TEMPORAL ORGANIZATION OF SWEDISH TONAL ACCENTS: THE EFFECT OF VOWEL DURATION

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I. Introduction

Since Meyer's publications (Meyer 1937, 1954) the increasing interest of phoneticians in the Swedish word accents has resulted in many investigations, e.g. Malmberg (1953, 1955), Hadding-Koch (1961), Öhman (1965), Alstermark and Erikson (1971), Erikson and Alstermark (1972), Gårding and Lindblad (1973), Löfqvist (1973). A production model of the Swedish tonal accents was proposed by Öhman (1967) and criticized and amended by Gårding (1970). Both proposals are discussed by Bruce (1974) who provides new acoustical evidence concerning the tonal accents of the Stockholm dialect in stressed but non-focal sentence position. Gårding (1973) established a preliminary typology, based on the characteristics of the f_0 manifestations in bisyllabic words, not only for the Swedish accents but also for the other Scandinavian (Norwegian and Danish) word accents.

Investigating the effect of vowel duration on the f_0 contour of the stressed vowel, Erikson and Alstermark (1972) presented data for a Stockholm speaker in the stressed vowel of accent 2 in nonsense words. They discuss two ways in which the f_0 contour of accent 2, which in this dialect is mainly falling throughout the vowel segment, may be modified when vowel duration is decreased:

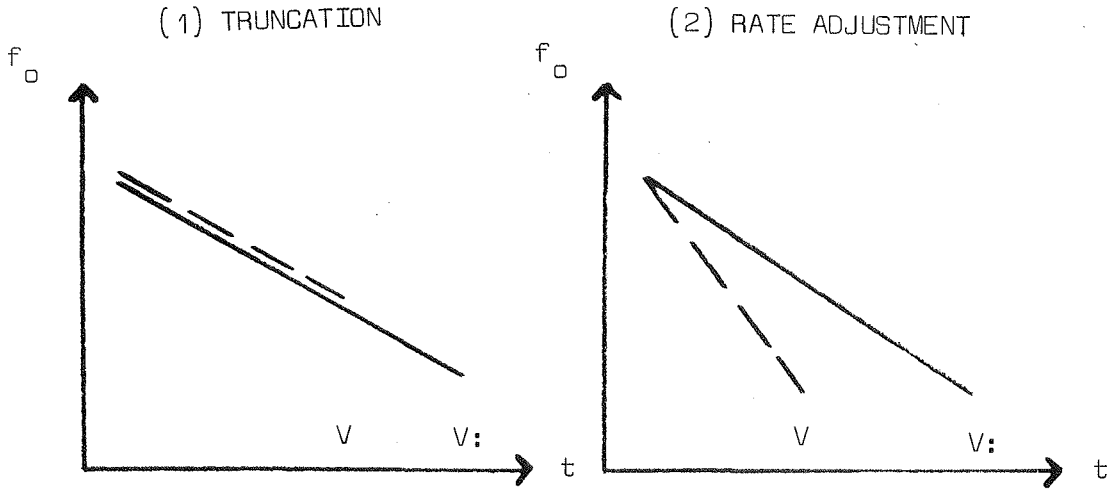
(1) TRUNCATION: the falling f_0 contour of the short vowel, starting at the same frequency level as that of the long one, merely ends earlier, which means that its last part is cut off or truncated.

(2) RATE ADJUSTMENT: the f_0 contour of the short vowel, starting from the same level as that of the long one, falls more rapidly towards the end, thus implying a reorganization of the tonal contour due to the shorter vowel duration.

The complete shape of the long vowel contour, the fall from the initial f_0 maximum to the final f_0 minimum, is preserved. The f_0 contour of the short vowel is compressed and the final f_0 minimum has to be reached in a shorter time. Therefore the curve has to fall more rapidly.

These two hypotheses are illustrated like this:

Figure 1. Erikson's and Alstermark's hypotheses:



The findings of Erikson and Alstermark support the truncation hypothesis in the case of accent 2 of their Stockholm informant.

The aim of this paper is to provide further information on the effect of vowel duration on the f_o contours of the stressed vowel segments of Swedish tonal accents. We preferred to work with meaningful words (in order to be able to use naive informants), and we studied both accents of several speakers representing different dialects.

As a consequence of the varying segmental features of the meaningful words in our material it is often not possible to correlate an observed change of the f_o contour with one phonetic feature only. Nevertheless we believe that our data will satisfy the purpose of an introductory investigation. Of course, further and more strictly controlled studies will be necessary.

II. Material

As we intended to work with informants who have no phonetical training, we chose four quadruplets of meaningful, bisyllabic, non-compound test-words from Elert's list of minimal pairs contrasting accent 1 and accent 2 (Elert 1972).

The most radical shortening of the vowel segment is achieved, as Erikson and Alstermark demonstrated, as a combination of phonological

(by means of the long-short opposition) and phonetical conditioning (by means of the voiced-voiceless opposition). One pair of testwords (first line of each set below) contained a long vowel followed by a voiced stop. The corresponding pair (second line of each set below) contained a phonemically short vowel followed by a voiceless stop. The following four sets of testwords (a-d) were chosen:

	accent 1	accent 2
(a)	tag-en (def.pl. of "grip")	tagen (past.part. of taga = "to take")
	tack-en (def.pl. of "thanks")	tacken (solemn imperative of 2nd pers. pl. of tacka = "to thank")
(b)	stig-en (def.sing. of "path")	stigen (past.part. of stiga = "to rise")
	stuck-en (def.sing. of "stucco")	stucken (past.part. of sticka = "to stick")
(c)	steg-en (def.pl. of "step")	stege-n (def.sing. of "ladder")
	skott-en (def.pl. of "shot")	skotte-n (def.sing. of "Scotsman")
(d)	Hagen (e.g. family name)	hage-n (def.sing. of "grove")
	back-en (def.sing. of "crate")	backe-n (def.sing. of "hill")

The four sets of testwords contain the following structural (segmental) variations; firstly between the pair with long vowel and that with short vowel, secondly between the four sets themselves. The difference of voicedness of the medial consonant following long and short vowel respectively, however, is built into the material and common to the four sets. The feature of voicedness of the follwoing consonant is not expected to affect the f_0 of the preceding vowel (Lehiste and Peterson 1961). In Löfqvist's data (1973), however, there seems to be such an effect on the f_0 peaks but this raising or lowering effect is not consistent, not even for the two speakers (1 and 3) of the same dialect (Skåne).

In set (a) the pair with long vowels is segmentally and phonemically identical to that with short vowels, but there is an allophonic difference of vowel quality between the long and the short vowel, in IPA symbols [ɑ] and [a] respectively. This difference of vowel quality is also found in Erikson's and Alstermark's nonsense material.

The pairs in set (b) differ in the phonemic vowel quality, (/i/, vs /ʉ/), those in set (c) differ in the phonemic vowel quality (/e/ vs /o/) and in consonantal contoxt. (Thc long vowel is preceded by a dental and followed by a velar stop, and vice versa for the short vowel.) The pairs of set (d), finally, show the same allophonic difference in vowel quality as set (a), both containing the vowel phoneme/a/, but the initial consonants differ. Vowel quality affects f_0 (Lehiste and Peterson 1961), open vowels having the lowest f_0, close vowels the highest.

Between the four sets there is also a difference as to the number of initial consonants. Sets (a) and (d) are alike in having one single initial consonant, whereas in sets (b) and (c) the stressed vowel is preceded by an initial consonant cluster consisting of /s/ and the unaspirated voiceless stops /t/ and /k/ respectively. According to Rapp (1971) the number of prevocalic initial consonants does not seem to affect the f_0 of the following vowel.

III. Informants

Our material is derived from seven speakers representing several Swedish dialects:

1. MV, Malmö	female,	20	years	old
2. EW, Helsingborg	" ,	32	"	"
3. EH, Stockholm	" ,	20	"	"
4. LGP, Nybro,	male ,	23	"	"
5. BD, Jämshög,	female,	19	"	"
6. BS, Jönköping,	" ,	21	"	"
7. JT, Ryd,	male ,	28	"	"

The geographical distribution of the dialcets investigated is shown in figure 2. Each informant's speech is typical of the local area.

IV. Recordings

The testwords were embedded in the carrier sentence: Jag sa _____ där (I said _____ there). The test sentences were spoken with primary stress on the test words uttered as answers to the question: "What did you do there?". Each testword was repeated seven times with a falling sentence intonation and the items in each set were presented in the following order: long vowel accent 1, long vowel accent 2, short vowel accent 1,

short vowel accent 2. The sentences were spoken at approximately the same rate and with a tempo most convenient to each speaker. The test sentences were recorded on a Studer A 62 tape recorder, speed 7.5 ips, in the sound-proof room of the Phonetics laboratory. The microphone was a Sennheiser MD 421 placed about 15 cms from the speaker.

As a buffer the informants produced the quadruplet Polen - pollen (accent 1) and pålen - pållen (accent 2), all four words differing in spelling. The buffer was not analysed.

V. Analysis

The productions of the four sets of testwords were analysed via a FONEMA analysis assembly and a Frøkjaer-Jensen intensity meter yielding a duplex oscillogram, a f_0 curve and an intensity curve, all three written out on a Philips Oscillomink, paper speed 100 mm/sec. Duration was calibrated continuously by a time marker (100 msec). F_0 was calibrated for each speaker from a test tape. Five repetitions of each testword were selected for measurement.

The beginning and the end of the stressed vowel segments were marked on the duplex oscillogram and on the f_0 curve. The f_0 curve during the vowel segment was drawn to connect the end points of the sweep oscillations. In a few cases the curve was smoothed. Consequently the f_0 curves to be measured do not contain any articulatory ripple. For measurements of f_0 we chose a number of points along the contour. The beginning (first vocal cord vibration) and the end (beginning of the occlusion of the stop), were taken for every stressed vowel segment. In order to catch the relevant features of the f_0 contours between the beginning and the end thus defined we determined those points along the curve where it showed a marked change of direction. These points are:

(1) a f_0 maximum or peak, defined as the turning point of the curve from rise to fall,

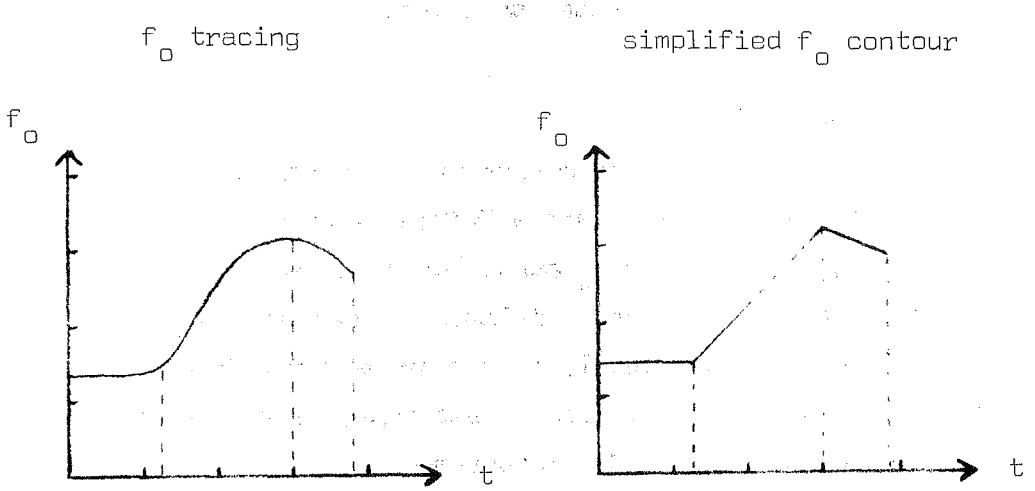
(2) a f_0 minimum or dip, the turning point of the curve from fall to rise,

(3) a point where the contour shows a considerable change of rate,

(4) the beginning and the end of a level portion or plateau of the curve, turning points from fall or rise to level, and from level to fall or rise respectively.

The procedure for quantization is illustrated in figure 3. An example of an observed f_o tracing is given to the left. Upon it the points chosen for measuring f_o and their projection upon the time axis are indicated. To the right is shown the result, a simplified f_o contour containing all essential information of the contour.

Figure 3. Procedure for quantization of the f_o contours.



Given the simplified curves in our figures one can easily infer from the f_o tracings of accent 1 and accent 2 of /tagen/ and /tacken/ for each informant (tables 2-8 below) the characteristics of the real f_o contours in each testword.

The number of the intermediate points varies from 0 to 3. Therefore, the simplified f_o contours in the diagrams are determined by 2 to 5 points of measurements. Their location along the time axis was measured as well as the segment durations.

Durations are measured to the nearest 10 msec and f_o frequencies to the nearest 10 Hz. The arithmetic means are rounded to the half of the interval of measurement (5 msec and 5 Hz respectively). The range of measured f_o frequencies and durations within each series of five repetitions was relatively small. Therefore the arithmetic means may be considered reliable. Differences of 5 msec or 5 Hz in the data should not be considered relevant.

VI. Results

Tables 2–8 give the arithmetic means of the f_0 frequencies measured at the beginning and at the end of the stressed vowel segments and at the intervening points, together with the mean durations of these points from the beginning of the segment. The f_0 contours of the four sets of testwords for each informant are diagrammed schematically in figures 4–8, 10, and 12. The diagrams of the left-hand column pertain to accent 1, those to the right to accent 2. The diagrams represent the following sets of testwords from top to bottom: (a) tagen, tacken, (b) stigen, stucken, (c) stegen, skotten, (d) hagen, backen. Vowel durations are normalized so that all the long vowel segments are given the same length in the figures. Accordingly the short vowel length indicates the duration of the short vowel relative to the corresponding long one. Thus it may be seen that the informants shorten the vowel segments to a different degree. The locations of the points representing f_0 measurements are proportional to their durations from the beginning of the segments.

