A STUDY OF INTERNAL OPEN JUNCTURE IN BRITISH ENGLISH

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1. Introduction

The aim of the present paper is to investigate certain acoustic properties of internal open juncture[1] in the dialect of British English called Received Pronunciation.[2] More specifically duration of segments before and after internal open juncture are considered, and, to a lesser degree, the intensity of certain consonants. Other aspects, e.g. formant transitions and voice assimilation, were excluded.

Generally speaking internal open juncture may be expected to occur where there is spacing of letters in a written or printed text, but this is not true of all cases. In the phrase 'not at all' the /t/ in 'at' is pronounced as if it belongs to the following word, see Gimson (1962 p. 275); in 'Plato' some American phoneticians state that the /t/ is pronounced as if word-initial, see Gleason (1955 p. 43) and Hockett (1955 p. 172).

In handbooks of British English phonetics the manifestation of internal open juncture has been described impressionistically from Sweet (189o) to Gimson (1962), and, to my knowledge, only one phonetic experiment on internal open juncture has been published, viz. O'Connor

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1) By different phoneticians termed internal open juncture, open juncture, internal juncture, and open transition.

2) For a description see Jones (1967 p. xviii).

and Tooley (1964). They made an auditory investigation with paired phrases only differing in respect to placement of internal open juncture which occurred either between vowel and consonant or between consonant and vowel. All tape-recordings with glottal stop were rejected.[3] Voiceless stops were found to be the most efficient juncture-markers whereas the results for voiceless fricatives, voiced fricatives and stops, and voiced continuants are rather poor.

American phoneticians have, on the other hand, delved deeper into the problem both from a phonological and a phonetic point of view. Since Trager and Bloch (1941) coined the term juncture it has been an integral part of most American linguistic analyses, including generative grammar, but the status of internal open juncture has been different in the various linguistic schools.[4] The first large-scale phonetic study was made by Lehiste (1960), and later several papers on the acoustic and auditory properties of internal open juncture have been published. Lehiste (1960) found that post-junctural allophones of almost all phonemes are considerably longer than either pre-junctural or medial allophones; vowels are excluded from this rule: they are longer finally than initially and initial allophones may start with laryngalization. Hoard (1966) states that pre- and post-junctural consonants show systematic difference of duration particularly when there is no glottal stop, only in one contrastive pair did he find significant difference in vowel duration (longer pre-junctural vowel in 'Nye trait' than medial in 'nitrate'); like Lehiste, Hoard found that post-junctural consonants are longer than pre-junctural.

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3) This was done because the authors believe that glottal stop is an unequivocal boundary marker.

4) Lehiste (1960) gives an exhaustive treatment of the problem.

From the above may be concluded that an acoustic investigation of internal open juncture in RP was needed, so I decided to undertake such an experiment to determine whether its manifestations in RP could be compared to those found for American English. I also wished to see if the status of final and initial /n/ is still so precarious as it once was, e.g. the words 'umpire' and 'nickname' were in Middle English metanalyzed from 'a noumpire' and 'an ekename'.

2. Experiment

2.1. Phonetic notation

The notation follows that used by Jones (1967) with the divergencies mentioned below. "+" indicates possible placement of internal open juncture; "?" stands for glottal stop, creaky voice or laryngalization (not separated and henceforward termed glottal stop); "V" for vowel; and "C" for consonant. Square brackets are used for phonetic and slants for phonemic notations.

2.2. Material

When reading articles on juncture I collected a vast number of contrastive pairs only differing in respect to placement of internal open juncture, e.g. of the type 'gay mate', 'game eight'. To limit the material I selected those pairs where internal open juncture occurs either between vowel and consonant or between consonant and vowel, i.e. /..V+CV../ and /..VC+V../. Two pairs with internal open juncture contrasting with close juncture[5] were also included, as well as one phrase exemplifying metanalysis

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5) Close juncture is generally signalled by absence of spacing in a written text.

in modern English and one with /n/ in close juncture. Table I shows the phoneme combinations and Tables II and III the actual phrases.

Three lists were made incorporating the phrases in random order. To ensure uniform stress- and intonation-pattern I thought it necessary to use the same frame for all phrases. As the phrases did not all belong to the same substitution class they were inserted into the quotation frames "The password is '...'" (list A) and "He said, '...'" (list B); in the third list the phrases were inserted as contrastive pairs with no frame, each phrase occurring twice, the second time in reverse order of the first.

2.3. Subjects

For the experiment I chose six subjects who had all spent their formative years in the Home Counties and belonged to the socio-linguistic group that speaks RP. They were from 25 to 46 years old, four male subjects were from the staff of Hull University, one female and one male were from the staff of the University of Copenhagen.

2.4. Recordings

The subjects were first asked to read aloud lists A and B, each list four times; then they were shown the list with contrastive pairs (list C) which they only read once; hereby I got ten recordings of each phrase for each subject. For lists A and B the subjects were asked to read them with a uniform stress- and intonation-pattern, they themselves chose their tempo, only for list C were they asked not to exaggerate the difference between the contrastive pairs.

That list C was given them after reading the two other lists was done to prevent the subjects knowing what was under investigation. I did not succeed in this; they all discov-

TABLE I

Phoneme-combinations included in the material

Post-junctural or post-consonantal vowel

Pre-consonantal or pre-junctural vowel	i:	i	æ	ɔ:	u:	ə	ei	ai	əu	au
i:		z	d		z		m	l		
ɔ:										t
u:	d									
ə							n		(l)	
ei		k		k		(t)	m	t,d		
ai							l			
əu							m			

All consonants in the table occur medially. Those in brackets may be preceded, but not followed, by internal open juncture, the others may occur both with preceding and following internal open juncture.

	V cs	%	S	clos. cs	%	S	op.int. cs	%	S	C-V cs	? cs	%?
shore tower short hour	19.2 13.4	72	*	11.7 5.6	5o	*	8.6 5.4	62	*	5.7	1.2	75
grey tie great eye	23.3 16.1	72	*	9.9 6.1	66	*	9.3 6.o	66		6.8	1.2	75
may kill make ill	15.9 11.1	72	*	12.7 7.9	64	**	9.o 6.o	65		5.7	2.2	7o
may call make all	15.5 11.2	76	*	11.5 7.4	68	*	9.4 6.3	66		4.3	2.2	63
average		73	***		62	***		65	***	5.6	1.6	71
New Deal nude eel	19.7 21.2	1o7		8.8 4.3	5o	***	2.9 3.8	143		5.7	3.1	76
free Danny freed Annie	18.6 18.5	1oo		9.o 3.9	47	*	2.5 4.2	2o8		4.7	2.1	75
grey dye greyed eye	26.1 27.1	1o5		9.9 4.1	46	*	2.5 4.3	2oo		5.6	2.2	77
average		1o4			48	***		184	**	5.3	2.5	76

TABLE II - Averages for all subjects

V: vowel duration, clos.: closure of stop, op.int.: open interval of stop, V-C: interval between stop and following vowel or glottal stop, ?: glottal stop, %?: percentual occurrence of glottal stop, %: /..V+CV../ in percentage of /..VC+V../, S: level of significance, * indicates significant difference at the 5% level, ** at the 1% level, and *** at the o.1% level.

TABLE III

Averages for all subjects

As Table II, except that C stands for consonant duration.

	V cs	%	S	C cs	%	S	C-V cs	? cs	%?
see zinc seize ink	19.4 19.7	1o3		11.5 9.8	87		5.7	2.6	7o
see zoos seize ooze	21.1 21.7	1o3		12.4 1o.4	84	*	5.7	1.9	72
average		1o3			85	**	5.7	2.2	71
hoe-maker home-acre	16.2 13.5	87		9.2 7.7	84		3.6	6.5	38
gay mate game eight	21.6 17.3	83	*	9.2 1o.o	11o		5.7	4.o	77
see Mabel seem able	14.8 12.7	87	*	8.7 8.9	1o1		4.o	5.4	63
average		85	**		98		4.4	5.3	59
a nation an Asian	6.7 6.3	94		9.6 5.8	6o	***	2.8	4.5	47
a name an aim	6.5 6.9	1o6		1o.1 6.7	66	***	4.7	3.3	63
average		1oo			63	***	3.7	3.9	55
I laid I'll aid	17.6 19.9	11o		1o.2 8.9	88		3.9	5.1	67
see lying seal eyeing	18.4 16.4	9o		8.6 1o.1	115		7.2	3.4	71
average		99			1o3		5.6	4.1	69

ered at least some of the contrastive pairs. Two things may account for this: (1) they all had a degree in modern languages (five in English and one in German) and may therefore have some knowledge of English phonetics, and (2) some of the phrases were far-fetched and perhaps suspicious.

