

CONSTANCY AND VARIATION IN SWEDISH WORD ACCENT PATTERNS

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INTRODUCTION

0.1. Goals

The Scandinavian languages are famous for their word accents. In these languages a stressed syllable is connected with one of two accents usually called acute (Accent 1) and grave (Accent 2). Both accents occur in polysyllabic words but monosyllables can only have the acute accent. The great majority of the polysyllabic words have predictable accent. The rules that assign the correct accent to a word are morphologically and phonologically determined and apply rather uniformly to all Scandinavian languages. The phonetic manifestations of the accents, however, occur in a bewildering variety. In Norwegian and Swedish, every major dialect or group of dialects uses characteristic pitch patterns for the two accents and in Danish they are distinguished by the presence or absence of *stød* (a kind of glottal stop). This variation has intrigued generations of scholars and made the word accents one of the favourite themes of Scandinavian phonetics. Going through the literature of the past decades we do indeed find a large number of papers and dissertations that deal with the subject from various angles, for instance for Swedish:

Data collection and description, acoustic analysis: Fant (1954, 59), Malmberg (1959), Witting (1961, 68).

Perceptual aspects: Malmberg (1955, 67), Hadding (1961), Jassem (1963), Segerbäck (1966), Johansson (1970).

Aspects of speech recognition: Svensson (1971), Lindblom and Svensson (1973).

Physiological aspects: Öhman et al. (1967), Gårding et al. (1970), Lindqvist (1972).

Timing and coordination of speech signals: Öhman (1965), Eriksson and Alstermark (1972).

Models: Öhman (1967), Gårding (1970).

Programs for synthesis: Liljencrants (1971).

Linguistic analysis: Malmberg (1962), Elert (1964, 70, 71), Öhman (1966), Teleman (1969, 70), Lindau (1970), Linell (1972).

But in spite of all this activity it is not exaggerated to say that we lack a representative post-spectrograph collection of data that shows us how the tone accents behave in different kinds of speech in different parts of the country.

The primary goal of our project (from which this is the first report) is to supply a set of registrations of accents produced in systematically varied contexts by systematically chosen speakers.

There are a large number of questions that we want to ask this material. For instance:

1. Is it possible to set up reasonable rules by which we can generate all the observed contours for a given speaker?
2. Can we make these rules general enough to fit all the speakers of a given dialect?

And the most ambitious question:

3. Given a set of rules for different dialects, can we write the rules in such a way that they fit the whole language area and bring out similarities and dissimilarities satisfactorily?

The last question is treated in the third chapter, entitled Form by Substance. This elliptic phrase also recalls what we regard as an essential theme in the works and teaching of Bertil Malmberg. We dedicate our paper to him on the occasion of his sixtieth birthday.

0.2. Outline

Chapter 1 contains the preliminaries to our work. For the benefit of the reader who is not familiar with the Scandinavian languages we have collected some of the most important facts about the word accents in Section 1.1.

The manifestation rules that the presentation of our new accent data is leading up to will be given in terms of an analysis of Swedish accents which developed from a critical study of Öhman's work on intonation (Öhman 1967, Gårding 1970). Öhman's original model and the revised model will be summarized in 1.2. The choice of dialects and speakers was motivated by a study of Meyer's Intonation im Schwedischen with its collection of word accent data from the whole Scandinavian language area (1.3.). Our selection of speech material will be presented in 1.4. Measurements and their acoustic and physiological background will be treated in 1.5.

Chapter 2, Accent manifestations, contains our new data, their description and interpretation in the following order:

2.1 Stockholm

2.2 Skåne

2.3 Gotland

2.4 Västergötland

Chapter 3, Form by substance, will summarize similarities and dissimilarities in the word accent data presented in Chapter 2. Tentative general rules will be set up.

0.3. Prosodic analysis and terminology

Our prosodic transcription of Swedish words uses length for vowels, three degrees of stress (primary, secondary and no stress) and the grave accent. The grave accent can only occur in connection with primary stress. In accordance with common usage, primary stress, which has not the grave

accent, will be called the acute accent. The following symbols are used: /˙/ for the acute accent (primary stress), /˘/ for the grave accent. Secondary stress is marked by a vertical accent mark on the line /,/. The position of the accent symbols shows the onset of the stressed syllable.

To obtain simple rules that generate fundamental frequency contours for utterances of varying segmental composition, we need the syllable as a reference unit. Hence the location of the syllable boundaries becomes important. The syllabification used in the sequences of our material agrees with earlier analyses (e.g. Gårding 1967, Ch.1 and 1971). A stressed syllable in non-final position has the structure ...V:- or ...VC-.

In certain cases, e.g. for Skåne acute, the morpheme may be a more adequate reference unit than the syllable (see 2.2).

Another reference unit which has been found useful in the rules for a certain dialect (Västergötland) is the mora. According to our analysis a stressed vowel counts two morae and an unstressed syllable one mora in non-final position. For examples of our morphological analysis, transcription, and syllabification, see Table 1.1.

We should like to emphasize that we regard our analysis as preliminary.

1.1. Some facts about the accents

The accents will be described in relation to other prosodic features, morphological structure and juncture. Some examples are presented in Table 1.1.

A simple word has one stressed syllable. Length can only occur with stress. Compounds and derivatives may have two stressed syllables, here analysed as primary and secondary. The grave accent is always combined with primary stress. Other primary stresses are called acute accents. The great majority of Swedish words are stressed on the first syllable. A considerable number of polysyllabic words have stress on the second syllable and there are many tetrasyllabics with stress on the third. French loans (of recent date) are stressed finally.

The acute accent can occur in any syllable irrespective of the word boundary, but the grave accent never occurs in the last and has a strong predilection for the first. All monosyllabics carry the acute accent. An overwhelming majority of initially stressed bisyllabics have the grave accent.

Monosyllabic roots have the acute accent in accordance with the phonological rule stated above. Bisyllabic roots with stress on the first syllable may have either of the two accents. A great number of unstressed inflectional suffixes (e.g. plural suffixes for nouns, the past tense suffix etc.) require the grave accent in the preceding root. Hence a root morpheme with the acute accent as a free stressed form will have the grave accent when combined with these suffixes. Examples are found under (4), Table 1.1.

A small number of unstressed inflexional suffixes do not change

the accent of the root morpheme. A statistically very important group here is the definite suffix for nouns (Examples under [3]). Compounds and derivatives usually have the grave accent (Example [6]).

A knowledge of the morphological structure of the words makes it possible to predict the distribution of the accents for a large part of the vocabulary. (For a discussion of various solutions to these problems in the framework of generative grammar, see Linell 1972.) There are about 350 so called minimal pairs but the morphological structure of the members of a pair differs in most cases (Elert 1971).

A great deal of discussion has been devoted to the surface manifestations of the accents and their alleged dynamic or tonal character has been a moot question in the phonetic discussion and literature (e.g. Gjerdman 1952, 54, Malmberg 1953, 55, 59).

The notation of the Dictionary of the Swedish Academy (acute: $\overset{4}{\underset{0}{\text{anden}}}$, grave: $\overset{3}{\underset{2}{\text{anden}}}$) implies an interpretation of the different manifestations of the accents as a difference in stress distribution.

The accents are not marked by the orthography. Native speakers normally do not make any accent mistakes. As a rule interdialectal understanding is not hampered by a lack of the accent distinction in one of the interlocutors (as may be the case when a Swede talks to a Swedish speaking person from Finland). A dialectal difference in pitch pattern is of course noticed but does not impede communication (see discussion in Malmberg 1955 and 1962). Differences in pitch patterns are in fact less striking to a native speaker than differences in distribution rules. There are some categories of words that are assigned different accents depending on the dialect.

Foreigners have great difficulty in mastering the accents. This holds for pronunciation as well as rules. The grave accent is often mistaken for a word stressed on a later syllable. The rendering of French oxytones

Table 1.1. Categories of words carrying the acute or grave accent

Acute (Accent 1)		Grave (Accent 2)						
	conventional spelling	phonetic transcription with syllabification	morphological structure	translation	conventional spelling	phonetic transcription with syllabification	morphological structure	translation
(1)	and	[ˈand]	(and)	duck	(2) ande	[ˈan-dɛ]	(and)(e)	spirit
	Polen	[ˈpo:-lɛn]	(po:lɛn)	Poland	påle	[ˈpo:-lɛ]	(po:l)(e)	pole
	café	[kaˈfe:]	(kafe:)	coffee-shop	ända	[ˈɛn-da]	(ɛnd)(a)	end
(3)	anden	[ˈan-dɛn]	(and)(n)	the duck	russin	[ˈrus-sin]	(rusin)	raisin
	änder	[ˈɛn-dər]	(ɛnd)(r)	ducks	pélar	[ˈpo:-lar]	(po:l)(e)(ar)	poles
	änderna	[ˈɛn-dɔ(r)-na]	(ɛnd)(r)(n)(a)	the ducks	ändor	[ˈɛn-dɔr]	(ɛnd)(a)(or)	ends
(5)	tisdag	[ˈti:s,da(g)]	(ti:s)(da:g)	Tuesday	(6) badrum	[ˈba:d,rum]	(ba:d)(rum)	bathroom

(early loans) in Swedish as grave accents shows that there is more similarity between these categories than between oxytones and the acute accent. Example under (2).

1.2. Models

Öhman (1967) used a very suggestive and inspiring intonation model to analyse and generate the pitch curves of various dialects in statement intonation. The components of his model are stepfunctions, which represent the on- and offset of nerve signals. Generally speaking, the model transforms these stepfunctions to pitch curves by a physically and physiologically motivated smoothing procedure. There are two linguistic elements in his treatment of Swedish, tone accents and sentence intonation. Tone accents (acute and grave) are generated as negative pulses, superimposed on a positive step which represents sentence intonation. By timing the pulse in various ways in relation to the step, Öhman obtained the configurations that he needed to approximate tone accents in different dialects. According to Öhman's model then, dialectal variation is the result of a difference in timing between the pulse and the step. The acute accent of one dialect (e.g. Stockholm) may have the same time order between the pulse and the step as the grave accent in some other dialect (e.g. Skåne). Öhman tried to correlate the negative pulse to some activity pattern in the vocalis and cricothyroid muscles with pitch inhibiting effect. An EMG investigation with probes into these muscles failed to support his hypothesis, however (Öhman et al. 1967).

A revised model was suggested by Gårding (1970). According to this model the fundamental frequency of a Swedish utterance is the combined result of responses to sentence intonation, stress and one tone accent. It has some support in an EMG investigation (Gårding et al. 1970) which showed that similar activities - pulses - were found in two pitch

controlling muscles (m. vocalis and m. cricothyroideus) both in connection with falls and with rises. Whether a syllable has rising or falling pitch may depend on how it is timed in relation to these pulses. In the two speakers and the speech material used for the EMG investigation, no need was felt for a special pitch-inhibiting or pitch lowering mechanism in connection with the tone accents. A fall could be explained as a consequence of a relaxation of muscles that had been activated earlier. All the pitch movements, then, could be regarded as the result of differently timed positive pulses. The revised model has also support in the pitch curves collected by Meyer. From what can be seen in his data (cf. Fig. 1.1), a common feature of the grave accented words in the great majority of the dialects was that in the later parts of their contours the grave words repeated the pitch movement of the acute ones. This repeated part was interpreted as a "delayed sentence intonation" (Gårding 1970 p. 42). A similar view had been advanced by Haugen (Haugen and Joos 1954).

The new data to be presented in Chapter 2 makes it possible to develop this model a bit further.

1.3. Dialects

According to the analysis of the tone accent data made by Meyer (1937 and 1954), the so-called Svea dialects (Central Sweden) exhibit two kinds of intonation, Svea intonation proper and the Mining district intonation (Bergslagen). Meyer uses slightly schematized pitch curves of bisyllabic words with contrastive accents to show the difference between these two dialectal types. In the Svea intonation, the acute accent has a peak towards the end of the first syllable and the grave accent has a peak in the second syllable which is preceded by a fall in the first syllable. The accents of the Mining district have one peak each but

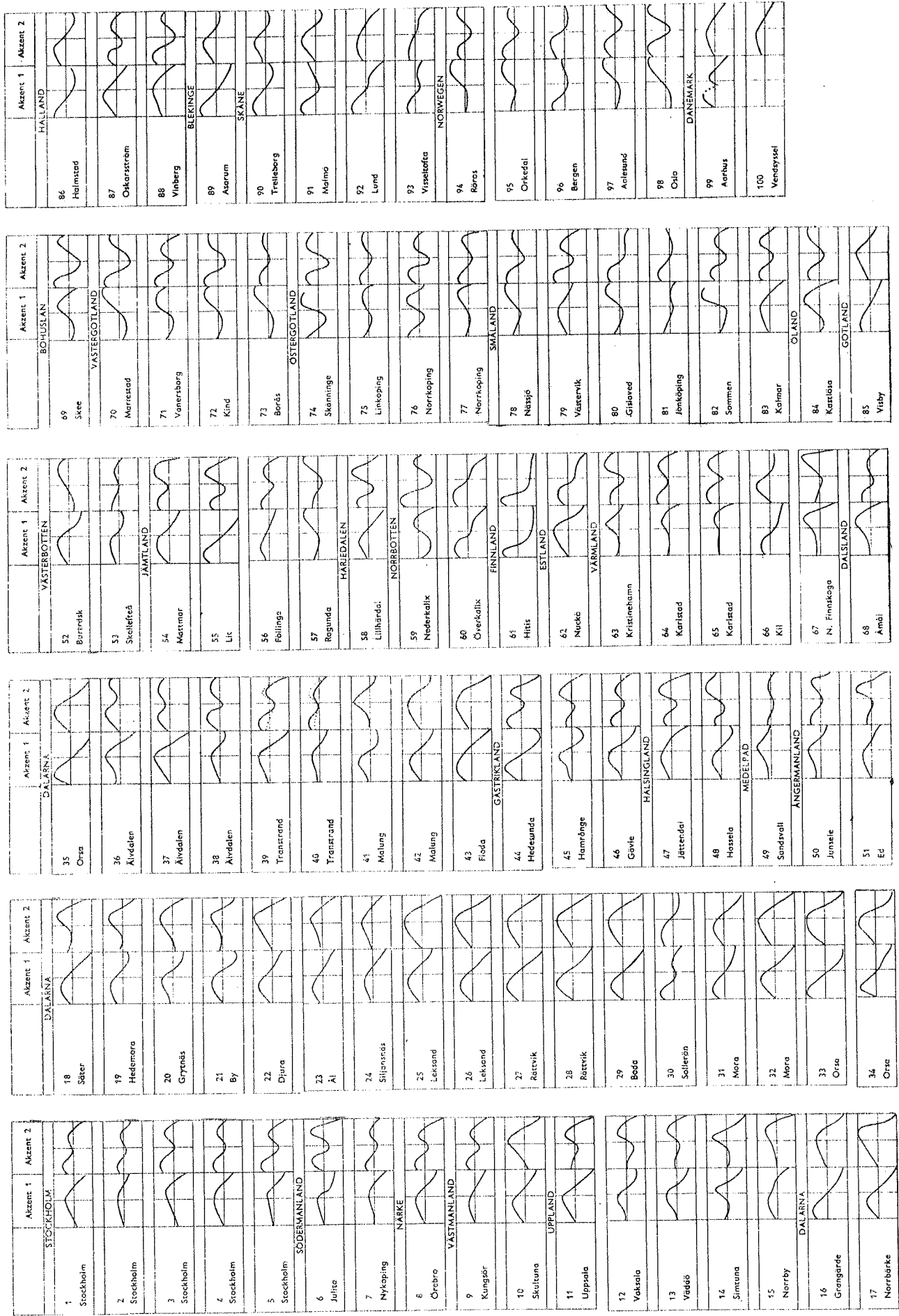


Figure 1.1. Schematic acute and grave pitch patterns of a hundred Scandinavian dialects according to E.A. Meyer: Die Intonation im Schwedischen, part II. From Ohman 1967.

the peak comes later in the grave words. In Part I, which deals with the Svea dialects, Meyer also mentions in passing a third type of intonation common to the Göta dialects (between Southern and Central Sweden). By a systematic treatment of Swedish intonation and tone accent variation Meyer made an essential contribution to Scandinavian dialectology. Part II which deals with the dialects of the north was edited posthumously. It has no summary or analysis of the data, but concludes with a collection of pitch curves representing all the different dialects investigated by Meyer. Figure 1.1 which gives an idea of the pitch variation connected with the Scandinavian accents uses Meyer's data collected in Part II.