Below each table (2–8) the optimal f_0 contours (one repetition of the long vowel pair ˈtagen – ˋtagen and the short ˈtacken – ˋtacken) for accent 1 and accent 2 of each informant are given as tracings from the oscillograms. With their aid correct f_0 contour can be inferred from each of the schematized.

Like Erikson and Alstermark, we use the contours of the long vowels as the reference when comparing the contours of the long and the short vowels. This does not imply any causal relationship. It would be equally reasonable to relate a comparison to the short vowels.

(a) The shortening of the stressed vowel

The degree of shortening of vowel duration from long vowel to short vowel varies among the speakers. The arithmetic means of the stressed vowel segment durations of the four testwords, the relative duration of the short vowel as a percentage of the corresponding long one (the vowel ratio V/V:), and the difference in % are given in table 1.

Table 1. Segment durations, vowel ratios and difference of vowel ratios between accent 1 and accent 2.

	Accent 1			Accent 2			Difference V/V: %
	MEAN DURATION msec		V/V:	MEAN DURATION msec		V/V:	
	LONG	SHORT	%	LONG	SHORT	%	
1. MALMÖ	176	114	65	189	118	63	2
2. HELSINGBORG	164	95	58	173	79	46	12
3. STOCKHOLM	229	88	38	239	79	33	5
4. NYBRO	174	98	56	176	93	53	3
5. JÄMSHÖG	205	98	48	205	83	40	8
6. JÖNKÖPING	276	110	40	261	98	38	2
7. RYD	221	120	54	208	105	50	4

It is found that the duration of the short vowel of accent 1 relative to the long one is always larger than that of the short vowel of accent 2 in spite of the differences in vowel quality. Thus it seems that the stressed vowel segment of accent 2 is shortened more than that of accent 1. The same relationship is found for speakers 1 from Skåne and 2 from Västergötland in Löfqvist (1973).

(b) F_0 contours

1. MALMÖ (MV, Table 2, Figure 4)

Manifestation in the long vowels

The f_0 curve of accent 1 falls during most of the long vowel segment, preceded by a short rise in three testwords but not in ´stegen. In ´stigen, the other testword beginning with the /st-/-cluster, this initial rise of only 5 Hz might also be looked upon as a plateau. It is considerably higher in ´tagen (20 Hz) and ´Hagen (40 Hz).

Accent 2 has a mainly rising contour with a short fall during the final quarter of the stressed vowel segment. In `stigen, however, the contour

did not rise immediately at the beginning of the vowel but stayed at the initial low level for about 17 % (35 msec) of the segment. The appearance of this initial plateau seems to be a consequence of the larger duration (210 msec or about 25 %) of the /i/ segment compared to the duration of the long vowel /e/ (170 msec) in `stegen. Increased vowel duration due to a slower speaking rate makes a low level contour precede the rise of accent 2 in this dialect. The rise is delayed (Gösta Bruce, personal communication).

Vowel shortening

The short vowel segments display the most characteristic features of the long vowels, that is a falling f_0 in accent 1, a rising f_0 in accent 2. But the short f_0 curves differ from the long ones in one main respect. Minor variations apart, the final portions of the long vowel contours of both accents are missing in the short vowels. They are truncated.

2. HELSINGBORG (EW, Table 3, Figure 5)

Manifestation in the long vowels

This speaker belongs to the same dialect as the Malmö informant. The f_0 contour of the tonal accents of both speakers are very similar in shape. The curve of accent 1 falls throughout the long vowel segment from an initial high level for this speaker, independent of initial consonants.

The f_0 contour of accent 2 is characterized by a rise preceded by a rather short and slight initial fall and followed by a final fall. The f_0 in the long and short vowels of accent 2 started from approximately the same frequency, whereas this was the case for only two test pairs for accent 1, viz. ´stigen - ´stucken, and ´Hagen - ´backen.

Vowel shortening

When vowel duration is decreased radically the shape of the long vowel contour is retained in the short vowel segments. But again, several minor changes are observed.

The short vowel contours of accent 1 start with a short rise while for the long vowels they are level at the beginning. The peaks are either higher than the high level of the long vowel contour (´stucken), lower

(ˊskotten) or at the same level (ˊtacken, ˊbacken). After the peak the short vowel contours fall more rapidly than for the corresponding long vowels, representing instances of rate adjustment as is the case with the initial rise. Thus the short contours are totally reorganized (compressed).

Compression is also found in the short vowel contours of accent 2. The complete shape of the long vowel contours (slight initial fall or level, rise, fall or level) is preserved, except for the absence of the initial fall in ˋskotten which may be due to the different place of articulation of the preceding stop. The short vowel contours rise more rapidly than for the long vowels. The peaks of the short vowel contours are lower in ˋtacken and at about the same level in ˋstucken, ˋskotten, and ˋbacken.

Comparing this informant's changes with those of the Malmö speaker, we find one main difference. The short vowel contours of the Malmö speaker for both accents represent mainly a truncation of the final part of the long vowel contours, whereas the complete shape of the long vowel contours of the Helsingborg informant is preserved but compressed in the short vowels.

Thus we find that two speakers of the same local dialect use different means for manifesting the tonal accents in short vowels followed by a voiceless consonant.

3. STOCKHOLM (EH, Table 4, Figure 6)

Manifestation in the long vowels

The f_0 curve of accent 1 of the long vowel is characterized by a rise which, except for ˊHagen, is rather slight while in ˊstigen and ˊstegen the contour ends in a plateau. The short rise of accent 2 seen in ˋtagen and ˋhagen is missing in ˋstigen and ˋstegen, which might be due to the initial consonant cluster. Otherwise the long vowel of accent 2 shows a falling f_0 throughout the vowel segment.

Vowel shortening

The characteristic pattern of the long vowel f_0 curves of the tonal accents is preserved in the short vowel segments. The short vowels of accent 1 are

characterized by a mainly rising contour, those of accent 2 by a mainly falling one. The final parts of the long vowel contours of both accents are truncated. The rising-falling pattern of `tagen appears also in `tacken, but in `backen there is no rise, the $f_0$ contour falling throughout the short vowel segment as it is in `stucken and `skotten, which begin with a consonant cluster. Besides the truncation of the final parts the short vowel f_0 curves of both accents are shifted upwards along the frequency axis by about 20 Hz in most cases. These considerable frequency shifts of the short vowel contours do not seem to be a consequence of differences in segmental structure between the four sets of test words because they appear in all of them. The frequency-shifted short vowel contours may be due to the voicelessness of the following consonant or to the phonologically short vowel or both.

4. NYBRO (LGP, Table 5, Figure 7)

Manifestation in the long vowel

Accent 1 is manifested as an initial fall towards about one third of the long vowel segment followed by a rise during the remaining part of the vowel segment, thus displaying a f_0 minimum in the first half of the vowel.

Accent 2, on the contrary, has a f_0 maximum at the beginning of the vowel, in `stigen and `hagen manifested as a plateau, although the greater part of the segment is characterized by a fall.

Vowel shortening

When vowel durations are decreased by about 50 %, the remaining short vowel contours, in general, preserve the main pattern of the long ones.

It is notable, however, that for this informant the asymmetrical consonant context of the stegen - skotten pair does not change the shape of the contours.

The changes in the short vowel contours of this informant are rather difficult to interpret.

In `backen the contour seems to be compressed although it does not rise more rapidly. The remaining three short vowel contours of accent 1 are truncated because the f_0 minimum appears at about the same point of

time as in the long vowel contours. The long final rise of the long vowel contours is considerably shorter in the short ones indicating that the final part of the rise is truncated.

All the short vowel contours of accent 2 show some kind of reorganization. In `stucken and `skotten the curves of the short vowels are compressed. Both short [a] vowels have similar contours. They share one feature, namely the fall, with the other two contours. As it is steeper in `tacken and `backen than in their corresponding long vowels, even these curves may be counted as instances of compression.

5. JÄMSHÖG (BD, Table 6, Figure 8)

Manifestation in the long vowels

The f_0 manifestations of both tonal accents in the long stressed vowels of this informant show a rather similar contour: a fall at the very beginning and a rise which is longer in accent 1 than in accent 2. But whereas accent 2 always has a rather long and considerable fall (about 30 Hz) from the f_0 peak to the segment boundary, this fall is only slight or nonexistent in accent 1.

Vowel shortening

When vowel duration is decreased the short vowel f_0 contours of both accents end with a f_0 maximum. In general, the short vowel segments of both accents are characterized by a rising contour, and in most cases the brief initial fall is preserved. The final falling parts of the long vowel contours of both accents never remain, they are truncated. Thus the f_0 manifestations of the tonal accents in the stressed vowels become rather similar to each other. There are, however, some differences between the remaining short vowel contours of accent 1 and 2. The short vowel contours of accent 1 end mostly at a higher frequency level than the corresponding ones of accent 2. Furthermore, the f_0 difference between the final f_0 and the f_0 minimum is larger in the short accent words than in the corresponding words of accent 2. The rising rate is higher in all short accent 1 words than in the corresponding ones of accent 2, except for ´backen.

The correct manifestations of the tonal accents in the minimal tonal

pair ´backen and `backen by the informant were checked perceptually by the informant herself some weeks after the recordings had been made and also by a trained phonetician (GB) of our laboratory. It is true that the perceptual difference between accent 1 and accent 2 in this testpair and for this speaker is rather small.

The f_0 values of backen were then measured on narrow-band spectrograms made on a Voice Print PV 10. The f_0 was measured at the beginning, the minimum, and the final maximum in the 4th and 5th partials and calculated to the nearest 5 Hz, taking the mean of both if necessary.

In the case of backen we find it necessary to consider briefly the contour of the second (and final) syllable of the testwords as well. For the Jämshög speaker f_0 tracings of hagen and backen from the oscillograms are given in Figure 9. It will be seen that for this informant the high f_0 level of the second syllable of accent 1 is preserved in the testword with the short vowel while the rise of accent 2 is changed into a more level contour.

6. JÖNKÖPING (BS, Table 7, Figure 10)

Manifestation in the long vowels

The informant's accent 1 is manifested in the long vowels as a f_0 fall during at least the first half of the vowel, an f_0 minimum, and a final, slight rise towards the segment boundary. In ´tagen and ´Hagen, both with the vowel /a/, the fall is preceded by a short rise by 15 Hz.

The f_0 contour of accent 2, starting from about the same frequency level as accent 1, remains at this high level or rises slowly towards the middle of the vowel and falls towards the end of the vowel segment.

Vowel shortening

1. tacken, stucken, and skotten

When the vowel duration is decreased the fall of accent 1 and the high frequency level of accent 2 are preserved on the whole. The final part of the long vowel contours are truncated. But some slight variations may be noted. The short vowel curve of accent 1 in ´stucken is merely cut off at the segment boundary. In ´tacken the fall of f_0 dominates the vowel after the short rise at the very beginning. But the f_0 curve falls more

rapidly than in the long vowel. Towards the segment boundary the rapid fall is slowed down as is the case in ´skotten. But here the f_0 falls at the same rate as in the corresponding long vowel.

2. backen

The contours of the short [a] vowel of backen of both accents deviate totally from the short vowel contours of the other three testwords which show a similar overall pattern. The correct performance of the tonal accents in ´backen and `backen was checked perceptually some months later. Narrow band spectrograms and measurements were made of all productions, as for the Jämshög informant.

As to segment durations, the short [a] vowels do not deviate from the short vowel segments of the other testwords (see Table 7). They are not even the shortest segments.

The most pertinent difference between the short vowel contours of accent 1 and 2 in backen lies in the steeper rise and in the final fall of the contour of accent 2.

In the case of backen we find it necessary to consider briefly the contour of the second (and final) syllable of the testwords as well.

Figure 11 gives the f_0 oscillogram tracings of one representative production each of hagen and backen for both accents. It can be seen that the f_0 contour of the second syllable of accent 1 has changed, too. The rise of the second syllable of ´Hagen has become a high level. The pattern of the f_0 contour of the second syllable of `hagen and `backen is not changed, however, remaining rising even after the short vowel followed by the voiceless medial stop.

7. RYD (JT, Table 8, Figure 12)

Manifestation in the long vowels

Accent 1 is manifested as a falling f_0 reaching its lowest level in the second half of the long vowel, in ´stigen as late as at the segment boundary.

The contour of accent 2, unlike accent 1, rises, after an initial short fall in `tagen and `stegen, towards a f_0 maximum at about the middle of the long vowel segment. It then falls during the second half, reaching

the same low frequency level at the segment boundary as the corresponding curve of accent 1.

Vowel shortening

When vowel duration is decreased the final parts of the long vowel contours of both accents are missing in all cases but one ('stucken). Apart from the truncated long vowel fall of accent 2, the remaining short vowel contours, except for 'stucken, are compressed resulting in a steeper rise.

(c) Conclusions

To sum up we will attempt in the following table to characterize the main change in the short vowel contours compared to the long ones for each informant and for each accent.

Table 9. Main changes in the short contours.

		Accent	
Figure	Informants and place	1	2
4	MV, Malmö	Truncation	Truncation
5	EW, Helsingborg	Compression	Compression
6	EH, Stockholm	Truncation	Truncation
7	LGP, Nybro	Truncation	Compression
8	BD, Jämshög	Truncation	Truncation
10	BS, Jönköping	Truncation	Truncation
12	JT, Ryd	Truncation	Truncation
			Compression

Table 9 suggests that the short contours of our seven informants are derived from the long ones by the principles of truncation in most cases and by compression in a few cases irrespective of the shape of the f_0 contours of the word accents.

Within the same dialect speakers can differ in the kind of change observed. Furthermore, a speaker may show truncation in one accent and

compression in the other. Both principles may be combined within one accent.