The tape-recordings were made with professional equipment in the language laboratory of Hull University and in the Institute of Phonetics in Copenhagen.

A mingographic recording containing a duplex-oscillogram, a fundamental frequency curve, and two intensity curves (one linear without filtering and one logarithmic with high-pass filtering at 500 cps) were made.

3. Results for /..V+CV../ and /..VC+V../

The averages for all subjects are here considered; the level of significance has been calculated by means of a pair test based on the average for each subject (see Croxton 1953 p. 228f).

3.1. Vowels

The duration of vowels (termed "V" on tables and figures) before pre-junctural consonant and before internal open juncture was measured. Vowels are considered beginning where the intensity curves have reached the 'vowel-level', i.e. when they have stopped rising sharply (this is perhaps not quite correct, as the beginning of the vowel is excluded, but the absolute difference between two sets of measurements is not affected by this). As it was impossible to separate /r/ and /j/ from following vowel, /rV/ and /jV/ were measured instead (it is generally supposed that there is no difference in the duration of consonants that are separated from a following internal open juncture by one or two segments, so including them in the measures for vowels should not influence the differences in vowel duration).

The vowels are considered terminating where the intensity curves start falling sharply before stops, continuants, and pause. Before /z/ it was difficult to determine this point, because the intensity of /z/ was often higher than that of the vowel which, furthermore, did not fall; the only point common to all cases was where the high-pass filtered intensity curve and the duplex oscillogram started their respective sharp rise and fall. This point was therefore chosen to ensure comparable measurements, in spite of the inconsistency which then arises in the vowel durations, since the closing movement before stops is considered as part of the closure, whereas before /z/ it is included in the vowel. It was likewise difficult to separate /l/ from the preceding vowel, so these measurements are not reliable.

Vowels are significantly shorter before /tkm/ than before /+/, see Tables II and III, and Figs. 1 and 2. There is no significant durational difference before /dznl/ and before /+/.

3.2. Consonants

3.2.1. Obstruents

What is termed "clos." on Table II (and V) is roughly corresponding to the closure of the stops, it is measured from the point where the vowel ends to the release of the stop. For /tkd/ the closure is significantly longer pre- than post-juncturally, see Figs.3 and 4. To ascertain whether the closure measured for post-junctural stops was closure and not closure plus pause (pause and closure look alike on the mingograms) sonagrams were taken of a few phrases with particularly long closures.[6] From these it seems safe

6) This investigation was suggested by professor Eli Fischer-Jørgensen.

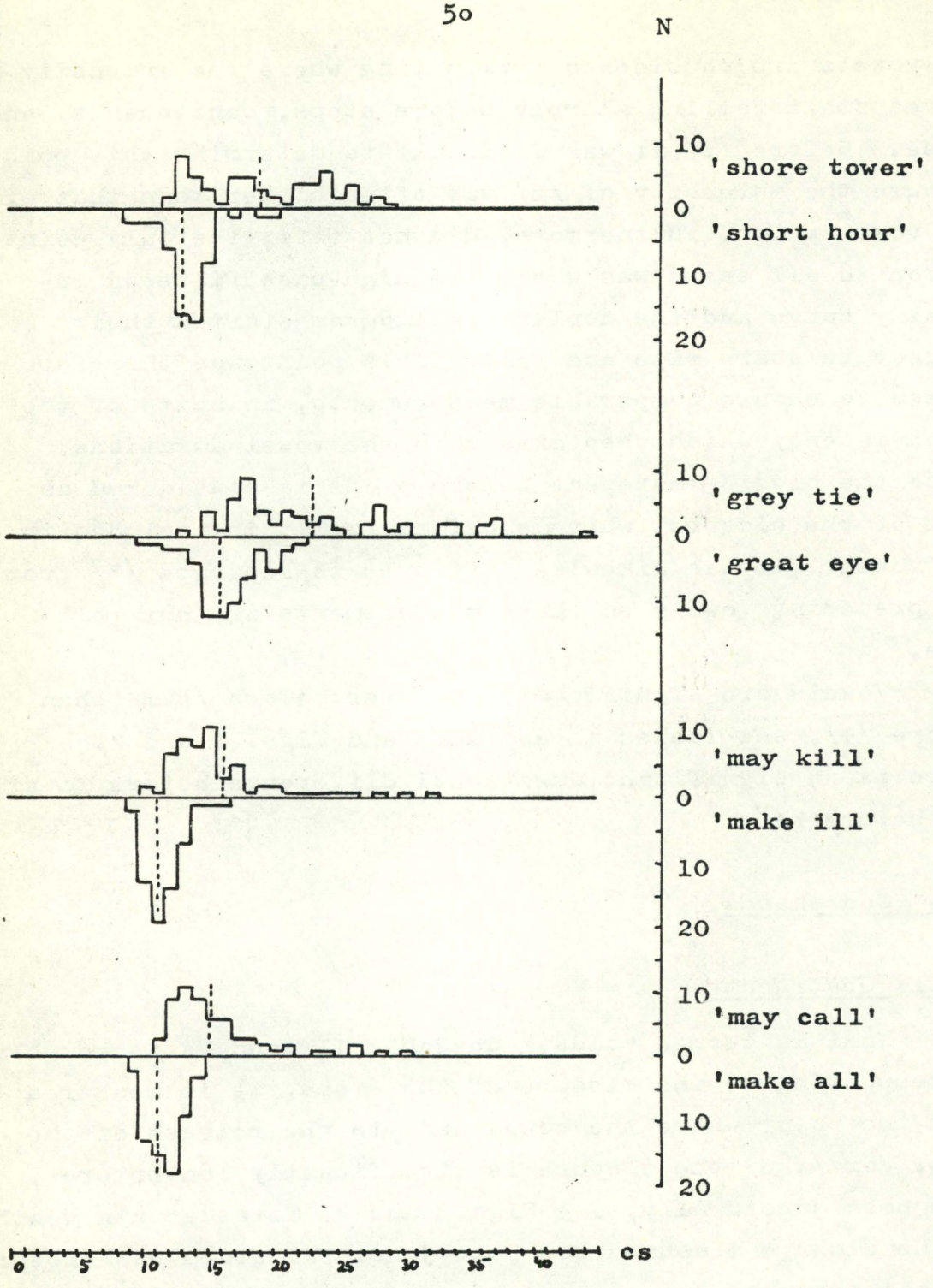

Figure 1.

Dispersion of vowel duration for all subjects.

Dotted line indicates average.

