CLOSE AND LOOSE CONTACT ("ANSCHLUSS") WITH SPECIAL REFERENCE TO NORTH GERMAN [1]

Eli Fischer-Jørgensen
and Hans Peter Jørgensen

1. Introduction

North German is generally assumed to have a difference in contact (Anschluss, Silbenschnitt), short stressed vowels being described as having close contact (festen Anschluss, scharf geschnittenen Akzent), long and unstressed vowels as having loose contact (losen Anschluss, weich geschnittenen Akzent). [2]

E. Sievers (26, p. 222 ff) was the first to give a detailed description of the difference: "Hier wird der Sonant bei den kurzvocaligen Wörtern (voll, kamm, fass, hat, sollt etc.) durch den folgenden Consonanten in einem Moment abgelöst, wo er noch voll und kräftig ertönt (unmittelbar hinter dem Silbengipfel), der jähe Absturz der Exspiration fällt in den oder die silbenschliessenden Consonanten, die daher kräftig beginnen, aber mehr oder weniger abrupt endigen; bei den lang-

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1) This report is a summary (with various additions and modifications) of two papers: Eli Fischer-Jørgensen, "Untersuchungen zum sogenannten festen und losen Anschluss", and Hans Peter Jørgensen, "Der Intensitätsverlauf beim sogenannten losen und festen Anschluss im Deutschen", both of which were published in 1969 (references 7 and 18). A more detailed account of speakers and material is found in these papers. The acoustic investigations have been carried out by HPJ, the investigations of physiological factors and of duration by EFJ. We are grateful to various staff members and students of the Institute for help. Some of the modifications have arisen from a discussion in the Institute of Communication Research and Phonetics in Bonn.

2) The terminology "checked vowels" versus "unchecked vowels" is more often applied to the distributional difference (presupposing a following consonant versus not presupposing a following consonant).

vocaligen (wōl, kām, lās, rāt, hōlt etc.) erfolgt die Umstellung der Organe für den Consonanten, nachdem der Sonant bereits deutlich geschwächt ist (also eine merkbare Zeit nachdem der Silbengipfel passirt ist); der Consonant setzt daher auch mit nur mässiger Stärke ein, kann aber bei dem langsamen Decrescendo der Silbe deutlich und bequem ausklingen." In dissyllables there is also a difference of syllabic boundary (Sievers 26, p. 225).

Jespersen, who has taken over the distinction from Sievers, gives the following description (15, p. 2o2 ff): "Kommt er [der Konsonant] schnell und bricht den Vokal in dem Augenblick ab, wo dieser am kräftigsten gesprochen wird, so haben wir festen Anschluss ..... Wenn er dagegen erst eine Zeit nach der kräftigsten Aussprache des Vokals kommt, wenn der Vokal also vor Eintritt des Konsonanten etwas geschwächt ist, so haben wir losen Anschluss." Thus Jespersen leaves out the description of the particular initial force of the consonant after close contact, and considers the dynamic movement of the vowel as decisive. If the peak of the vowel is followed by a decrease before the arrival of the consonant, the contact is loose, otherwise close.

Sievers' description is at the same time physiological and auditory ("der jähe Absturz der Exspiration" .... "voll und kräftig ertönt"), Jespersen's purely physiological ("kräftig gesprochen").

According to Jespersen the difference between close and loose contact is found not only in German, but in all Germanic languages, whereas Slavonic and Romance languages have loose contact in all types of syllables. Many phoneticians have accepted Jespersen's description, e.g. Broch and Selmer (1, p. 1o9 ff), L. L. Hammerich (11, p. 58 ff), and, particularly for German, the editors of Siebs, Deutsche Hochsprache, 16. ed. (25, p. 27 ff) (whereas Siebs did not mention this distinction himself). Martens, in his phonetic textbook for German (21, p. 1o5), follows Sievers and Jespersen in considering the short vowel to have a stronger tendency to close contact than the long vowel, but he finds that the type of following consonant is more important, the contact being close before voiceless consonants, loose before voiced consonants.

On the whole, Jespersen's description seems to be widely accepted for North German, Dutch and Norwegian. In Danish the close contact is at least weaker than in German, and it is hardly found in modern Copenhagen pronunciation. Phoneticians have hesitated to accept the difference between close and loose contact for English. Jones does not mention the phenomenon, whereas Heffner uses the terminology "close and loose nexus" (12, p. 183). He identifies his close nexus both with Jespersen's "festen Anschluss" and with Stetson's consonant arrested syllables; but these identifications are not very convincing. As already mentioned, Jespersen considers close contact to be conditioned by short vowels. Heffner, on the other hand, considers it to be conditioned by a following voiceless consonant. Finally, according to Stetson, a consonant can be arresting in all types of closed syllables (cf. e.g. 27, p. 7).

The disagreement is probably due to the fact that the auditory difference is rather subtle. On the other hand, it cannot simply be considered as a convention taken over from one phonetic textbook into the other. The tests carried out by the present authors, as also the tests carried out by Fliflet (8), seem to indicate that phoneticians who have learnt the distinction, react in a meaningful way to test items. There seems to be a subjective auditory dimension which people can be trained to perceive in the same way as e.g. volume for pure tones, and which may perhaps best be described as a feeling of the consonant being more or less intimately connected with the vowel.

A closer examination of syllabic contact is of particular interest for two reasons:

(1) It has been maintained by Trubetzkoy (28, p. 176 ff and p. 196 ff) that the difference of contact should be distinctive in German, whereas the difference of vowel length should be redundant. His main arguments are (a) that by this interpretation it is possible to remove some of the counterexamples to the general law that a language cannot at the same time have distinctive length and dynamic accent, (b) that in final position, where both length and contact are neutralized, and where

the unmarked member of the opposition should be expected to occur, German has only long vowels, evidently without close contact. As 'short' and 'not cut off by the consonant' must be the naturally unmarked members of the oppositions, it must be an opposition of contact. (c) In unstressed syllables we have short vowels with loose contact. (The first of these arguments is not convincing, since it seems to be a tendency rather than a law.) Roman Jakobson (13, p. 24) also sets up a contact feature: "in the case of the so-called c l o s e contact (scharf geschnittener Akzent), the vowel is abridged in favour of the following arresting consonant, whereas at the o p e n contact (schwach geschnittener Akzent), the vowel displays its full extent before the consonant starts". Languages where both stress and length are distinctive are said to be quite exceptional.

(2) The presence or absence of close contact after short vowels seems to be connected with a number of other characteristic features of the languages in question, particularly features of syllabic structure. Languages which are considered to have close contact after short vowels, are generally characterized by a strong dynamic accent, by the lack of a clear syllabic boundary after short vowels, by a relatively high frequency of closed syllables and by a predominance of final consonant clusters. Moreover their short vowels are normally lax, and their voiceless stops in most cases aspirated (with Dutch as an exception). These relations have been treated in more detail by EFJ (3) and by Fliflet (1o).

On this background it may be of interest to ask the following questions:

(a) What are the articulatory and acoustic correlates of the auditory impression, and, in particular, can the phonetic description given by Sievers and Jespersen be confirmed?

(b) Is it possible to set up a separate and independent articulatory or acoustic dimension, or is the auditory impression conditioned by a combination of already known acoustic dimensions (as it is the case with the auditory dimensions volume and brightness)?

(c) What are the most important acoustic cues for the perception of close and open contact?

We have no definitive answers to these questions, but we have tried to give some contributions to a solution, and some suggestions for further investigations.

For this purpose it seems most practical to concentrate on a language in which the difference between close and loose contact seems obvious to many phoneticians, e.g. German.

2. The acoustic and physiological correlates of syllabic contact

2.1. The dynamic movement of the vowel

2.1.1. A physiological examination of the dynamic movement of the vowel might be undertaken by means of electromyography, preferably of the expiratory muscles. We have not had occasion to do this, but it is evidently a desideratum.

A recording of the air flow might also be expected to show a difference, but numerous curves, taken for this purpose and for other purposes, show that the air flow of the vowel is so strongly influenced by the air flow required by the surrounding consonants that e.g. the vowels of both [taːl] [tɔl] and [ta'lɛnt] will have decreasing air flow, whereas the vowels of e.g. [liːt] [lɪt] and [litur'giː] will have increasing air flow (we will return to the air flow in the section on the force of the consonant).

2.1.2. As for the acoustic correlate of the loudness movement of the vowel, it is natural to look for it in the intensity movement. It might perhaps also be due to the movement of frequency, but in the material used in this investigation no difference could be detected in the frequency movement of the vowels. Thus the intensity movement remains.

In the paper by EFJ from 1941 (3), the results of a preliminary investigation of the intensity movement of German vowels were given (p. 57 ff). The material consisted of the vowels of two German records. Although at least one of the speakers had a rather pronounced close contact, no difference in the placement of the intensity peak could be detected for either of the speakers. Both in short and long vowels the peak could be found anywhere in the vowel from the beginning to the end with an average around 50%. Also measurements of the absolute distance between peak and end showed complete overlapping.

Later von Essen (2) has examined 16 pairs of words spoken by a German subject. He found a constant difference, but not quite of the sort one should expect according to Sievers. The peak was never found at the very end of the vowel, but the fall after the peak was more abrupt in short than in long vowels, the angle between the base line and a line drawn through the point of the peak and the end point of the vowel being double so large in short vowels as in long vowels. This result is, however, based on a very restricted material, and, moreover, the measurement was made on the oscillogram of the oscillomink, which means that only frequencies below 800 cps are included, that phase differences influence the result, and that the angle changes with the overall intensity of the signal. This investigation does therefore not prove very much.

The present investigation, undertaken by HPJ, is based on a much larger material, and more measurements have been made. The texts consisted of word series of the type piepe, Lippe, tapern, tappe, liebe, lebe, Ebbe, lieb, lob, Grab, Tipp, Topp, ab etc., containing combinations of different vowels followed by the consonants p t k b d g f s m n l. Some of the lists contained also examples of unstressed vowels, but they were not measured. Some of the lists were spoken several times with different word order. A restricted number of examples were also spoken in sentences. There were six speakers, four North Germans (KV, HT, NB and HP) and two coming from the Northern part of the Rheinland (HL and WS). From an auditory point of view they all had close contact after short vowels, although not all of them to quite the same degree, the extremes being KV, who had a pronounced close contact, and HP, who had a relatively weak contact, perhaps due to a long stay in Denmark. The total material consisted of 2066 words with stressed vowels.

The word series and sentences were spoken on tape, and a mingographic recording containing a duplex oscillogram, a fundamental frequency curve and two intensity curves (one without filtering, and one with highpass filtering at 500 cps) was made (see Fig. 1).