VII. Discussion

The alternation of voiced stop versus voiceless stop in the testpairs was built into the material on the assumption that a following consonant does not affect the f_0 contour of a preceding vowel (Mohr 1971, Leandersson and Lindblom 1971). An investigation of the effect of the segmental context on a given f_0 contour of a Gothenburg male informant was carried out at the laboratory. It reveals very clearly that the whole f_0 curve of accent 2, a rising-falling pattern (the peak being located at a point about one third from the beginning of the vowel segment), is raised considerably, by about 20 Hz, before a voiceless stop compared with a nasal, and somewhat less compared with the corresponding voiced stop. The f_0 contour of accent 1, however, which falls throughout the vowel, appears not to be affected by the different features of the following consonants /m, b, p/. Partly contradictory evidence is reported in Löfqvist (1973). That is why we do not want to give attention to the frequency-shifted short vowel contours found with some of the informants. It is tempting to associate the f_0 raising in short vowels, before voiceless stops, and in fast speech (Gårding etal., 1975) with one common mechanism: a greater tension of the muscles of the vocal organs.

Apart from minor variations, it seems that for the whole material of our seven informants the short vowel contour of the first, stressed vowel are achieved by two main strategies or programmes:

(1) Certain parts of the f_0 contours are not manifested. They are truncated. The remaining parts of the contours of both accents may (a) still be different from each other or (b) they may resemble each other.

(2) The complete shape of the contour is compressed. Therefore the curve has to rise or fall more quickly (rate adjustment).

In general, we only find support for the two hypotheses discussed by Erikson and Alstermark (1972). We agree with them in calling the one effect of vowel duration on the f_0 of Swedish word accent for truncation, but we prefer to call the other effect for compression which is a more general term for covering that change than is rate adjustment. A

compressed contour must be produced with an increased speed for the rise or the fall, although the absolute values of the f_0 maxima or f_0 minima of the long contours need not be reached.

As to these tonal accents several linguists (e.g. Elert 1970, 46 and references there) hold that there is only one phonemically relevant tonal accent, namely accent 2. It is manifested in the first stressed syllable and is followed by a contour similar to that of accent 1 (e.g. Gårding 1970, Gårding and Lindblad 1973), which is considered to be the manifestation of the sentence intonation. The data of Alstermark and Erikson (1971) support this assumption as does Bruce (1974). He points out that the first syllable of accent 2 in the Stockholm dialect may be a manifestation of the "pure" accent 2 and that the "pure" accent 1 is not realized in sentence stressed position where the f_0 contour is determined by the sentence intonation instead.

Thus it seems that shortening of the vowel of the first syllable in an accent 2 word merely affects the tonal accent while it changes the sentence intonation contour in accent 1.

A deviating contour is found in one of the short vowels of the Jönköping informant: the short vowel contour of ´backen shows a rise, unlike the falling f_0 curves in all the other testwords. As the f_0 curves of `backen are characterized by a rise, the short vowel contours of both accents in the stressed vowel have become very similar. And yet, the tonal contrast in these two word is preserved, the tonal difference being signalled in the second syllable.

The observed changes in all the testpairs of the Jämshög informant and the radical reorganization of the short vowel f_0 contour of the Jönköping informant result in diminishing the tonal contrast in the first syllable. A decrease of a given contrast or the neutralization of a given distinction are often found in segmental phonology.

But as the domain of the tonal accent 2 is at least a bisyllabic word, the second syllable (or another following syllable depending on the stress and accentuation rules of the dialect, see Bruce 1974) will be available for the accent manifestation if there is no neutralization due to the deletion of stress.

At least one instance of radical deviation and the resulting similarity of the short vowel contours in the first syllable, as well as other reasons, motivate a study of not only the f_0 curves of one syllable but

also those of the whole word (consisting of at least two syllables) in further investigations.

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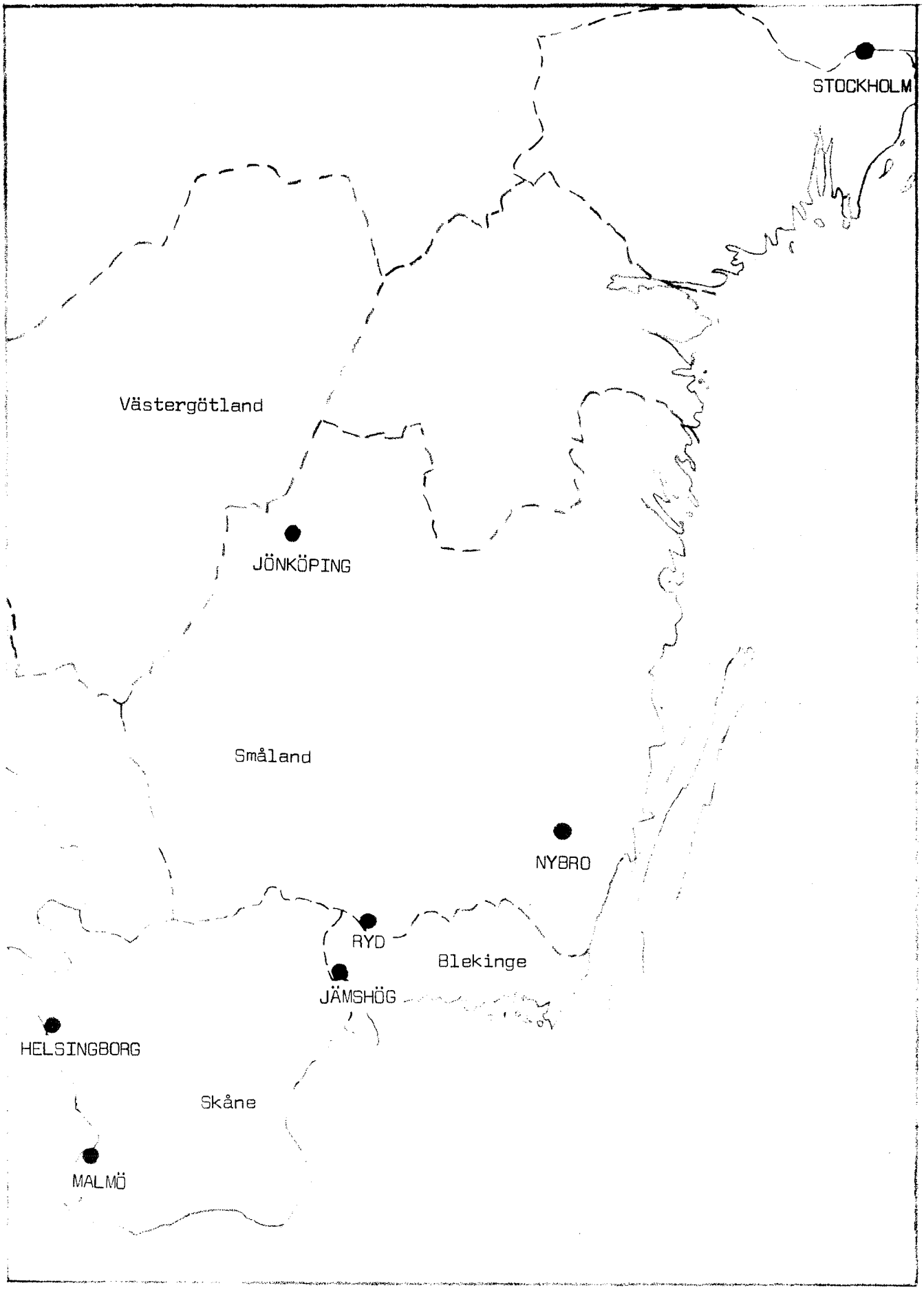


Figure 2. The geographical distribution of the informants.

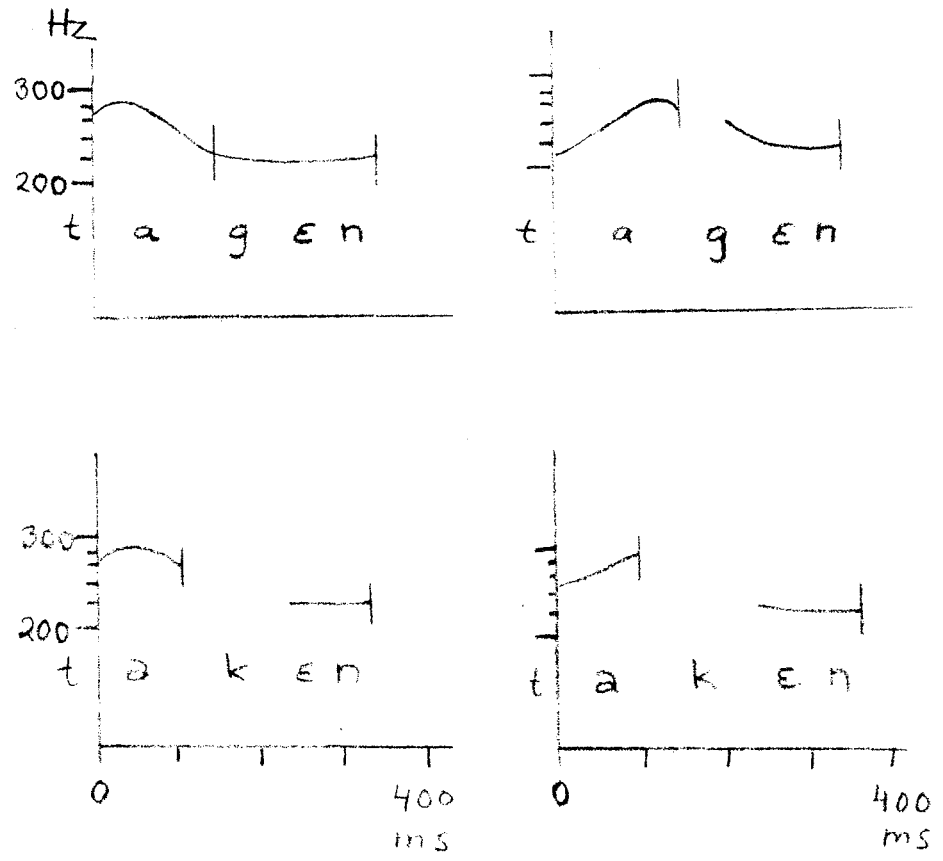
Table 2. MALMÖ

F_o values (in Hz) and durations (in msec).

	Accent 1				Accent 2			
tagen	f_o:	270	290	220	230	300		280
	t :	0	25	145	0	140		175
tacken	f_o:	275	295	260	250			300
	t :	0	35	105	0			105
stigen	f_o:	295	300	205	230	230	290	260
	t :	0	30	185	0	35	160	210
stucken	f_o:	300	305	220	235			315
	t :	0	25	125	0			130
stegen	f_o:	285		200	240	275		265
	t :	0		170	0	125		170
skotten	f_o:	280		240	230			285
	t :	0		95	0			105
hagen	f_o:	235	275	195	210	280		260
	t :	0	50	205	0	165		200
backen	f_o:	245	270	230	205			285
	t :	0	55	130	0			130

F_o tracings of tagen and tacken, accent 1 to the left, accent 2 to the right.

Malmö.



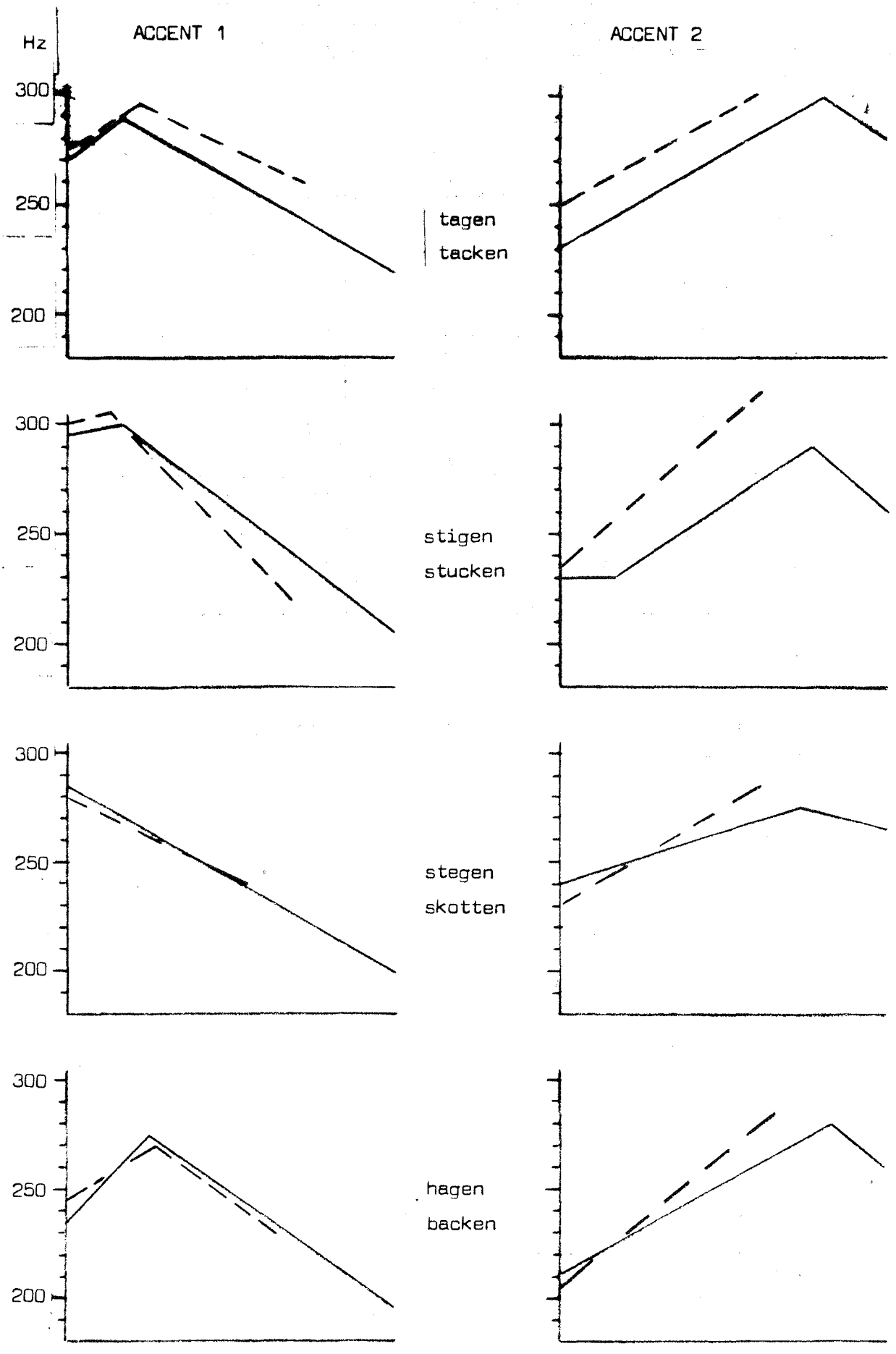


Figure 4. Simplified f_0 contours of the first vowel segment. MALMÖ
The duration of the long vowels is normalized.
Dashed line: short vowel