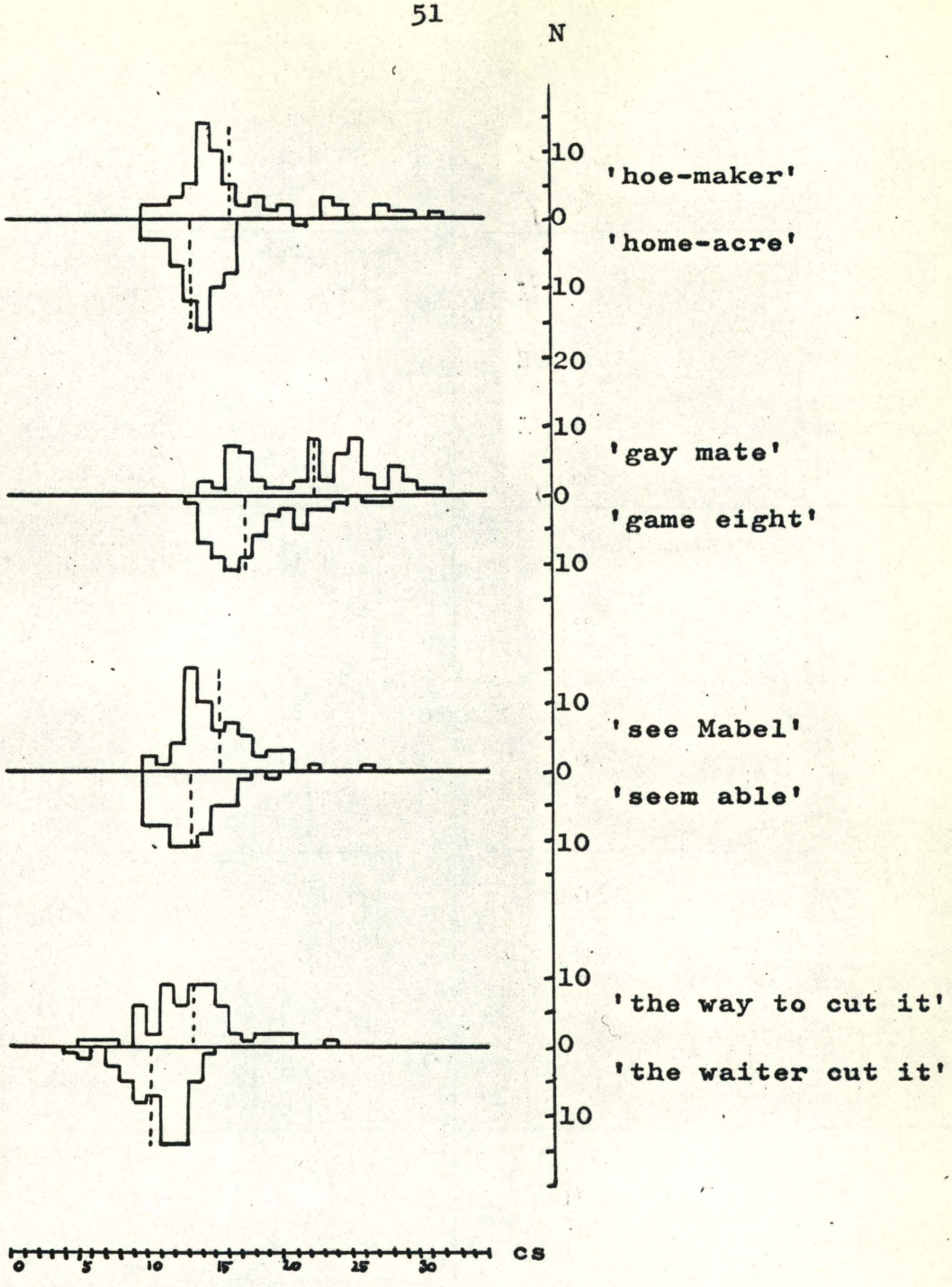

Figure 2.
Dispersion of vowel-duration.

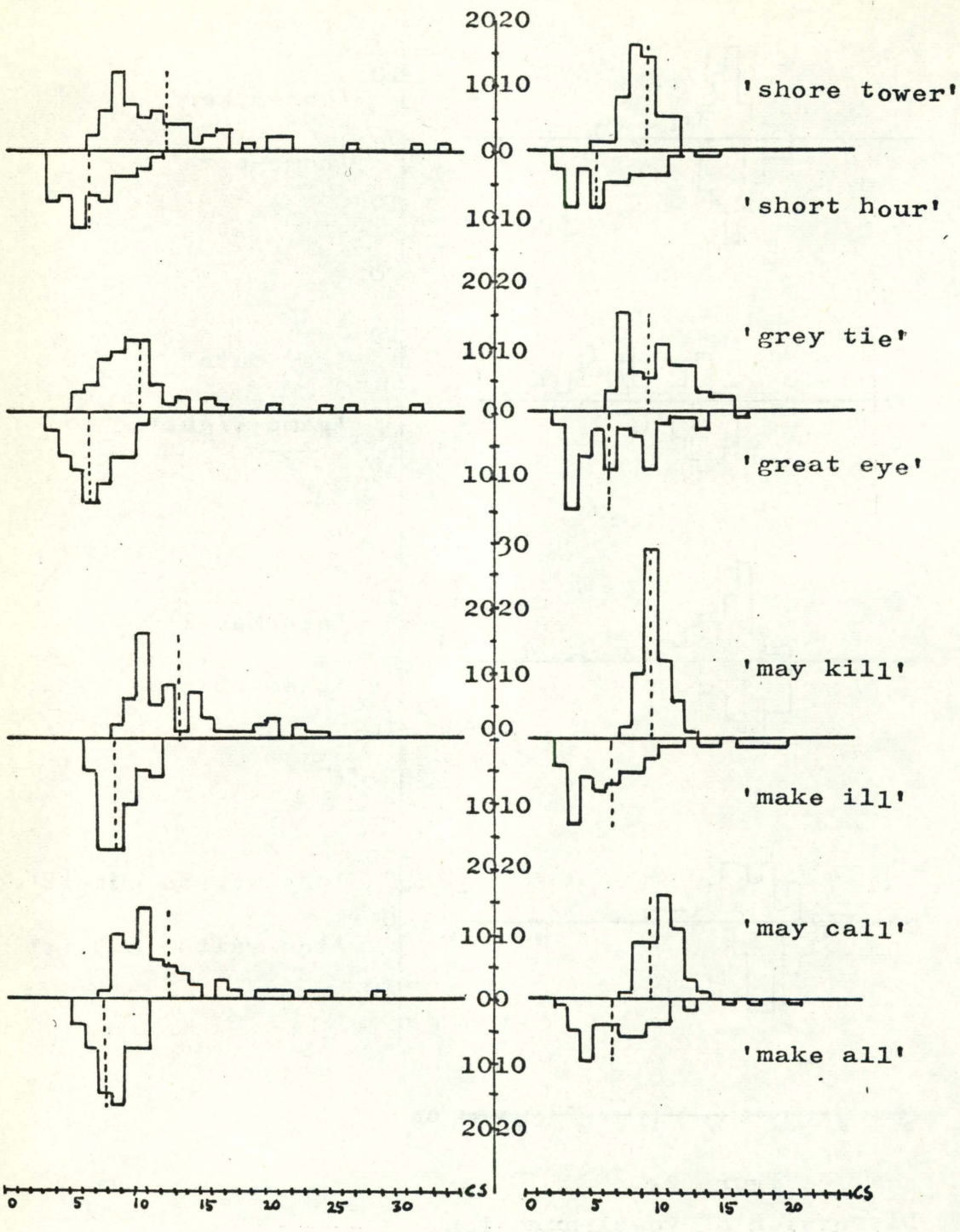

Figure 3.

Dispersion of duration of closure (to the left) and of open interval (to the right) for unvoiced stops.

