48	96.0

The group V. situations, parts '1' and '3' (accompanied by distractions) compared with parts '2' and '4' (not accompanied by distractions) respectively, show the amount of the movement occurring during situations of severe distraction. The averages of about five hundred ratios are:

Averages for part 1..... 2.1 and 2.0
 Averages for part 2..... 1.3 and 1.3
 Difference..... .8 and .7

Table V. *A* shows that 92.5 per cent. and 90 per cent. of the ratios of part '1' are above the averages of part '2.'

Averages for part 3.....	1.9 and 1.8
Averages for part 4.....	1.5 and 1.3
Difference.....	.4 and .5

TABLE V. A

COMPARISON OF THE AMOUNT OF MOVEMENT WITH DISTRACTION WITH THE AMOUNT OF MOVEMENT WITHOUT DISTRACTION. (FOR THE TASK 'EXPERIMENTAL PSYCHOLOGY.')

Upper Curve				Lower Curve			
Above Average		Below Average		Above Average		Below Average	
No.	%	No.	%	No.	%	No.	%
37	92.5	3	7.5	36	90.0	10	10.0

TABLE V. B

COMPARISON OF THE AMOUNT OF MOVEMENT WITH DISTRACTION WITH THE AMOUNT OF MOVEMENT WITHOUT DISTRACTION. (FOR THE TASK, RECITING THE MULTIPLICATION TABLES.)

Upper Curve				Lower Curve			
Above Average		Below Average		Above Average		Below Average	
No.	%	No.	%	No.	%	No.	%
31	77.5	9	22.5	30	77.0	9	23.0

Table V. B discloses the fact that 77.5 per cent. and 77 per cent. of the ratios of part '3' are above the averages of part '4.' Both of the comparisons made here indicate that there is a significant difference between the conditions compared, particularly in the case of the first comparison. The conclusion follows that when laboring under a severe distraction, the subjects tend to greater movement of the tongue than when they are under lesser strain.

Another distraction was filing on a piece of brass while the subject performed a problem in mental multiplication (group V., part '6'). Mental multiplication was also carried out in the absence of any distraction (group I., parts '3' and '4'). The averages of approximately eight hundred ratios are:

Averages with distraction.....	1.6 and 1.5
Averages without distraction.....	1.2 and 1.2
Difference.....	.4 and .3

TABLE VI

COMPARISON OF THE AMOUNT OF MOVEMENT DURING MENTAL MULTIPLICATION WITH
DISTRACTION WITH THE AMOUNT OF MOVEMENT DURING MENTAL
MULTIPLICATION WITHOUT DISTRACTION

Upper Curve				Lower Curve			
Above Average		Below Average		Above Average		Below Average	
No.	%	No.	%	No.	%	No.	%
27	67.6	13	32.4	25	62.6	15	37.5

From Table VI. we find that 67.6 per cent. and 62.6 per cent. of the ratios with distraction are above the average of the ratios without distraction. This is probably somewhat significant, but the percentages are not high enough to warrant our drawing any definite conclusion as to the facilitating influence of the filing distraction on tongue movements.

To ascertain the effect of being pressed for speed in per-

TABLE VII

COMPARISON OF THE AMOUNT OF MOVEMENT DURING EXTREMELY RAPID INTERNAL
SPEECH WITH THE AMOUNT OF MOVEMENT DURING NORMAL INTERNAL SPEECH

Upper Curve				Lower Curve			
Above Average		Below Average		Above Average		Below Average	
No.	%	No.	%	No.	%	No.	%
26	65.0	14	35.0	22	55.0	18	45.0

forming a given task, the ratios of the movements recorded while reciting the alphabet several times, as rapidly as possible with constant urge to increase the speed with each repetition (group V., part 5), were compared with the average ratios of movements during 'normal' internal speech such as group I. situations.

Averages with speed..... 2.2 and 2.0
 "Normal" averages..... 1.2 and 1.2
 Difference..... 1.0 and .8

The absolute differences between these ratios are large, but when we look at Table VII. and find that only 65 per cent

and 55 per cent. of the ratios of movements while speeding are above the averages of the ratios of movements during 'normal' internal speech, we must conclude that these differences are not very significant. A glance at Table XIII. (Appendix) column '5,' will explain why the absolute difference is so great and yet not significant. Two subjects, 'B' and 'F,' practically whispered when reciting the alphabet under these conditions, and the rest of the subjects behaved very much as they did during 'normal' internal speech.