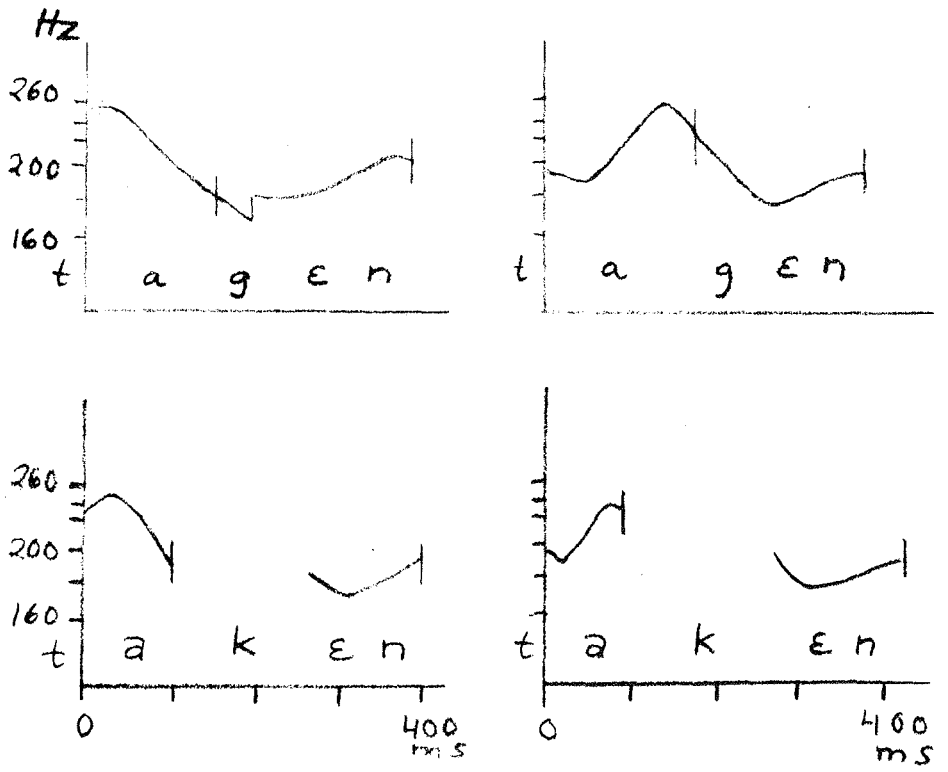
Table 3. HELSINGBORG

F_o values (in Hz) and durations (in msec).

	Accent 1				Accent 2			
tagen	f_o:	255	255	190	195	190	250	220
	t :	0	40	150	0	55	155	185
tacken	f_o:	240	255	195	195	190	235	230
	t :	0	30	100	0	35	65	85
stigen	f_o:	215	215	160	180	175	210	200
	t :	0	40	170	0	35	140	170
stucken	f_o:	220	225	175	185	185	210	210
	t :	0	15	75	0	15	50	65
stegen	f_o:	240	240	170	180	175	220	205
	t :	0	45	180	0	45	135	170
skotten	f_o:	210	225	160	180		220	210
	t :	0	25	90	0		40	60
hagen	f_o:	235	235	175	190	185	240	220
	t :	0	35	155	0	40	135	165
backen	f_o:	230	235	170	185	185	235	225
	t :	0	35	115	0	25	80	105

F_o tracings of tagen and tacken, accent 1 to the left, accent 2 to the right.

Helsingborg.



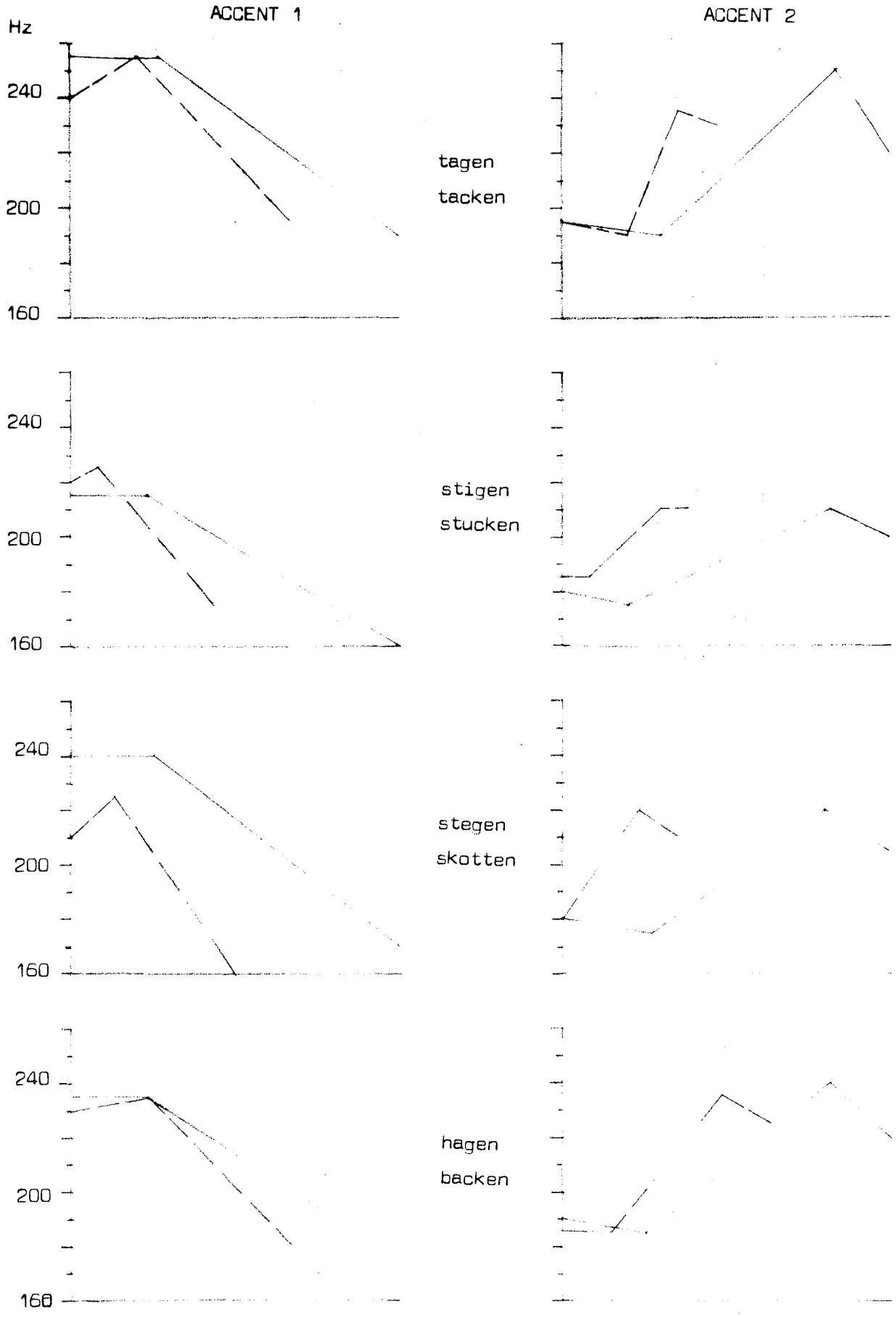


Figure 5. Simplified f_0 contours of the first vowel segment. HELSINGBORG
The duration of the long vowels is normalized.
Dashed line: short vowel

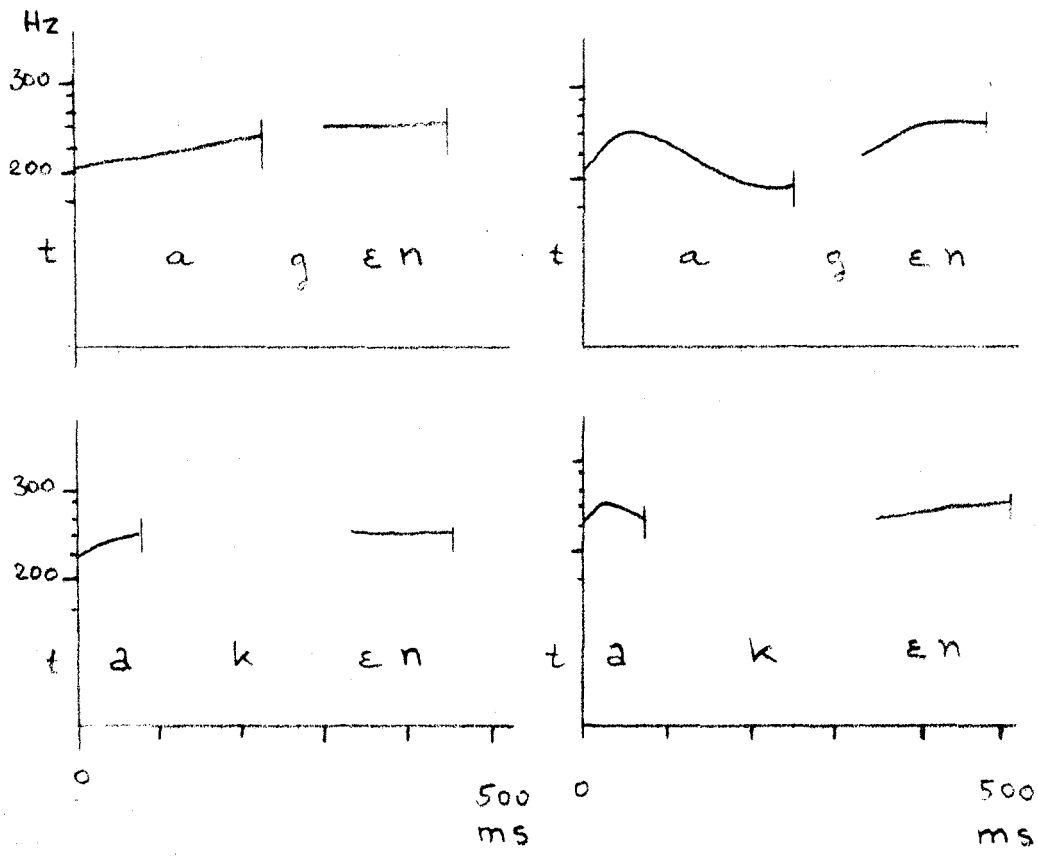
Table 4. STOCKHOLM

F_o values (in Hz) and durations (in msec).

	Accent 1			Accent 2		
tagen	f_o:	220	240	240	260	195
	t :	0	240	0	50	260
tacken	f_o:	235	260	250	270	250
	t :	0	95	0	30	90
stigen	f_o:	245 255	255	270		215
	t :	0 120	190	0		215
stucken	f_o:	270	280	280		260
	t :	0	80	0		65
stegen	f_o:	235 260	260	260		200
	t :	0 200	255	0		240
skotten	f_o:	250	260	280		255
	t :	0	90	0		80
hagen	f_o:	230	285	240	250	200
	t :	0	230	0	50	240
backen	f_o:	235	270	255		245
	t :	0	95	250		80

F_o tracings of <u>tagen</u> and <u>tacken</u>, accent 1 to the left, accent 2 to the right.

Stockholm.