The following measurements were carried out: (1) the absolute distance (in cs) from the intensity peak to the end of the vowel, (2) the relative distance from the peak to the end, i.e. the distance in percentage of the total duration of the vowel, (3) the intensity fall (in dB) from the peak to the end of the vowel. The measurement was made on the unfiltered curve, but a measurement of the filtered curve would not have changed the general result.

In some cases the location of the peak was problematic. Fig. 2 shows, in schematic form, the different types of curves and the point chosen as the peak. Type c, with increasing intensity to the very end of the vowel, was found relatively often, both in long and short vowels. In type g it would probably have been more correct to consider the peak as being quite at the end (as in c), because also in this case the vowel has kept its full intensity at the implosion of the consonant (this latter point was chosen in the previous investigation (3)). But the distance from the point chosen (the cross in Fig. 2) to the end of the vowel is generally short in type g, and a different method of measurement would not have given a better distinction of the two types of vowels.

The averages of the different measurements are given in table I. This table also contains a measurement of the steepness of the curve calculated as the fall in dB divided by the distance in cs. This calculation is based on averages only.

It appears from the table that the short vowels do not have their peak quite at the end, but at a distance of 3.5 cs on the average (or 37% of the total duration of the vowel). However, all speakers have a longer distance from the intensity peak to the end in long vowels than in short vowels, the average difference being 4.0 cs. For KV the difference (5.8 cs) is evidently significant, but not for HP (1.7 cs), cf. also the histograms in Figs. 8 and 9.

The relative distance is also longer in long vowels than in short vowels (except for HP where the opposite is the case)

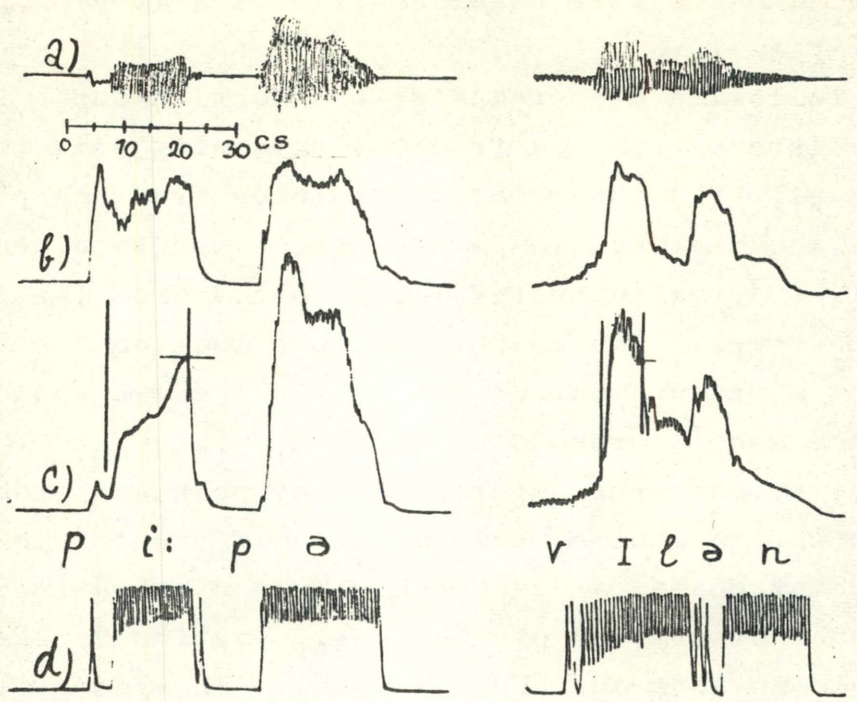

Fig. 1.

a) duplex oscillogram,

b) logarithmic intensity curve, highpass filtered at 500 cps,

c) linear intensity curve without filtering,

d) fundamental frequency curve.

Speaker KV.

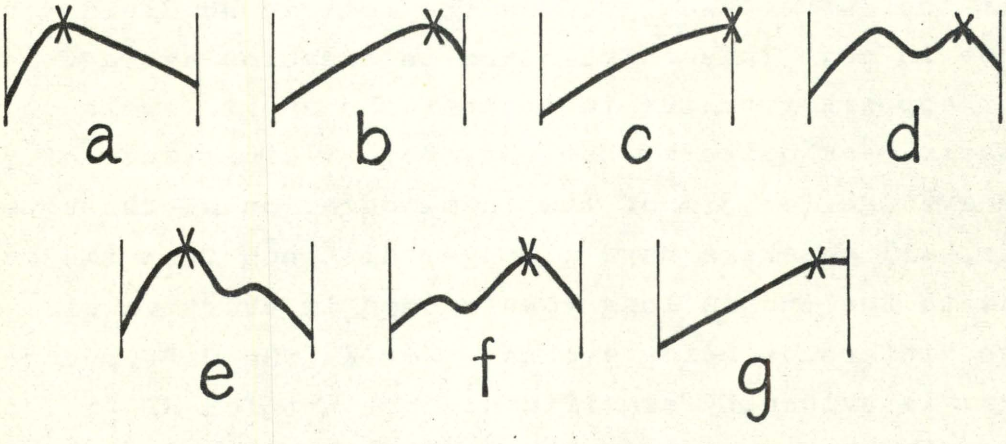

Fig. 2.

Schematic drawing of different types of intensity curves. The point chosen as peak is indicated by a cross.

TABLE I

Placement of intensity peak and fall of intensity in long and short vowels in German

Sp.	N	dist. cs	dist. %	fall dB	steepness dB/cs
LONG VOWELS					
KV	(265)	9.0	50.4	3.4	0.38
HT	(318)	6.6	36.4	2.2	0.33
HP	(266)	6.0	28.8	2.3	0.38
WS	(142)	8.8	41.4	2.3	0.26
NB	(54)	8.8	49.6	4.2	0.48
HL	(54)	6.0	37.0	3.0	0.50
General average		7.5	40.6	2.9	0.39
SHORT VOWELS					
KV	(224)	3.2	37.4	1.9	0.59
HT	(273)	2.8	21.8	1.2	0.43
HP	(238)	4.3	42.0	2.3	0.53
WS	(137)	3.4	31.7	1.7	0.50
NB	(48)	4.3	44.0	2.7	0.63
HL	(48)	3.1	34.5	2.5	0.81
General average		3.5	36.8	2.1	0.58

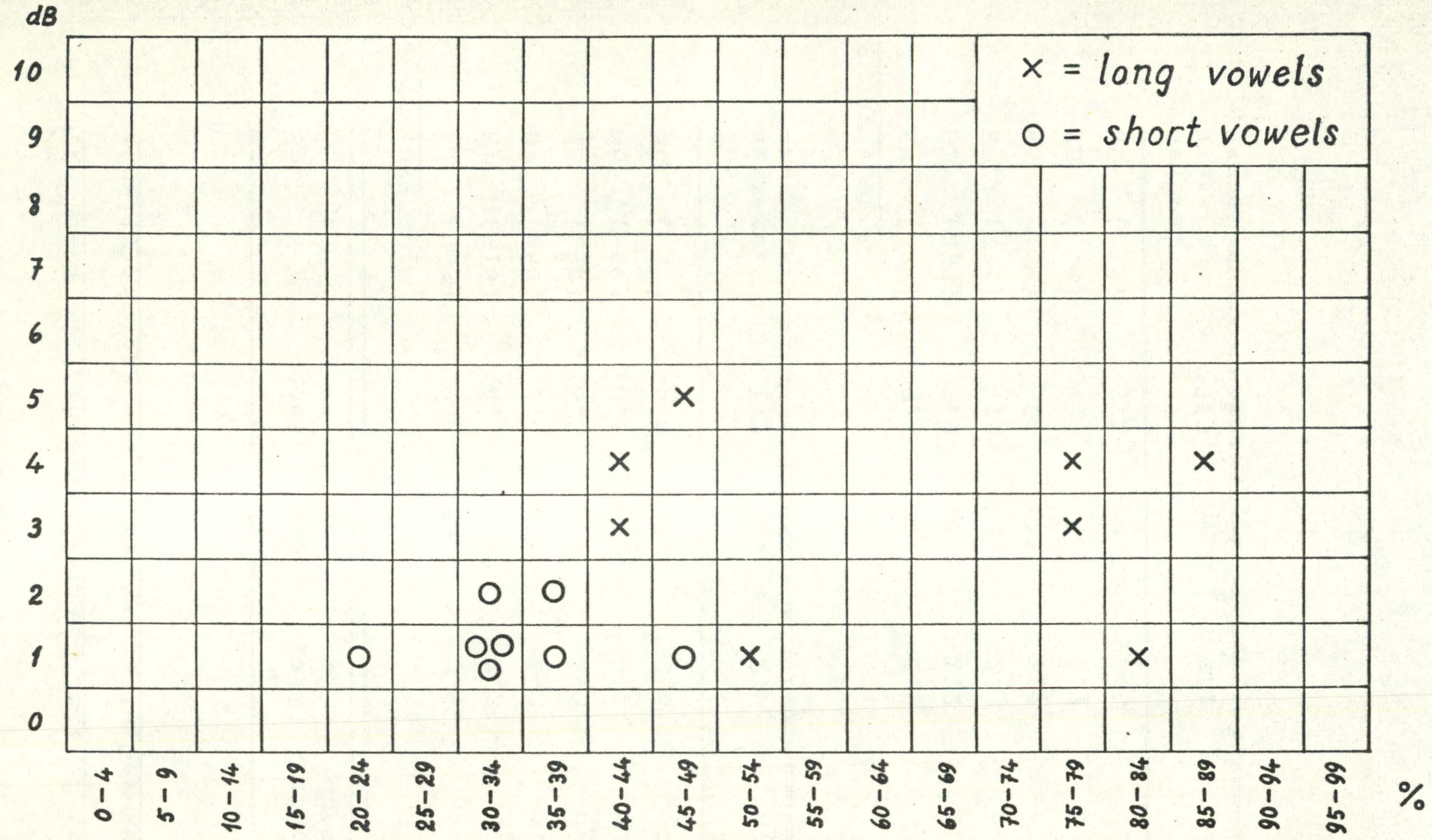

Fig. 3.