Having noted thus far that the increase in the amount of tongue movements is primarily determined by conditions of nervous tension, rather than the content of internal speech, it becomes of interest to ascertain how the amount of movement during the 'normal' internal speech (situations of group I.) compares with the amount of movement during blank situations.

TABLE VIII

COMPARISON OF THE AMOUNT OF MOVEMENT DURING NORMAL INTERNAL SPEECH
WITH THE AMOUNT OF MOVEMENT DURING THE BLANK SITUATIONS

Upper Curve						Lower Curve					
Above Ave.		Equal		Below Ave.		Above Ave.		Equal		Below Ave.	
No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
23	45.2	14	27.4	14	27.4	16	32.0	21	42.0	13	26.0

Averages during 'normal'..... 1.2 and 1.2

Averages during 'blank'..... 1.1 and 1.1

Difference..... .1 and .1

The absolute difference is slight, and a glance at Table VIII., showing 42.2 per cent. and 32 per cent. of the 'normal' ratios above and 27.4 per cent. and 42 per cent. equal to, and 27.4 per cent. and 26 per cent. below the averages of the 'blank' ratios, confirms the conclusion that the difference between the two groups of ratios is not very significant. Therefore tongue movements during internal speech without any increased tension are not significantly greater than those during 'blank' situations.

An attempt was made to get at the effect on tongue move-

ments of performing a task involving difficult verbal formulation. For this purpose average ratios of movement during writing from dictation and during the reading of a very difficult Polish paragraph were compared with the average ratios of 'normal' movements. The first group (writing) is exactly equal to the normal group. The average ratio of the second group (reading) is actually .05 less than the average ratio of the normal. This is surprising. However, the Polish proved to be so very difficult that most subjects did not even attempt pronunciation, but merely slurred it over. In this case it is to be expected that the Polish material would effect results more similar to the blank situations than to any other. In view of these facts, we must conclude that increasing the difficulty of the material of inner speech alone, does not increase the amount of tongue movements. It appears to have no effect.

To determine the effect of emotional disturbance upon parts of the tongue movements two methods were used: (1) during some experiment the subject was pinched, slapped in the face, hair pulled, or struck on the back, and (2) at the end of every sitting the subject was questioned as to his mood during the day. The first method showed no visible change either in the quality or quantity of movement, nor was any definite change noticeable when the subject himself reported emotional disturbance, except in two cases where there seemed to be slightly more tremor than ordinary.

In view of all of the above facts, it seems clear that the amount of tongue movement is not dependent upon the content of internal speech, nor even upon the presence or absence of internal speech, but upon other bodily activity which either precedes or accompanies internal speech.

DISCUSSION

The results of this study have shown: (1) that there is no qualitative correspondence between overt speech and implicit speech during the verbal formulation of the same ideas, and further that there is no constant similarity between implicit movements made during this same verbal formulation; there-

fore the identity of the tongue movements and the elements of internal speech is precluded, (2) that a shift to other language mechanisms probably does not take place, and (3) that there is no evidence for quantitative variations in implicit speech corresponding to changes in internal speech.

Listing the various tasks in the experiment according to their rank in the accompanying amount of tongue movement we have:

1. Reciting silently the alphabet as rapidly as possible. Average 2.10.
2. Thinking 'experimental psychology' while singing 'ah' and tapping the table. Average 2.05.
3. Reciting silently the multiplication tables of 7's and 9's, while singing 'ah' and tapping with the fingers. Average 1.85.
4. Thinking following whispering. Average 1.75.
5. Mental multiplication during filing distraction. Average 1.55.
6. Reciting silently the multiplication tables of 7's and 9's after doing so under distraction. Average 1.40.
7. Thinking 'experimental psychology' after doing so under distraction. Average 1.30.
- 8.5. Writing a passage from dictation. Average 1.20.
- 8.5. Thinking without any distraction and following no distraction. Average 1.20.
10. Reading silently a Polish passage alternating with whispering of it. Average 1.15.
11. Blank. Average 1.10.