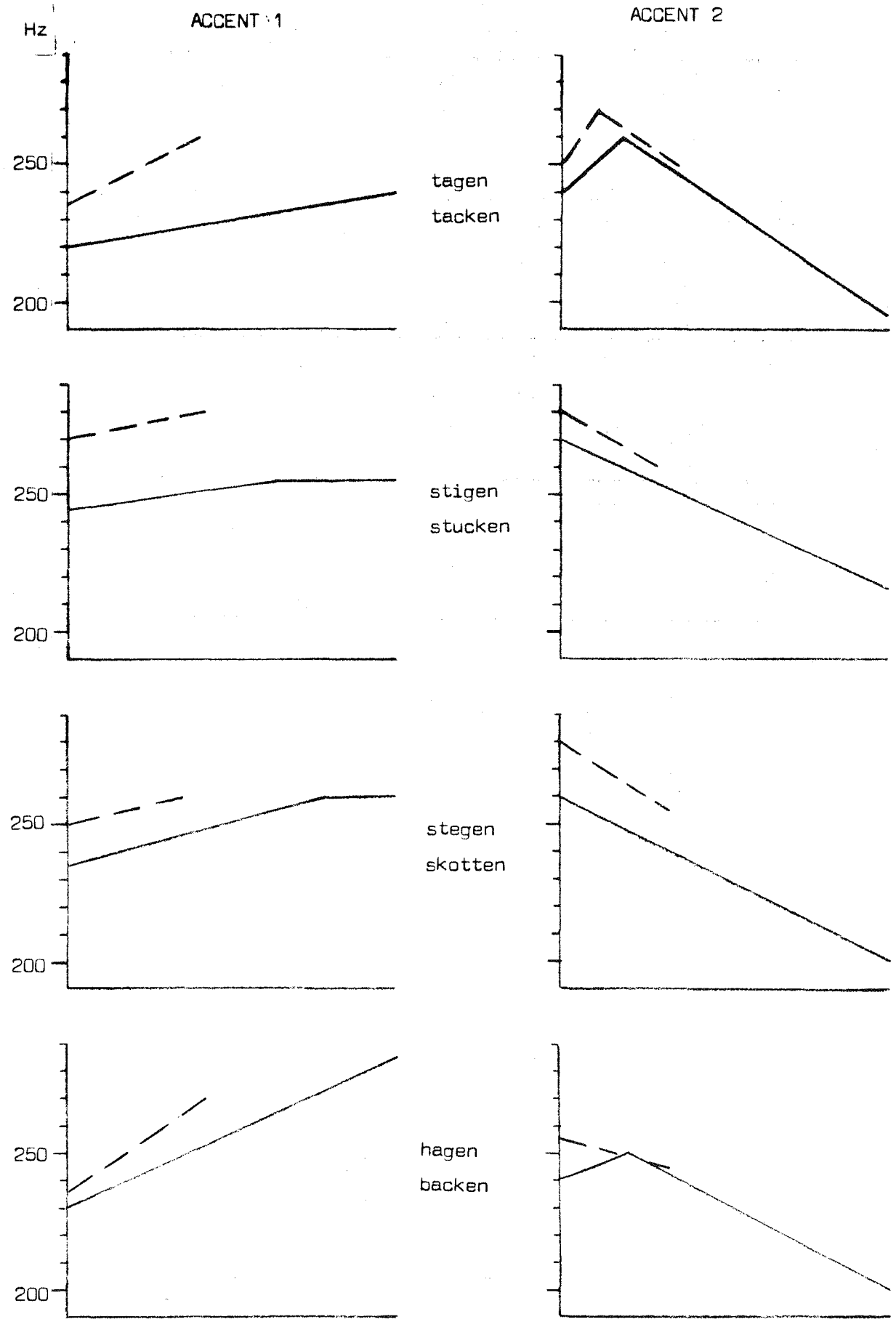


Figure 6. Simplified f_o contours of the first vowel segment. STOCKHOLM
The duration of the long vowels is normalized.
Dashed line: short vowel

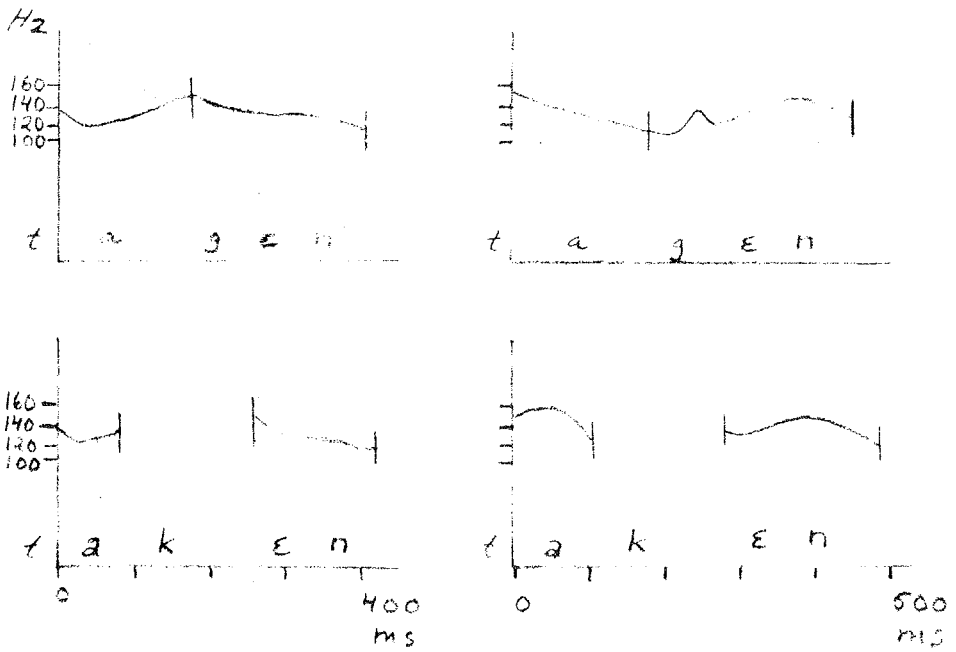
Table 5. NYBRO

F_o values (in Hz) and durations (in msec).

	Accent 1				Accent 2		
tagen	f_o:	135	115	155	150		115
	t :	0	45	180	0		180
tacken	f_o:	135	125	135	145	155	125
	t :	0	40	90	0	50	90
stigen	f_o:	130	120	140	140	140	110
	t :	0	50	150	0	55	160
stucken	f_o:	150	130	140	150	150	130
	t :	0	40	90	0	20	90
stegen	f_o:	135	130	140	145	115	115
	t :	0	55	160	0	145	175
skotten	f_o:	140	135	145	150	135	135
	t :	0	35	95	0	45	90
hagen	f_o:	125	110	140	155	155	120
	t :	0	75	205	0	50	190
backen	f_o:	140	120	150	140	145	130
	t :	0	25	115	0	65	100

F_o tracings of <u>tagen</u> and <u>tacken</u>, accent 1 to the left, accent 2 to the right.

Nybro.



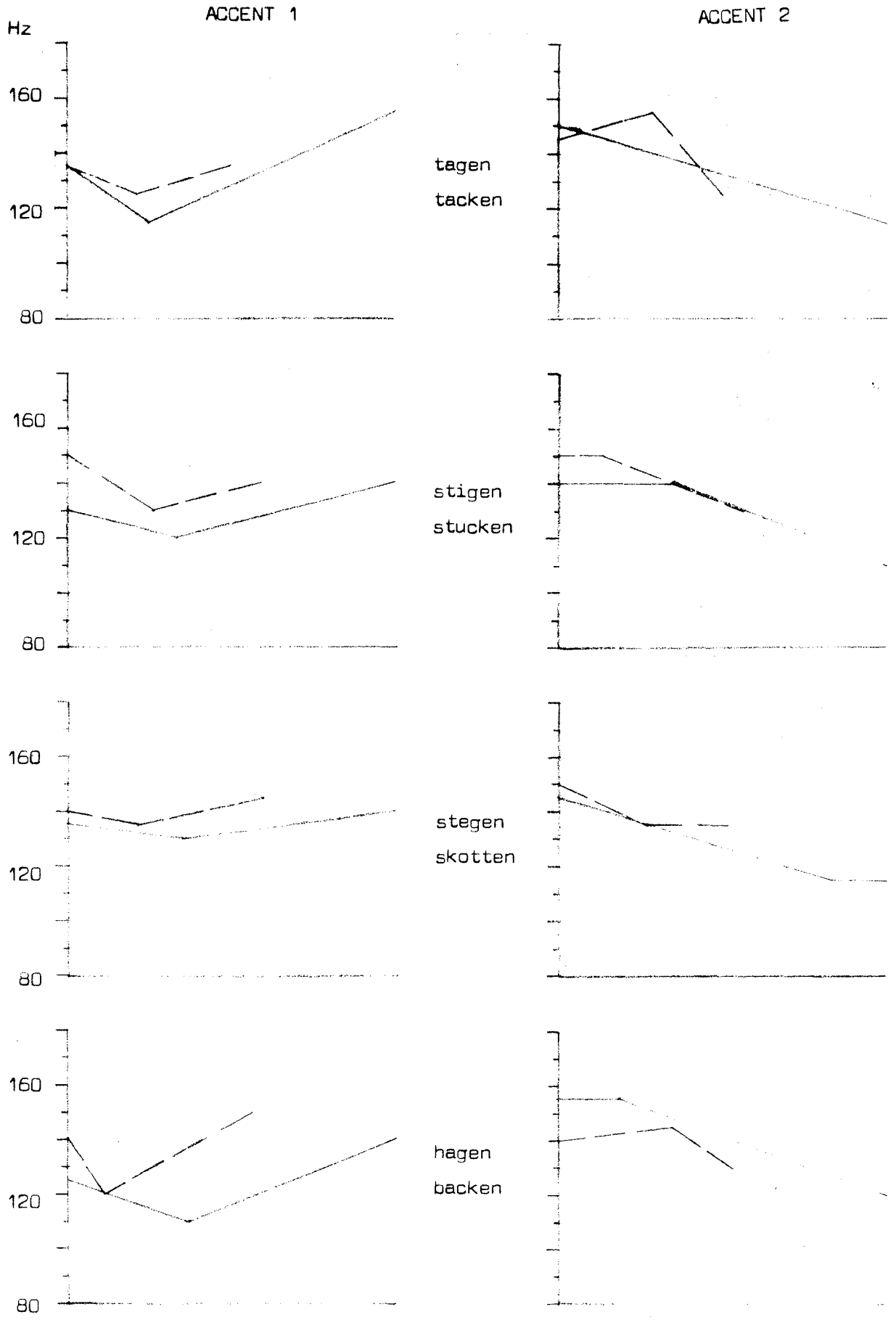


Figure 7. Simplified f_0 contours of the first vowel segment. NYBRO
The duration of the long vowels is normalized.
Dashed line: short vowel

Table 6. JÄMSHÖG

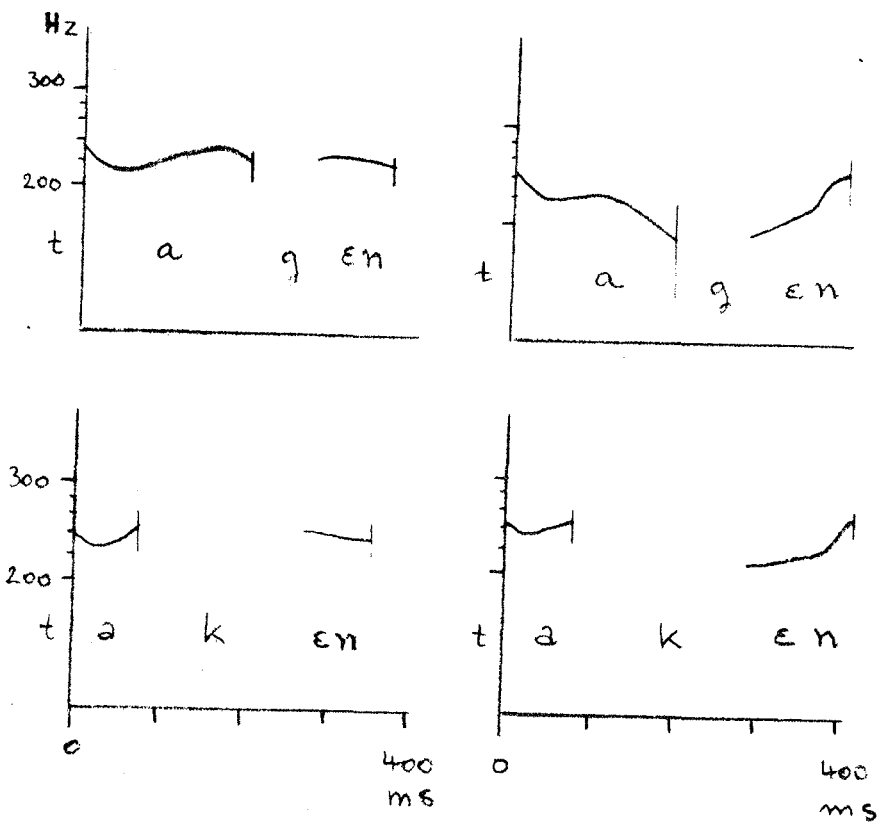
F_0 values (in Hz) and durations (in msec).

	Accent 1					Accent 2			
tagen	f_0:	250	210	240	220	250	230	240	190
	t :	0	50	170	210	0	40	100	200
tacken	f_0:	240	230		250	250	230		240
	t :	0	20		80	0	20		80
stigen	f_0:	235	210		240	240	215	235	210
	t :	0	35		200	0	30	115	215
stucken	f_0:	240	220		240	230			235
	t :	0	20		85	0			70
stegen	f_0:	220	210	240	235	230	220	240	220
	t :	0	35	150	210	0	20	115	205
skotten	f_0:	215			255	220	220		240
	t :	0			100	0	15		80
hagen	f_0:	230	210	245	235	225	210	235	200
	t :	0	30	165	200	0	20	110	200
backen	f_0 [1]:	210	200		245	210	205		235
	t :	0	25		125	0	25		100

[1] measured on narrow-band sonagrams

F_0 tracings of tagen and tacken, accent 1 to the left, accent 2 to the right.

Jämshög.