Relative distance from the intensity peak to the end of the vowel (horizontally) and fall in dB (vertically). Speaker WS: i:/ɪ + s

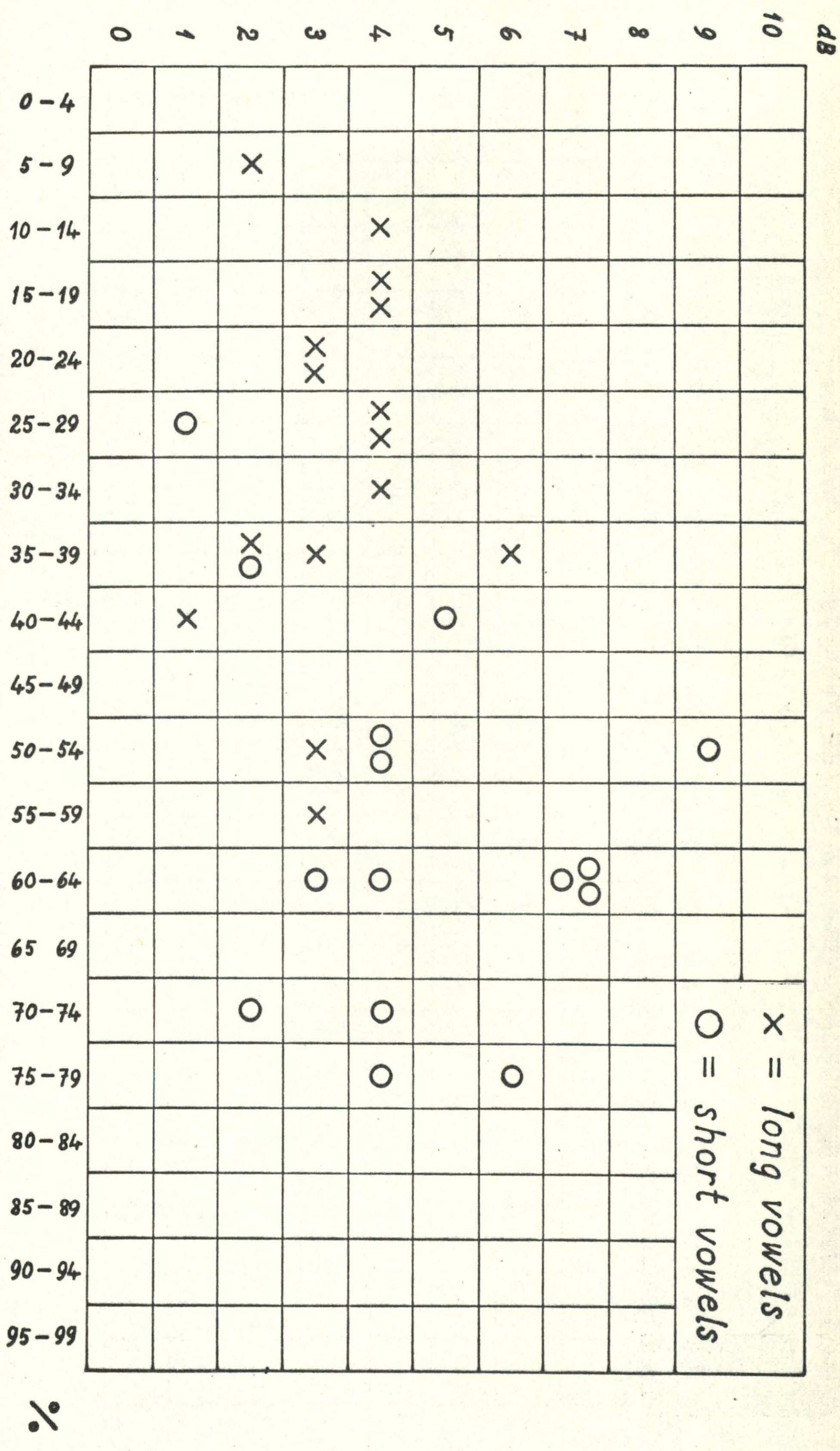

Fig. 4.

As Fig. 3. Speaker HP: a:/a + s

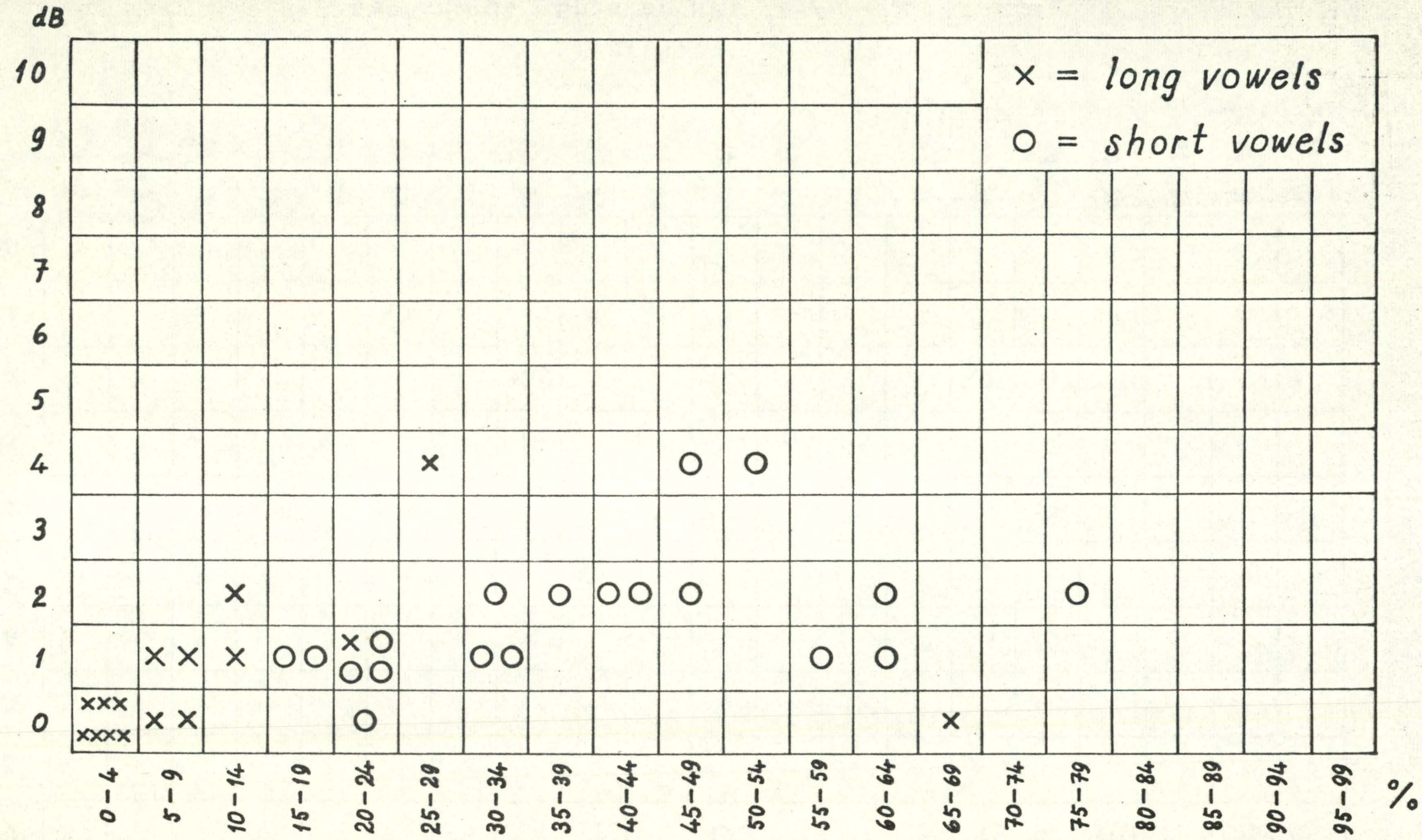

Fig. 5.

As Fig. 3. Speaker HP: i:/ɪ + 1

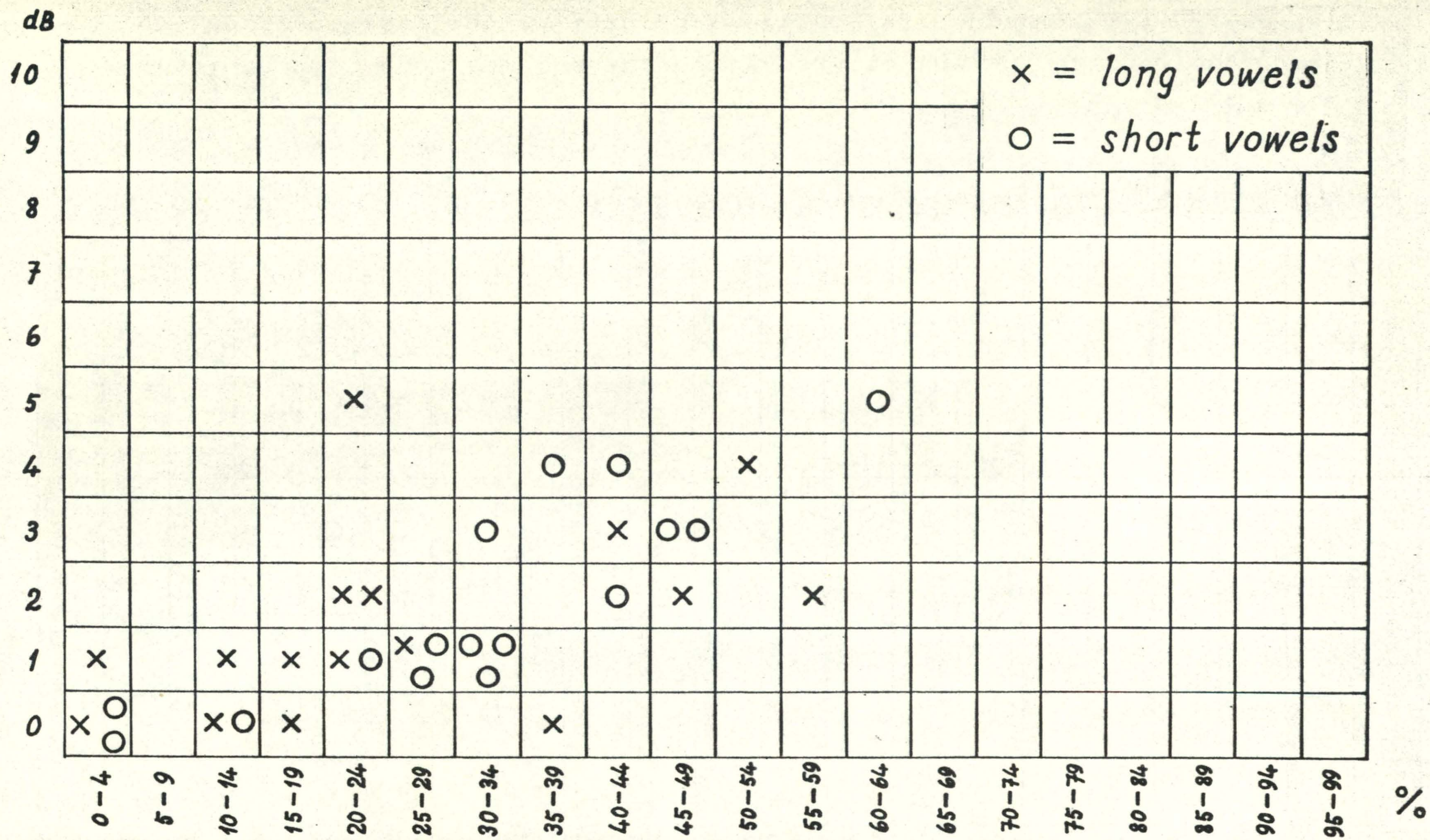

Fig. 6.