The total range of movement as shown in this table is from 1.10 to 2.10. The indication is that the amount of movement is proportional to the distraction, the amount of other bodily activity involved, and the amount of tension as shown in trying to think at high speed and the like. But to specify definitely which of the experimental tasks involve the greater and the lesser amounts of nervous tension is practically impossible in the present state of our knowledge. However it is possible to classify these ten tasks into two general groups: (1) the tasks involving the more difficult

problems, such as thinking under severe distraction, and having to intersperse each repetition of a thought word with the same word whispered, and (2) the situations involving just thinking without any simultaneous external or bodily activity. It is interesting to note that all situations falling into the first class, occupy the first five ranks in order of movement; all situations falling in the second class occupy the last five ranks; and also that the two situations in class two which most resemble those of class one, occupy ranks '6' and '7.'

The suggestion from this work is, then, that the overt movements of the tongue which are observed during internal speech ought to be interpreted as the mere chance result of neural irradiation, rather than as specific elements in the thought processes. In this respect they resemble drumming with the fingers, facial contortions, tics, and the like, which appear in individuals during emotional stress. This supports the position taken by Lashley ('24) in so far as increased irradiation goes with increased activity of the tongue, but does not support his statement that specific implicit movements are more likely to occur at such times.

To determine whether the tendency to such random motor activity varies consistently from one individual to another, the other activities of the subjects under tension were compared with the amount of tongue movement. Data on facial expression for six of the subjects were available from the experiments of Landis ('24), who measured the amount of muscular movement shown during emotional situations. The correlation obtained between the average amount of movement of the facial musculature in emotion, and the average amount of tongue movement in this experiment is $R = 0.37$. This would indicate that there is some positive relationship, but it is not high enough to be diagnostic. Furthermore it is based on only six cases. It is interesting to note, however, that the person ranking first (out of twenty-five subjects) in facial movements, also ranked first (out of eighteen subjects) in tongue movements.

On the whole, the results of these experiments throw no

light upon the actual mechanism of internal speech. There is no indication of a correspondence between movements of the tongue and verbal formulations in thought. This leaves only the hypothesis that the activities are intra-neural, and do not necessarily involve complete motor expression at each stage of the process.

CONCLUSIONS

1. Movements of the tongue are not universal in internal speech or verbal thought.

2. When they do occur, they correspond to movements in overt speech of the same words only in 4.4 per cent. of the cases of this experiment.

3. Repetition of the same verbal thought is accompanied by repetition of similar tongue movements in only 10 per cent. of the cases where movement occurs.

4. When tongue movements do not occur, it is not likely that other overt language mechanisms are functioning in place of the tongue.

5. Movements of the tongue occur more readily after the tongue has been activated in overt speech.

6. They occur more readily under distraction.

7. They occur more readily when working for speed.

8. Emotional disturbance has only a very slight effect on the quantitative increase of tongue movements, within the limits of this experiment.

9. Tongue movements are not so much dependent upon the content of internal speech as they are upon conditions of nervous irradiation and muscular tonus.

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APPENDIX

Ratios of Amount of Movement by Subjects and Situations

TABLE IX

THE AVERAGE AMOUNT OF MOVEMENT FOR EACH SUBJECT ON EACH TASK IN THE GROUP I SITUATIONS

Upper Curve

Subjects	1 ¹	2	3	4	5	6	7	Blank	Ave.
A.....	1.9	1.8	1.2	1.8	2.3	—	1.9	—	1.8
D.....	1.3	1.0	1.0	1.2	—	—	1.3	—	1.2
H.....	1.0	1.1	1.1	1.2	1.2	1.0	1.0	—	1.1
L.....	1.2	1.3	1.3	1.8	1.2	1.3	—	—	1.3
M.....	1.2	1.0	1.1	1.2	1.0	1.0	1.1	1.0	1.1
O.....	1.1	1.2	1.1	1.1	1.1	1.1	1.1	—	1.1
P.....	1.2	1.1	1.4	1.1	1.1	1.2	—	1.2	1.2
Q.....	1.0	1.1	1.0	1.0	1.0	1.0	—	1.1	1.0
Ave.....	1.2	1.2	1.1	1.3	1.3	1.1	1.3	1.1	1.2 ²