The criteria that were used by Meyer for a characterization of the Svea and Mining district dialects can also be used for the rest of his material. The following table shows a tentative tonal typology based on Meyer's material of bisyllabics.

Table 1.2. Tentative tonal typology for accents in Swedish dialects

	Accent 1	Accent 2	Region
Type 0	one peak In the stressed syllable No distinctive difference	one peak In the stressed syllable	Isolated marginal cases in the far North, Finland
Type 1	one peak	one peak	
Type 1A	Early in the stressed syllable	Late in the stressed syllable	South (former Danish provinces)
Type 1B	Late in the stressed syllable	Early in the post-tonic syllable	Gotland (in the Baltic), Dalecarlia
Type 2	one peak	two peaks	
Type 2A	In the stressed syllable	One in each syllable	Central Sweden (Svea dialects)
Type 2B	In the posttonic syllable	One in each syllable	Between Southern and Central Sweden (Göta dialects)

Type 0 is represented by the dialects that do not possess a tone accent contrast: Swedish dialects in Finland, and dialects in the north of Sweden.

Type 1A is represented by dialects in the South of Sweden (numbers 90-92 in Fig. 1.1). Dialects in Dalecarlia (Central Sweden) and Gotland are examples of Type 1B (number 16-29, 85).

Type 2A contains by far the most common patterns. Dialects in Halland (87, 88), in East Småland (79, 83), and Central Swedish dialects (1-9, 44-48) belong to this type. The Göta dialects (Västergötland and Östergötland), Bohuslän, Dalsland, and Värmland are representatives of 2B (63-77, 94, 95, 97, 98).

Figure 1.2 presents a tonal dialect map for Sweden which has been made in collaboration with Benson, following principles developed at the Dialect Archives at Lund University. (For other applications of these principles, see Benson 1958 and 1970). A symbol in the map refers to our interpretation of Meyer's data. The accent typology has later been extended to embrace all Scandinavia (Gårding 1973).

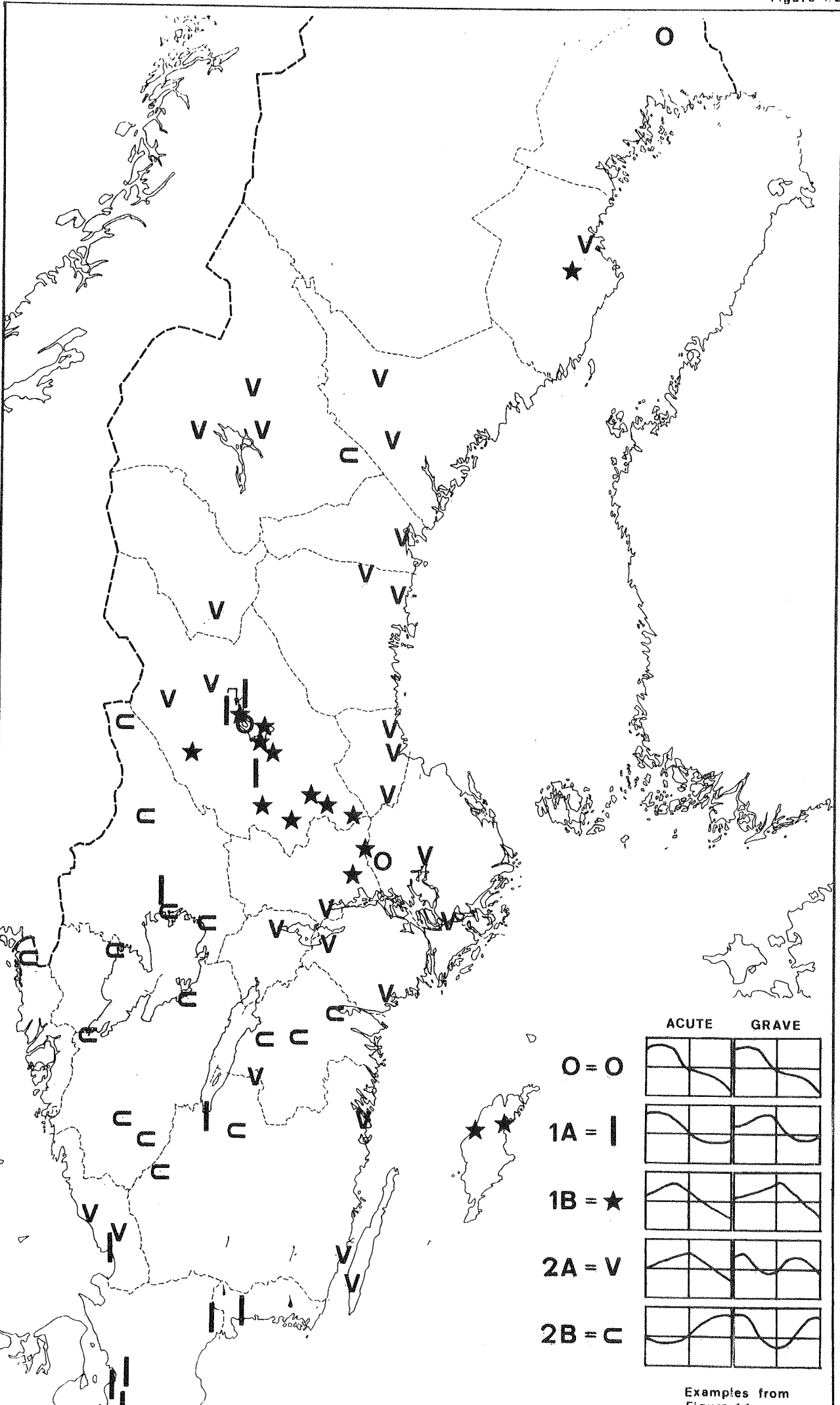
The four tonal types of contrastive accents found in Meyer's material motivated the choice of speakers for our investigation.

1A	Skåne	Speakers EG, PL
1B	Gotland	Speakers ALa, TS
2A	Stockholm	Speakers CS, CÖ
2B	Västergötland	Speakers JA, ALö

For further information about our speakers see Appendix 1.

1.4. Material

The core of our material consists of Swedish words of one, two, three, and four syllables with stress on the first. About one half of the words carry the acute accent, the other half the grave accent. The words are



listed in Appendix 2. In the list there are several minimal pairs of varying phonetic shapes where the two members are contrasted by accent, e.g. Polen [ˈpo:lɛn], pålen [ˈpo:lɛn], änderna [ɛndəna], ändorna [ɛndəna].* These pairs and the monosyllabic Pål [ˈpo:l] will receive special attention. The fact that the members of the two pairs are spelled differently turned out to be a great asset. Helped by the spelling the speakers gave more consistent responses to these test items than to the other ones. Part of our test words are compounds. They will not be treated in this report. There are a few nonsense words in our list. These words could not be used with non-linguist speakers and even with phoneticians they tended to create confusion. We also tried to make our speakers produce nonsense words of four syllables contrasted by accent but with limited success.

The test words appear both isolated as utterances and embedded in a carrier sentence in four different contexts, namely as neutral and emphatic statements and as neutral and emphatic questions. Every word then appears eight times in a regular test situation.

For statements the frame jag såg - där (I saw - there) was used with the test word in stressed position. To make the frame natural for questions, the word order and the pronoun had to be changed: såg du - där (did you see - there). The stress conditions were the same as for statements.

To secure the elicitation of intonation patterns that had about the same attitudinal meaning for various speakers, a situational context was described on the test sheet for each of the four prosodic series.

These descriptions were as follows:

Neutral statements: With frame: "Imagine that you are saying the following sentences as neutral pieces of information". Without frame: "The sentences are meant to be answers to questions like, Who is coming? What did you see?"

* In the last word the pronunciation of the second vowel varies, [ɔ], [u], [ø].

Emphatic statements. For each sentence a contrasting clause was added in brackets on the test sheet, for instance, Jag såg Pål där (but not Per).

Neutral questions. With frame: "Ask the questions with a moderate degree of interest". Without frame: "You think you have heard the test word but you ask to be on the safe side".

Emphatic questions. A contrasting clause was added as above. "Did you see Pål there?" (not Per).

Up till now we have made recordings with eight subjects, each dialectal area being represented by two speakers (Appendix 1). A recording session was preceded by a short training period. The training lasted until the speakers felt secure and at ease and knew what prosodic pattern they were going to use for a certain situation. It was often difficult to get emphatic responses, particularly from those speakers who were not used to our laboratory. An additional complication is of course that emphasis is a graded expression for a graded feeling. There seem to be two prosodic extremes for emphasis. Judged by the pitch curve, one is just slightly different from the unemphatic contour. The other uses low pitch for the frame and spreads the direction changing movements of the contour over the emphasized word. The two extremes can perhaps be transcribed and their fundamental frequency curves schematized as follows.

Neutral

¹jaso:po:ldε:r¹



jaso:po:ldε:r

Low emphasis

¹jaso:po:ldε:r¹



jaso:po:ldε:r

High emphasis

¹jaso:|¹po:l|³ldε:r¹



jaso:po:ldε:r

The vertical lines in the transcription of the highly emphatic sentence indicate a slowing down of tempo in connection with the main stress

(phrase juncture). Judged according to the given scale our speakers have generally used low emphasis.

The recordings were made in the studio of the Phonetics Institute in Lund. The equipment is a Studer tape recorder (tape speed 7 1/2 inch/sec.).

After a recording session the tape was checked for acceptancy by the speaker and the investigators. The following acoustic records have been used:

Fundamental frequency curves, duplex oscillograms and intensity curves, obtained by a Fonema phonetic analysis assembly and a Mingograph 34 T. Wide and narrow band spectrograms obtained by a Sonagraph PV-10 (Voice-print Laboratories).

1.5. Measurements

It is customary to look for the influence of prosodic factors on the speech wave in the behaviour of the fundamental frequency (F_0), and of the intensity, and in the duration and spectral character of the acoustic segments. The acoustic records of our material permit us to study the effect on these parameters of systematic changes in stress, accent, and sentence intonation.

Segmentation and duration of segment. The segmentation was made by means of the spectrograms and duplex oscillograms. In addition to the usual acoustic segments - approximately corresponding to phonemes - the voiced segments were divided into subsegments if they contained local fundamental frequency maxima or minima. The durations of the acoustic segments and subsegments are given in Appendix 3.

Fundamental frequency curves. A fundamental frequency curve (pitch curve for short) is described by the position of its local maxima (peaks) and minima (valleys) in relation to the acoustic segments and to the frequency

scale. Minor inflections in the curves that can be referred to articulatory movements - articulatory ripple - will not be regarded as peaks or valleys.

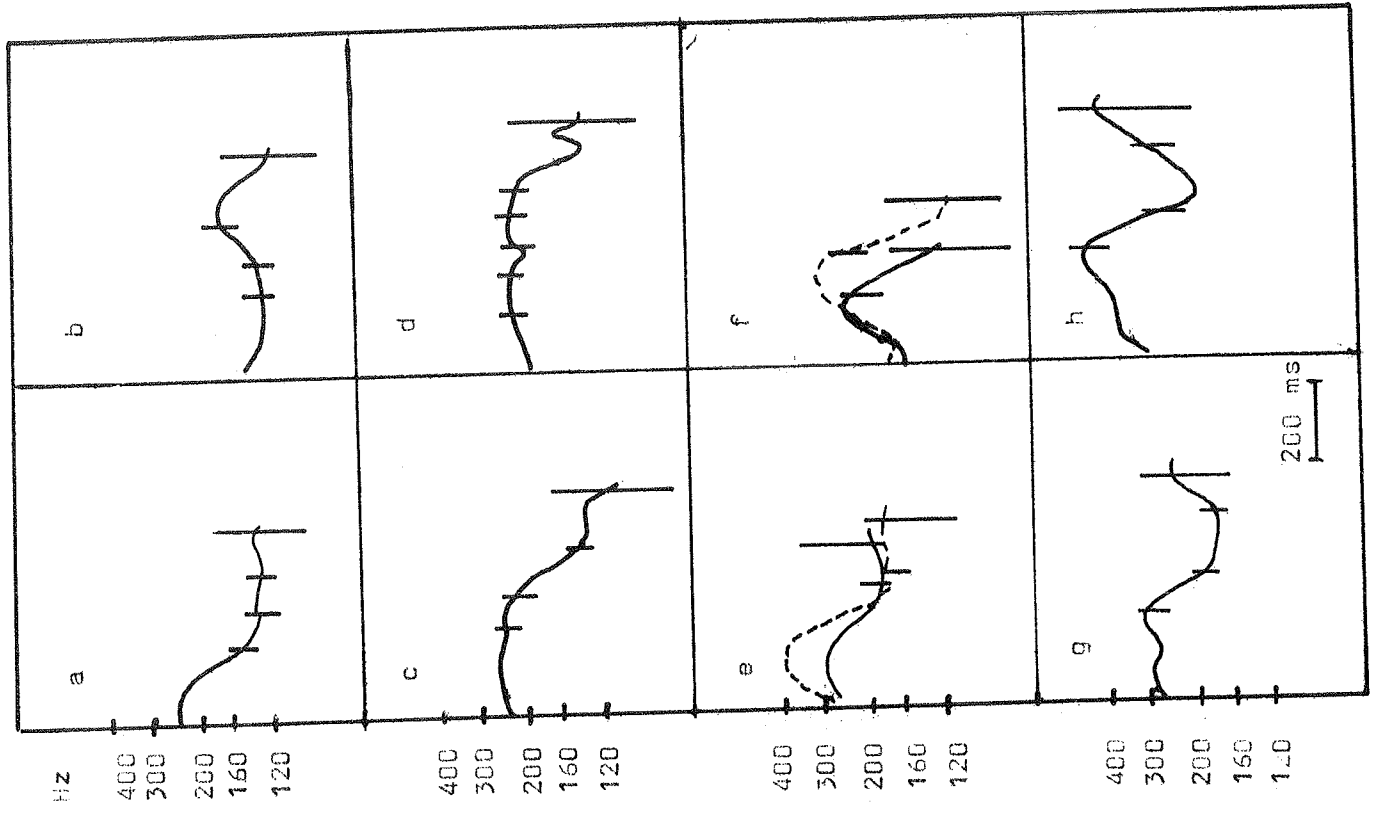
Figure 1.3 shows examples of typical maxima and minima. The mainly falling contours in 1.3.a has a peak in connection with the stressed syllable and the mainly rising contour in 1.3.b has a valley in the corresponding syllable. Since we want our acoustic measurements to be physiologically relevant, we are particularly interested in the timing of the rises and falls that constitute these peaks and valleys.

We shall also consider the shape of the peaks and valleys. Some peaks are more adequately described as plateaus. See for instance Figure 1.3, c and d.

A comparison of the peaks that occur in neutral and emphatic speech shows that for some speakers a higher peak seems to be reached by means of a faster movement, in other cases no change of rate is noticeable in the curve. Instead the peak has been pushed forward to a later time in the acoustic segment in which it occurs. Figure 1.3, e and f, shows two examples of these phenomena, which will be discussed in a later report.

Articulatory ripple. Apart from the well known minor dips in F_0 caused by voiced obstruents, we have also found local deviations in the curves which may be connected with the diphthongisation of the vowel [o:] peculiar to the Gotland dialect (Fig. 1.3, g and h).

Normalisation of the curves. For a comparison of different contours, speakers and dialects, it is necessary that we can also express our data in relative terms. For a given speaker then we need to know his ordinary range of pitch, his high and low etc. To this purpose we used the following method. For one speaker we plotted curves from the five selected testwords under the four selected prosodic situations (20



a) EG, Skåne

Polen, neutral statement

b) ALö, Västergötland

Polen, neutral statement

c) CS, Stockholm

Polen, emphatic statement

d) CS, Stockholm

änderna, neutral statement

e) ALa, Gotland

Pål, neutral (—) and
emphatic (---) statement

f) ALö, Västergötland

Pål, neutral (—) and
emphatic (---) question

g) ALa, Gotland

Polen, neutral statement

h) ALa, Gotland

Polen, emphatic question

Figure 1.3. Examples of measurements. See text 1.5.

curves in all) on top of each other. We did this in two graphs first with the beginning and then with the end of the utterances as a common time reference. Figure 1.4 shows the result of this procedure.

We notice, most clearly in the curves that have been lined up according to the beginning of phonation, that the pitch curves seem to start from a common point or locus on the frequency scale. It is natural to assume that this point represents the laryngeal state prevailing when the vocal folds are in adducted position and the subglottal pressure is built up in expectancy of the phonation to start.