As Fig. 3. Speaker KV: a:/a + 1

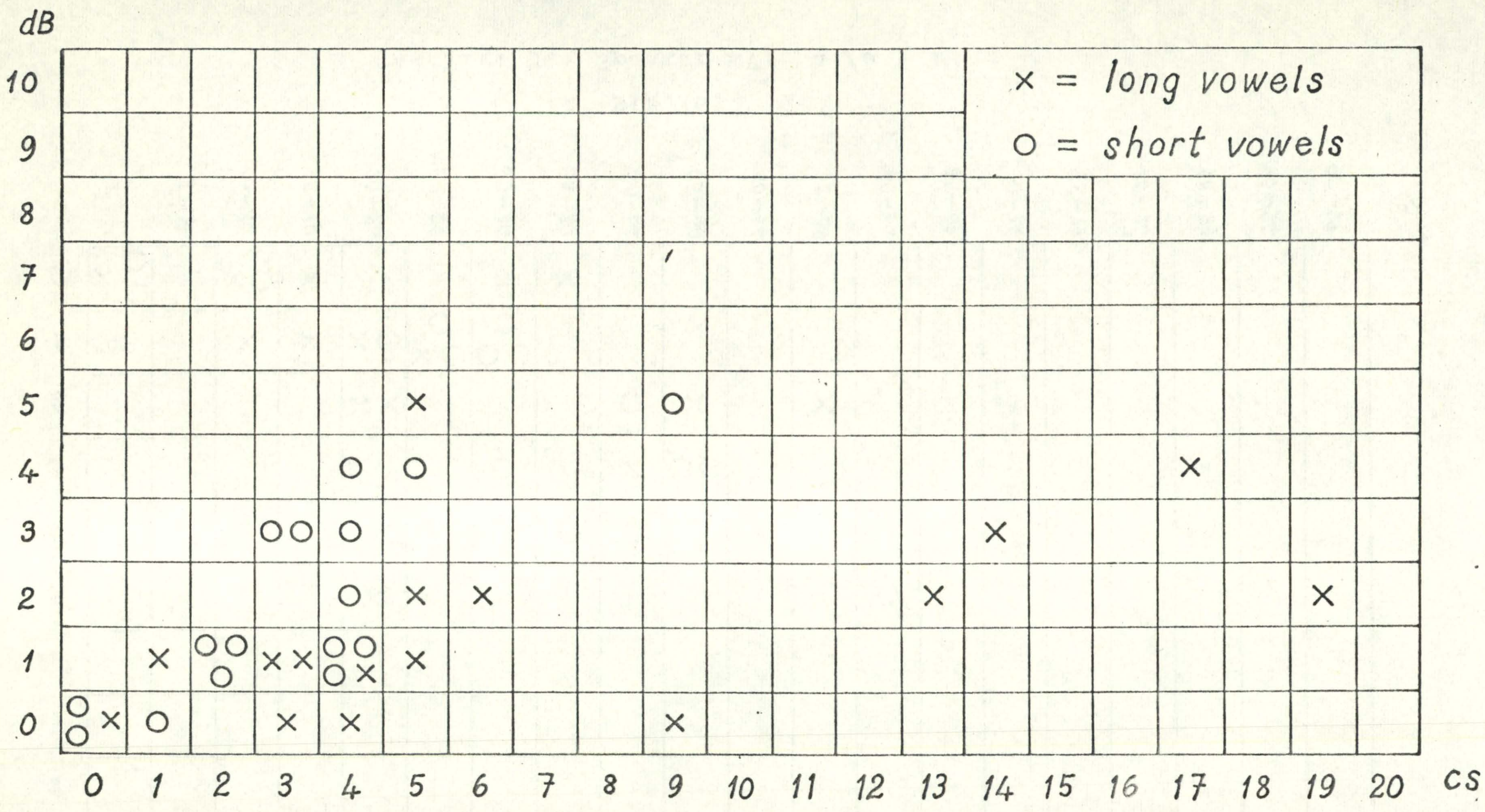

Fig. 7.

Absolute distance from the intensity peak to the end of the vowel in cs (horizontally) and fall in dB (vertically). Speaker KV: a:/a + 1

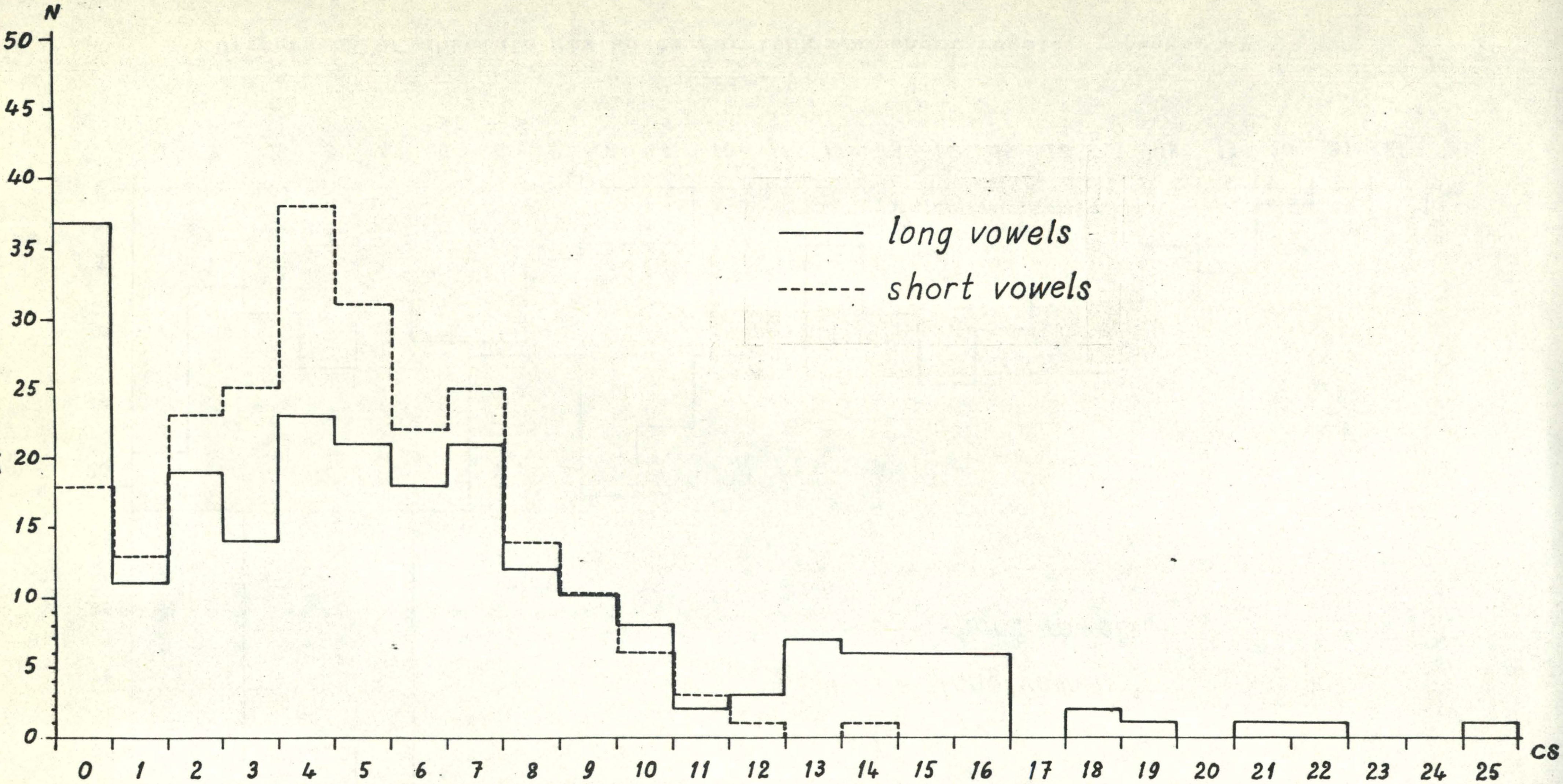

Fig. 8.

Dispersion of absolute distances for long and short vowels. Speaker HP.