Lower Curve

Subjects	1	2	3	4	5	6	7	Blank	Ave.
A.....	1.4	—	1.1	1.6	2.1	1.6	1.6	—	1.6
D.....	1.1	1.1	1.0	1.2	—	—	1.2	—	1.1
H.....	1.0	1.1	1.1	1.1	1.0	1.0	1.0	—	1.0
L.....	1.1	1.3	1.3	1.7	1.5	1.5	—	—	1.4
M.....	1.1	1.0	1.1	1.2	1.0	1.0	1.1	1.0	1.1
O.....	1.1	1.1	1.1	1.1	1.3	1.1	1.1	—	1.1
P.....	1.3	1.1	1.4	1.1	1.1	1.1	—	—	1.2
Q.....	1.0	1.1	1.0	1.0	1.0	1.0	—	1.1	1.0
Ave.....	1.1	1.1	1.1	1.3	1.3	1.2	1.2	1.1	1.2

¹ The numerals at the head of each column refer to the number of the tasks as numbered on page 11.² Blanks not included in the average. This is true of Tables IX.-XIII. inclusive.

TABLE X
THE AVERAGE AMOUNT OF MOVEMENT FOR EACH SUBJECT ON EACH TASK IN THE
GROUP II SITUATIONS

Upper Curve

Subjects	1 ¹	2	3	Blank	5	6	7	8	9	Ave.
D.....	1.4	2.1	1.5	1.2	1.3	2.7	3.3	1.2	—	1.8
H.....	1.1	1.5	1.3	1.1	2.2	1.8	2.5	—	—	1.7
K.....	1.8	2.2	1.1	1.2	—	—	—	—	—	1.7
L.....	1.4	—	1.1	1.1	1.2	1.2	1.3	—	—	1.2
M.....	1.1	1.2	1.1	1.1	1.2	1.1	—	—	—	1.1
B.....	—	—	—	—	—	—	—	4.5	—	4.5
G.....	1.1	—	—	—	—	—	—	1.2	—	1.2
N.....	1.9	—	—	—	—	—	—	1.7	—	1.8
C.....	—	—	—	—	—	—	—	—	1.3	1.3
F.....	—	—	—	—	—	—	—	—	2.9	2.9
R.....	—	—	—	—	—	—	—	—	1.3	1.3
Ave.....	1.4	1.7	1.2	1.1	1.5	1.7	2.3	2.2	1.8	1.8 ²

Lower Curve

Subjects	1	2	3	Blank	5	6	7	8	9	Ave.
D.....	1.6	1.4	1.3	1.1	1.3	3.4	2.0	—	—	1.8
H.....	1.1	1.2	—	1.1	2.0	2.9	1.8	—	—	1.8
K.....	1.7	2.1	1.1	1.1	—	—	—	—	—	1.6
L.....	1.4	—	1.1	1.1	1.2	1.2	1.4	—	—	1.3
M.....	1.1	1.1	1.1	1.1	1.2	1.2	—	—	—	1.1
B.....	—	—	—	—	—	—	—	3.2	—	3.2
G.....	—	—	—	—	—	—	—	—	—	—
N.....	1.3	—	—	—	—	—	—	1.5	—	1.4
C.....	—	—	—	—	—	—	—	—	1.4	1.4
F.....	—	—	—	—	—	—	—	—	1.9	1.9
R.....	—	—	—	—	—	—	—	—	1.8	1.8
Ave.....	1.4	1.4	1.2	1.1	1.4	2.2	1.7	2.4	1.7	1.7

¹ The numerals at the head of each column refer to the number of the tasks as numbered on page 12.

² No. 3 not included in this average.

TABLE XI

THE AVERAGE AMOUNT OF MOVEMENT FOR EACH SUBJECT ON THE TASKS OF GROUP III

Subjects	Upper Curve		Lower Curve	
	Internal Speech	Blank	Internal Speech	Blank
D.....	1.5	3.0 ¹	1.2	2.7 ¹
G.....	1.1	1.1	1.1	1.0
H.....	1.2	—	1.3	—
M.....	1.0	1.0	1.0	1.0
Q.....	1.0	1.1	1.1	1.1
Ave.....	1.2	1.1	1.1	1.0

¹ Thrown out because the subject did not follow the instructions of the experimenter.