In the curves that have been plotted with the time reference at the end of the utterances, we notice a similar phenomenon. Some of the curves have rising pitch but we shall now only consider the falling ones. We notice that the falling curves are well assembled and converge towards a common point on the pitch scale. This point is interpreted as representing the typical neutral laryngeal state at the end of an utterance. This ending point is somewhat lower than the neutral starting point, which may be explained by the lowered subglottal pressure, caused by the diminished supply of pulmonary air at the end of the utterance.

Combining these hypothetical beginning and ending points of the pitch curves for one speaker by a straight line we get an axis that shows the general downward drift of sentence intonation in a falling contour. The shape of a contour can now be described as peaks (maxima) above and valleys (minima) below this axis. We notice that the peaks seem to favour two high levels on the frequency scale in this kind of speech. (Compare the measurements in Appendix 3.)* These levels will be referred to as mid and high. The level below the neutral axis at which many of the curves turn upwards will be called low.

There is a great deal of discussion of the mechanisms behind these

* A similar method was used in a comparison of Swedish and English intonation patterns (Gårding 1960).

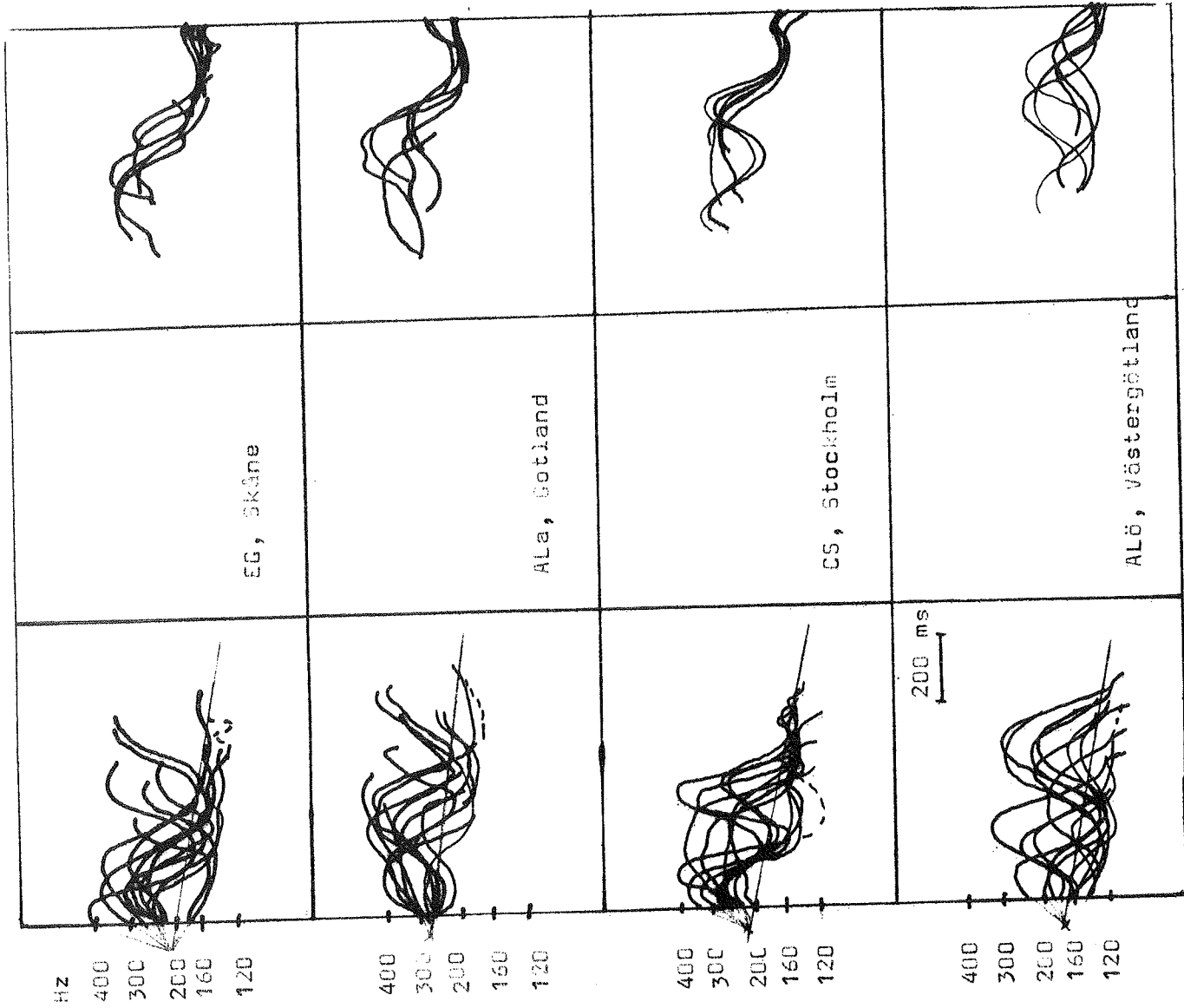


Figure 1.4. Normalisation of the F_0 curves. See text 1.5.

lows at the present time (Lindqvist 1972, Harris 1970, and Sawashima 1970). Pitch lowering is much less well understood than pitch rising. It has not been possible to correlate pitch lowering to the activity of any particular intrinsic muscle. Disregarding ripple, pitch falls may of course have several causes: A relaxation of tensor muscles that have been activated earlier, a fall in the subglottal pressure, a downward movement of the larynx by means of the extrinsic muscles. (See e.g. Sonninen 1968.) With the neutral axis drawn according to the method presented in Figure 1.4, the fall hardly seems impressive enough to call for a pitch lowering muscle. Anyway, we shall be particularly interested in the effect on lows or valleys in the pitch curves of different degrees of stress and different accents.

Chapter 2

ACCENT MANIFESTATIONS

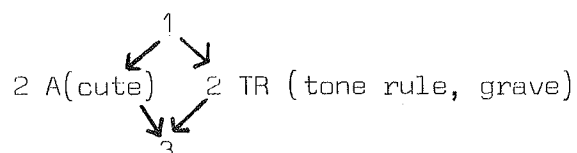
Figures 2.1.1, 2.2.1, 2.3.1, 2.4.1 show the pitch curves that have been traced from the mingograms of five words uttered by eight subjects in four different prosodic situations (prosodies), namely as neutral and emphatic statements and as neutral and emphatic questions. Going from top to bottom of a figure, the effect of a change in one of the prosodic variables can be studied in the fundamental frequency curve. Horizontally the utterances vary in phonological structure. The utterances are Pål [ˈpo:l], Polen [ˈpo:lɛn], pålen [ˈpo:lɛn], änderna [ɛndəna], ändorna [ˈɛndəna]. (For morphological structure syllabification and translation see Table 1.1.)

The data will be treated in the following order:

- | | | |
|-----|---------------|------------------|
| 2.1 | Stockholm | Speakers CS, CÖ |
| 2.2 | Skåne | Speakers EG, PL |
| 2.3 | Gotland | Speakers ALa, TS |
| 2.4 | Västergötland | Speakers ALö, JA |

Data from all our speakers have been analysed in the same way but we have chosen one speaker from each dialect as the prototype (the first mentioned in the list above). The intradialectal differences will be analysed more systematically later.

For each speaker we shall give a general description of the pitch curves that represent the four selected prosodies. After each prosody we shall summarize our observations by giving them the form of a set of rules to a fictitious vocoder which is supposed to generate the pitch curves under observation. The rules are flow diagrams of the following type:



The input to our rules is: Phrases consisting of one to four syllables. Needed information: Acoustic segments, syllable boundaries, location of terminal juncture, location of stressed syllable, accent (grave or not), type of stress (emphasis or not), sentence intonation (question or not).

Rule 1 assigns the correct pitch curve to the last syllable. It gives the terminal pitch characteristics to the contour which at the same time show the general direction of the sentence intonation. Rules 2 A and 2 TR give pitch to the stressed syllable and represent the fundamental frequency response wanted for the two accents. Rule 3 is an automatic join rule that completes the utterance. It fills in the pitch of the part of the utterance that is between the stressed syllable and the final one. Rule 3 makes it possible to handle tri- and tetrasyllabic utterances.

It should be noted that a later rule cannot change the F_0 curve assigned by an earlier.

*

Our analysis is still on the descriptive side and our generative rules are descriptive and "output oriented" rather than analytical. What we do here and in the next chapter is preliminary work preparing for a stricter analysis in terms of the revised Öhman model where pitch is generated by smoothing stepfunctions.

2.1 Speaker CS, Stockholm

Neutral statements

Figure 2.1.1 shows that all the five utterances with statement intonation end in a fall from mid to neutral pitch level. The fall starts at the beginning of the vocalic segment of the last syllable and reaches neutral at the end of the same segment.

All utterances except one end with hook-like local maxima of short

duration. When the last consonant is l or n, it levels off a preceding fall. These effects will be disregarded in the rules.

The timing of the fall is clearly determined by the end of the utterance. In the bisyllabic words there is some evidence of a slight delay (~40 msec) in the fall of the grave accented words as compared to the acute ones. The fall rate is related to the duration of the vowel segment in which it occurs. The shorter the vowel the faster the fall. The shape of the pitch curve before the final fall is determined by accent and number of syllables. Common to all the neutral statements is that mid level is reached during the stressed syllable.

For the acute accent there is no change of level until the final fall begins. The location of the peak in the stressed syllable of the acute words depends on the number of syllables in the word. In the monosyllabic words the peak occurs earlier than in the polysyllabic ones. This difference can be interpreted in the following way.

Let us suppose that the location of the acute peak is determined by the command "late in the stressed syllable" and that the neutral statement requires a final fall of a certain duration. In polysyllabics these two requirements do not interfere with each other. Both can be fulfilled. In a monosyllabic, however, the final fall requires an early peak and there is a conflict. Speaker CS resolves this conflict by giving the upper hand to the early peak command (i.e. the sentence intonation).

The acute statement contours can be generated by the following rules:

1. Give the vocalic segment of the last syllable falling fundamental frequency from mid to neutral.
2. Reach mid level late in the stressed syllable (in V in ...V: - syllables and in C in ...VC - syllables).
3. Reach the mid level of the last syllable by the shortest way possible.

If the rules are applied in this order, the monosyllabic utterances

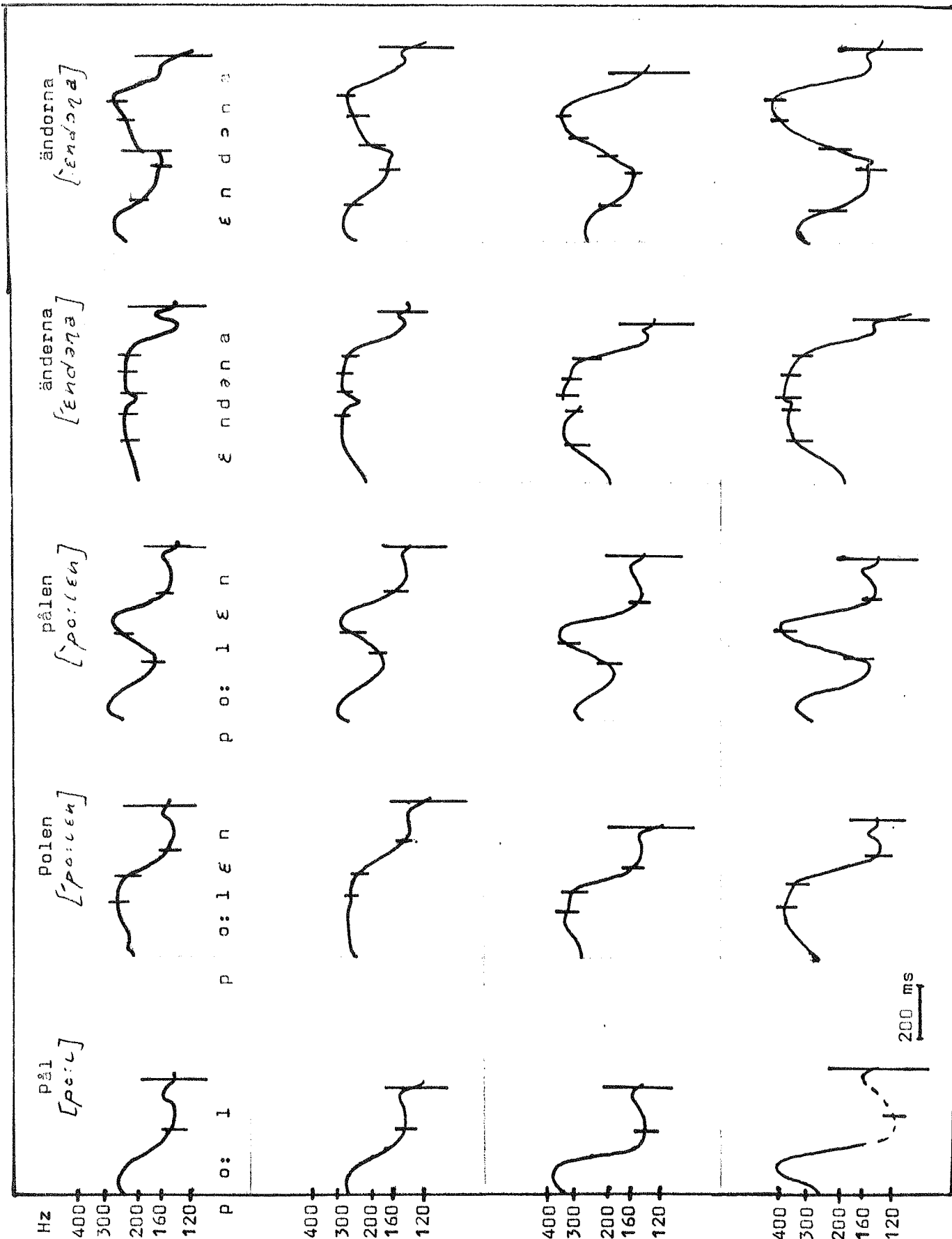


Figure 2.1.1. Acute and grave accents under various prosodies. Speaker: CS, Stockholm. F₀ curves traced from mingograms.

will get a final fall and the peak will get its right position compared to the polysyllabic utterances.

For the grave accented words mid level is reached early in the stressed vocalic segment. The curve falls immediately and reaches neutral level at the end of the syllable (that is in V in ...V:- and in C in ...VC-). From there it rises at once until it reaches the last vocalic segment where the final fall begins. The rate of the rise depends on the number of intervening syllables.

The grave statement contours can be generated by the following rules:

1. Give the vocalic segment of the last syllable falling fundamental frequency from mid to neutral. (The rule is identical with Rule 1 for acute words, but we have to remember a slight difference in the timing of the peak that precedes the fall in the last syllable.)
2. Reach mid level in the stressed syllable as early as possible and fall to neutral.
3. Reach the mid level of the last syllable by the shortest way possible.

A comparison of the rules that generate Speaker CS's neutral statements shows that Rules 1 and 3 are identical.

The rules that generate acute and grave neutral statements can of course also be written in such a way that the common characteristics of the contours are brought out more clearly.

The flow diagram that generates neutral statements for acute and grave words can for instance look as follows:

1. Give the vocalic segment of the last syllable falling fundamental frequency from mid to neutral.
- 2 A(cute). Reach mid level late in the stressed syllable.
- 2 TR (tone rule). Reach mid level early in the stressed syllable and fall to reach neutral at the end of the syllable.
3. Join

As usual the join rule means completing the pitch contour by interpolation going the shortest way.

The rules, as they now stand, reflect a linguistic analysis according to which the intonation of an acute accented word as an isolated utterance represents the combined fundamental frequency response to stress and sentence intonation. The effect of rule 2 TR (tone rule) can be regarded as a modification of the basic, acute contour.