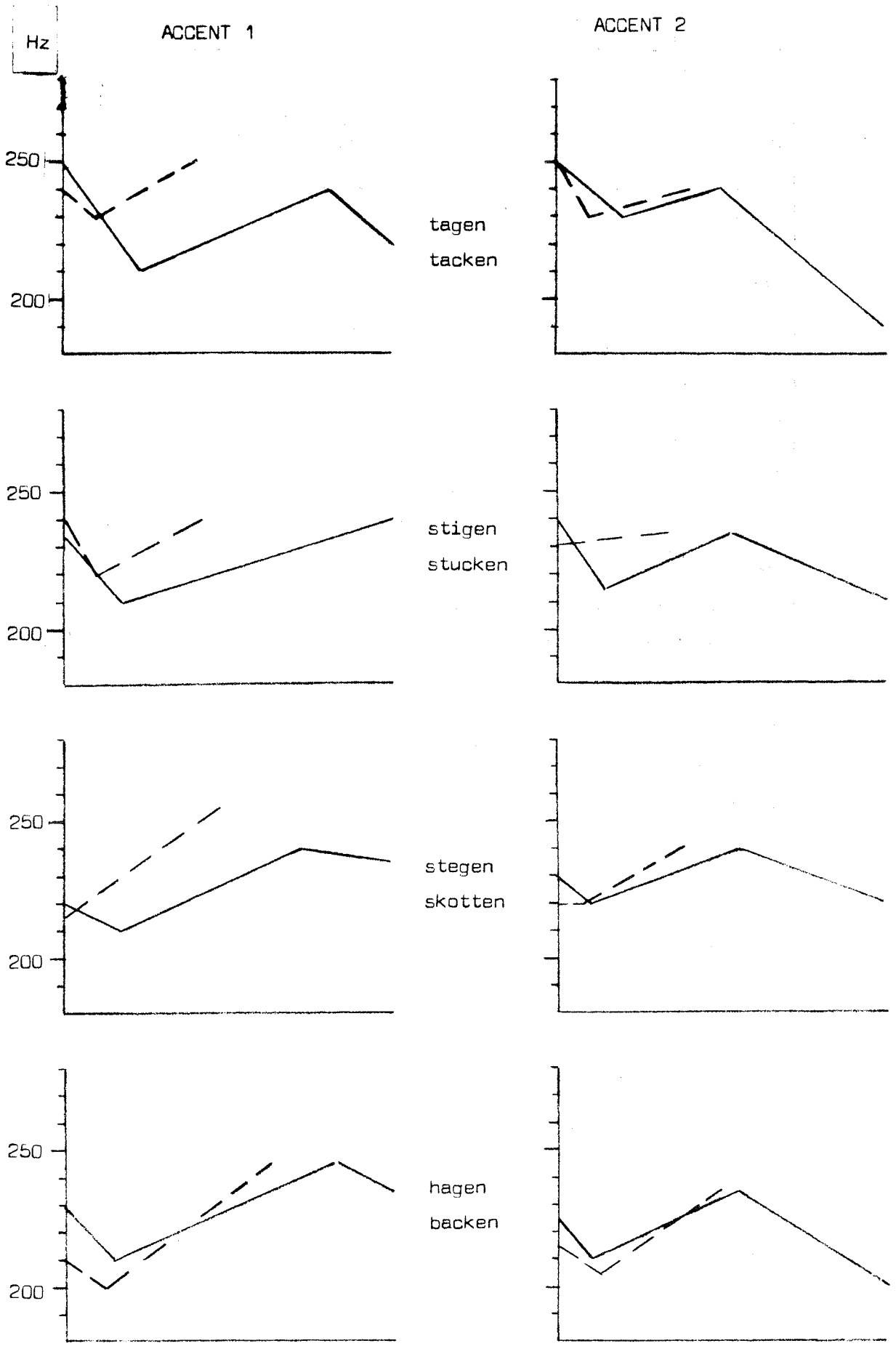


Figure 8. Simplified f_0 contours of the first vowel segment.JÄMSHÖG
The duration of the long vowels is normalized.
Dashed line: short vowel

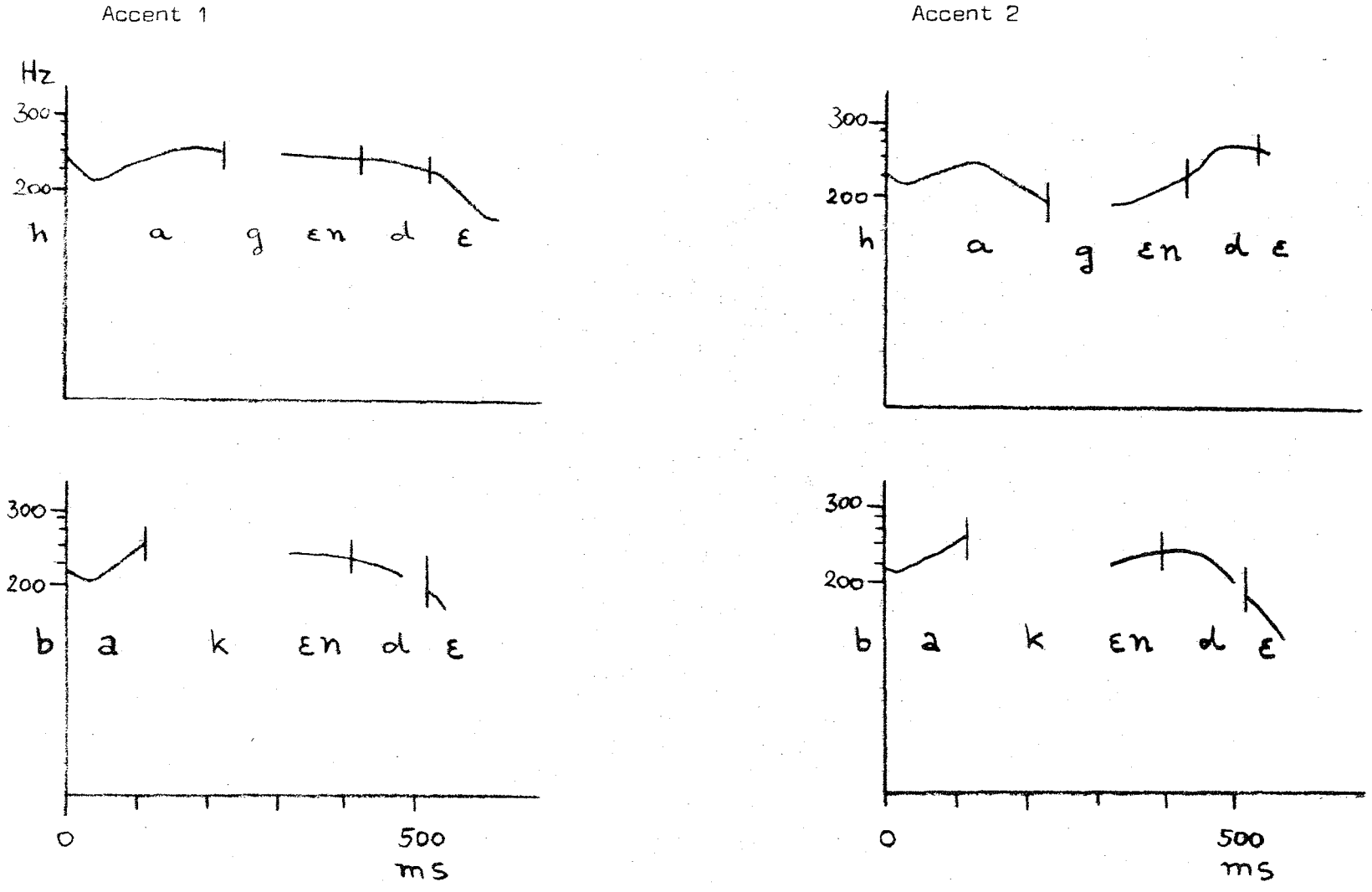


Figure 9. F_0 tracings of <u>hagen</u> (above) and <u>backen</u> (below), accent 1 to the left, accent 2 to the right. Jämshög informant

Table 7. JÖNKÖPING

F_o values (in Hz) and durations (in msec).

		Accent 1				Accent 2				
tagen	f_o:	230	245	170	190	230	240	230	240	200
	t :	0	20	210	290	0	20	60	140	290
tacken	f_o:	235	250	190	180	245				260
	t :	0	20	85	120	0				100
stigen	f_o:	245	180		195	240	240			195
	t :	0	140		235	0	130			210
stucken	f_o:	245			200	255				255
	t :	0			85	0				85
stegen	f_o:	260	185	180	195	255	270	255		210
	t :	0	120	200	280	0	105	165		270
skotten	f_o:	255	215		200	245	260			245
	t :	0	70		125	0	50			105
hagen	f_o:	230	245	165	185	230			250	190
	t :	0	30	210	290	0			120	275
backen	f_o[1]:	240	230		260	240	235	265		260
	t :	0	25		110	0	20	75		100

[1] measured on narrow-band sonagrams

F_o tracings of tagen and tacken, accent 1 to the left, accent 2 to the right.

Jönköping.

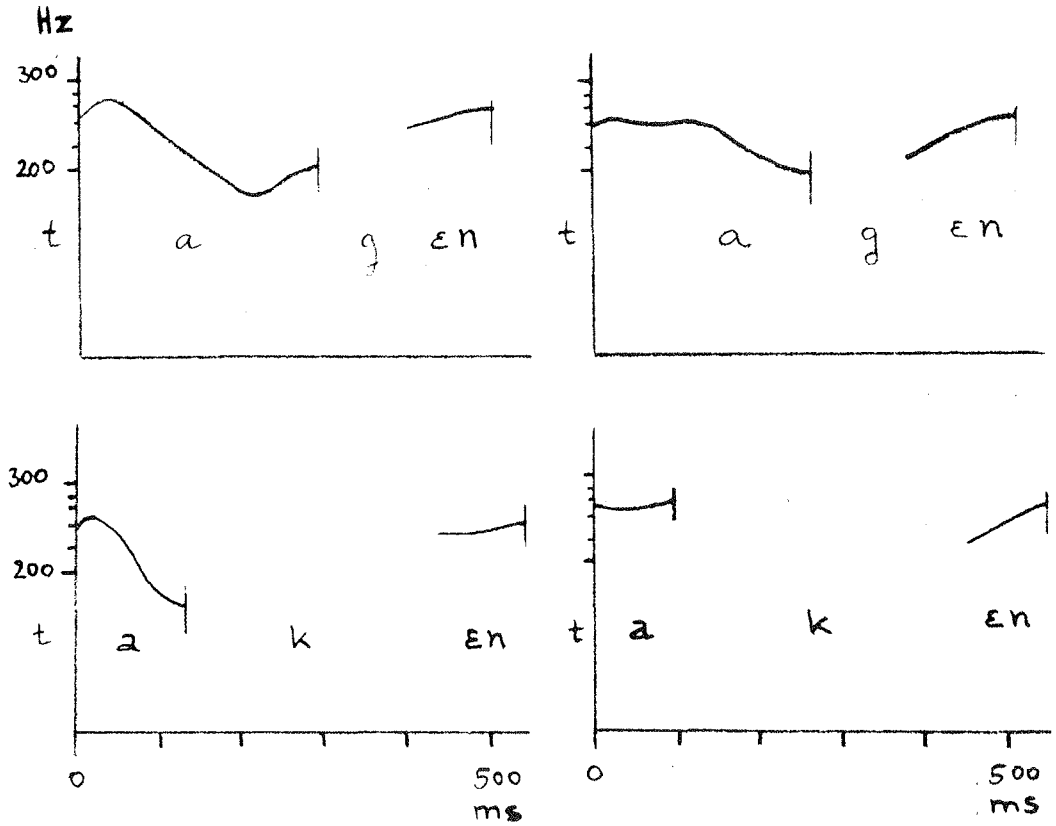


Table 6. JÄMSHÖG

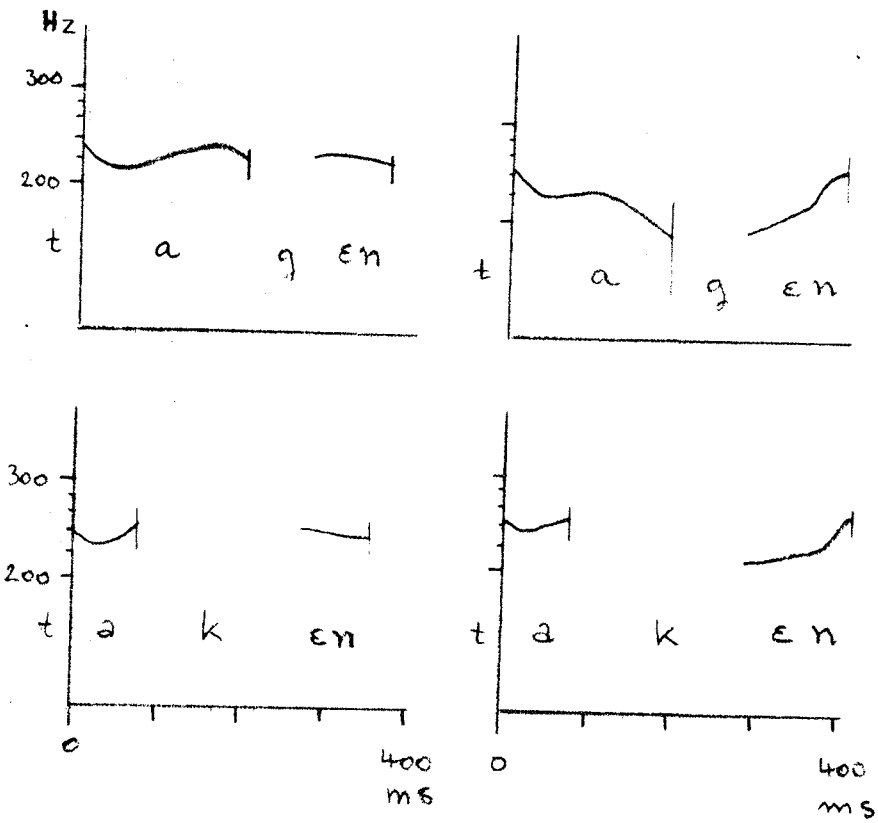
F_o values (in Hz) and durations (in msec).

	Accent 1					Accent 2			
tagen	f_o:	250	210	240	220	250	230	240	190
	t :	0	50	170	210	0	40	100	200
tacken	f_o:	240	230		250	250	230		240
	t :	0	20		80	0	20		80
stigen	f_o:	235	210		240	240	215	235	210
	t :	0	35		200	0	30	115	215
stucken	f_o:	240	220		240	230			235
	t :	0	20		85	0			70
stegen	f_o:	220	210	240	235	230	220	240	220
	t :	0	35	150	210	0	20	115	205
skotten	f_o:	215			255	220	220		240
	t :	0			100	0	15		80
hagen	f_o:	230	210	245	235	225	210	235	200
	t :	0	30	165	200	0	20	110	200
backen	f_o[1]:	210	200		245	210	205		235
	t :	0	25		125	0	25		100

[1] measured on narrow-band sonagrams

F_o tracings of tagen and tacken, accent 1 to the left, accent 2 to the right.