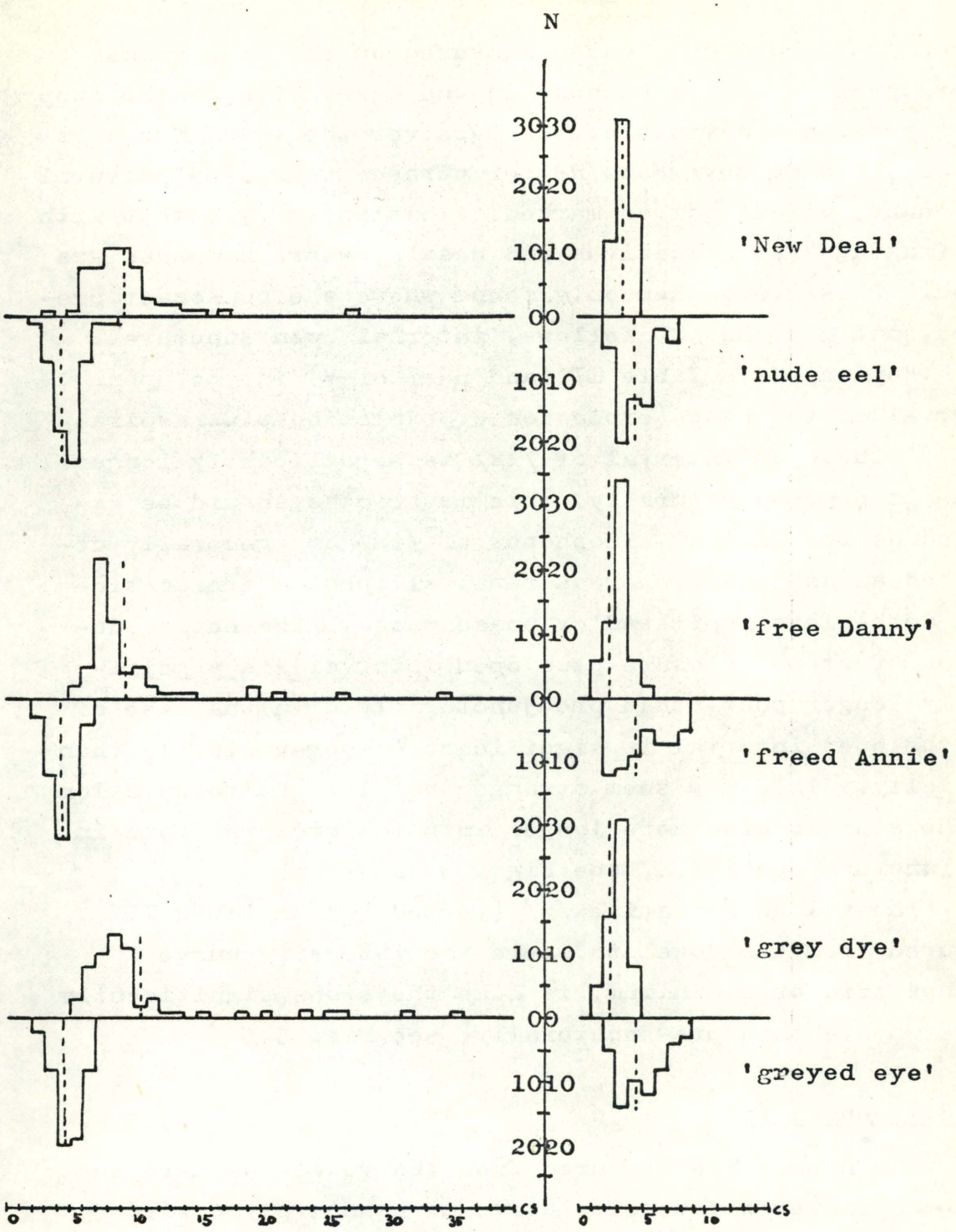

Figure 4.

Dispersion of duration of closure (to the left) and open interval (to the right) for /d/.

to conclude that the closure measured on the mingograms never covers a pause, because in the cases with dental stop the implosion was visible, and moreover the vowel formants showed the same movements as for phrases with pre-junctural consonant, albeit not so marked. This is in agreement with the findings for fricatives and nasals, where no pause was found. Pauses are then only found where the consonant precedes, and not when it follows, internal open juncture.

"op.int." on Table II (and part of V) is the open interval of the stop (explosion or explosion plus aspiration). The open interval of /tk/ is significantly longer post- than pre-juncturally, this is also as should be expected as the initial allophones of /tk/ are generally described as aspirated whereas final allophones are considered to be less aspirated or unaspirated. The entire duration of stops (closure plus open interval) is significantly longer post- than pre-juncturally. In the case of /d/ the open interval is significantly longer finally than initially. This may seem strange, but the entire duration of the stop is also here longer in post-junctural than in pre-junctural position, see Figs. 3 and 4.

The voiced fricative /z/ (termed "C" on Table III), measured from the vowel to where the intensity curve reaches zero or a minimum, is like the stops significantly longer post- than pre-juncturally, see Fig. 5.

3.2.2. Sonorants

The nasals are measured from the vowel to where the high-pass filtered intensity curve moves sharply upwards or downwards. /m/ differs from the other consonants in that there is no significant difference of duration. But /n/ shows exactly the same durational difference as that found for obstruents, see Fig. 5. For /l/ no difference was found, but the segmentation was not reliable.

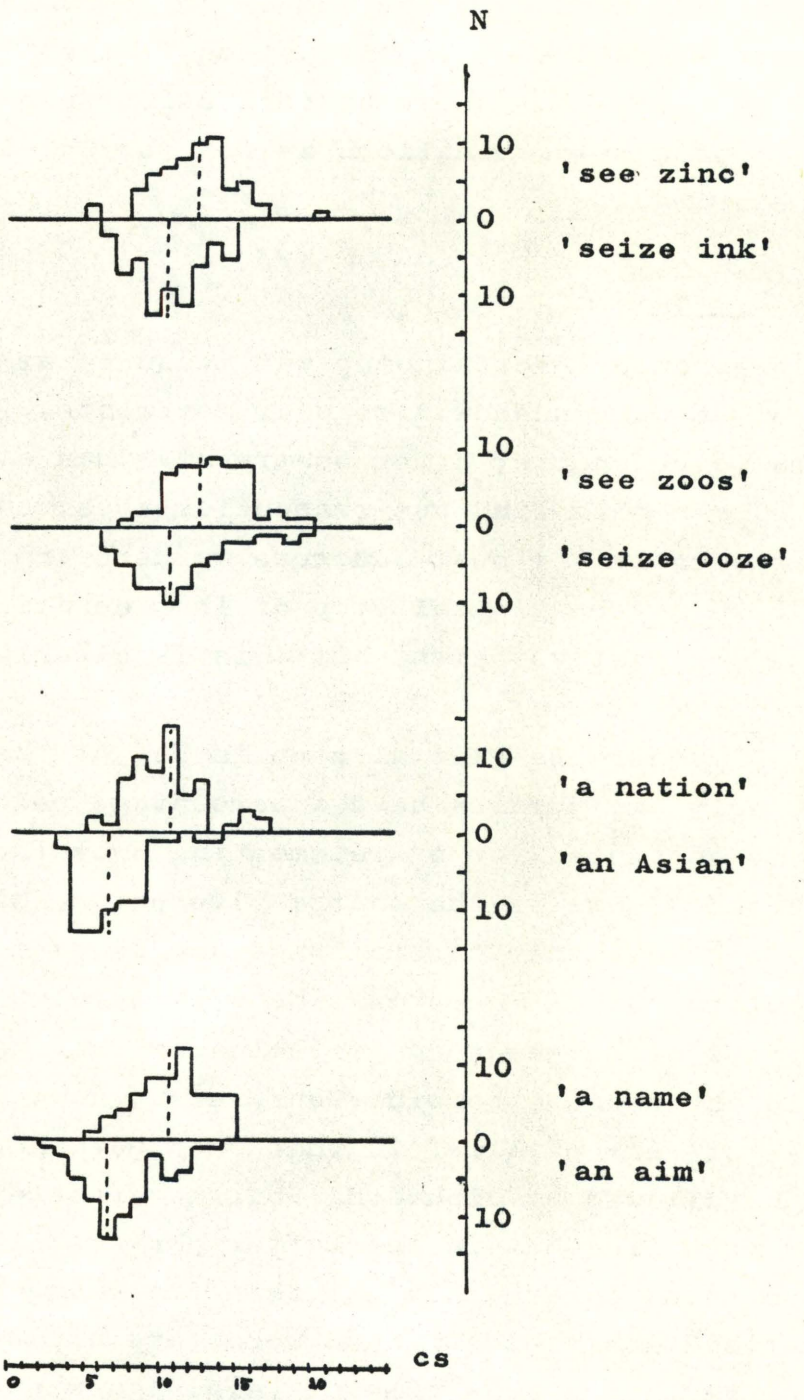

Figure 5.

Dispersion of consonant duration.