Emphatic statements

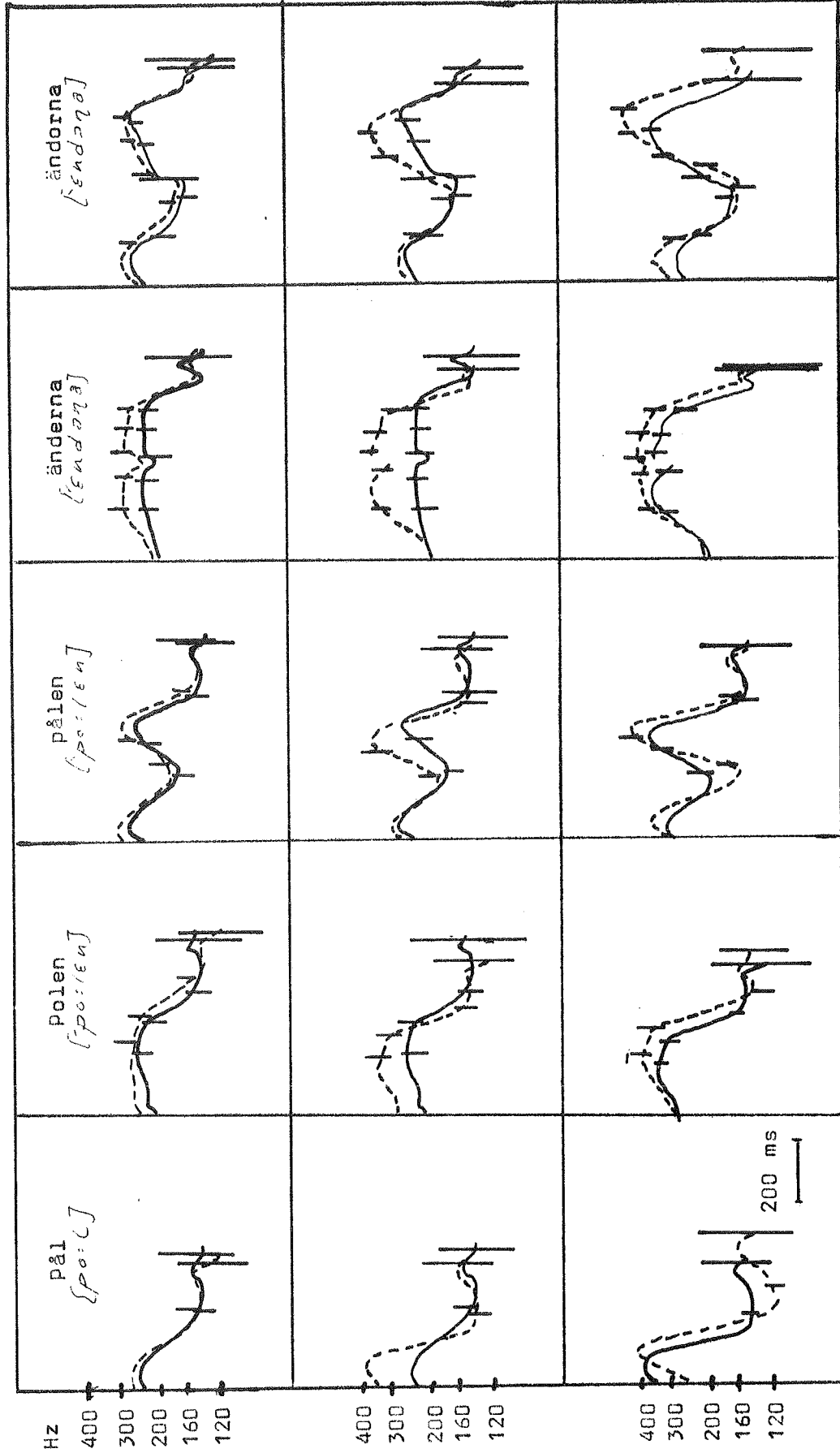
The emphatic statements of CS have practically the same pitch characteristics as the neutral ones. Figure 2.1.2 shows the emphatic utterances superimposed on the neutral ones. The only difference is that the level reached in the peaks of plateaus is a little higher. It is possible that the difference between the neutral and emphatic statements produced by this speaker is not great enough to be functionally valid.

Neutral questions

Figure 2.1.2 shows the neutral questions of Speaker CS superimposed on the statements. We notice that the last peak or the plateau in each utterance carries the mark of the question, that is a rise to high level and a subsequent fall from there. This means that in the double-peaked curves, it is the second peak that is elevated. The rising rate is higher for the higher peaks but the rate of fall is unchanged in all the utterances except the monosyllabic one. There are practically no changes of duration and no timing differences.

Obviously the question rules are very similar to the statement rules: The tone rule remains unchanged.

In the rest of the rules mid (from the neutral statements) is exchanged for high:



Neutral statement ———
Emphatic statement - - - - -

Neutral statement ———
Neutral question - - - - -

Neutral question ———
Emphatic question - - - - -

Figure 2.1.2. Contrasting prosodies (F₀). Speaker: CS, Stockholm.

1. Give the vocalic segment of the last syllable falling fundamental frequency from high to neutral.
- 2 A(cute). Reach high level late in the stressed syllable.
- 2 TR (unchanged). Reach mid level early in the stressed syllable and fall to reach neutral at the end of the syllable.
3. Join

The rules reflect what is obvious in the contours of Figure 2.1.1, that in the grave words it is the last peak that is modified by the question intonation and in the acute words it is the single peak that is similarly modified. The domain of the question intonation command is the whole word in the utterances consisting of acute words. In the utterances consisting of grave words the domain starts at the beginning of the post-tonic syllable and ends with the completion of the utterance.

Emphatic questions

In Figure 2.1.2 the emphatic questions have been superimposed on the neutral ones. We notice that they have roughly the same contours. Some differences are noticeable however. The monosyllabic emphatic question is lengthened and there is a slight lengthening trend in the stressed syllable of the other utterances as well. The last grave word is also lengthened in the posttonic syllable. It is noteworthy that the segment before the pitch peak (the pre-peak segment) is mainly responsible for the increase of duration. The peak is delayed as it were by the higher degree of stress. All the peaks are somewhat raised. This raise is much smaller than what we find when we go from neutral statements to questions. The rate of the rise in the emphatic questions varies a bit but the fall rate remains the same, as was also the case in the earlier discussed prosodies.

Pending further investigation of changes in fundamental frequency brought on by emphasis we shall give the following tentative rules.

1. Length adjustment rules in the stressed syllable, and possibly also in the posttonic syllables of grave words.
2. Generative rules for neutral questions,

Rules 2 will operate on acoustic segments which have been lengthened in a way which cannot yet be specified.

If the duration of muscular activation and relaxation is lengthened without any other concomitant change of the activation pattern, the result should be constant rates, higher peaks and deeper falls.

2.2 Speaker EG, Skåne

Neutral statements

Figure 2.2.1 shows that all the five utterances with statement intonation have a falling fundamental frequency from mid level to low.

The timing of the fall is related to accent. The fall starts early in the stressed syllable for the acute accent and late in the same syllable for the grave one. In the acute accented words the fall includes the consonant following the stressed vowel. After the fall the curve remains at a low level: (The utterance final local maximum of small elevation and duration will be disregarded in the rules for this speaker as for Speaker CS, 2.1.) The fact that the consonant is included in the fall suggests that the pitch movement may be tied to the stressed morpheme rather than the stressed syllable. The word Polen should then be analysed as the definite form of pol. (The definite form is not uncommon in geographical names.) More information is needed to clarify this point.

In the grave words the end of the fall occurs in the last syllable.

Because of the different location of the peaks in the acute and grave

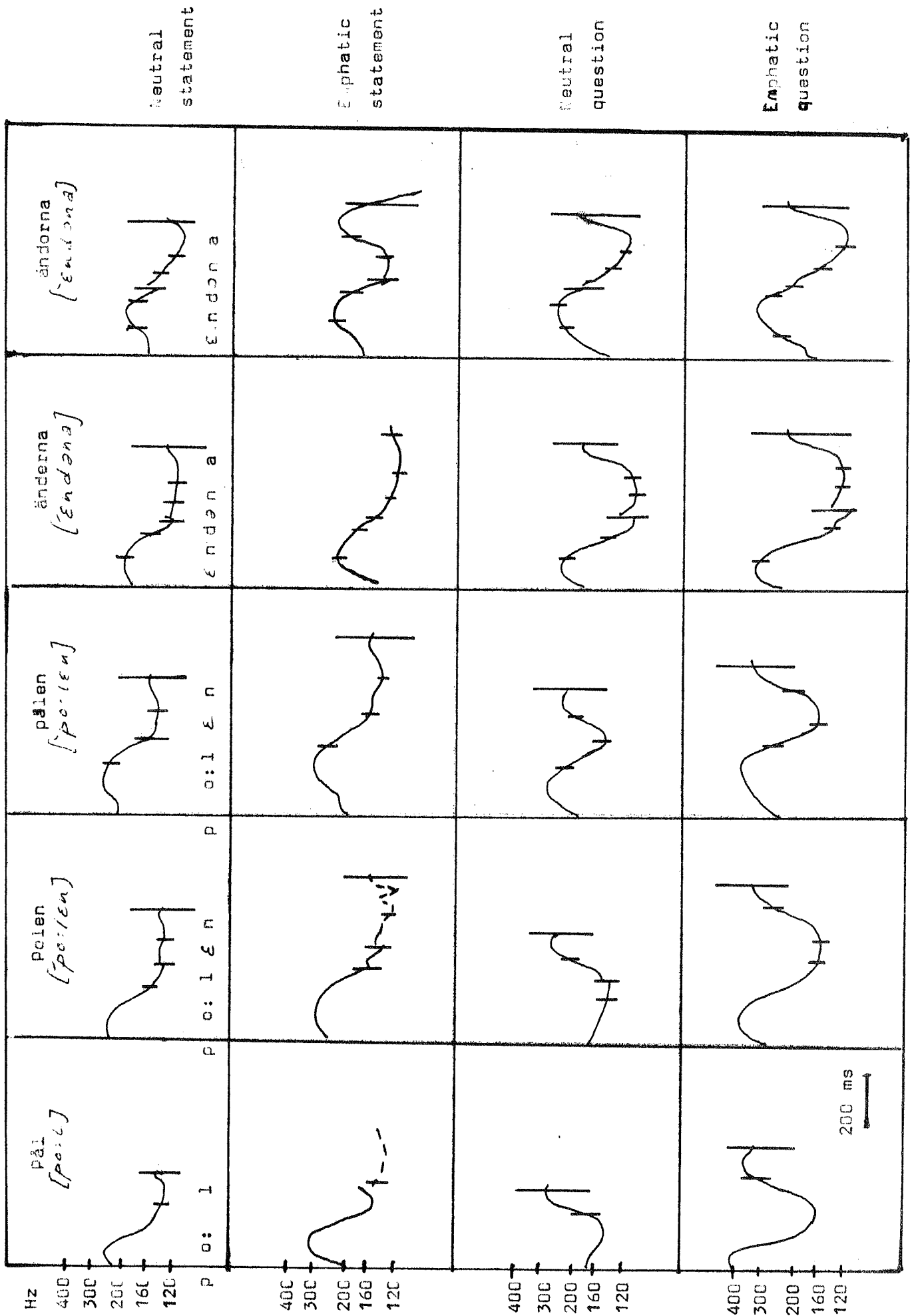


Figure 2.2.1. Acute and grave accents under various prosodies. Speaker: EG, Skåne. F₀ curves traced from mingograms.

accented words, the beginning of the contour is also different. With the early peak in acute there is hardly time for any rise to develop, but with the late peak (grave) the beginning rising part of the contours becomes predominant.

Rules that generate EG's neutral statements:

1. Give low level to the latter part of the last vocalic segment.
- 2 A(cute). Reach mid level early in the stressed syllable and fall to reach low at the end of the last posttonic consonant.
- 2 TR. Reach mid level late in the stressed syllable.
3. Join

Emphatic statements

The emphatic statements have contours similar to the neutral ones (Fig. 2.2.2). Emphasis lengthens the utterances however, and as in our earlier emphatic material, it is the stressed syllable that is lengthened most. The peaks are higher and in the first three utterances they are reached later in relation to the articulatory events. Also the duration of the post-peak part of the vowel increases.

A fundamental frequency contour representing a given sentence intonation can be likened to a rubber band with a certain elasticity. Under emphasis the contour can be stretched in various ways and to a certain extent without losing its identity. We are interested in knowing the limits to this stretching.

For the acute accented statements the most yielding part is the stressed syllable. Here the curve can be stretched both horizontally and vertically. When the posttonic vowel begins, the curve has always reached low. For the grave accent, however, also the posttonic syllable(s) have a certain elasticity. The low level is not reached until the last syllable.

We can summarize the rules that will generate the emphatic contours for Speaker EG in the following way:

1. Length adjustment rules.
2. Generative rules for neutral statements, possibly with mid exchanged for high.

Neutral questions

The questions have a falling-rising fundamental frequency contour. For the polysyllabic utterances the rise starts at the beginning of the last vocalic segment. The preceding fall comes from a late peak in a grave accented syllable. In the acute words the fall starts immediately from a neutral level.

The following rules will generate the neutral questions:

1. Give rising fundamental frequency from low to mid to the last syllable starting in the vocalic segment.
- 2 A(acute). Fall to low in the stressed syllable. 2 TR. Rise to reach mid at the end of the stressed syllable.
3. Join.

Emphatic questions

Apart from the usual lengthenings which again favour the stressed vowel, the acute curves have become double-peaked due to the addition of an extra peak early in the stressed syllable. The difference between the acute and grave utterances is in the timing of the first peak in relation to the acoustic segments. In the grave accent - as usual - the peak comes late in the stressed syllable as compared to an early peak in the acute words. This timing rule is undisturbed by emphasis.

Rules:

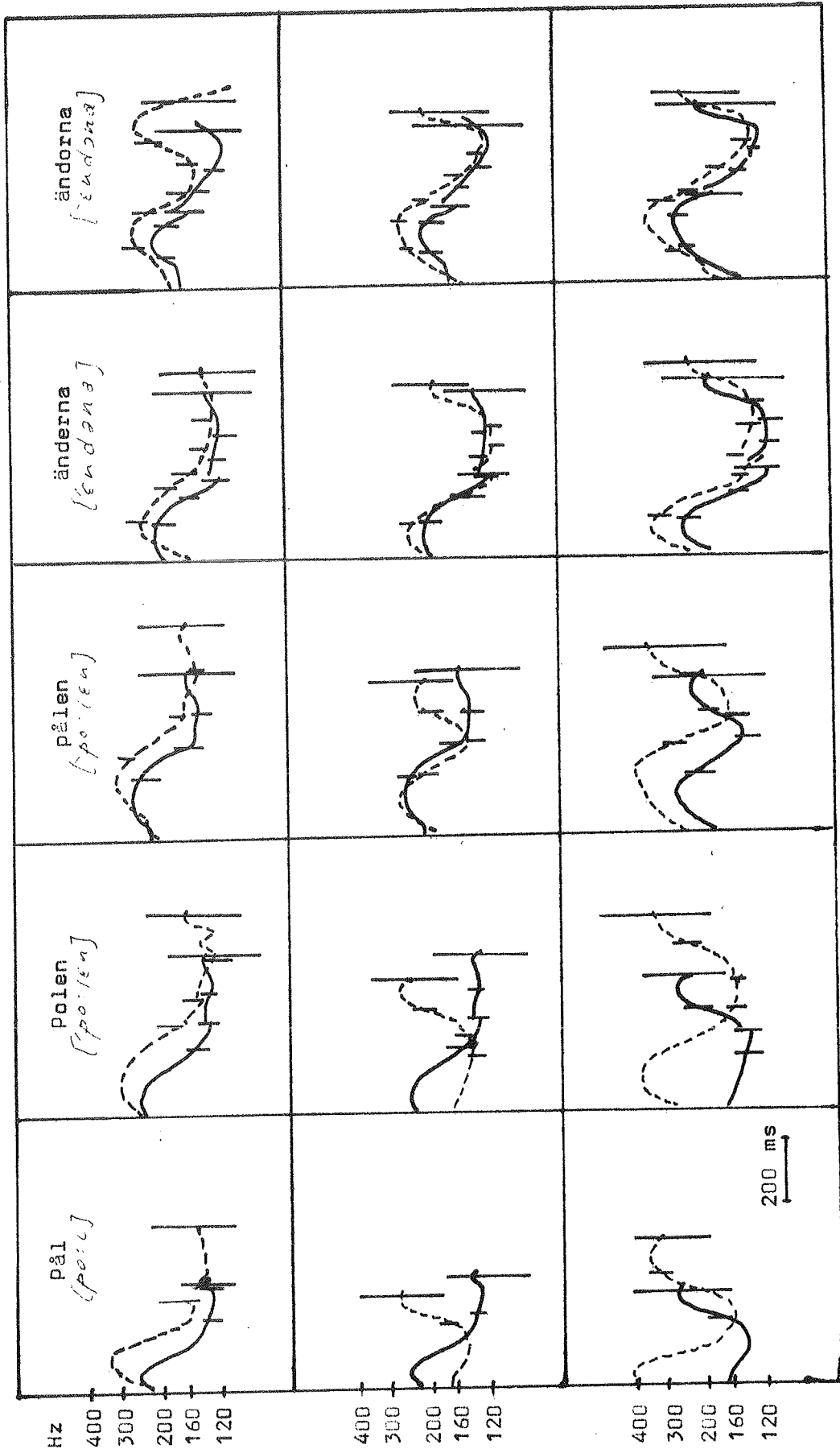


Figure 2.2.2.2. Contrasting prosodies (F₀). Speaker: EG, Skåne.