Jämshög.



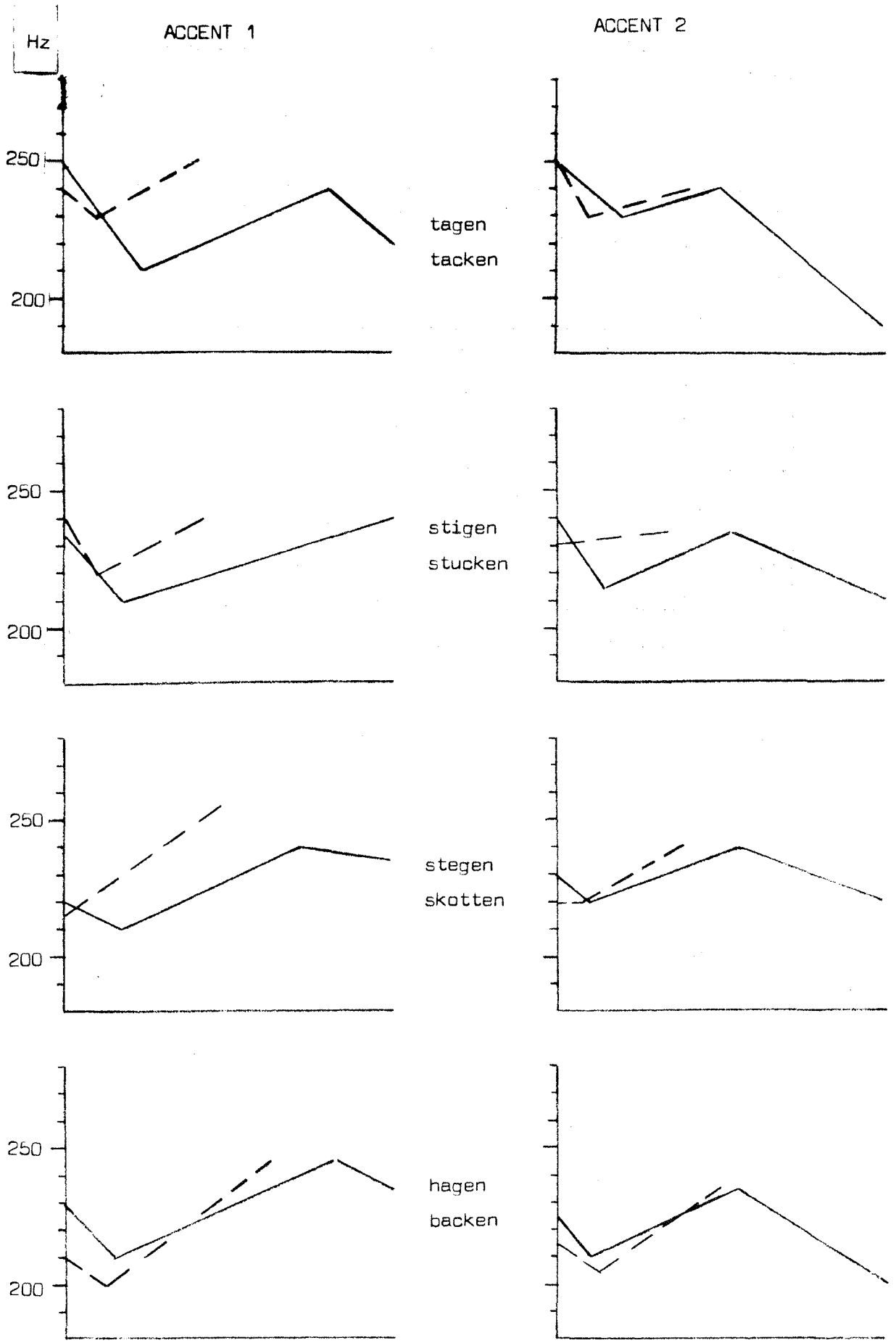


Figure 8. Simplified f_0 contours of the first vowel segment.JÄMSHÖG
The duration of the long vowels is normalized.
Dashed line: short vowel

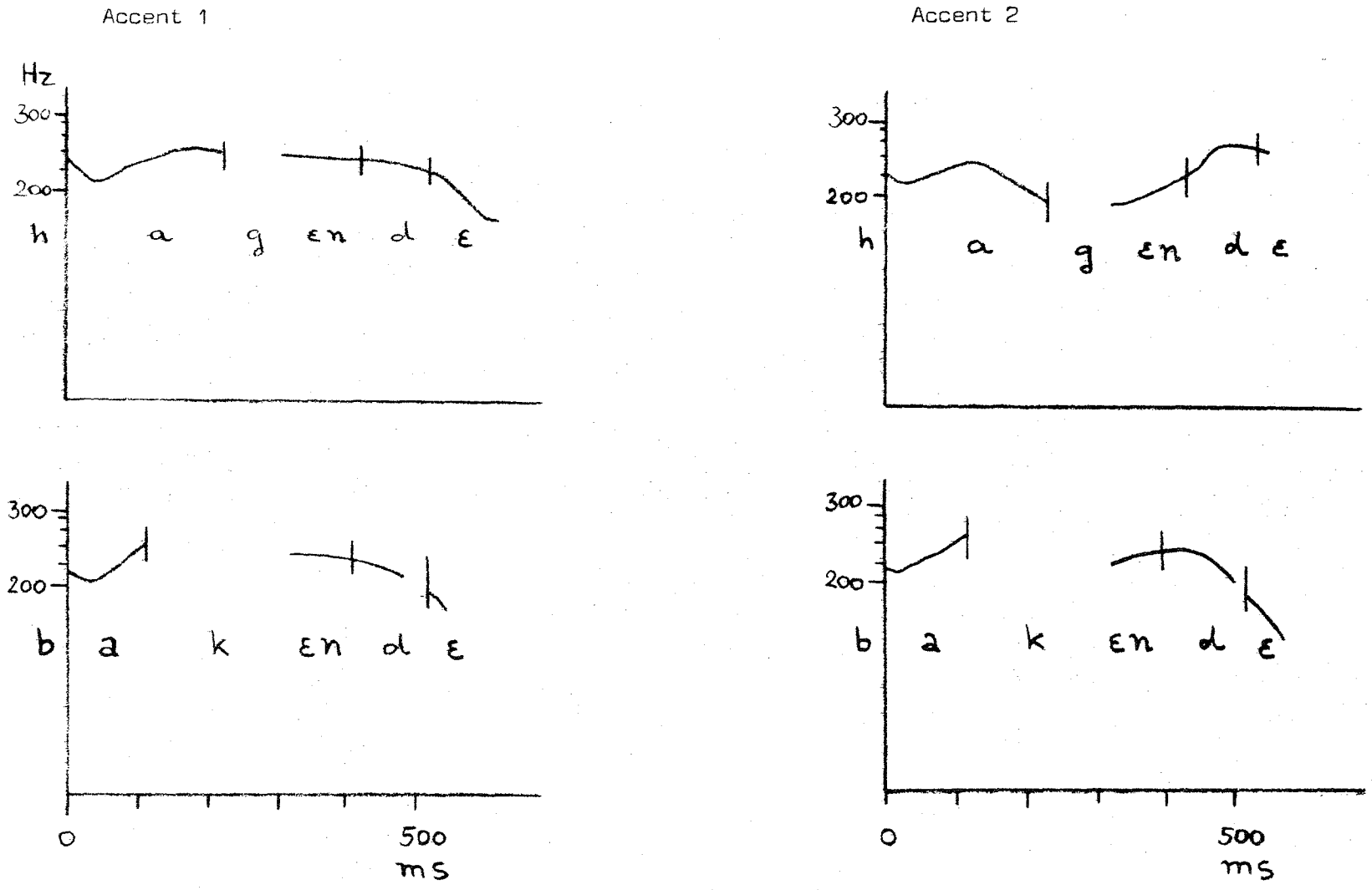


Figure 9. F_0 tracings of <u>hagen</u> (above) and <u>backen</u> (below), accent 1 to the left, accent 2 to the right. Jämshög informant

Table 7. JÖNKÖPING

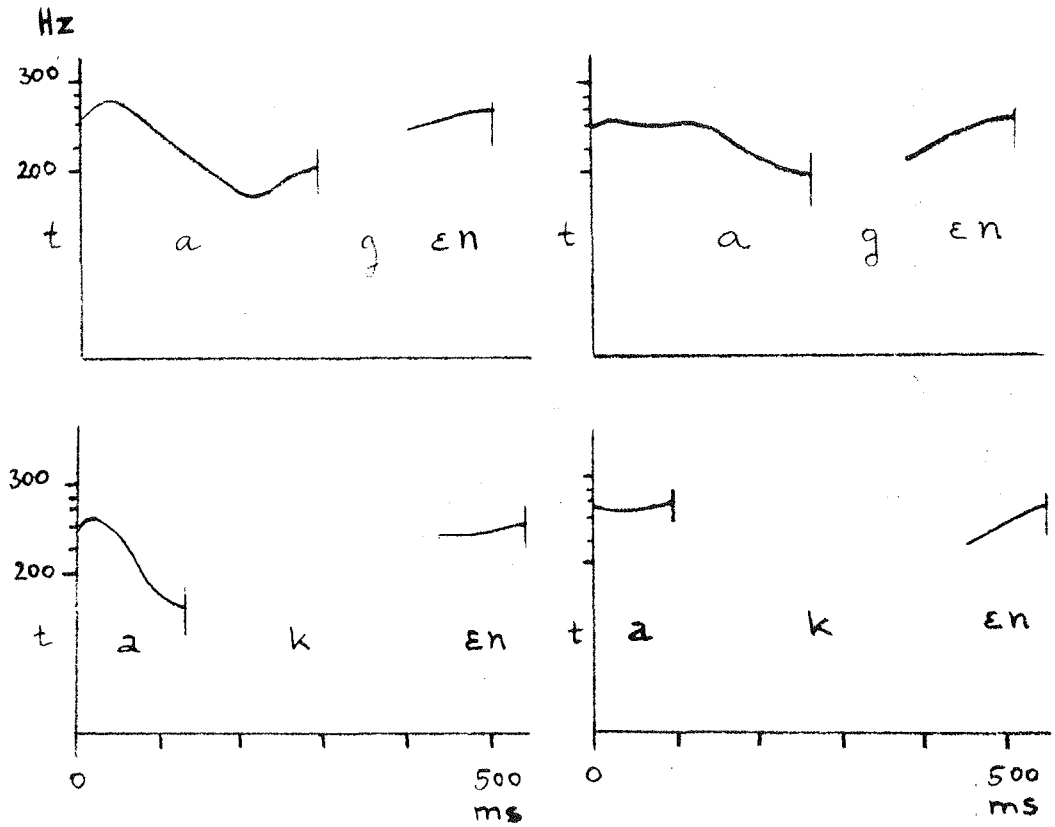
F_0 values (in Hz) and durations (in msec).

		Accent 1				Accent 2				
tagen	f_0:	230	245	170	190	230	240	230	240	200
	t :	0	20	210	290	0	20	60	140	290
tacken	f_0:	235	250	190	180	245				260
	t :	0	20	85	120	0				100
stigen	f_0:	245	180		195	240	240			195
	t :	0	140		235	0	130			210
stucken	f_0:	245			200	255				255
	t :	0			85	0				85
stegen	f_0:	260	185	180	195	255	270	255		210
	t :	0	120	200	280	0	105	165		270
skotten	f_0:	255	215		200	245	260			245
	t :	0	70		125	0	50			105
hagen	f_0:	230	245	165	185	230			250	190
	t :	0	30	210	290	0			120	275
backen	f_0[1]:	240	230		260	240	235	265		260
	t :	0	25		110	0	20	75		100

[1] measured on narrow-band sonagrams

F_0 tracings of tagen and tacken, accent 1 to the left, accent 2 to the right.

Jönköping.