3.3. Interval from /C/ to [ʔ] or /V/

This was measured from the end of the consonant to where the curves again show amplitude, on Tables II, III and V it is termed"C-V". The durational difference between the different phoneme-combinations is not very great and may be disregarded.

3.4. Glottal stop

The duration of glottal stop was measured as the interval where the curves show irregular movements. This interval seems to be shorter after obstruents than after sonorants. I can only find one reason for this: unvoiced stops are apparently the best juncture markers and therefore there need not be glottal stop of long duration to separate the contrastive pairs, but this is clearly not true for either /d/ or /z/.

Generally there is glottal stop in 7o% of the phrases /..VC+V../, only two phrases have a percentage below 5o. The 7o% may be accounted for by remembering that the subjects had noticed some of the contrastive pairs, moreover some of them spoke rather carefully as one tends to do in front of a microphone. There must be a particular reason for the phrases with less than 5o%; clearly this may not be sought in the phoneme-combinations, e.g. 'home-acre' and 'game eight' are parallel in that they both have nasal preceded and followed by diphthong, but nevertheless glottal stop is more frequent in the latter phrase. The cause must then be found on other levels than the phonemic. In most grammatical analyses compound words are closer connected than, say, noun plus numeral (e.g. 'game eight'). It is therefore reasonable to suppose that this closer grammatical connection has been signalized by fewer instances of the strong juncture-marker glottal stop.

Considering the other results for the pair /həu(+)m(+)eikə/ ('hoe-maker':'home-acre') there are no significant differences in the averages for all subjects; all subjects do, however, have significant durational differences: two have both longer pre- than post-junctural vowel and shorter pre- than post-junctural consonant, one has longer pre- than post-junctural vowel, and three have shorter pre- than post-junctural consonant. It may then be concluded that there is here no stable feature signalizing internal open juncture.

It is curious to note that there are fewer instances of glottal stop in 'an Asian' than in 'an aim' though they have the same grammatical structure. One would also here suppose that indefinite article plus noun would be rather closely connected grammatically. The discrepancy between the two phrases may perhaps be accounted for by the number of times 'an aim':'a name' has been mentioned as a contrastive pair in phonetic descriptions of English; the subjects may have recognized it and been on their guard against pronouncing the phrases alike and therefore introduced glottal stop. The reason 'an Asian':'a nation' is not mentioned as often is that it is not always a contrastive pair, 'Asian' being pronounced /eiʃən/, /eiʃjən/, /eisjən/, eizjən/ or /eiʒən/ (all subjects pronounced the phrases with identical segmental phonemes, though).

3.5. Maximum intensity of stops

The maximum intensity of the open interval was measured on the linear intensity curves, for male subjects the integration time was 10 ms and for the female subject 5 ms. Both integration times are rather long for the open interval of stops, i.e. the curve may not reach its maximum.

The maximum intensity was significantly higher for post- than for pre-junctural unvoiced stops, see Table IV and Fig. 6; but as long open interval is correlated with

TABLE IV

Averages for all subjects

As for Table II, except that op.int. stands for maximum intensity.

	op.int. dB	%	S
shore tower short hour	29 26	89	*
grey tie great eye	31 27	87	
may kill make ill	25 21	83	*
may call make all	25 21	83	**
average		86	***
New Deal nude eel	26 23	88	*
free Danny freed Annie	23 24	99	
grey dye greyed eye	25 25	101	
average		96	
the way to cut it the waiter cut it	29 30	104	
not at all	28		

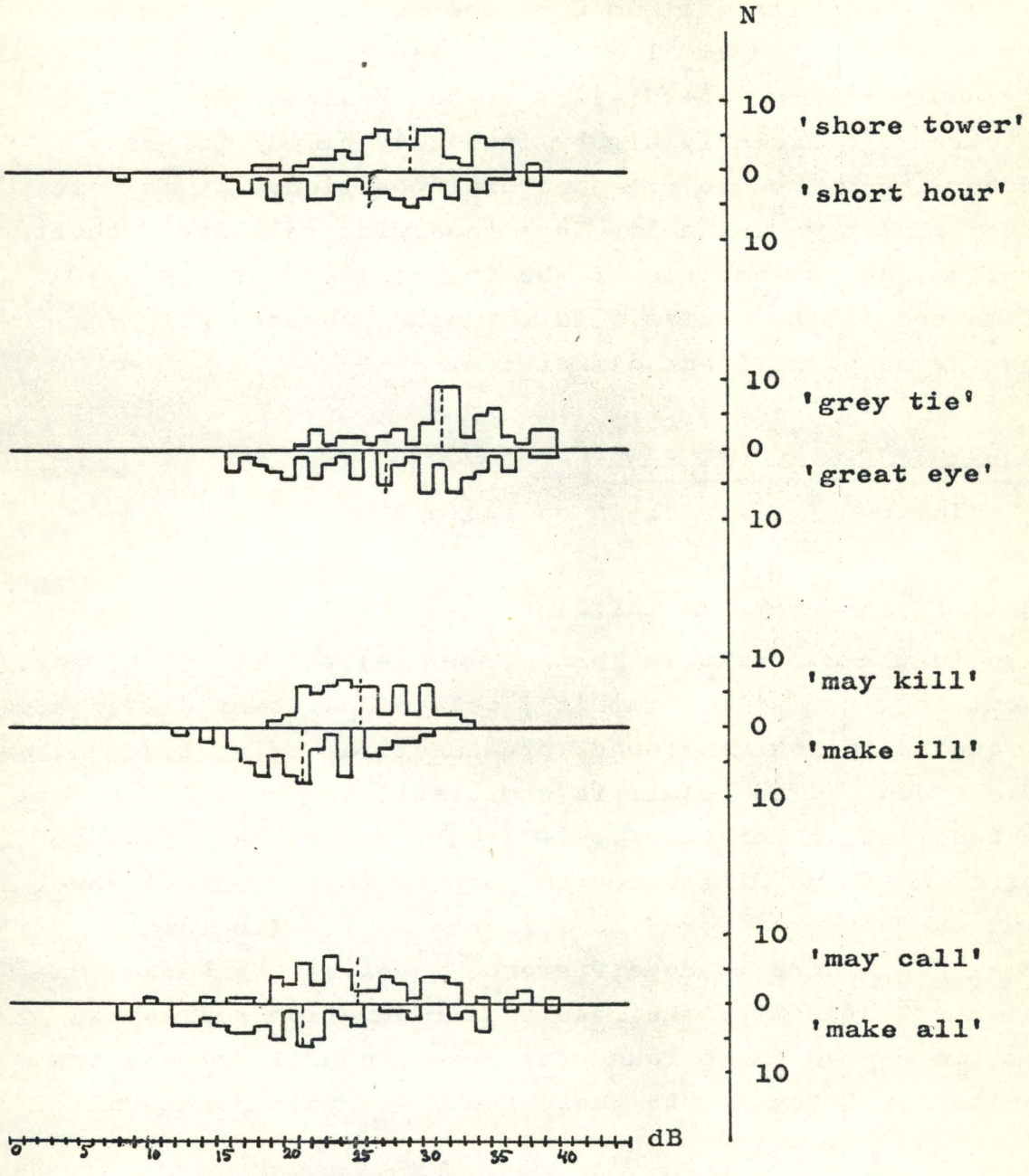

Figure 6.

Dispersion of maximum intensity of unvoiced stops.

high intensity one cannot be sure whether the intensity really reaches its maximum when the duration is long or whether it is a physical artifact, see Fig. 7.

Only for /nju:(+)d(+)i:l/ ('New Deal':'nude eel') is there significantly higher intensity of /d/ in post-junctural compared to pre-junctural position. It is noteworthy that high intensity here goes with relatively short duration, so the inertia of the intensity-meter has not influenced these results. In the other phrases with /d/ there is no significant difference.

4. Results for other cases

The results are shown on Table V.