TABLE XII

THE AVERAGE AMOUNT OF MOVEMENT FOR EACH SUBJECT AT EACH SITTING ON THE VARIOUS TASKS OF GROUP IV

Subjects	Upper Curve				Lower Curve			
	Silent Reading	Writing Dict.	Blank	Aver.	Silent Reading	Writing Dict.	Blank	Aver.
C.....	1.1	1.1	1.1	1.1	1.1	1.0	1.1	1.0
C.....	—	1.5	—	1.5	—	1.4	—	1.4
D.....	—	1.1	1.0	1.1	—	1.1	1.0	1.1
D.....	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E.....	—	1.4	—	1.4	—	1.2	—	1.2
F.....	—	1.3	—	1.3	—	1.1	—	1.1
G.....	—	1.1	—	1.1	—	1.1	—	1.1
G.....	1.0	1.1	—	1.1	1.0	1.0	—	1.0
H.....	—	1.9	—	1.9	—	1.0	—	1.0
J.....	1.3	1.2	—	1.3	1.2	1.3	—	1.3
J.....	1.2	1.2	1.1	1.2	1.1	1.1	1.1	1.1
O.....	—	1.3	—	1.3	—	1.2	—	1.2
R.....	—	1.8	1.4	1.8	—	1.4	1.4	1.4
Ave..	1.1	1.3	1.1	1.3	1.1	1.1	1.1	1.1

TABLE XIII
THE AVERAGE AMOUNT OF MOVEMENT FOR EACH SUBJECT ON EACH TASK IN THE
GROUP V SITUATIONS

Upper Curve

Sub- jects	1 ³	2	3	4	5	6	Blank	Ave.
A ¹	3.4	1.8	2.5	2.0	1.7	1.8	1.5	2.2
B ¹	1.7	1.5	1.5	1.9	4.3	1.9	1.4	2.1
C ¹	2.4	1.3	2.1	1.3	1.2	1.1	1.3	1.6
D ¹	1.7	1.1	1.7	1.1	1.1	1.3	1.1	1.3
E ²	2.1	1.4	2.1	1.7	1.7	1.1	1.0	1.7
F ²	2.4	1.3	2.2	1.5	6.9	4.0	1.4	3.1
G ²	1.6	1.1	1.6	1.3	1.1	1.3	1.1	1.3
H ¹	1.5	1.1	1.4	1.1	1.2	1.2	1.1	1.2
I ²	2.0	1.4	2.2	1.6	1.2	1.3	1.0	1.6
J ²	2.5	1.3	1.9	1.2	1.3	1.3	1.1	1.6
Ave..	2.1	1.3	1.9	1.5	2.2	1.6	1.2	1.77

Lower Curve

Sub- jects	1	2	3	4	5	6	Blank	Ave.
A.....	2.6	1.5	2.0	1.5	1.4	1.7	1.3	1.8
B.	1.6	1.5	1.5	1.6	3.4	1.5	1.2	² 1.9
C.....	2.6	1.3	1.7	1.1	1.2	1.1	1.3	1.5
D.....	2.2	1.2	2.0	1.2	1.2	1.3	1.1	1.5
E.....	1.9	1.3	1.6	1.4	1.4	1.1	1.0	1.5
F.....	2.2	1.3	1.9	1.2	7.1	3.2	1.4	2.8
G.....	1.4	1.1	1.6	1.3	1.0	1.2	1.1	1.3
H.....	1.3	1.1	1.2	1.1	1.1	1.1	1.1	1.1
I.....	1.7	1.4	2.0	1.6	1.1	1.2	1.0	1.5
J.....	2.4	1.4	2.1	1.2	1.4	1.4	1.2	1.6
Ave..	2.0	1.3	1.8	1.3	2.0	1.5	1.2	1.65

¹ Averages of performances on six different days.

² Averages of performances on two different days.

³ The numerals at the head of each column refer to the number of the tasks as numbered on page 12.