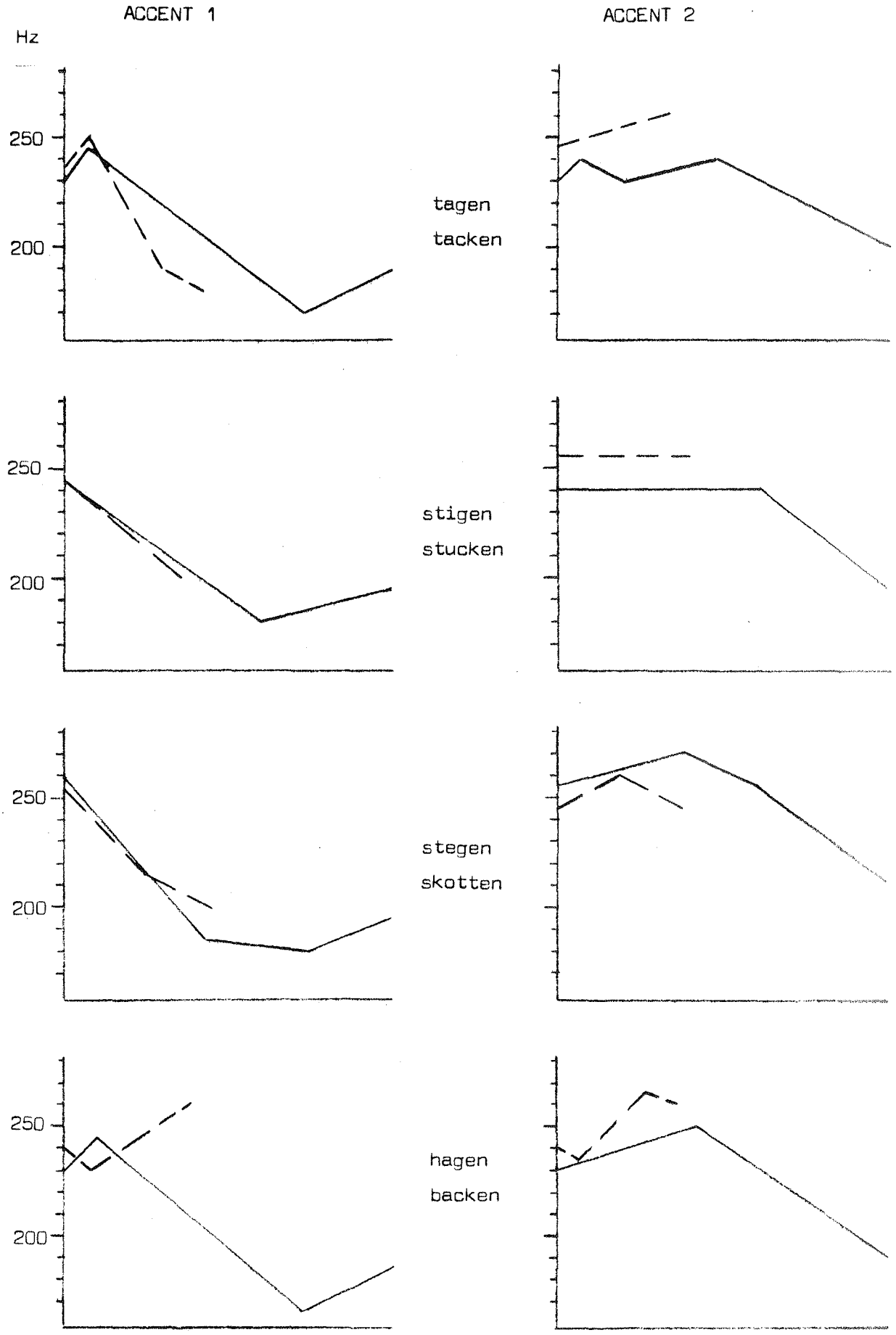


Figure 10. Simplified f_0 contours of the first vowel segment. Jönköping
The duration of the long vowels is normalized.

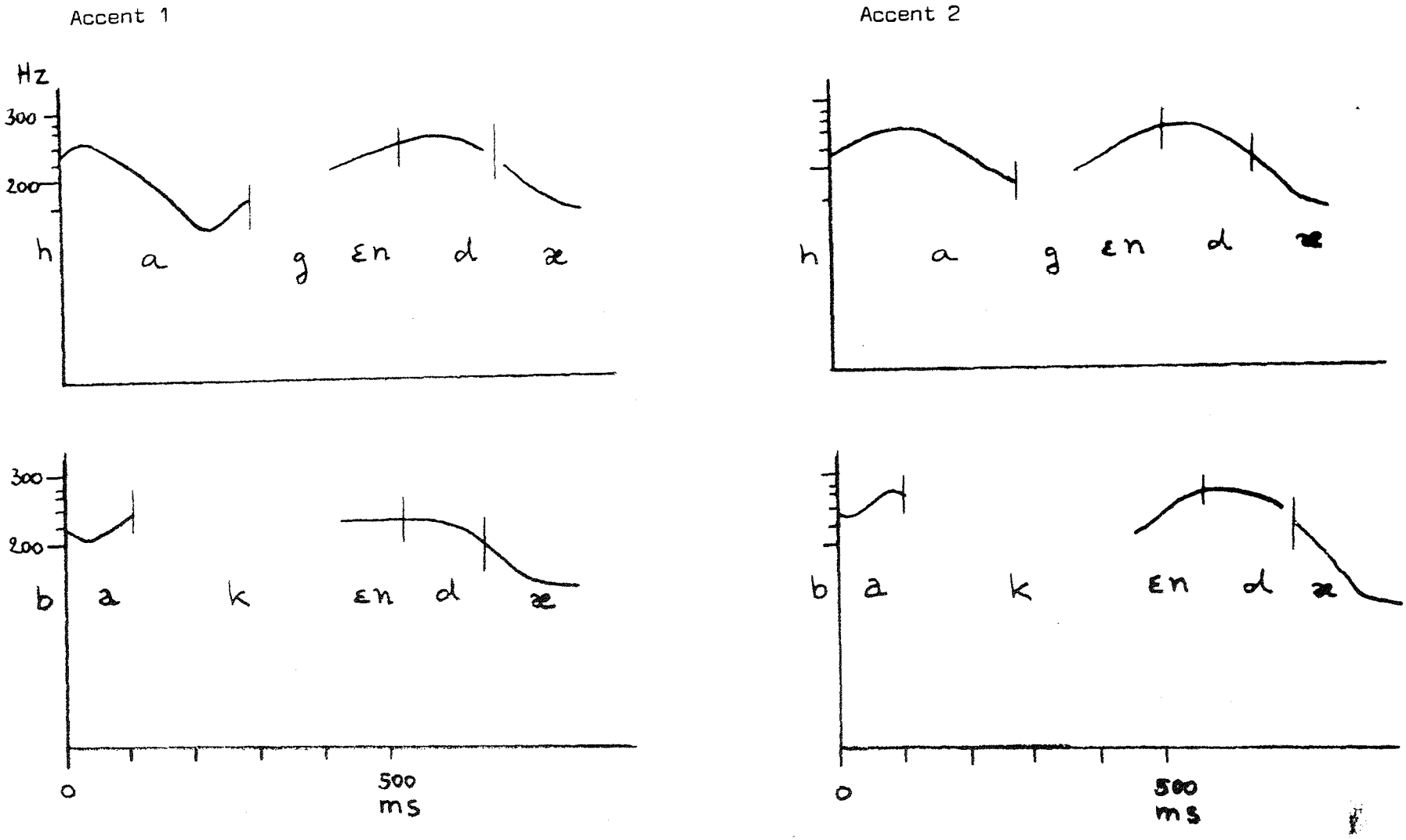


Figure 11. F_0 tracings of hagen (above) and backen (below), accent 1 to the left, accent 2 to the right. Jönköping informant

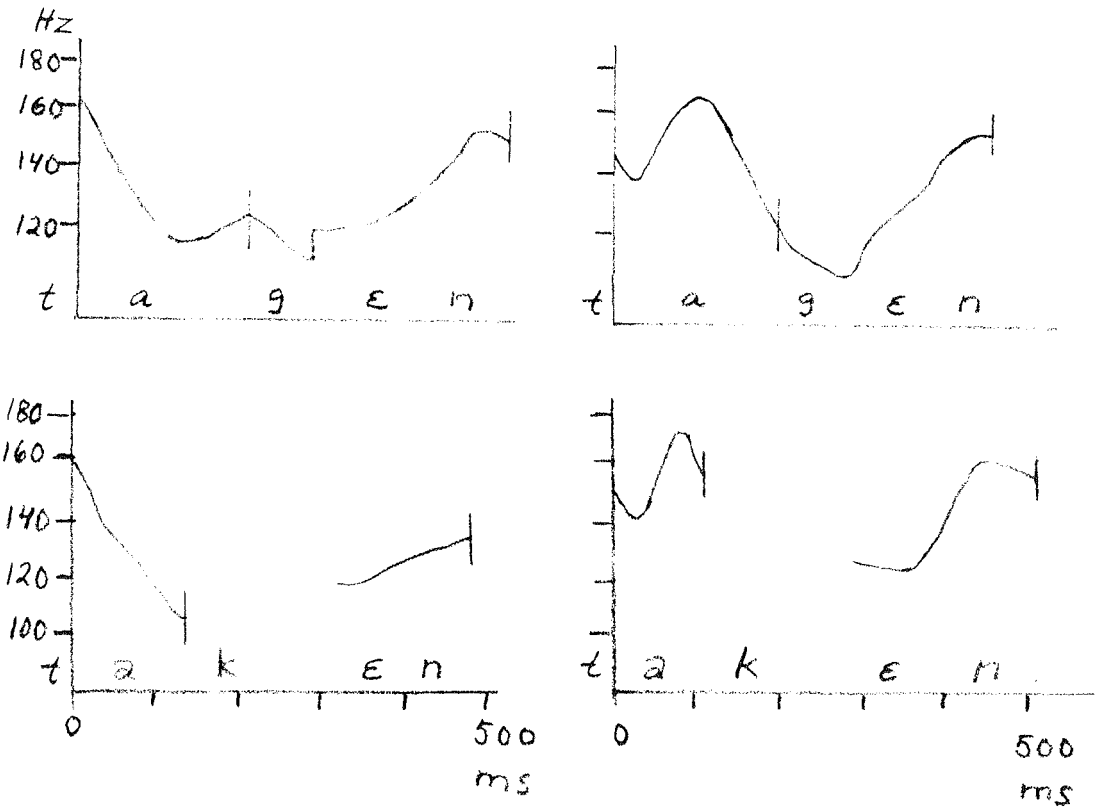
Table 8. RYD

F_0 values (in Hz) and durations (in msec).

		Accent 1			Accent 2			
tagen	f_0:	160	115	120	145	140	160	120
	t :	0	130	230	0	15	100	210
tacken	f_0:	160		115	150	140	170	155
	t :	0		130	0	25	85	110
stigen	f_0:	150		110	145		165	115
	t :	0		185	0		80	195
stucken	f_0:	160		115	150		165	155
	t :	0		100	0		60	90
stegen	f_0:	150	110	115	150	145	155	115
	t :	0	180	225	0	25	95	195
skotten	f_0:	165	135	120	155	145	160	155
	t :	0	50	115	0	35	80	100
hagen	f_0:	155	115	115	135		165	115
	t :	0	120	245	0		110	230
backen	f_0:	155	110	115	130	135	165	155
	t :	0	95	135	0	50	95	120

F_0 tracings of tagen and tacken, accent 1 to the left, accent 2 to the right.

Ryd.



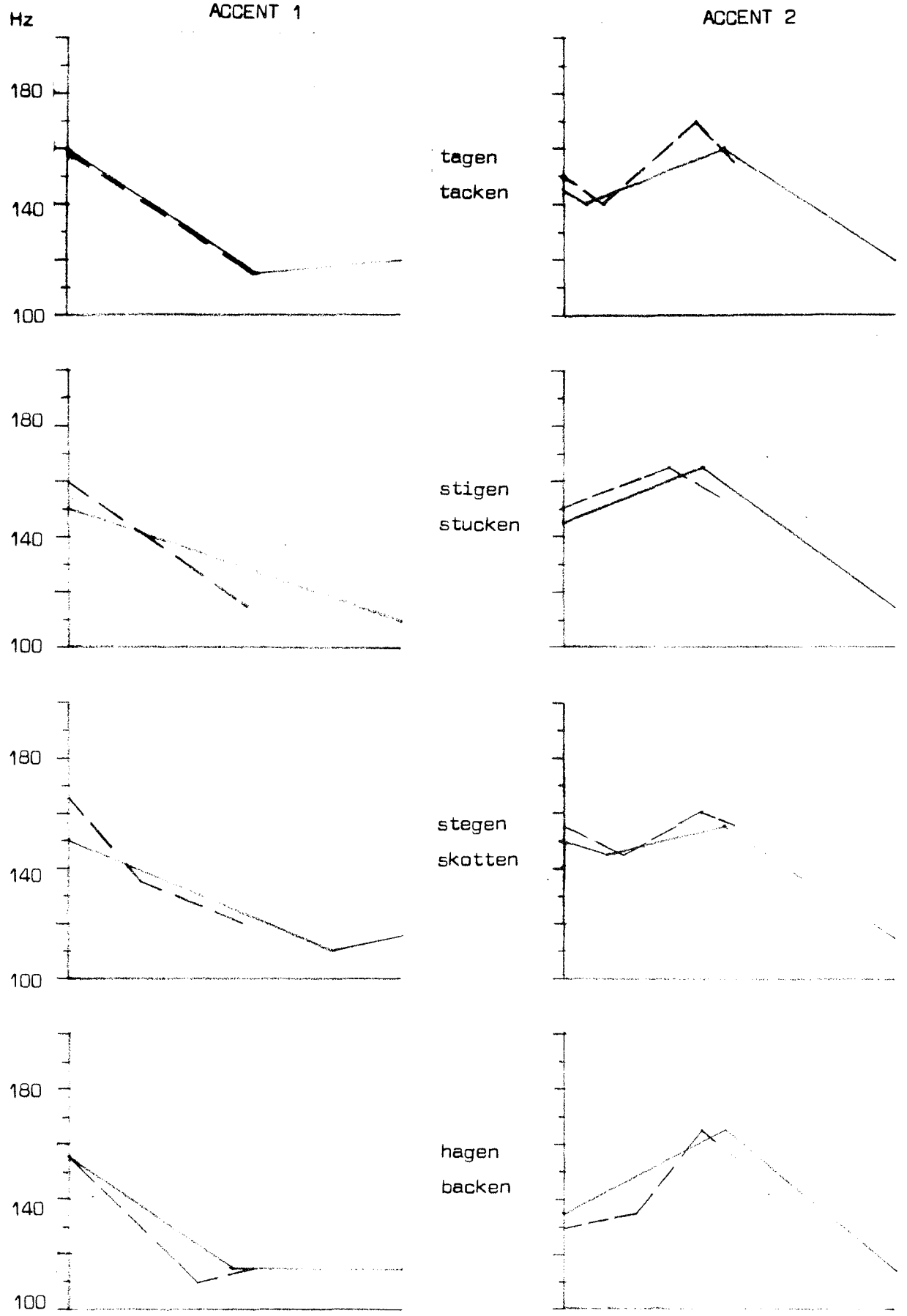


Figure 12. Simplified f_0 contours of the first vowel segment. RYD
The duration of the long vowels is normalized.
Dashed line: short vowel