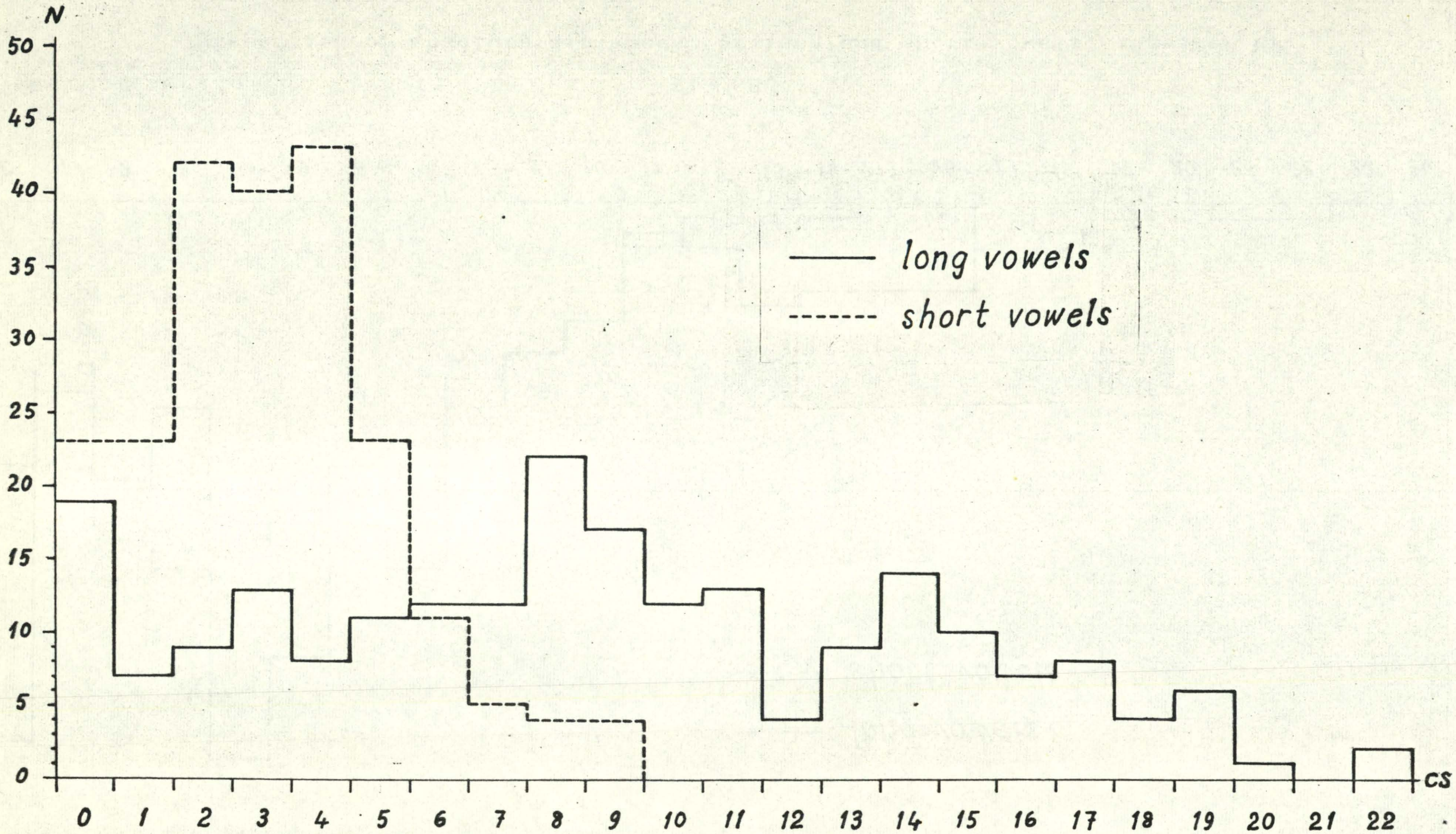

Fig. 9.

Dispersion of absolute distances for long and short vowels. Speaker KV.

the general averages being 4o.6% and 36.9% respectively. However the differences are very small, except for KV, and there is much overlapping between speakers, some of them having a longer distance in short vowels than others have in long vowels.

The fall in dB is greater in long vowels (except for HP, where it is the same), but also in this case the differences are small, the average difference being o.8 dB.

As for the steepness, all speakers have a steeper fall in short vowels than in long vowels, as they should have according to von Essen, but the difference is smaller as that found by von Essen, and it depends solely on the difference in absolute distance (the fall being more extensive in long vowels).

These are, however, average differences. The overlapping of individual examples is large in all cases, even in the case of KV's absolute distance, the most evident of all the average differences (see Fig. 9).

The absolute distance constitutes the most obvious difference between the two types of vowels. But this distance is not independent of the duration of the vowels. In the case of KV, for instance, 4o% of the values for the long vowels exceed the average duration of the short vowels (9.6 cs), which means that in a good many cases the limited duration of the short vowels prevents them from having the same distance from the peak to the end as the long vowels, and only if they were falling from the very beginning, could they have the same average distance as the long vowels. It is also evident that even if long and short vowels had the same relative distance, the absolute distance would be longer in long vowels; this might therefore also be expected to be the case in languages without close contact. For these reasons the relative distance has been examined in more detail than the absolute distance.

For all speakers long and short vowels have been placed in a coordinate system with the relative distance horizontally and the intensity fall in dB vertically (Figs. 3-6). According to Sievers' description the short vowels should be found at the zero point or at any rate close to the zero point, whereas the long vowels (having a long and extensive fall) should be found in the upper right part of the quadrangle. According to von Essen's theory the short vowels should be found above a line from the zero point through the center of the group of long vowels, and if the difference in steepness were very pronounced and due to both distance and fall, the short vowels should be found in the upper left part and the long vowels in the lower right part of the quadrangle.

When all vowels of a speaker is placed in such a diagram, the result is general confusion, both long and short vowels being dispersed over the whole space. Since this might be due to differences in vowel duration caused by the degree of opening of the vowel and the type of the following consonant, individual diagrams were made for each pair of vowels (e.g. i:/I, u:/U) before each consonant (e.g. i/I + t). 19o diagrams of this type were made. They give a very varied picture of the dispersion.

In 68 cases (approximately one third) a positive tendency to a distinction in agreement with Sievers' description can be seen, but only in 27 cases is this distinction clear in both dimensions (Fig. 3 is an example of this type). 19 cases show a directly opposite picture (Fig. 4); it may even be so that the long vowels are found close to the zero point (Fig. 5). In the majority of cases, however, long and short vowels are found all over the space without any clear tendency (Fig. 6). A consistent difference according to vowel quality and following consonant cannot be seen. A distribution in accordance with Sievers' theory is relatively frequent for y+t, e+k and ø+l, but it often happens that vowel + l shows the opposite tendency. Separate diagrams for monosyllables and dissyllables do not give a better distinction either.

There are some differences between the speakers, as can be seen from table II. ("Positive tendency" means agreement with Sievers' theory.)

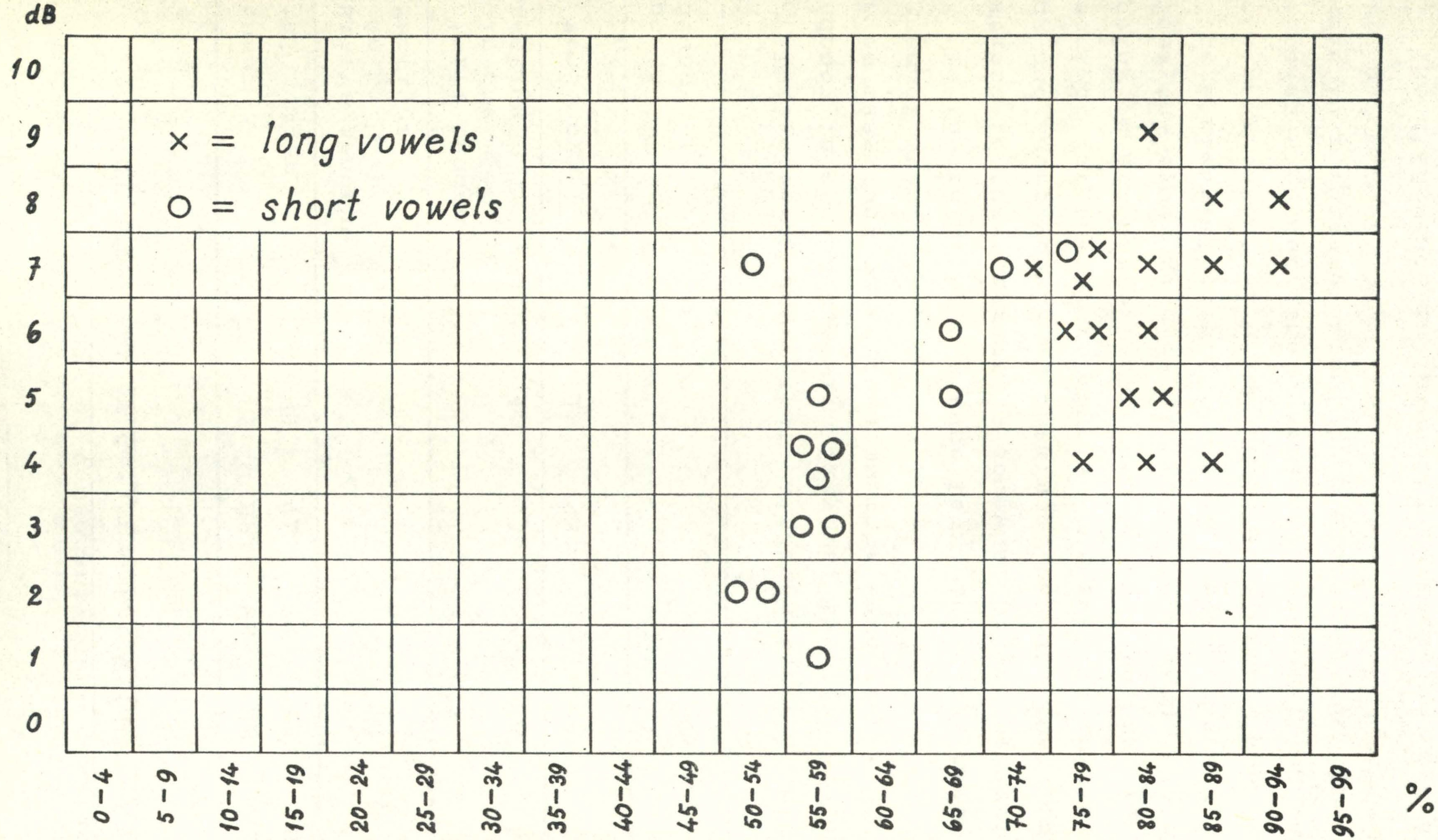

Fig. 10.

Relative distance from the peak to the end of the vowel (horizontally) and intensity fall in dB (vertically). Speaker ML (Czech): a:/a + s

TABLE II

Number of diagrams of consonant-vowel combinations showing agreement or disagreement with Sievers' theory

Speaker	KV	HT	HP	WS	NB	HL	Total
Total number	41	41	41	37	15	15	190
positive tendency in both directions	8	9	1	5	2	2	27
positive tendency in one direction	12	10	3	8	4	4	41
no tendency	21	19	30	22	7	6	105
opposite tendency	0	3	7	2	2	5	19

This clearly shows that, although there is a certain tendency in accordance with Sievers, the counter-examples are so many that these cues must be said to have a very low degree of stability.

If the relative distance is replaced by the absolute distance in the diagrams, a somewhat better separation between long and short vowels is obtained, because there is a limit to the right for the short vowels, but even in this case the overlapping is extensive. This can be seen in Fig. 7, which comprises the same examples as Fig. 6, but with absolute distance as the horizontal axis. (This figure, by the way, shows a certain agreement with von Essen's theory.) When all vowels are taken together, the overlapping between long and short vowels in respect of absolute distance is very great (see Figs. 8 and 9).