4.1./..V+CV../ and /..VCV../

In the contrastive phrase /ðəwei(+)təkʌtit/ ('the way to cut it':'the waiter cut it') only significant difference in vowel duration was found, pre-junctural being longer than medial vowel. The result is comparable to those found for the contrastive phrases /..V(+)t(+)V../; one may conclude that it makes no difference in respect to percentual vowel duration whether a vowel is followed by pre-junctural or medial /t/. There is no difference in either consonant duration or intensity; the results for duration correspond most closely to those found for pre-junctural /t/ and the results for intensity to those found for post-junctural /t/.

The results for /ə(+)ləun/ ('a loan':'alone') are unreliable because of the vocalic quality of /l/, which makes the segmentation difficult.

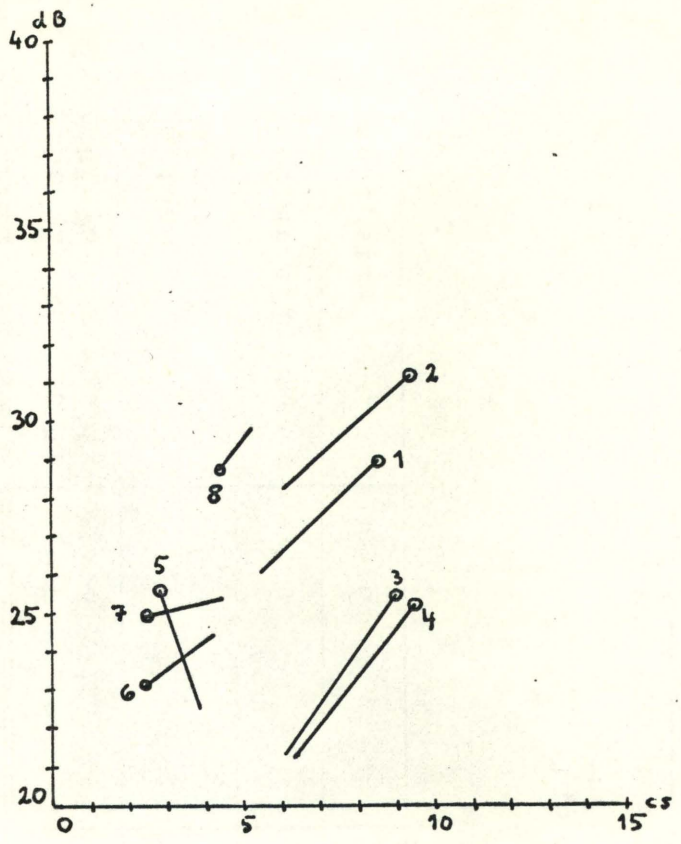

Figure 7.

Maximum intensity of stops compared to duration of open interval.

Circle indicates result for post-junctural and end of line result for pre-junctural or medial stop.

1. /ʃ ɔ:(+)t(+)auə/
2. /grei(+)t(+)ai/
3. /mei(+)k(+)il/
4. /mei(+)k(+)ɔ:l/
5. /nju:(+)d(+)i:l/
6. /fri:(+)d(+)æni/
7. /grei(+)d(+)ai/
8. /ðəwei(+)təkʌtit/

	V cs	%	S	clos. cs	%	S	op.int. cs	%	S	C cs	%	S
the way to cut it the waiter cut it	12.8 1o.o	79	*	5.9 5.8	97		4.3 5.2	121				
a loan alone	7.4 6.9	93								1o.3 9.1	91	
not at all	3.4			6.5			6.5					
analysis	5.6									7.o		

TABLE V

Averages for all subjects

As for Tables II and III.

4.2. Unpaired phrases

4.2.1. 'not at all'

After repeated listenings of the tapes it was found that all subjects used the initial allophone of /t/ in 'at'. Because the vowel in 'at' is short and unaccented its duration cannot be compared to that of the contrastive pairs with /t/. The duration of /t/ is closest to that found for pre-junctural /t/, the intensity does not belong clearly to either group. It then seems to be the case that for perceiving initial /t/ it is sufficient that the distance C-V is zero.

4.2.2. 'analysis'

In this word the first vowel is slightly shorter than that in the contrastive pairs /..V(+)n(+)V../, the duration of /n/ is closest to that of pre-junctural /n/.

5. Results for two subjects

Two subjects had results that differed slightly from those of the others; they are, however, included in the averages, but it also seemed worth-while to consider them separately. The results of the percentual duration of segments are shown on Figs. 8 and 9.

5.1. Female subject IN

The most evident divergency from the other subjects is in the open interval of unvoiced stops, it being longer pre- than post-juncturally. There may be several reasons for this. IN is bilingual, her father being English and her mother Danish.[7] In English there are in final position six stop-phonemes, in Danish, on the other hand, we have only three stop-phonemes in this position, generally pronounced

7) She spent her childhood and youth in England, and for the last 2o years she has lived in Denmark.

[b̥ d̥ g̥], so it is common for Danes not to make any distinction between voiced and unvoiced final stops when speaking English. Therefore she may exaggerate the difference between the two sets of stops by aspirating the unvoiced ones to make the Danes perceive the difference. It could, of course, equally well be an individual variation. The entire consonant duration is still longest for post-junctural unvoiced stop.

The open interval of /d/ is also abnormally long, but it shows the same tendency as for the other subjects. But the open interval is so long pre-juncturally that there is practically no difference between the entire duration of post- and pre-junctural /d/.

The duration of /z/ is longer pre- than post-junctually; the opposite was the case for the other subjects. In /geim+eit/ ('game eight') and /si:m+eibəl/ ('seem able') the /m/ was likewise abnormally long. It is curious to note that in /həum+eikə/ ('home-acre'), where there is only one instance of glottal stop, the /m/ is significantly shorter in this position than post-juncturally.

She used glottal stop in most post-junctural vowels.

It is doubtful whether IN's results should be included in the averages or not. The following appears to happen to levels of significance if her results were excluded: for duration of open interval of /tk/, and for duration of /z/ they would improve, whereas the opposite is the case for vowel duration before /tk/ and for open interval of /d/.

5.2. Male subject PW

This subject read the lists most naturally and rapidly. This may account for his very sparing use of glottal stop.

He is the only subject who does not have a significant difference in vowel duration before unvoiced stops. The open interval of /d/ is shorter pre- than post-juncturally