1. Give rising fundamental frequency from low to high to the last syllable starting in the vocalic segment.
- 2 A(cute). Rise to reach high at the beginning and fall to reach low at the end of the posttonic consonant.
- 2 TR. Rise to reach high at the end of the stressed syllable.
3. Join.

2.3 Speaker ALa, Gotland

Neutral statements

The statements are characterized by a mainly falling fundamental frequency contour (Fig. 2.3.1). The latter part of the last acoustic segment of the utterances has a small rise from low to neutral level. The timing of the main fall is dependent on the accent. For acute words the fall starts in the stressed syllable. For the grave words the fall starts at the beginning of the posttonic syllable. The shape of the curve before the fall is of course also dependent on the accent. The acute polysyllabic words with the earlier peaks are characterized by a slow, smooth rise. In the grave words with the later peaks the rise is preceded by a small dip which gives the curve the shape of an S leaning forwards. The small difference in the shape of the curve in the first syllable of acute and grave words, S (grave) versus no S (acute) may be the result of a difference in timing between the rising commands for the two accents. For grave the command comes later and the dip preceding the rise may be a consequence of a decreased pressure drop across the glottis when phonation starts.

In the monosyllabic utterance the duration of the terminal fall dominates the contour. With the given schema it seems inconvenient to formu-

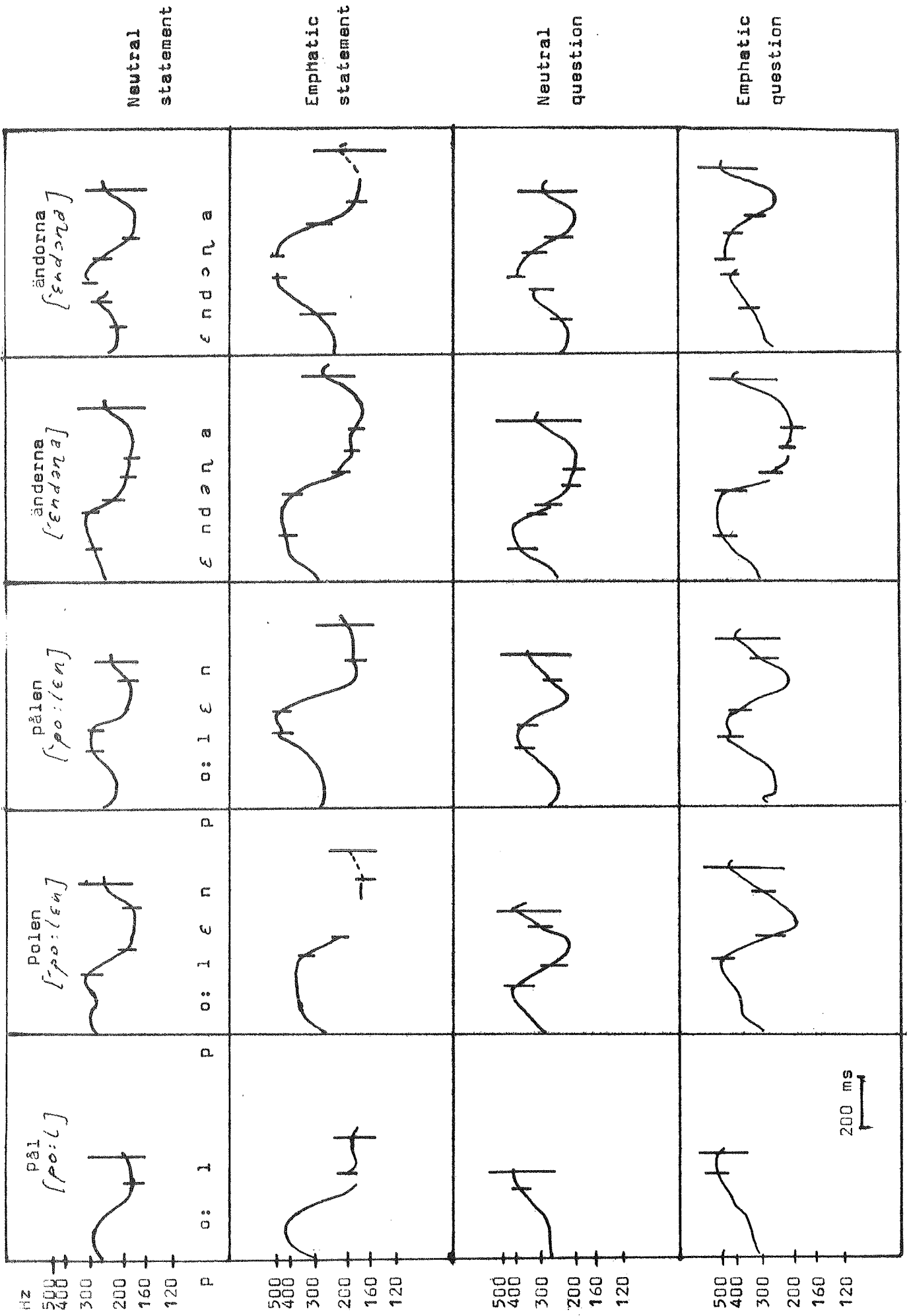


Figure 2.3.1. Acute and grave accents under various prosodies.
 Speaker: ALA, Gotland. F₀ curves traced from mingograms.

late rules that include both monosyllabic and polysyllabic statements.

The following rules generate ALA's neutral polysyllabic statements:

1. Give rising fundamental frequency to the latter part of the last syllable from low to neutral.
- 2 A(cute). Rise to reach mid at the end of the stressed syllable. 2 TR. Stay level one mora and rise to reach mid at the beginning of the posttonic syllable.
3. Join.

Emphatic statements

The emphatic statements have contours that are very similar to the unemphatic ones, as can be seen in Figure 2.3.2. All the emphatic statements are lengthened and this lengthening seems to affect the stressed vowel mostly, in particular the pre-peak portion of the curve. The timing of the rises and falls in relation to the acoustic segments is the same but the peaks are at a higher level. The rate of rise is higher but the falls have similar slopes except in the monosyllabic utterances. Here emphasis produces a faster fall.

Rules:

0. Preparation Rule. Adjust the durations of certain segments.
1. Give rising fundamental frequency to the last voiced segment from low to neutral.
- 2 A(cute). Rise to reach high at the end of the stressed syllable. 2 TR. Stay level one mora and rise to reach high at the beginning of the posttonic syllable.
3. Join.

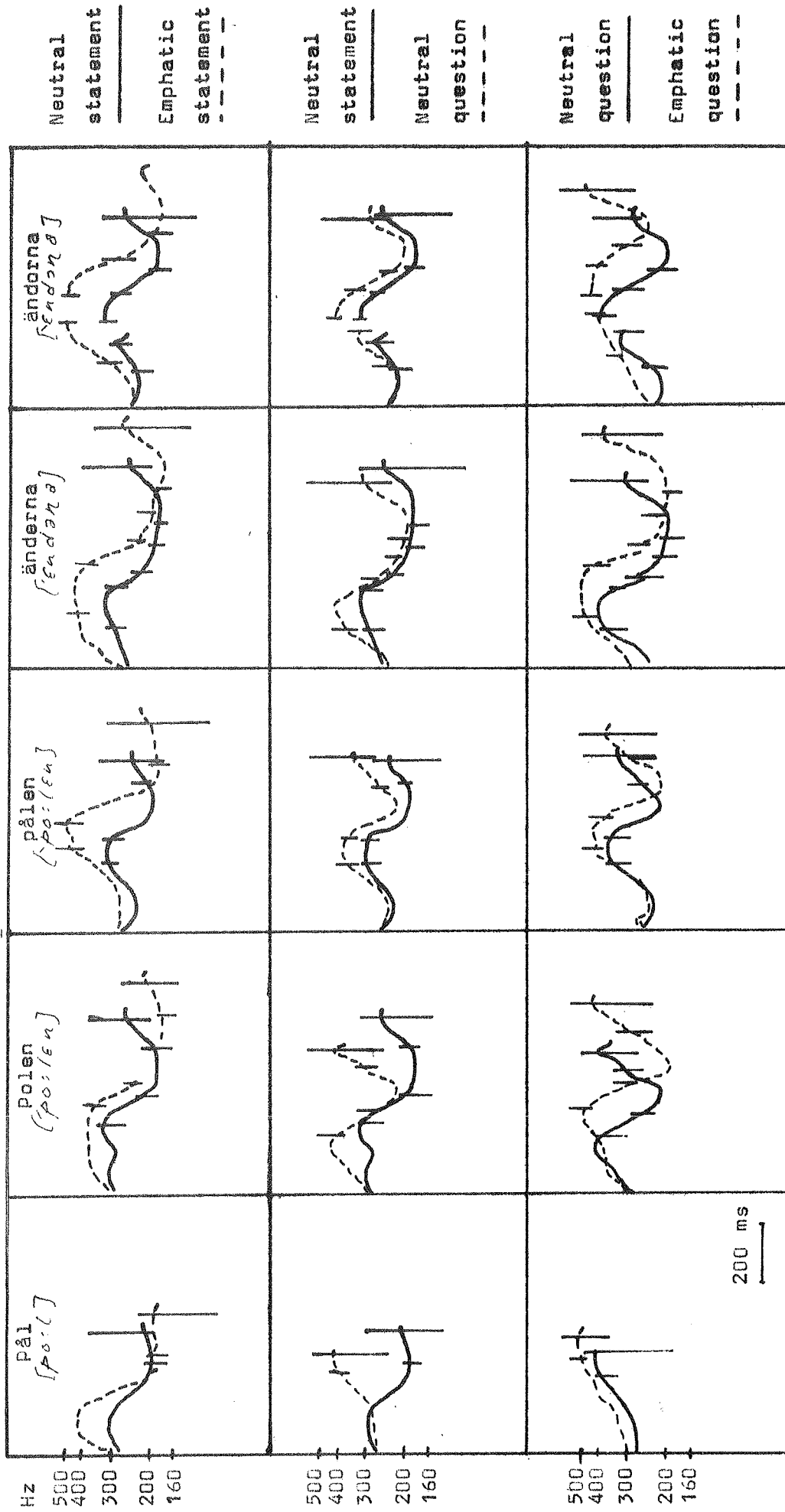


Figure 2.3.2. Contrasting prosodies (F₀). Speaker: ALa, Gotland.

Neutral questions

The questions end in rising fundamental frequency from low to mid level. The rise starts towards the middle of the vocalic segment of the last syllable.

Rules:

1. Give rising fundamental frequency from low to mid to the last syllable starting in the middle of the vocalic segment.
- 2 A(cute). Rise to reach high at the end of the stressed syllable. 2 TR. Stay level one mora and rise to reach high at the beginning of the posttonic syllable.
3. Join.

Emphatic questions

The emphatic questions are lengthened and the stressed vowel has the largest part of this lengthening. The timing of the rises and falls in relation to the acoustic segments remains roughly the same. The peaks are a little higher and the rate of rise and fall is similar.

Rules:

0. Length adjustment rules.
1. Rules for neutral questions.

2.4 Speaker ALö, Västergötland

Neutral statements

The last vowel of the neutral statements has rising fundamental frequency (Fig. 2.4.1). The rise starts at the beginning of the vocalic segment of the posttonic syllable. In the utterances in which the last syllable ends in a consonant [l, n], this consonant has falling pitch. In the polysyllabic acute accented words, the terminal rise is preceded by a fall

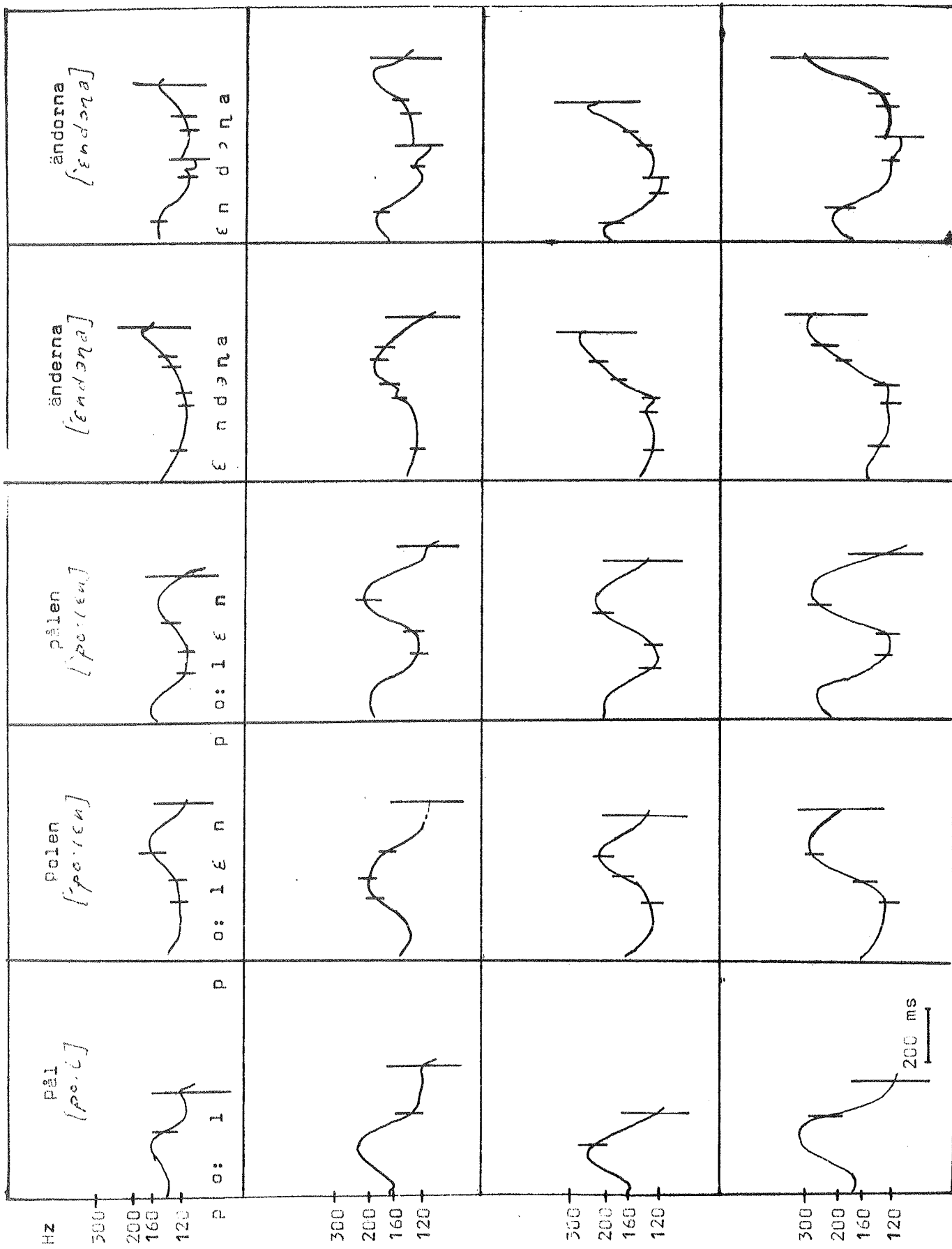


Figure 2.4.1. Acute and grave accents under various prosodies. Speaker: ALö, Västergötland. F₀ curves traced from mingrams.

starting from neutral level at the beginning of the stressed vocalic segment. This fall reaches low early and stays there till the rise begins in the posttonic syllable. In the grave accented words, the curve falls from a mid peak placed in the beginning of the vocalic segment to reach low at the beginning of the posttonic syllable. The regular schema does not fit the monosyllabics. The rules that will be proposed in the next chapter fit this dialect better.