The difference in intensity movement between short and long stressed vowels in German is thus not consistent, but it may still be true that German vowels have their intensity peak closer to the end than vowels in Romance and Slavonic languages. This requires further investigations, but the comparisons we have made with a restricted material does not show any consistent difference. 45 word pairs spoken by a Czech subject were measured according to the same method as the German words. The speaker has in all cases a relatively long distance from the peak to the end of the vowel (50% or more), so that in this sense she has loose contact in both long and short vowels, but the contact is looser (according to Sievers) in long than in short vowels, and there is a clear distinction between the two groups in both directions. (See Fig. 10.)

One French speaker also had a greater distance from the peak to the end of the vowel than the German speakers, but a preliminary examination of a more extensive French material showed for several speakers a clear tendency to rising intensity in close vowels. Finally a Danish subject with Copenhagen pronunciation and a contact which was very loose from the auditory point of view, had two intensity peaks in most vowels (combined with a falling-rising tone), and both in short and long vowels sometimes the first peak and sometimes the last peak was the stronger of the two.

One might also expect a difference in <u>formant transitions</u> to be associated with close and loose contact, but an extensive material of spectrograms used for formant measurements of German long and short vowels (HPJ 17), did not show any consistent difference. Fliflet (9), on the other hand, has found longer transitions in short vowels than in long vowels in German. The question needs further investigation.

2.2. The force of the consonant

2.2.1. Physiological measurements

Also for the examination of the force of the following consonant electromyographic measurements would be of great interest. It has, however, not been possible to use this method in the present investigation. Instead we have measured the <u>organic pressure</u> at the point of articulation by means of a small rubber bulb connected with an electrical manometer. The material consists of a restricted number of word pairs (113 in all) with short and long vowel followed by a labial consonant. They were spoken by two different speakers, HP and CH, both from Northern Germany.

For f the results are not very reliable because of the relatively weak labiodental constriction. The stops p, b and m, however, show for both speakers a higher pressure after short vowel than after long vowel, both in medial and in final position. The variation is relatively great, which is normal in the case of lip pressure, but when the words are compared in pairs, the difference is found to be statistically significant at the 1% level for CH and at the o.1% level for HP, and in most cases it exceeds the motoric difference limen found by Malécot (19).

Besides the organic pressure the duration of the consonant seems to give a good indication of the force of articulation (EFJ 6, pp. 73, 8o and 1o5). The present investigation shows that both speakers have a longer consonant after short vowels than after long vowels. Moreover there is an evident correlation between duration and organic pressure in the sense that a particularly great difference in organic pressure corresponds to a great difference in duration. This can be seen in table III which shows the percentual increase of organic pressure and duration after short vowels compared to long vowels.

TABLE III

Percentual increase of lip pressure and duration of the consonant after short vowels compared to the values found in the position after long vowels

cs	-p-	-p	-b-	-m-	-m	-f-	-f
CH							
number	(8)	(12)	(6)	(15)	(6)	(13)	(1o)
lip pressure	1o%	12%	52%	2%	4o%	(-4%)	(27%)
duration	12%	11%	27%	2o%	44%	58%	22%
HP							
number	(8)	(12)	(8)	(12)	(8)	(8)	(7)
lip pressure	55%	7%	84%	92%	12%	(11%)	(47%)
duration	42%	7%	71%	58%	1o%	33%	21%

The same correlation is seen by a comparison between the two phenomena medially and finally for p and m, both speakers having higher lip pressure and longer duration in final m than in medial m, and lower lip pressure and duration in final p than in medial p (with the exception that CH has higher lip pressure (and also longer duration) in final p than in medial p after short vowel). There is no difference in the rate of increase of the organic pressure after short and long vowels.

The relative prolongation of the consonant after short vowel is confirmed by a larger material comprising 1142 word pairs spoken by ten different subjects, the seven speakers mentioned above and three others, two North Germans (WL and GR) and one from the Rheinland (GJ). All ten speakers have longer consonants after short vowels than after long vowels, the general average being a prolongation of 27% and the individual averages ranging from 10 to 74%.

The long vowel is for all subjects approximately twice as long as the short vowel. This means that the relation C/V (the relative duration of the consonant compared to the vowel) would give a still greater difference between the two word types than the simple duration of the consonant. This relation is, however, very variable due to the specific durations of different types of vowels and consonants and to the influence of the consonant on the duration of the vowel. For most speakers the relation is, e.g., higher for long vowel + fs than for short vowel + l.

As a third indication of force of articulation, one might think of the air flow. The air flow at the moment of transition from vowel to consonant has been measured by means of the aerometer in 292 word pairs with following ptk bdg and fs, spoken by four subjects (KV, HT, HP and WS). All speakers have stronger air flow after short vowels than after long vowels, and the difference is significant at the 0.1% level, except for HT's stops. The percentage of word pairs showing a stronger air flow after short vowels is for the four speakers 93, 67, 83 and 80 respectively. The relative increase of air flow after short vowels can be seen in table IV.

TABLE IV

Relative increase of air flow after short vowel compared to the air flow after long vowel (number of examples in parentheses)

Speaker	KV		HT		WS		HP	
	N	%	N	%	N	%	N	%
ptk	(24)	31	(26)	5	(46)	22	(42)	21
bdg	(6)	43	(6)	8	(2o)	13	(1o)	11
fs	(3o)	61	(41)	26	(16)	12	(25)	32

A further difference can be seen in f and s. The air flow curve for these consonants has generally two peaks, one just at the start and one at the end of the consonant. After short vowels the first is relatively higher, after long vowels the second. This is true not only of dissyllables, as giessen, bissen, but also of monosyllables of the type misst, giesst (but not finally).

The intra-oral air pressure of the consonant has been measured in 138 pairs with stops and fricatives for two speakers (HP and CH). It was found to be higher after short vowels, and the difference is significant (except for HP's fs, which showed the opposite tendency), but the differences are relatively small (5% for pt and 21% for bd for both speakers, 22% for CH's fs and -5% for HP's fs), and for most consonants they are below the motoric difference limen found by Malécot (2o). There was no constant difference in the rise of the air pressure.

2.2.2. Physical intensity of the consonant

Corresponding to the differences found in the physiological curves, one should expect to find a difference in physical intensity. It has, however, not been possible to find any difference in the case of stops and fricatives. As for the stops, they have normally a very weak implosion, which is hardly measurable, and no difference could be detected on the mingograms neither in the implosion nor in the explosion. As for the fricatives, there was no difficulty of measurement, but no difference of intensity could be seen, although the difference of air flow and duration was clear. Now, the relation between force of articulation and physical intensity is rather complicated in the case of fricatives, since the constriction of a fortis consonant may be narrowed beyond the point where the relation between air flow and constriction is optimal for the production of noise. It is possible that the difference of duration is sufficient to give an impression of stronger intensity, although the difference amounts to only some 1o-2o%. As far as the stops are concerned, one cannot exclude the possibility that oscillograms taken at high speed might show some differences in the implosion.

In the nasals and l, however, a tendency to stronger intensity after short vowels is apparent, although for these consonants no difference of air flow was visible, only a difference of duration and (in m) of lip pressure.

The average intensity of the first 5 cs of m, n and l was measured and compared with the last 5 cs of the preceding vowel for the speakers KV, HT, HP and WS. The tendency to stronger consonant after short vowel than after long vowel is particularly evident for HT, and in some combinations the consonant is stronger than a preceding short vowel, but weaker than a preceding long vowel. For the speakers KV, HP and WS the tendency is, however, not so clear, and when all words with the same sound combination (e.g. y:/Y + t) are taken together, the tendency is only evident for e:/ɛ and ø:/œ. However, if the words are compared in pairs (Höhle/Hölle etc.), the tendency is evident for HT, KV and WS, but not for HP. This can be seen from table V.

TABLE V

Percentage of pairs in which the consonants l, m, and n have stronger (a) or weaker (c) intensity after short vowel than after long vowel, or the same intensity after long and short vowels (b)

	Number of pairs	a stronger	b same	c weaker
HT	1o2	76%	19%	5%
KV	9o	78%	11%	11%
WS	48	67%	1o%	23%
HP	89	38%	2o%	42%

3. Is there an independent acoustic or physiological dimension corresponding to the impression of contact?

If the curves had shown an evident and stable difference in the intensity movement of the two types of vowels, it would have been possible to consider this as a separate acoustic dimension. But, as shown above, the overlapping is so extensive that this is not possible.

On the physiological plane one might think of the air flow at the implosion as a specific correlate to syllabic contact, although no difference could be seen for l (the nasals must be left out of consideration, since only the air flow from the mouth was recorded). E. A. Meyer (23) considered this as the decisive factor, languages with close contact being characterized by a more open position of the glottis, and consequently by aspirated consonants, lax vowels with relatively strong air flow, and audible noise at the implosion. This sounds very plausible (although, as mentioned above, Dutch constitutes an exception as it has unaspirated stops, but short lax vowels), and it may be the best explanation of the differences found between Germanic languages on one hand

and Romance and Slavonic languages on the other (this has also been emphasized by A. Thelin in an unpublished thesis), but it can hardly be set up as an independent dimension in German, at any rate if we look for a phenomenon which should be characteristic of the transition from vowel to consonant, for the stronger air flow in words with short vowels is not restricted to the implosion, it is found throughout the preceding vowel, and even in the initial consonant (in 74% of 114 comparable pairs with initial ptkbgvfh). It might therefore be more correct to consider it as a characteristic of short syllables without direct correlation to the contact phenomenon. Very restricted material from Danish, French and Swiss German shows a similar, although weaker, difference between syllables with long and short vowels. In German the difference may be enhanced by the laxness of the short vowels.

The remaining factors are differences of duration and of consonant intensity. The correlation to vowel duration in stressed syllables (but not in unstressed syllables) is evident, but this is not a separate contact dimension. The differences of consonant duration and intensity are less stable, but evidently not accidental. Fliflet is probably right, when he states (10) that a syllable with a short and lax vowel + a long strong consonant will be perceived as having close contact, whereas a syllable with a long and tense vowel + a short and weak consonant will be perceived as having loose contact. But, as he demonstrates, this is not only valid for Germanic languages; there is a widespread tendency in various languages to combine vowel and consonant types in this way, although this tendency is not universal. (In Danish, for instance, consonants are not usually longer after short vowels than after long vowels, see EFJ (4), p. 46, and (5), p. 188). Anyhow, this is not a simple and independent physiological or acoustic cue for the perception of contact.

We seem to be faced with a perceptual phenomenon, which has complex correspondences both acoustically and physiologically. In this case it is important to investigate the relative importance of the cues. On the basis of our material we can only do this for the acoustic cues.