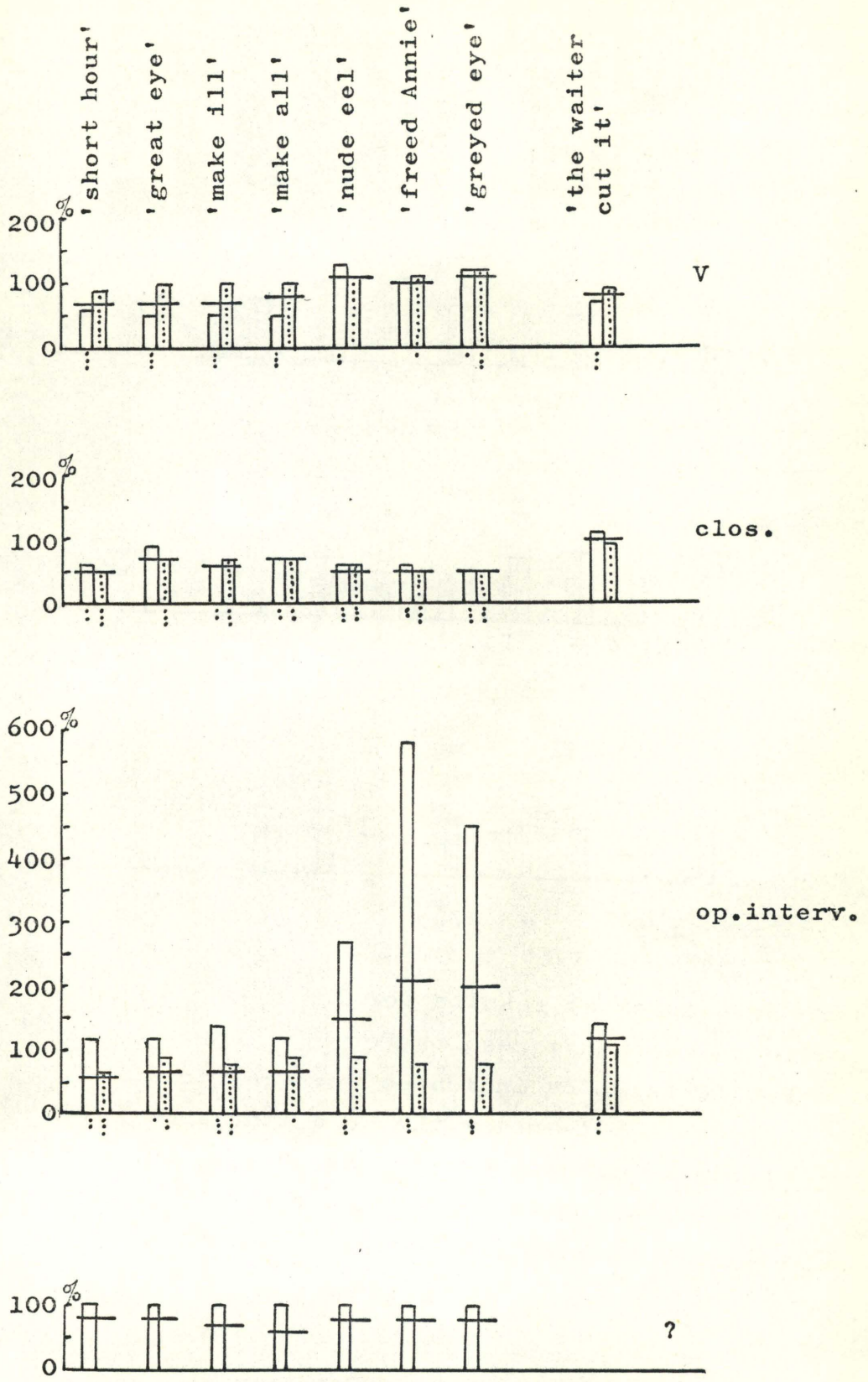

Figure 8. (Legend see Figure 9.)

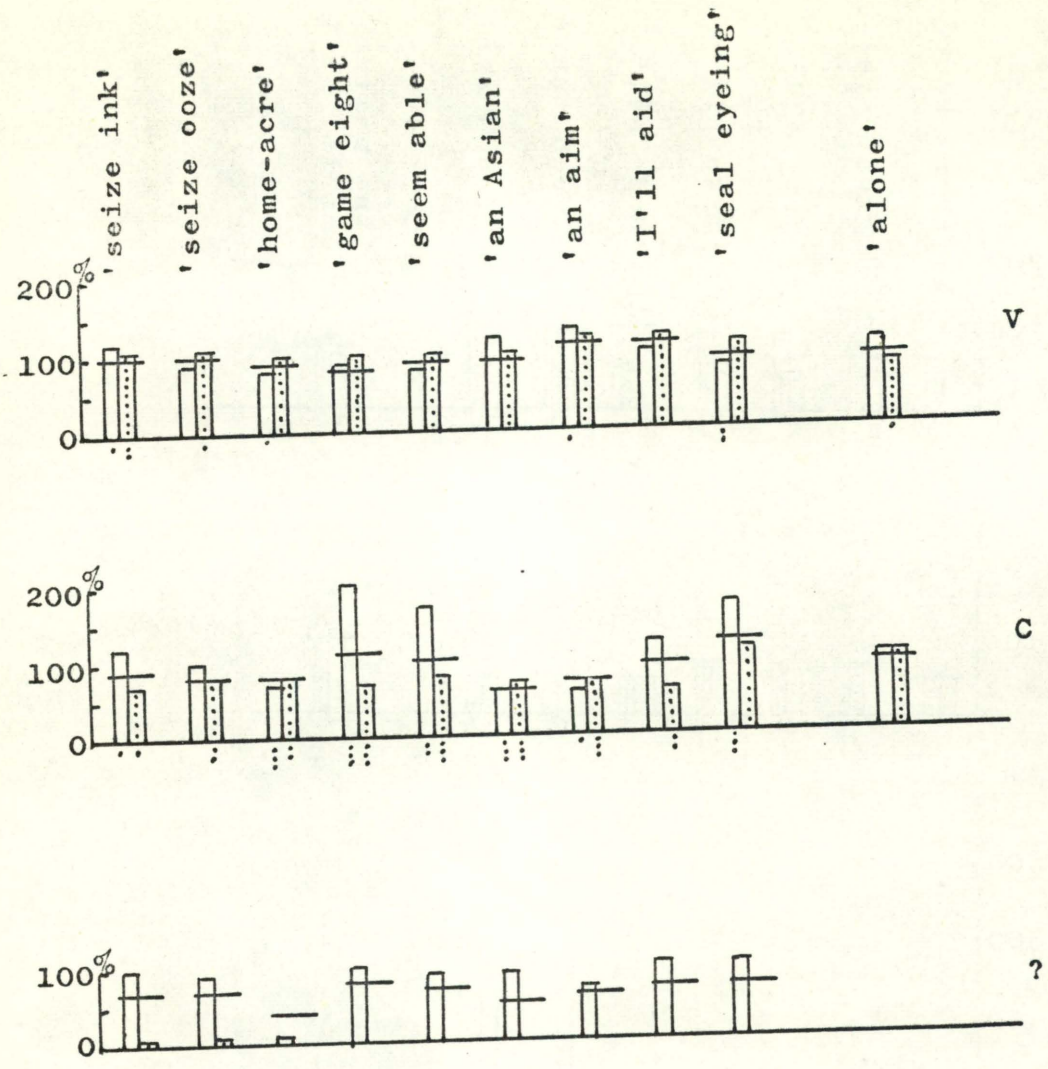

Figure 9.

White columns: results for IN.
Dotted columns: results for PW.
Horizontal line indicates average for all subjects. Dots below the zero line show level of significance , one dot at the 5%, two dots at the 1%, and three dots at the 0.1% level.
Other symbols as for Tables II and III.

(the opposite was the case for all other subjects), so the entire duration of /d/ is markedly longer post-juncturally. The duration of /m/ was shorter in pre-junctural position in all three contrastive pairs, so it may be supposed that the phonetic difference between close and less close grammatical connection disappears with increasing speed of utterance.

If PW's results were excluded from averages it seems to improve the levels of significance for vowel duration before /tk/ and open interval of /d/.

6. Conclusion

The results may be summarized thus (see Figs. 10-12): vowels are shorter before unvoiced stops and, to a lesser degree, /m/, than before voiced stops, voiced fricatives, /n/, and internal open juncture. Consonants other than /m/ are shorter before internal open juncture than after internal open juncture; medial /n/ has the same duration as final /n/ whereas medial /t/ corresponds to initial /t/. Furthermore post-junctural vowels may be preceded by glottal stop and pause (no pauses were found before post-junctural consonant). These two things seem, however, to disappear with increasing speed of utterance and closer grammatical connection, as also do differences in vowel duration before unvoiced stops with or without internal open juncture.

The results found for RP then correspond closely to those found for American English by Lehiste (1960) and Hoard (1966). Lehiste states that pre-junctural allophones of consonants may sometimes be drawled, this explains the long pre-junctural consonants of IN. Hoard's results agree completely with those found for PW. It appears that there is no difference between the manifestation of internal open juncture in American and British English.