Rules that generate ALÖ's polysyllabic neutral statements:

1. Give rising fundamental frequency (neutral to mid) from the posttonic syllable to the end of the last vocalic segment.
- 2 A(cute). Fall to reach low towards the end of the stressed syllable.
- 2 TR. Rise to reach mid level at the beginning of the stressed syllable and fall to reach low at the end of the same syllable.
3. Join.

Emphatic statements

The emphatic statements end in a rising-falling contour. The rise starts in the middle of the stressed syllable for the acute words and at the beginning of the posttonic syllable for the grave ones. Since the rate of rise is similar for both accents, there will be also a difference in the timing of the fall in relation to the acoustic segments. For the grave accent the fall starts later, more specifically near the end of the last vocalic segment, but for the acute accent the fall begins in the posttonic syllable. We notice also that the valleys and peaks occur relatively later in the longer words as compared to the shorter ones.

For the rules generating all of our earlier curves (except the monosyllabic Gotland statements) it has been possible to use the same schema

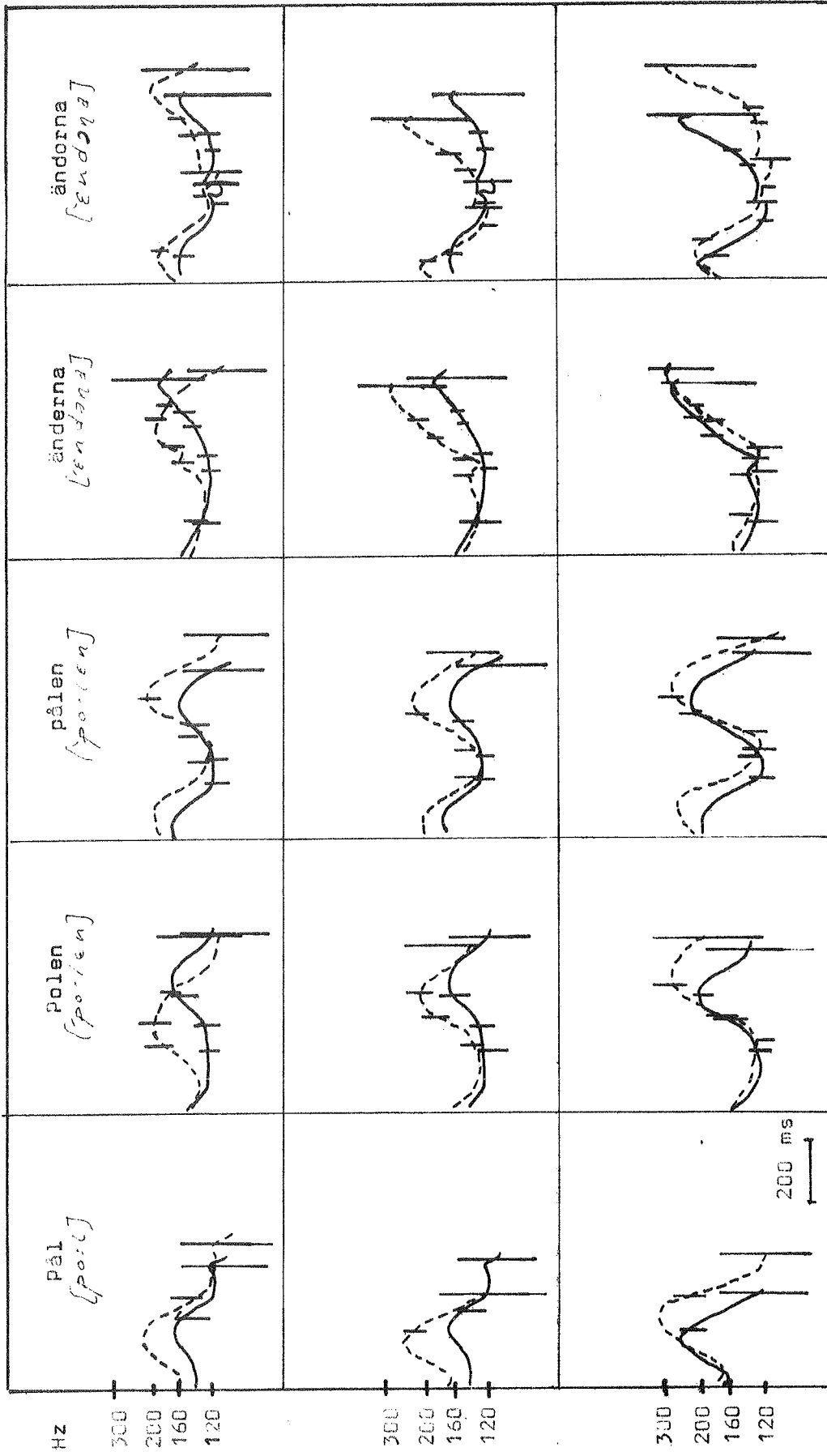


Figure 2.4.2. Contrasting prosodies (F₀). Speaker: ALÖ, Västergötland.

independently of dialect, prosodic contour and accent. Rule 1 took care of the terminal pitch movement and gave the general direction of the sentence intonation. Rules 2 generated the variations in the stressed syllable due to accent, and Rule 3 joined the beginning with the end in a manner which was automatic and independent of the number of intervening syllables. The reason why the rules could be set up in this way was of course that the intonation of the grave accented words "caught up" with the intonation of the acute ones towards the end of the utterances and had the same terminal characteristics.

It is clear that our earlier schema does not fit Speaker ALÖ's emphatic statements, for the simple reason that the grave accent does not just modify the basic contours in the middle but it causes a delay of the pitch movements that remains constant all through the utterances. This delay can be estimated to be one mora.

The rules ought to reflect this situation, for instance:

- | | |
|---|--|
| <p>1 A(cute). Fall to reach low
in the middle of the stressed
syllable.</p> | <p>1 TR. Reach mid level in the
stressed syllable as early as
possible and fall to reach low
at the end of the syllable.</p> |
| <p>2. Rise to reach high one mora later.</p> | |
| <p>3. Fall from there.</p> | |

Neutral questions

The neutral questions look as if they had been pronounced with two different intonation contours. The first three utterances end in a rising falling contour and the posttonic part of the trisyllabics, is mainly rising. We notice that the fall of the contour in the bisyllabic utterances occurs in the terminal [n]. For the time being we attribute this fall to the final consonant. The rise starts at the end of

the stressed syllable in the polysyllabic acute words and at the beginning of the posttonic syllable in the grave ones. (The rise seems to creep onward a little in the longer words towards the end of the utterance.)

Rules generating ALö's polysyllabic neutral questions up to the last consonant:

1. Give rising fundamental frequency from low to high starting at the beginning of the posttonic syllable.
- 2 A(cute). Fall to reach low towards the end of the stressed syllable. 2 TR. Rise to reach high level at the beginning of the stressed syllable and fall to reach low at the end of the same syllable.
3. Join.

Emphatic questions

The emphatic questions are lengthened as compared to the neutral ones, but they have similar contours. The lengthening affects the stressed syllable in the acute words and both syllables in the bisyllabic grave words. In most cases the rate of rises and falls does not change with emphasis.

Rules:

0. Preparation Rules.
1. Rules for neutral questions.

Chapter 3

FORM BY SUBSTANCE

In this chapter we shall summarize our earlier observations and try to make them subject to generative rules whose structure is the same for all the dialects.

In our pursuit of constancy we have tried various basic units in the contours, terminal parts, posttonic parts and the entire acute contour. A discussion of these units will follow below. As will be shown, it is the entire acute contour that is best adapted to general rules.

It should perhaps be stressed that our general rules - as they appear here - are not meant to be orders to a vocoder like our earlier rules for individual speakers but are of a more qualitative nature.

Intensity and duration will receive full attention in a following report which will also have a more detailed treatment of the monosyllabics.

3.1. Terminals

A common feature in all the dialects is that fundamental frequency curves derived from utterances with the same sentence intonation (expressing statements or questions) are similar in their final parts, independently of the accent and the number of syllables carried by the utterances. These similar parts - terminals - will be regarded as part of the fundamental frequency response to the sentence intonation command. Figure 3.1 in which the grave accented words have been superimposed on the grave ones bring out this final similarity. The terminals can be described as follows:

	Neutral statements	Neutral questions
Stockholm	Fall from mid	Fall from high
Skåne	Fall from mid	Rise to mid

Gotland	Fall from mid	Fall from high
Västergötland	Rise to mid	Rise to high

We notice (Fig. 3.1) that apart from differences in the direction of the fundamental frequency in the dialects there are also differences in the timing of the terminals in relation to the acoustic segments and syllables. The different timing is dependent on accent, sentence intonation and dialects. The following table brings out these differences. (Only the polysyllabic neutral statements and questions have served as examples.)

Table showing the beginning of the final common part of the pitch curve for acute and grave words in relation to syllable

Dialect	Acute		Grave	
	Statements	Questions	Statements	Questions
Stockholm	early last	early last	early last	early last
Skåne	early stressed	early last	late stressed	early last
Gotland	late stressed	late stressed	early post-tonic	early post-tonic
Väster-götland	early post-tonic	early post-tonic	early post-tonic	early post-tonic

The table shows that there is a great deal of dialectal variation in the timing of the terminals. In Skåne and Gotland the terminal of the grave is delayed as compared to the acute but in Stockholm and Västergötland they are independent of accent. It is clear that the terminals do not constitute a tonal unit that is very useful for dialect independent general rules.

3.2. Sentence intonation and acute

In the utterances consisting of neutrally stressed acute words, the shape of the fundamental frequency curve in the stressed syllable is dependent on the sentence intonation in the following way: Preceding a falling or a raised level-falling sentence intonation, the acute accent will have rising pitch, before a rising sentence intonation it will have falling

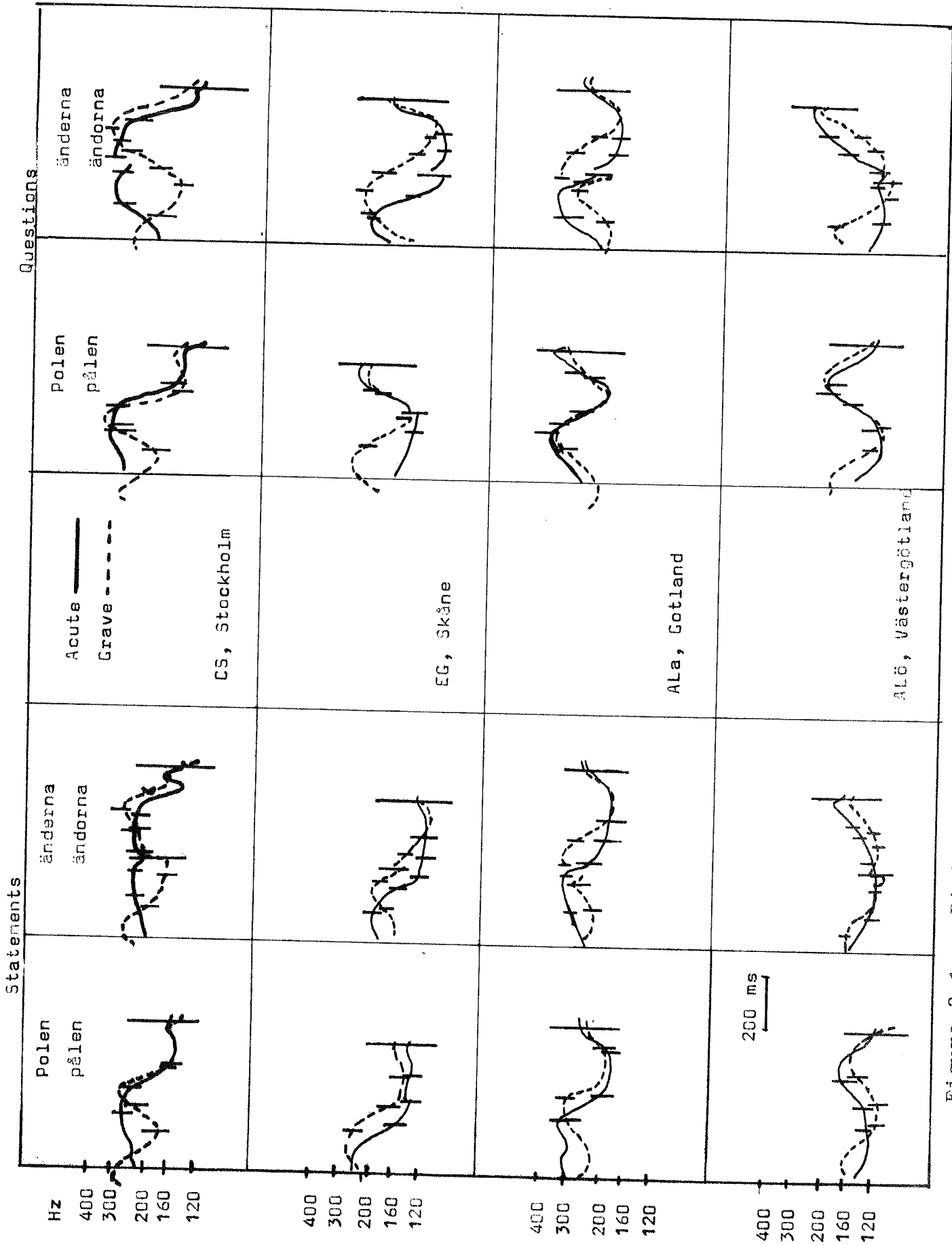


Figure 3.1. Dialectal variation of acute and grave accents in statements and questions.

(or low) pitch. In the material studied here these relations are general and independent of dialects and prosodies. (A Västergötland statement [rising sentence intonation] with the acute accent looks very similar to a Skåne question with the same accent [rising sentence intonation]). This means that the acute accent turns up in different fundamental frequency shapes in one and the same dialect depending on the general direction of the fundamental frequency imposed by the sentence intonation. Since the situation seems to be similar in other languages, analysed as having no word accent but only stress and intonation, and since we want our analysis of Swedish to fit a general intonation model, we shall regard the acute accent as stress and its pitch manifestation as dependent on sentence intonation. This is a common point of view (see Elert 1970, p. 46, and literature quoted there).

3.3. Basic intonation unit = acute + sentence intonation

A sentence cannot be uttered without having both stress and intonation. We shall now regard these components as one unit, called the basic intonation unit of the sentence. As we shall see later, it will be needed for our analysis of the grave accent and useful for our general rules.

In terms of rises and falls the basic intonation unit of the polysyllabics of our four speakers can be described as follows:

	Statements	Questions
Stockholm	rise mid-fall	rise high-fall
Skåne	rise mid-fall	fall-rise mid
Gotland	rise mid-fall(rise)	rise high-fall(rise)
Västergötland	fall-rise(fall)	fall-rise high(fall)

(Pitch movements within brackets may be irrelevant.)

The table shows that only the Västergötland speaker uses rising intonation in statements. This is a famous characteristic of all Swedish dialects belonging to the Götamål and also of East Norwegian dialects. (Tonal type 2B, Table 1.2 and Figs 1.1 and 1.2.) The Skåne speaker alone marks her questions by reversing the intonation pattern of the statements.

In this way the South Swedish speaker behaves similarly to speakers of other Germanic languages such as Danish, German and English. The others choose to rise to and fall from a higher level. This way of intoning questions is similar to question intonation patterns in some Slavic languages and Hungarian, to give just a few examples. We shall also recall that Skåne statements are different from those in Stockholm and Gotland in the timing of the fall, which is early in the stressed syllable as compared to late for the others.

3.4. Grave accent = precontour + basic unit

Figure 3.1 with the superimposed accents derived from our four dialectal prototypes shows, what has been mentioned in connection with the analysis of Meyer's data (1.2), namely that the pitch movements in the acute curves recur in the grave ones. The grave curves can be described as having an extra happening or feature in the beginning of the stressed syllable, which delays and to a certain extent shrinks or modifies the basic, acute curve. All the grave accented words, independently of dialect, are characterized by a rise somewhere in the stressed syllable. As we shall see later, the absolute timing of this rise and its further development depends on the timing and the general direction of the basic intonation.

We shall now try to find some common basic principle for how acute accents are turned into grave ones.

In the following table (Table 3.1) we shall present some pertinent data collected from Figure 3.1.