4. The relative importance of the acoustic cues

4.1. Comparison of speakers

Some very preliminary conclusions might be drawn from the fact that, according to the subjective impression, some speakers have a closer contact than others, the extremes being KV (with a very close contact after short vowels) and HP (with a relatively loose contact). The measurements show that KV's short vowels have a shorter absolute and relative distance from the peak to the end of the vowel, and a less pronounced intensity fall than HP's short vowels, whereas the difference in steepness is negligible. On the other hand NB has almost the same averages as HP, and his contact sounds almost as close as that of KV. HP has more overlapping between the two types than KV, but this is above all due to the fact that his long vowels have a shorter distance from the peak to the end of the vowel than the long vowels of the other speakers (in many cases the peak is quite at the end of the vowel) and that the intensity fall of his long vowels is relatively small, whereas KV's long vowels have a particularly long distance to the peak and an extensive fall. Thus the contact of HP's long vowels should sound relatively close, but this was not obvious. As for the physical intensity of lmn, HP has no difference after long and short vowels, and KV has a clear difference. On the other hand, HP's difference of lip pressure and duration is larger than that of CH, whose short vowels sound quite typical. Out of ten speakers HP has even the next highest prolongation of consonants after short vowels (47%), and one of the highest C/V relations. The absolute duration of his vowels is, however, longer than those of KV, HT or CH.

According to these observations the peak placement should be more important than the relation between vowel and consonant, but the conclusions are not very safe.

4.2. Test

4.2.1. In order to get a better measure we made a test consisting of 84 German words taken from the tapes used for the acoustic measurements and (for comparison) two Czech, two

French and two Danish words, thus 9o words in all, of which 67 should have close contact, and 23 have loose contact, according to the traditional description. The words were chosen in such a way that there were two or more examples of the same or similar words differing in respect of duration or of the dynamic movement of the vowel. These similar examples were placed close to each other on the test tape, and the listeners were allowed to go back and forth on the tape and repeat the words. The listeners were eight Danish phoneticians and dialectologists, who were familiar with the concept of close and loose contact. They were asked to judge each word in respect of close and loose contact on the basis of a seven point scale comprising the steps (1) very close, (2) close, (3) close rather than loose, (4) questionable, (5) loose rather than close, (6) loose, (7) very loose.

The listeners found the test meaningful, and the answers do not seem to be accidental. All steps in the scale were utilized, the percentage of utilization being (1) 19%, (2) 3o%, (3) 19%, (4) 5%, (5) 8%, (6) 12%, (7) 7%. It is worthy of note that No. 4 (questionable) comprises only 5% of the answers, that the extreme judgments (1) and (7) are never found together for the same word, and that (1) and (6) were only combined in 6 words, and similarly with (2) and (7). This may, however, to some extent be due to theoretical knowledge about the "right" answers. Most of the German words were immediately recognizable as German, and, with exception of the word "lieb", all German words with long vowels were heard as loose, and all German words with short vowel as close by the majority of the listeners. But none of the 8 listeners distributed their answers mechanically in this way. They all heard some short vowels as loose and (with one exception) some long vowels as close, and the three degrees in each group were fully utilized. The two Czech words (bas and basu) were heard by the majority as close, and the two French words (basse and dix) as loose, whereas the two Danish words in Copenhagen pronunciation (kasse, bisse) were almost evenly distributed on loose and close.

There was little evidence for the assumption that voiceless consonants should have closer contact than voiced consonants (cf. Martens and Heffner). The average answers were:

<u>short vowel:</u> +<u>sf</u> 2.3 +<u>lmn</u> 2.5 +<u>ptk</u> 2.7 +<u>d</u> 3.o

<u>long vowel :</u> +<u>s</u> 6.o +<u>ptk</u> 6.1 +<u>l</u> 6.9

(there were no examples of long vowel + <u>d</u>, <u>m</u>, <u>n</u>).

In view of the restricted number of examples, the only thing that can be said is that long vowel + <u>l</u> sounds definitely loose.

A consideration of the number of "loose" answers for short vowels, and "close" for long vowels gives a similar result:

<u>answer "loose" for short vowels:</u> +<u>ptk</u> 11% +<u>sf</u> 3%
+<u>lmn</u> 3% +<u>d</u> 0%

<u>answer "close" for long vowels :</u> +<u>ptk</u> 19% +<u>sf</u> 13%
+<u>l</u> 0%

<u>4.2.2.</u> The question of the <u>relative importance of the acoustic cues</u> was examined in different ways.

First the words were divided into five large groups: A, heard as close by all listeners, B, heard as close by the majority, C, heard as loose and close by equal numbers of listeners, D, heard as loose by the majority, E, heard as loose by all listeners. For each of these five groups separate averages were calculated for (1) vowel duration, (2) consonant duration, (3) consonant/vowel relation, (4) absolute distance from intensity peak to the end of the vowel, (5) relative distance, (6) fall in dB. The results are given in Fig. 11. There is an evident correlation between vowel duration and the five groups of answers from close to loose, and a certain correlation with the C/V relation, but as the consonant duration does not show anything, the agreement with the C/V relation must simply be dependent on the correlation with vowel duration. A certain correlation can also be seen for absolute distance, but, as mentioned above, this is partly dependent on the duration of the vowel. The other acoustic factors do not seem to have any influence on the answers. Steepness has been left out because it could only be calculated for part of the examples (not for those with zero fall), but it did not show any consistency either.

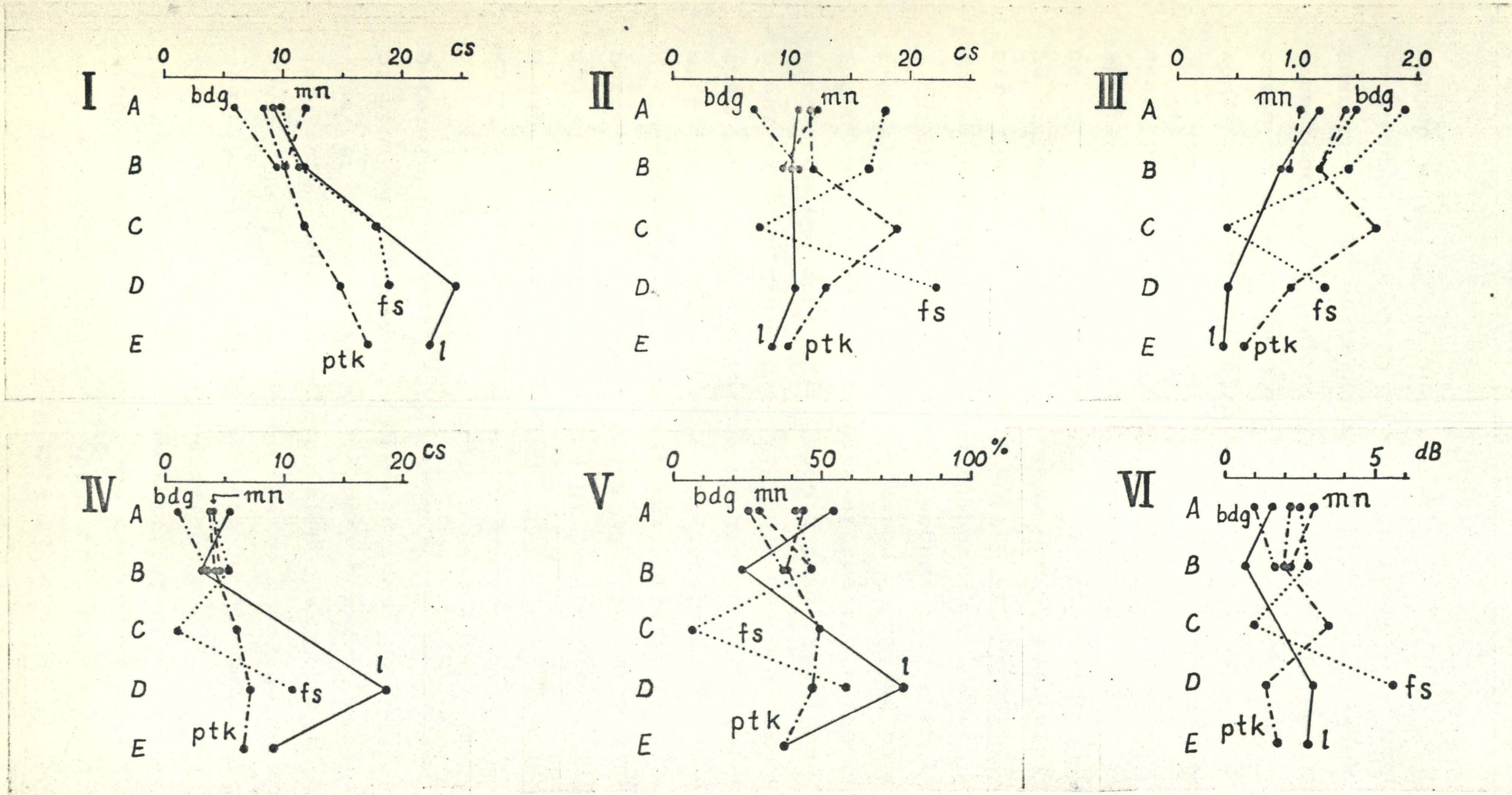

Fig. 11. Graphical presentation of the answers to the listening test divided into five groups (A. all judgments: close, B. majority of judgments: close, C. equal number of judgments: close and loose, D. majority of judgments: loose, E. all judgments: loose) and compared to the average values of I. vowel duration, II. consonant duration, III. cons./vowel, IV. absolute distance, V. relative distance, VI. intensity fall for ptk, bdg, fs, mn, l.

In order to examine this in more detail the average judgement was calculated for each word, and a number of scatter plots were made, in which the horizontal axis indicates the average judgements and the vertical axis the different acoustic factors. Only for vowel duration could a clear correlation be seen (Fig. 12). The difference in judgement between long and short vowels may partly be due to previous knowledge, but there is also a clear correlation with the group of long vowels. (Because of the difference of vowel duration before different types of consonants, vowels + ptk and vowels + fslmn were plotted separately and vowels + bdg were left out.)

Finally, in order to eliminate the influence of theoretical knowledge entirely, the judgements of identical or very similar words were compared in pairs, e.g. KV Güte I and II, HP Latte and HT Latte, HT hassen and HT passen etc. There were 65 such pairs, and out of these pairs 32 pairs with a clear difference of judgement were selected, the criterion being that (1) 5 out of 8 listeners should agree in considering one as more close than the other, and nobody should have the opposite view (or 6 out of 8 should agree, and only one have the opposite view etc.), or (2) that there should be at least one full step between the average judgements of the two words (e.g. 5.6 versus 6.6 or more). 23 of the 32 words fulfilled both conditions, 4 only the first, and 5 the second.