As for the examples without glottal stop it is possible that my material would also yield better results

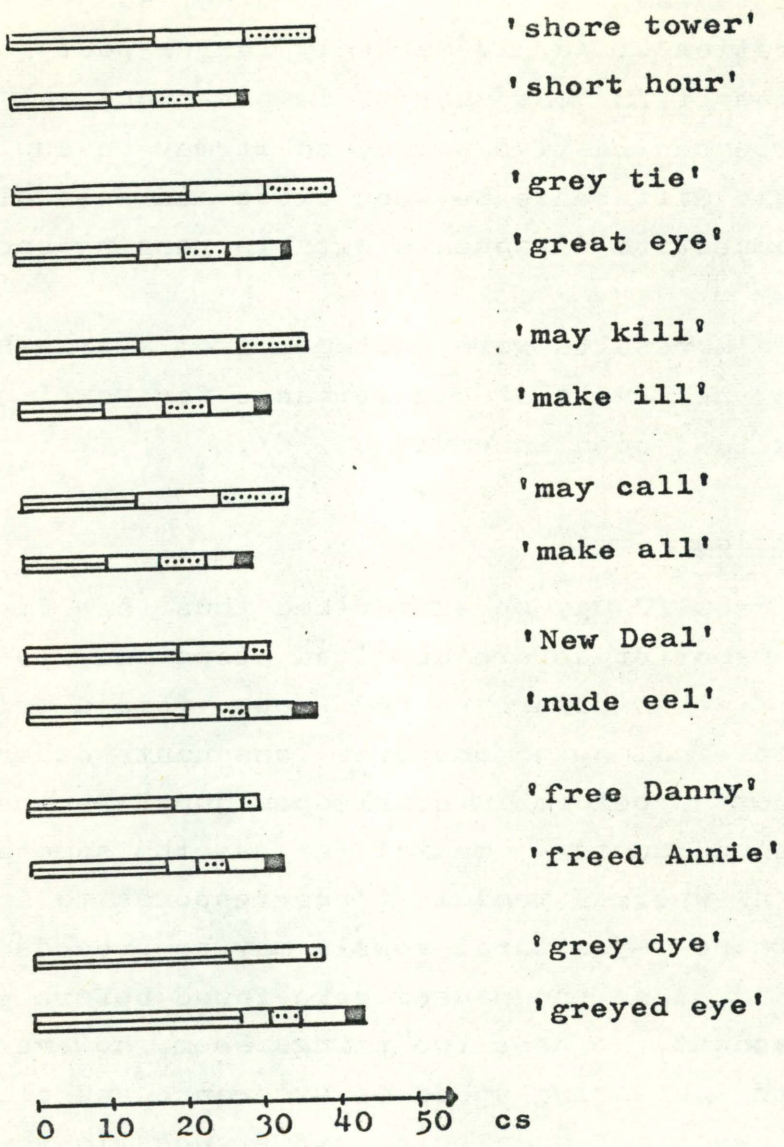

Figure 10.

Average duration of segments.

vowel duration

duration of closure or interval C-V

duration of open interval

duration of glottal stop.

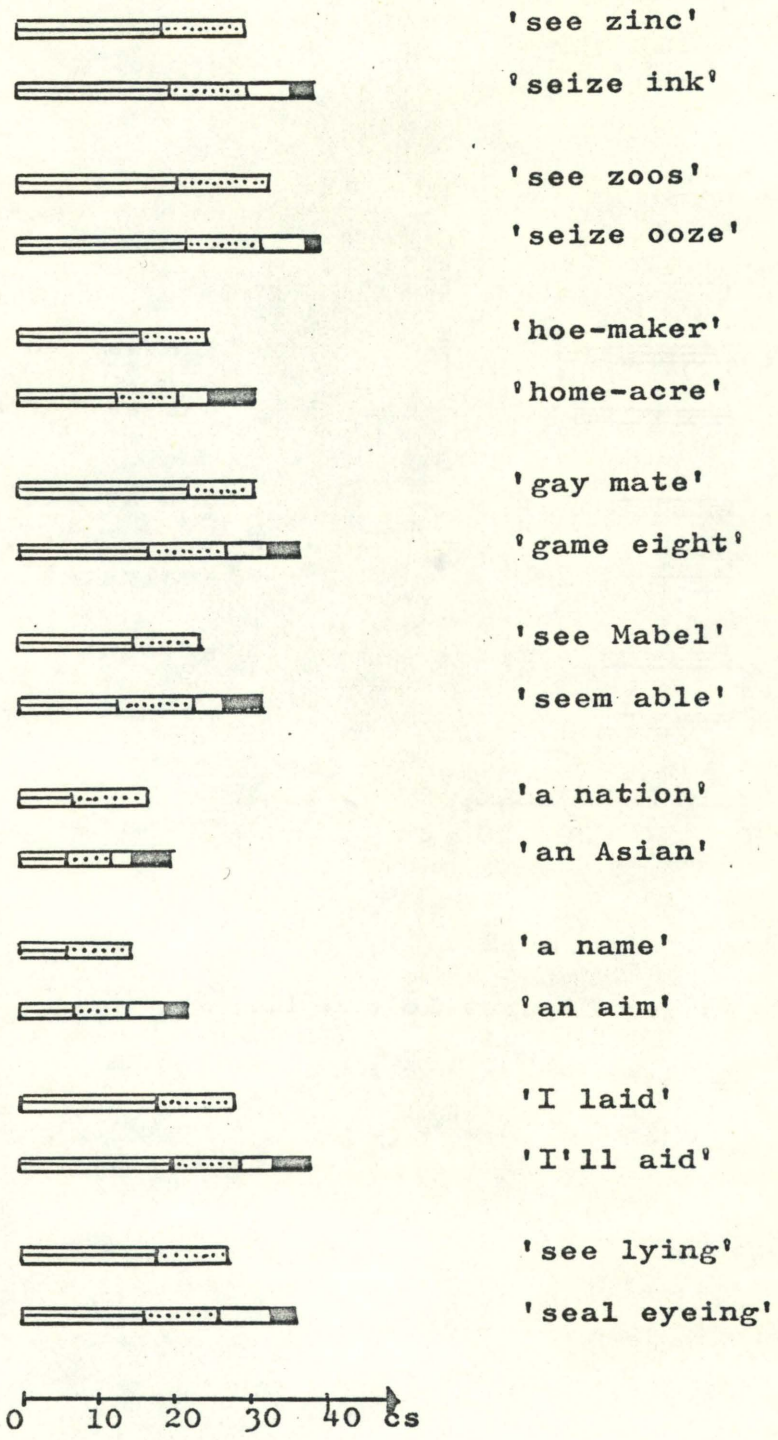

Figure 11.

As for Figure 10 except that

signifies consonant duration.

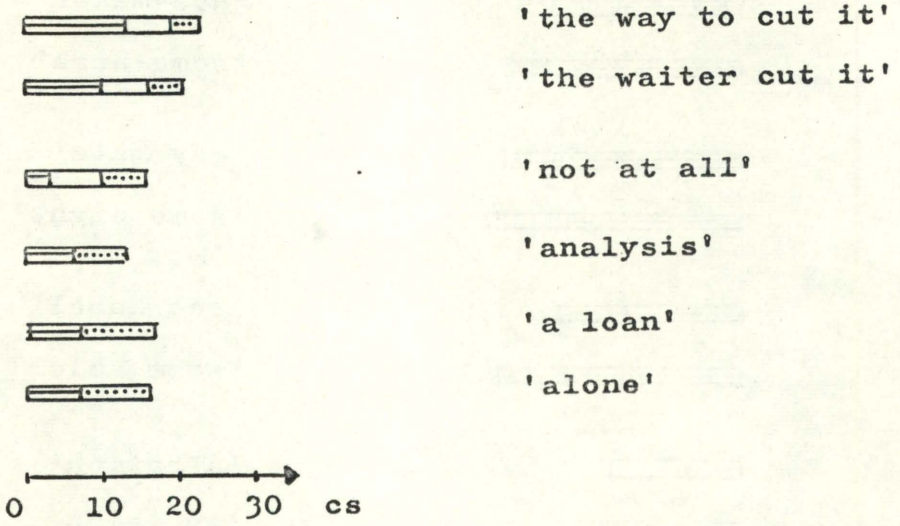

Figure 12.

As for Figures 1o and 11.

for unvoiced stops than for any other consonants in an auditory test in agreement with the findings of O'Connor and Tooley (1964). This is true not only of English; in an analysis of Swedish Gårding (1967) found that unvoiced stops and vowels were the best juncture-markers (in her material phrases with glottal stop were not excluded).

From the acoustic results it would not seem probable to mistake final for initial /n/, but it is not possible to verify until auditory tests have been made.

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