The table shows that the shape of the grave curves can be obtained by adding a pitch movement (grave precontour) to the basic unit (acute accent). This pitch movement is for Stockholm and Västergötland a peak (rise-fall or fall), for Skåne a rise, and for Gotland a low. We notice that the duration of the precontour and hence the delay

Table 3.1. Constructive elements for the grave accent

Statements	Shape of grave precontour	Shape of basic contour (acute)	Delay of basic contour	Shape of grave
Stockholm	rise-fall	rise-fall	2 morae	rise-fall = rise-fall
Västergötland	rise-fall	fall-rise	1 mora	rise-fall = rise
Skåne	rise	fall	1 mora	rise = fall
Gotland	fall-rise	rise-fall	1/2 mora	fall-rise = fall
Questions				
Stockholm	rise-fall	rise high-fall	2 morae	rise-fall = rise high-fall
Västergötland	rise	fall-rise high	1 mora	rise-fall = fall-rise high
Skåne	rise	fall-rise	1 mora (?)	rise = fall-rise
Gotland	fall	rise-fall-rise	1/2 mora	fall-rise = fall-rise

= means boundary between stressed and posttonic syllables

of the basic unit is 2 morae (one stressed syllable) for Stockholm. For Västergötland and Skåne it is approximately one mora (or less) and for Gotland half a mora.

There is then an interesting constancy in our dialectal variety. The grave accent is made up of a precontour and the acute contour.

Since acute and grave words are approximately equally long, the acute contour has to shrink in accordance with the time unit given for the delay in the table above.

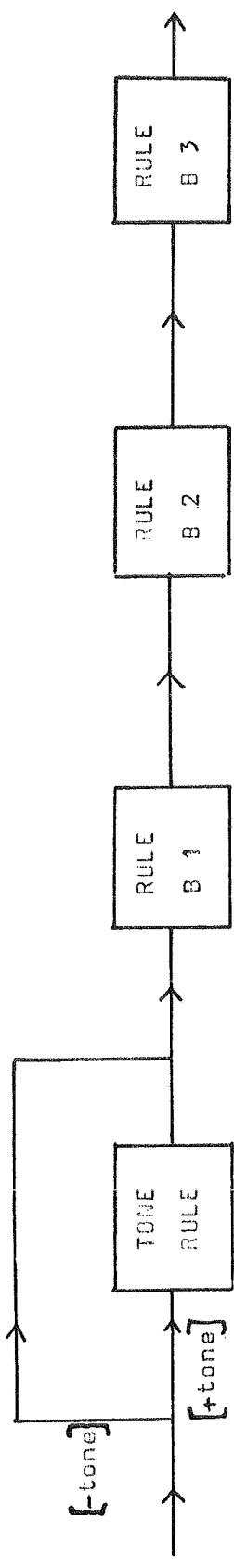
3.5. General rules

We shall now cast the preceding discussion in the form of a set of general rules. These rules will generate fundamental frequency curves for statements and questions in the four dialects we have chosen as representatives of the whole language area. The new rules reflect our analysis of the acute accent as being part of the basic intonation unit and the grave accent as precontour plus delayed basic unit. They will not have the precision of our previous rules for individual speakers, but they will reflect what we regard as essential dialect independent principles in Swedish intonation. The input to our rules consists as usual of phrases of one to four syllables including information of acoustic segments, syllable boundaries, prosody, and dialect.

Grave words are marked [+tone] and first pass through a special tone rule which gives them the precontour required by the dialect (Table 3.1). Figure 3.2 shows a block diagram of the process. Formally:

[+tone] Add precontour according to dialect.

Phrases marked [-tone] bypass this rule. All the phrases are then taken care of by the basic rules which are essentially the same as Rules 1, 2 A, and 3, used earlier to generate the contours of our individual speakers. Only 2 A needs some modification since it was expressed in terms



Rule content: Trace precontour according to dialect lect Apply Rule I according to dialect and prosody Add pitch movement prescribed in 2 A immediately after the precontour according to dialect and prosody Join

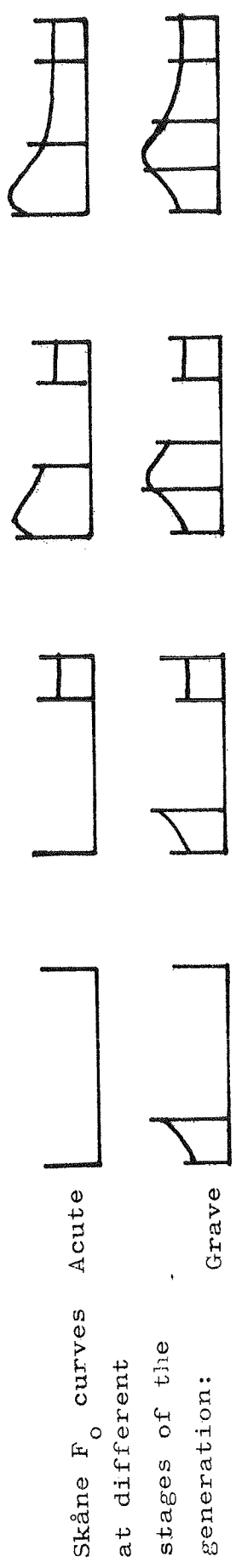


Figure 3.2. The working of the general rules. See text 3.5.

suitable for a stressed syllable only. The new modified rules will look as follows:

- B(asic) 1. Apply Rule 1 according to dialect and prosody.
- B 2. Apply pitch movement prescribed in 2 A according to dialect and prosody immediately after the precontour.
- B 3. Join.

When there is no precontour (as for the acute words), B 2 is of course identical with 2 A. One of the effects of the precontour is to delay the basic intonation unit. The time of the delay is determined by the duration of the precontour. Rule B 3 automatically takes care of the needed shrinking.

3.6. Comparison of the rules for the grave accent

Our former rules (Rules 2 TR) prescribed pitch movements for the stressed syllable of the grave accented words. According to our modified rules, the pitch of the stressed grave syllable is split into a precontour and a remainder which is spliced together with a time compressed basic intonation unit. The new rules reflect the interdependence of the acute and grave accents, which is common to all the investigated dialects. On the other hand the splitting and splicing and the evaluation of the delay in morae is perhaps rather subjective. We shall come back to a motivation of this process in a later publication that will treat the prosody of compounds.

3.7. Grave, a petrified "double stress" pitch contour?

Figure 3.1 shows that the stressed syllable connected with the grave accent is very stable in its pitch configuration. It is always manifested by pitch raised to a level above neutral and its general shape is practically undisturbed by the sentence intonation. Taken at its face value, it

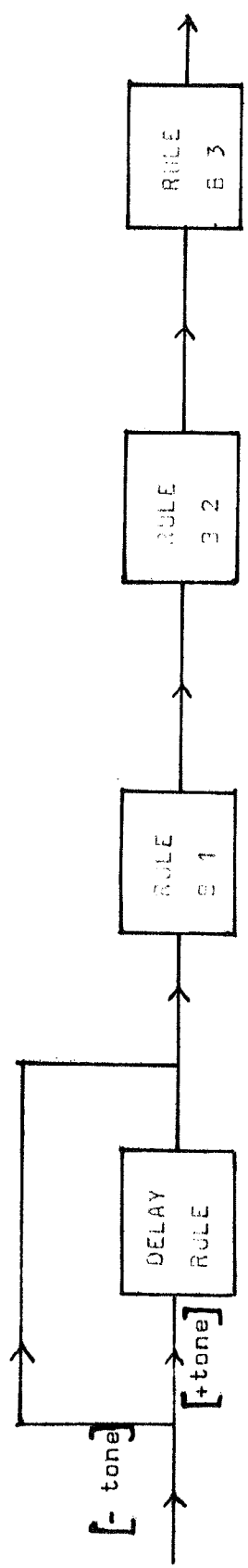
seems to deserve the status of an autonomous tone accent. But Table 3.1 shows that there is an interdependence between the shape of the precontour and the shape of the basic contour which recalls the dependence of the acute accent on sentence intonation. If the shape of the basic contour starts with a rise, the precontour will end in a fall and vice versa. In other words, knowing the shape of the early part of the basic unit we can predict the pitch movement of the grave accent.

Has this relation any significance? One explanation or interpretation of this stable relation between the grave precontour and the beginning of the basic unit is that these two tonal movements are reflexes of what was once the fundamental frequency response to two connected stressed syllables of which the first one had a pitch movement subordinated to that of the second which in its latter part was exposed to modifications imposed by sentence intonation.

There is historical justification for regarding the grave accent as a development of an earlier "double stress" pitch contour. The grave accent appears in words in which a posttonic syllable can be associated with length or stress in an earlier period of the language. Later, stress and length were lost but the pitch movements combined with the stresses were retained. We are well aware that we are not presenting a new hypothesis about the development of the grave accent. Similar views were expressed for instance by Ekblom (1929-31) and Kuryłowicz (1936). What is perhaps interesting is that we arrived at this hypothesis by an analysis of a piece of "substance", in this case the fundamental frequency curves derived from present day speakers of present day dialects.

3.8. Modified general rules

We shall leave the historical speculations and return to the fact that the grave precontour is practically predictable from the early part of the basic contour. This may of course be reflected by the rules. One



Rule content: Mark end of precontour according to dialect [- tone] Apply Rule I according to dialect and prosody [+tone] Add pitch movement prescribed in 2 A immediately after the precontour according to dialect and prosody Join

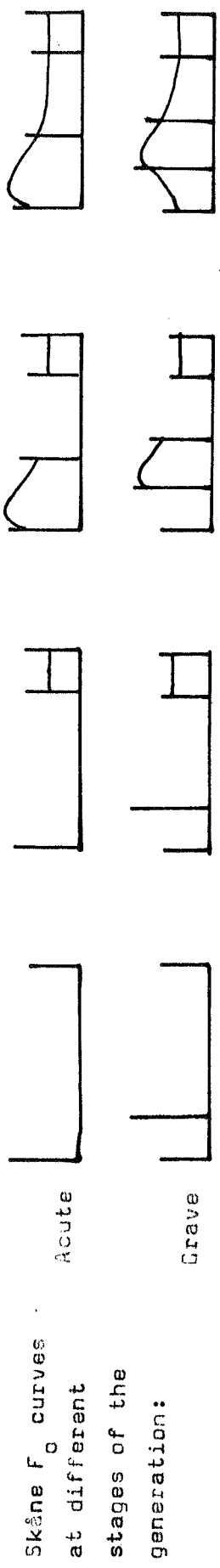


Figure 3.3. The working of the modified general rules. See text 3.8.

possible way of achieving this is to let the grave words pass through a delay rule which leaves a blank in the pitch curve for a time unit determined by the dialect. Later, passing through the join rule (3), expanded to embrace all blanks and not just the empty space between the stressed syllable and the end, the grave missing precontour will be filled in automatically from a neutral beginning. Figure 3.3 illustrates this process.

For the grave accent we may posit underlying forms with two stresses (of which one may be secondary) and regard the grave tone accent as a surface manifestation of double stressed forms. We shall come back to this solution in connection with our analysis of the compounds.

It may be claimed that the underlying double stressed forms that are posited for words with the grave accent have some reality for present day speakers.

In emphatic speech there is for all the dialects a larger increase of intensity and duration in the second syllable of the grave words as compared to the comparable syllable of the acute ones. If we assume that the grave has a second, latent stress, it looks as if the emphatic command were, "add energy to all stressable syllables", and that as a consequence of this command the latent stress comes to the fore. In Skåne grave the second syllable may under emphasis even get a peak in the fundamental frequency curve. (Fig. 2.2.2 first row, Item N:o 5.)

Deprived of phonation, as for instance in whisper, a speaker will also resort to his latent double stressed patterns, if he feels forced to bring out the acute-grave contrast (Jensen 1958, Hadding-Koch 1961, Segerbäck 1966).

3.9. Emphasis and fundamental frequency

The fundamental frequency response to emphasis is clearly dependent on the shape of the curve in the corresponding neutrally stressed syllable.

We have made the following observations:

If the corresponding neutrally stressed syllable has a pitch peak, this peak will be pushed to a later position in the syllable and upward on the frequency scale to a higher level. If the corresponding neutrally stressed syllable has a low after an early peak (Stockholm grave) this low will also be pushed forward and downwards to a lower level on the frequency scale. If there is no peak in the stressed syllable (as in contours with mainly rising sentence intonation, e.g. Västergötland) emphasis will cause a pitch peak to develop at the beginning of the stressed syllable.

3.10. Duration and intensity

Duration and intensity will be treated in more detail in a later report. Here we shall just sum up a few observations that have been made earlier in passing. Grave words are longer than acute ones for our Stockholm and Västergötland speakers. It should be noticed that in these dialects the lengthened grave is correlated to a more complicated pitch movement than the grave accent of the other dialects. Emphasis has a lengthening effect not only on the stressed syllables but also on the later syllables of the grave accented words.

Summary

1. Swedish has two accents distinguished by differences in fundamental frequency (pitch). The pitch curves derived from words with these accents show a great variety of patterns depending on the dialect (E.A. Meyer 1937, 54). When these patterns are classified by the number and the location of the pitch peaks, the dialects fall into four main types (Gårding 1970). Our first object was to complete Meyer's material by new registrations of accents, varying both dialect and prosody (intonation and stress

pattern). Recordings were made with speakers representing the four tonal types. The speech material consisted of mono-, bi-, tri- and tetrasyllabic words with contrastive accents in the polysyllabics. The words were uttered as neutral and emphatic statements and as neutral and emphatic questions. The recordings were analysed by means of spectrograph, pitch meter and intensity meter. The present report is mainly concerned with pitch.

2. The pitch contours by which an individual speaker manifests his accents under the four selected prosodies are described by means of a set of rules thought of as instructions to a fictitious vocoder. The rules vary with the dialect and so far only apply to the words under observation. It is clear, however, that they have more general validity.

Inputs to the rules are phrases of one to four syllables with primary stress on the first syllable. The input utterance is syllabified and carries the following information, stress (stress or not for each syllable), type of stress (emphasis or not), accent (grave or not), intonation (question or not). The rules are descriptive or "output oriented". The first two rules make use of four relative pitch levels (low, neutral, mid, high) and prescribe the pitch movement in the stressed and final syllables. They specify where in the syllable the pitch turns (early, mid, late) and the range of the movement (from mid to low, etc.). The third rule completes the pitch curve of the utterance. For all the dialects and prosodies the rules proceed in the following order:

- (1) Pitch is assigned to the terminal part.
- (2) Pitch is assigned to the stressed syllable (different rules for different accents).
- (3) Possible blanks between the stressed syllable and the terminal part are filled in by interpolation.

The third rule makes the program applicable to phrases with any number of unstressed syllables.

3. There is a constant relation between pitch manifestations of the two accents in all the dialects and prosodies. For a given prosody and dialect the pitch curve of the acute accent recurs with some delay in the grave one. The pitch of the stressed syllable of a grave word remains practically unperturbed by the prosody. In view of these facts we regard the acute accent as the basic intonation unit and the grave accent as consisting of a precontour followed by a delayed and time compressed basic intonation unit. The precontour is typical of the dialect but largely independent of prosody. This relation is formalised in a set of general rules. The first rule generates the precontour for the grave accent. The following rules generate the basic intonation unit and take care of the needed time compression (Fig. 3.2).

One possible linguistic interpretation of these relations is that the grave accent is the "petrified" pitch remainder of what was once the fundamental frequency response to a stress pattern combining two stressed syllables.

4. There is another constant relation in our contours which is dialect independent. The actual shape of the precontour is largely dependent on the shape of the basic unit. With a predominant fall in the basic unit (falling sentence intonation) the precontours will be rising (Skåne, Gotland). With a rising or rising falling basic unit (Stockholm, Västergötland) the precontour will be falling.

This constant dialect independent relation between the precontours and the basic unit makes it possible to modify our general rules. In the modified rules the input [+tone], i.e. the grave accent, generates a dialect dependent delay of the basic unit (Fig. 3.3). The precontour is then taken care of by a join rule with a neutral beginning.

The linguistic interpretation of the relations summarized under (4) is that the shape of the precontour of the grave accent is dependent on the sentence intonation of the dialect.

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Appendix 1

Information about the speakers

CS female, born in 1950. Grew up in Stockholm. Parents from Stockholm and Skåne.

CÖ male, born in 1945. Grew up in Stockholm. Parents from Skåne and the Swedish west coast (Dalsland and Halland).

EG female, born in 1920. Grew up in Landskrona. Parents from Skåne. Lived most of her life in Lund.

PL male, born in 1944. Grew up in Malmö. Parents from Småland and Halland.

ALa female, born in 1950. Grew up in Hangvar, Gotland. Parents from Skåne and Småland.

TS male, born in 1950. From Slite, Gotland.