These pairs were then compared in respect of the 7 acoustic factors mentioned above (for steepness only 16 pairs could be compared, since in 14 cases one or both of the members had no fall). The result is given in table VI, where + indicates shorter distance, smaller fall, shorter vowel, longer consonant, higher value of C/V and greater steepness.

The result is that there is an evident correlation with vowel duration, since in 29 out of 32 pairs the member indicated as more close has a shorter vowel. This correlation is even found in 19 out of 24 pairs where the majority is smaller than in the 32 selected pairs, i.e. the agreement is found in 48 out of 56 pairs in all (in the 8 remaining pairs there was no majority for any answer).

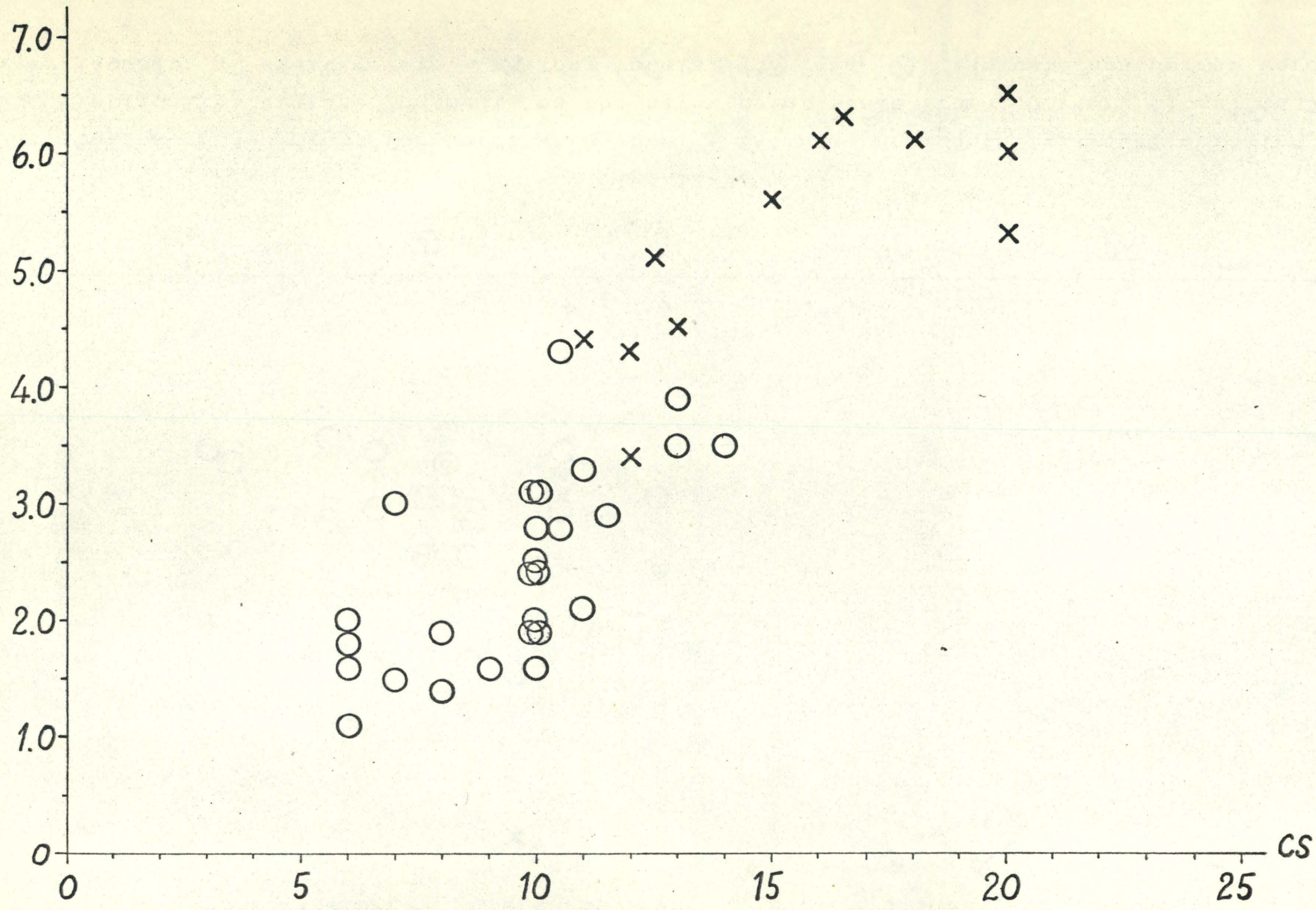

Fig. 12-A.

Distribution of judgments for words with vowel + ptk. Horizontally: vowel duration in cs. Vertically: average judgments on the seven point scale from 1.0 (very close) to 7.0

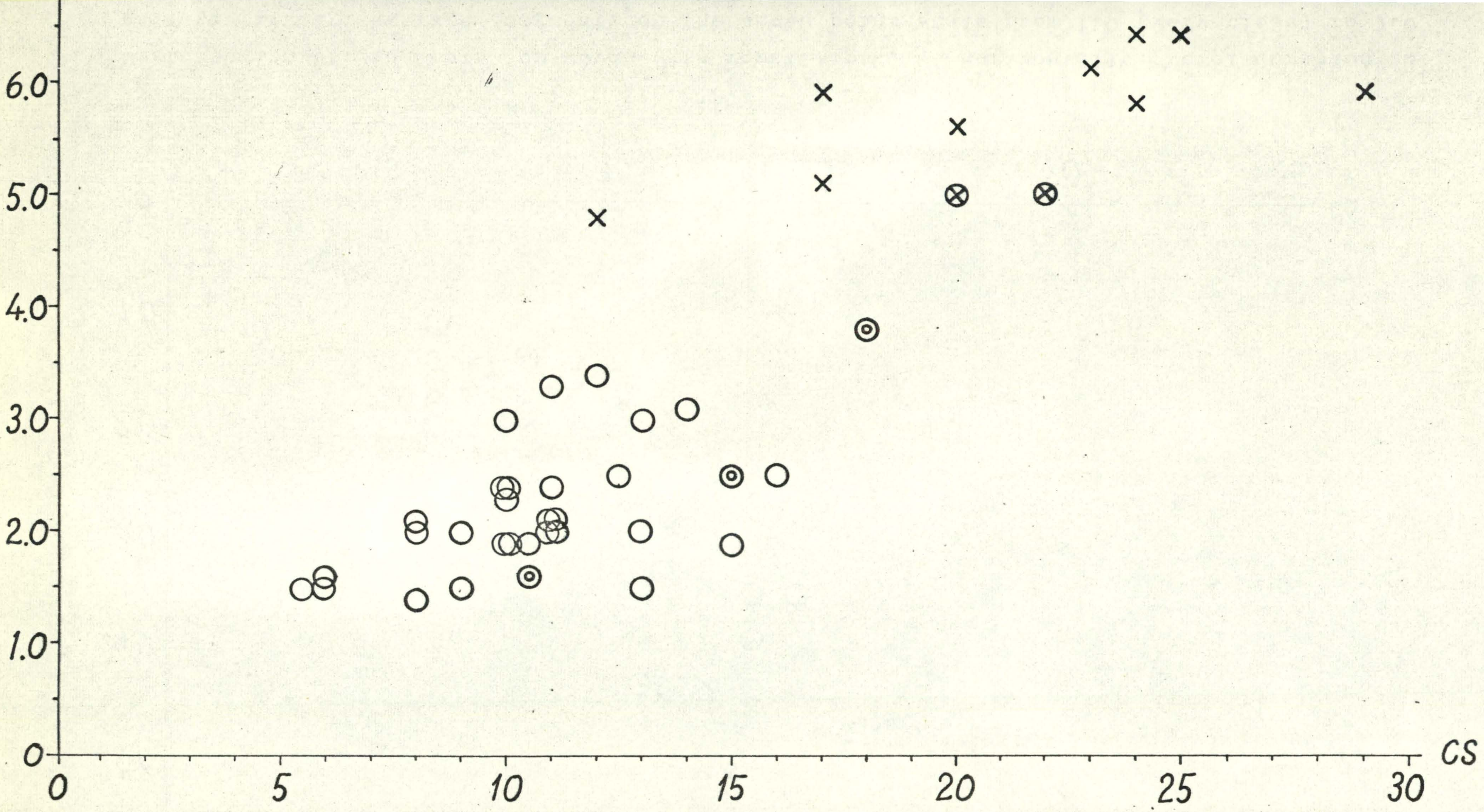

Fig. 12-B.

Distribution of judgments for words with vowel + fslmn. Horizontally: vowel duration in cs. Vertically: average judgments on the seven point scale from 1.0 (very close) to 7.0 (very loose). ○ short vowels, × long vowels. ⊙ and ⊗ indicate non German words.

TABLE VI

Acoustic factors connected with the impression of closer contact in pairs of similar words

	Duration			Intensity			
	V	C	C/V	abs. dist.	% dist.	fall	steep-ness
+	29	15	22	18	17	14	1o
0	2	1	5	4	3	5	1
-	1	16	5	1o	12	11	5

There is also a correlation with the C/V value, but in 15 out of 22 positive cases it is vowel duration that is the exclusive or dominating factor, not consonant duration. The absolute distance and the steepness may have some influence, but in all cases where the distance or the steepness are positive, the influence can also be ascribed to the vowel duration, whereas on the other hand there are many cases with long distance or weak slope which are nevertheless heard as close. The only thing which is proved is thus the influence of the duration of the vowel.

This is in good agreement with a test carried out by A. L. Fliflet, containing a great number of words from many languages, and of which he has given a brief report in (8). He used tape cutting and splicing, cutting the vowel from the start or the mid part of the consonant, and thus leaving the transition from vowel to consonant untouched. Fliflet found that a shortening of the vowel might change the perceptual impression of contact and syllabic structure completely, so that a word with pronounced loose contact before the cutting was heard with pronounced close contact after the cutting. However, he also found that the duration and perceptual loudness of the following consonant was of importance (but the loudness of the consonant was found to depend partly on its duration). This does not appear from our test, except that the duration of s seems to have some influence on the judgement. The acoustic intensity could only be compared for 14 pairs, of which 7 belong to the group with a clear majority, and here no correlation could be found. But the number of examples is too small. This problem needs further investigation.

According to the present investigation the impression of syllabic contact seems to be influenced predominantly by the duration of the vowel, and, according to Fliflet also, but not quite to the same extent, by the duration (and loudness) of the following consonant. This again shows that there is no independent acoustic (or physiological) dimension corresponding to the perceptual dimension of contact. It is based on a complex of already known acoustic dimensions.

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