ALö male, born in 1944. Grew up in Borås. Parents from Västergötland.

JA male, born about 1950. Grew up in Västergötland.

Appendix 2

Material

Test words

Translation

Speakers: TS, JA, EG, PL

*Pål	Paul
*Polen	Poland
*anden	the wild duck
ba`nanskalet	the banana-skin
*pålen	the pole
*badkaret	the bath-tub
*simbassäng	the swimming-pool
*badkar	bath-tub
*anden	the spirit
*värden	values
*tomten	the site
*värden	the host
*tomten	the brownie, Santa Claus

Speakers: EG, PL

*överstarna	the colonels
*pållen	the gee-gee
*änderna	the wild ducks
*pollen	pollen
*ändorna	the ends
*baderskorna	the bathing-women

Speakers: ALa, ALö, CS, CÖ

*tomtarna	the brownies
*värden	the host
ba`nanskalet	the banana-skin

ˆtomten	the site
ˆöverstarna	the colonels
ˆänderna	the wild ducks
ˆPål	Paul
ˆPolen	Poland
ˆvärden	values
ˆsimbassäng	swimming-pool
ˆvärd	host
ˆpålen	the pole
ˆanden	the wild duck
ˆtomten	the brownie, Santa Claus
ˆbaderskorna	the bathing-women
ˆbadkaret	the bath-tub
ˆanden	the spirit
ˆändorna	the ends
ˆbadkar	bath-tub

Speakers: ALa, ALö, EG, PL

ˆba: b

ˆba: bab

ˆba: bab

ˆba: babab

ˆba: babab

Appendix 3

Table 1.1. Durations of segments, locations of maxima and minima
 Speaker: CS, Stockholm

		p	o	l	ε	n	the whole word	F _o max ¹	F _o max ²	F _o min
Acute enframed	1'	170	190 [^] 20	80			460	260		
	1	160	210	70	20 [^] 60	110	630	260		
	2'	220	200 [^] 50	130			600	290		
	2	210	220	60	20 [^] 100	160	790	280		
	3'	200	200 [^] 30	100			540	260		
	3	170	210	80	20 [^] 80	120	670	260		
	4'	170	180 [^] 30	130			520	375		
	4	170	210	60	20 [^] 80	100	620	350		
Acute isolated	1'		30 [^] 220	170			440	240		
	1		200 [^]	100	100	170	560	240		
	2'		50 [^] 210	150			420	270		
	2		160 [^] 70	70	130	140	580	260		
	3'		70 [^] 180	160			400	375		
	3		170 [^]	80	120	120	490	350		
	4'		100 [^] 210	170			480	400		
	4		170 [^] 20	70	120	130	510	385		
Grave enframed	1	150 [^]	180 _^ 30	70	80 [^] 30	120	670	250	240	170
	2	190	30 [^] 190 _^	80	90 [^] 20	140	740	280	260	160
	3	(310)	30 [^] 200 _^	80	100 [^] 20	120	850	260	260	170
	4	150	30 [^] 190 _^	80	90 [^] 20	110	660	280	325	160
Grave isolated	1		20 [^] 190 _^ 20	100	40 [^] 110	170	630	260	240	160
	2		20 [^] 210 _^ 20	90	40 [^] 110	170	650	300	280	180
	3		30 [^] 150 _^ 30	80	40 [^] 100	180	610	300	350	190
	4		40 [^] 160 _^ 20	90	40 [^] 100	150	600	350	425	160

1. Neutral statement
2. Emphatic statement
3. Neutral question
4. Emphatic question

Prime after a figure means monosyllabic word

Two (or three) measurements for a segment means that it is divided into subsegments by a max (^) or a min (v). See text 1.5

Measurements in msec and Hz

Appendix 3

Table 1.2. Durations of segments, locations of maxima and minima
 Speaker: CS, Stockholm

		ε	n	d	ə	n	a	the whole word	F ₀ max ¹	F ₀ max ²	F ₀ min
Acute enframed	1	160	100	50	100	50	100	560	240		
	2	170	100	60	80	50	90	560	240		
	3	160	110	60	90	60	100	590	240		
	4	150	120	50	60	60	100	540	325		
Acute isolated	1	170	110	60	90	60	190	680	230		
	2	170	120	60	80	70	170	680	300		
	3	140	140	40	60	90	140	620	350		
	4	150	130	40	80	70	150	620	375		
Grave enframed	1	60 [^] 90	120 _↓	70	120	70	40 [^] 60	640	260	260	160
	2	90 [^] 80	120 _↓	80	100	70	70 [^] 40	660	240	240	160
	3	50 [^] 90	100 _↓	70	100	70	30 [^] 80	610	240	260	160
	4	60 [^] 100	110 _↓	60	100	60	30 [^] 90	610	290	375	150
Grave isolated	1	80 [^] 80	120 _↓	60	120	80	10 [^] 160	720	260	260	160
	2	80 [^] 90	110 _↓	60	110	70 [^]	200	740	280	260	160
	3	60 [^] 90	100 _↓	60	100	70 [^]	170	660	260	375	160
	4	60 [^] 100	130 _↓	70	120	70 [^]	190	750	340	475	160

1. Neutral statement
2. Emphatic statement
3. Neutral question
4. Emphatic question

Prime after a figure means monosyllabic word

Two (or three) measurements for a segment means that it is divided into subsegments by a max (^) or a min (↓). See text 1.5

Measurements in msec and Hz

Table 2.1. Durations of segments, locations of maxima and minima

Speaker: EG, Skåne

		p	o	l	ε	n	the whole word	F ₀ max ¹	F ₀ max ²	F ₀ min
Acute	1'	190	40^160	100			500	280		130
enframed	1	180	60^120	80	120	110	680	280		140
	2'	220	150^130	120			610	350		140
	2	220	140^110	90	100	110	760	325		150
	3'	150	70^160	80			460	300		120
	3	180	40^140	70	100	100	630	300		140
	4'	240	80^170	60			550	350		110
	4	190	70^160	80	90	100	690	375		120
	Acute isolated	1'		60^190	120			370	240	
1			50^150	90	100	130	520	240		140
2'			120^220	200			550	350		140
2			120^170	80	140	150	660	300		140
3'			150↘70	80^20			330	280		140
3			170	50↘20	90	50^40	430	280		140
4'			60^190↘110	90^70			520	425	375	160
4			100^220	60↘20	120	100^	620	400	350	160
Grave enframed	1	160	160^30	70	100	140	670	250		140
	2	200	130^120	60↘10	90	50^60	720	300	310	170
	3	180	160^50	80	100	120	700	280		140
	4	210	180^60	70	100	110	720	350		140
Grave isolated	1		150^60	90	110	130	540	240		140
	2		200^70	120	140	160	700	300		140
	3		120^60	100	20↘70	60^60	510	280	220	140
	4		230^50	80	50↘80	90^	600	400	350	160

1. Neutral statement

2. Emphatic statement

3. Neutral question

4. Emphatic question

Prime after a figure means monosyllabic word

Two (or three) measurements for a segment means that it is divided into subsegments by a max (^) or a min (↘). See text 1.5

Measurements in msec and Hz

Appendix 3

Table 2.2. Durations of segments, locations of maxima and minima

Speaker: EG, Skåne

		ε	n	d	ɔ	n	a	the whole word	F ₀ max ¹	F ₀ max ²	F ₀ min
Acute enframed	1	110 [^] 40	90	30	70	60	80	480	220		120
	2	150	40 [^] 60	40	60	50	90	500	250		120
	3	100 [^] 40	100	40	60	60	90	490	240		120
	4	90 [^] 60	110	60	70	60	90	550	280		120
Acute isolated	1	130 [^]	100	50	70	70	160	590	200		120
	2	130 [^] 20	110	40	80	90	160	650	230		120
	3	120 [^]	100	70	80 _↓	80	110 [^] 30	610	240	200	120
	4	80 [^] 60	120	70	100 _↓	70	150 [^]	660	300	220	130
Grave enframed	1	140	80	20 [^] 20	60	60	90	480	220		120
	2	150	30 [^] 90	40	30 _↓ 60	70	70 [^]	550	240	240	140
	3	140 [^]	100	50	80	50	90	520	240		120
	4	140	80 [^] 30	40	80	60	90	520	280		120
Grave isolated	1	110	60 [^] 50	50	60	70	150	560	200		120
	2	160	30 [^] 90	50	40 _↓ 60	70	50 [^] 90	650	240	230	130
	3	120	90 [^] 20	50	80	70	20 _↓ 110 [^]	580	260	200	120
	4	120	90 [^] 60	20	90	80	20 _↓ 140 [^]	650	350	220	120

1. Neutral statement
2. Emphatic statement
3. Neutral question
4. Emphatic question

Prime after a figure means monosyllabic word

Two (or three) measurements for a segment means that it is divided into subsegments by a max (^) or a min (↓). See text 1.5

Measurements in msec and Hz

Appendix 3

Table 3.1. Durations of segments, locations of maxima and minima

Speaker: ALa, Gotland

		p	o	l	· ε	n	the whole word	F _o max ¹	F _o max ²	F _o min
Acute	1'	160	140 [^] 30	60			400	310		200
enframed	1	150	150 [^] 10	60	90	80	550	315		190
	2'	180	210 [^] 50	80			510	335		260
	2	190	170 [^] 40	80	110	90	680	350		190
	3'	130	120 [^] 70	80			390	340		220
	3	120	160 [^] 30	70	80	80	550	325		180
	4'	170	200 [^] 40	80			490	450		300
	4	170	200 [^] 40	90	100	60	660	450		180
Acute	1'		100 [^] 210	130			450	290		190
isolated	1		190 [^] 60	80	80 _↓ 100	90 [^]	610	310	240	180
	2'		90 [^] 260	120			480	425		190
	2		210 [^] 90	80	150 _↓ 60	110 [^]	710	375	220	180
	3'		250	100 [^]			360	400		-
	3		170 [^] 30	80	70 _↓ 90	70	510	425	400	210
	4'		330	50 [^] 40			430	500		-
	4		250 [^] 40	90	60 _↓ 120	90 [^]	640	500	425	200
Grave	1	200	210	70 [^]	100	90	680	300		200
enframed	2	-	250	80 [^]	100	90	-	500		260
	3	100	170	60	10 [^] 80	80	500	320		220
	4	190	250	80 [^]	110	80	720	425		200
Grave	1		240	30 [^] 40	140 _↓ 60	100 [^]	600	290	230	200
isolated	2		290	60 [^] 40	200 _↓	150	730	475		180
	3		230	40 [^] 50	90 _↓ 90	100 [^]	600	375	340	210
	4		280	50 [^] 50	100 _↓ 100	90 [^]	680	475	400	220

1. Neutral statement
2. Emphatic statement
3. Neutral question
4. Emphatic question

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Measurements in msec and Hz

Appendix 3

Table 3.2. Durations of segments, locations of maxima and minima

Speaker: ALa, Gotland

		ε	n	d	ð	n	a	the whole word	F ₀ max ¹	F ₀ max ²	F ₀ min
Acute enframed	1	130	70 [^] 40	40	50	60	90	480	325		180
	2	140	80 [^] 60	50	90	70	90	590	350		190
	3	130	60 [^] 30	40	50	60	60	440	350		200
	4	140	60 [^] 70	50	100	70	80	580	450		200
Acute isolated	1	140	80 [^] 50	50	100	80	60 _↓ 130 [^]	700	325	250	190
	2	190	70 [^] 90	80	110	80	70 _↓ 150 [^]	840	450	280	180
	3	130	70 [^] 70	30	80	70	50 _↓ 140 [^]	640	425	325	200
	4	170	120 [^] 60	70	100	90 _↓	200 [^]	820	500	400	200
Grave enframed	1	120	100	50	20 [^] 60	50	80	490	325		200
	2	160	130	40	10 [^] 90	70	90	600	375		190
	3	120	90	40	10 [^] 80	60	80	500	350		190
	4	160	120	80 [^]	140	80	110	690	450		200
Grave isolated	1	120	110	60 [^]	100	80	80 _↓ 120 [^]	660	325	240	180
	2	150	140	90 [^]	130	90	100 _↓ 110 [^]	830	500	210	180
	3	140	120	40 [^]	100	70	60 _↓ 140 [^]	680	400	300	200
	4	160	140	50 [^]	110	80	60 _↓ 130 [^]	740	475	500	230

1. Neutral statement
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Measurements in msec and Hz

Appendix 3

Table 4.1. Durations of segments, locations of maxima and minima

Speaker: ALö, Västergötland

		p	o	l	ε	n	the whole word	F ₀ max ¹	F ₀ max ²	F ₀ min
Acute	1'	160	200 [^] 60	90			520	180		140
enframed	1	[^] 110	180 _↓ 40	60	90 [^]	100	590	150	180	130
	2'	160	190 [^] 80	120			550	200		140
	2	[^] 120	70 _↓ 170	70	50 [^] 30	130	640	160	200	130
	3'	130	220 [^] 10	100			450	200		180
	3	[^] 110	120 _↓ 90	60	70 [^] 20	100	580	150	200	140
	4'	120	200 [^] 50	90			470	270		200
	4	[^] 110	150 _↓ 90	60	70 [^]	90	580	160	280	130
Acute	1'		190 [^] 70	160			420	150	160	120
isolated	1		[^] 180 _↓ 20	80	100	30 [^] 160	580	140	170	120
	2'		150 [^] 150	180			480	220		120
	2		[^] 100 _↓ 150	30 [^] 50	80	180	580	150	200	140
	3'		150 [^] 40	110			300	240		120
	3		[^] 160 _↓ 60	60	100 [^]	170	540	170	210	130
	4'		210 [^] 80	150			440	325		120
	4		[^] 220 _↓ 20	70	100	30 [^] 130	570	170	280	130
Grave	1	110	60 [^] 160 _↓ 70		80	30 [^] 80	600	170	180	120
enframed	2	120	70 [^] 200 _↓ 80		90	30 [^] 100	700	200	200	120
	3	80	50 [^] 160 _↓ 20 _↓ 40		100	40 [^] 70	570	180	190	120
	4	80	60 [^] 190 _↓ 60		90	30 [^] 80	610	240	250	120
Grave	1		40 [^] 150 _↓ 40	40 _↓ 40	90	60 [^] 120	550	170	160	120
isolated	2		80 [^] 170 _↓ 40 _↓ 40		110	20 [^] 170	640	200	210	120
	3		60 [^] 130 _↓ 40 _↓ 30		110	40 [^] 160	580	200	220	120
	4		70 [^] 160 _↓ 40 _↓ 40		110	50 [^] 150	610	260	280	120

1. Neutral statement
2. Emphatic statement
3. Neutral question
4. Emphatic question

Prime after a figure means monosyllabic word

Two (or three) measurements for a segment means that it is divided into subsegments by a max (^) or a min (↓). See text 1.5

Measurements in msec and Hz

Appendix 3

Table 4.2. Durations of segments, locations of maxima and minima

Speaker: ALö, Västergötland

		ϵ	n	d	∂	n	a	the whole word	F ₀ max ¹	F ₀ max ²	F ₀ min
Acute	1	^110	80 _✓ 50	60	60	70	20^50	510	160	180	120
enframed	2	20^110	100 _✓ 40	60	70	60	40^60	550	160	200	120
	3	^120	70 _✓ 80	60	80	60	20^70	560	160	200	130
	4	^120	90 _✓ 120	40	60	70	40^50	590	180	240	130
Acute	1	^120	140 _✓ 30	40	100	40	80^40	600	160	180	120
isolated	2	^120	140 _✓ 40	40	60^20	60	130	620	150	200	130
	3	^120	20 _✓ 120	40	80	60	110^	560	140	280	130
	4	20^110	150 _✓	60	90	60	90^30	620	160	300	120
Grave	1	50^60	150 _✓	70	120	60	50^40	600	180	180	110
enframed	2	80^20	170 _✓ 10	60	110	70	50^90	680	190	200	120
	3	40^70	150 _✓	60	90	70	50^30	560	180	200	120
	4	70^40	200 _✓	60	100	60	60^20	610	220	280	120
Grave	1	70^20	170	30 _✓ 20	120	50	110^30	620	160	160	120
isolated	2	80^30	190 _✓	70	100	70	90^60	700	200	200	120
	3	40^30	110	60 _✓	120	50	100^20	520	200	240	120
	4	90^20	200	80 _✓	110	50	140^10	700	320	300	120

1. Neutral statement

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Measurements in msec and Hz