A STUDY OF THE ROLE OF SYLLABLE AND MORA FOR THE TONAL MANIFESTATION IN WEST GREENLANDIC

Hideo Mase

1. Introduction

The purpose of this investigation is to see the relation between syllable and mora in connection with the tonal manifestation of the word in phrase-final position.

A mora is here to be understood as a unit of length which consists of (C)V, i.e. a short vowel segment with or without a preceding consonant. A short vowel is a one-mora vowel and a long vowel is a two-mora vowel. A syllable-final consonant is also taken as a mora,while a syllable-initial consonant is a non-syllabic, non-mora consonant. Thus, a long (i.e. geminate) consonant consists of one mora and one non-mora consonant. The terms "mora vowel" and "vowel mora" will be used synonymously, and so will "mora consonant" and "consonant mora".

2. Earlier studies of Greenlandic prosodics and the purpose of the present investigation

2.1. Stress

The great 19th century scholar Kleinschmidt (Holtved 1964) recognized that stress placement in Greenland Eskimo is tied up with segmental word structure and has merely a demarcative function. Thalbitzer (1904) gave a less clear account, which was to some extent due to his failure to recognize consonant length correctly in all instances (many of Thalbitzer's apparent examples of contrastive stress placement are entirely predictable once the distinction between long and short consonants is made consistently). Petersen (1970) argues that stress is acquiring some relevance because there is a tendency to clip off the final parts of words in running speech without moving the stress from its position in the representations prior to clipping.

In the present study the problems of stress are disregarded.

2.2. Tonal accent and intonation

The following is a brief survey of previous literature on tone in Greenlandic Eskimo.

2.2.1. Thalbitzer's description of musical accent

First it should be mentioned that there is actually no tonal accent in this language, so what Thalbitzer calls "musical accents" are elements of intonation patterns. Further, the tonal patterns which he describes seem to be what is called a phrase-final intonation below. Our concern here is whether the tone base is a syllable or mora in his description.

Thalbitzer (1904) describes "musical accent" in terms of (combinations of) two relative pitches: high and low. He says (1904) that

> "a change of tone often takes place during the pronunciation of a long sound, and this change is chromatic, not sudden. But changes of tone from syllable to syllable seem to take place in sudden leaps." (p. 136)

A combination of pitches (for example, a high-low pattern) may, according to Thalbitzer, be realized on a short vowel, on a long vowel, or on two short vowels divided into two syllables.

As for the distribution of the three types of "tones", he says that in dissyllabic words both rising (i.e. low-high) and compound (i.e. high-low-high) patterns occur, but the former is the more frequent. In three-syllable words the compound pattern is normal. The last high pitch is usually higher than the first one. In polysyllabic words there is an instance where the syllables of a word fall into pairs, each of which is given a low-high pattern. But the realization of this pattern is often blocked by the occurrence of a compound pattern, i.e. a high-low-high pattern. There are no further descriptions of the tonal patterns of polysyllabic words. Anyway, we can see no systematic description of tonal phenomena in his work.

In table 2-1 some of Thalbitzer's word examples are given for illustration.[1]

---

1) Phonetic notation by Thalbitzer, and phonemic notation by me.

TABLE 2-1

Examples from Thalbitzer (1904)

(˥ = high, ˩ = low, ˧ = middle pitches)

1-syllable word:	[kʊ·k]	/kuuk/,		
2-syllable words:	[uneq]	/uniq/,	[mɑ·ne]	/maani/,
	[ik·ɑ]	/ikka/,	[qarλι·t]	/qarliit/,
	[ɑs·aq]	/assaq/,	[mɑ·wnɑ]	/maana/,
	[qup·aq]	/quppaq/,	[pιŋa··]	/piŋaa/,
	[qum·ut]	/qummut/,	[ɑwŋ·ɔ·q]	/aŋŋuuq/,
3-syllable word:	[täsɑne]	/tasani/,		
4-syllable word:	[sinip·ise]	/sinippisi/,		
5-syllable word:	[pujɔrs·imɑsɔq]	/pujursimasuq/.		

(The phonemicization follows Thalbitzer's transcription, which is not entirely correct as regards quantity. Note in particular that the last-mentioned 2-syllable word actually has a long vowel in the first syllable: modern West Greenlandic /aaŋŋuuq/. Note also that Thalbitzer does not have the distinction between two s-phonemes which is made in this paper. This is a matter of dialect difference. Editors' note.)

2.2.2. Collis/Petersen's description of intonation

Collis (1970 p. 277) says that according to Petersen (op. cit.), intonation is more important than stress.

Moreover, Collis makes the following statements, more or less as a paraphrase of Petersen:[1]

When the stress falls on the antepenultimate, it is accompanied by a rising pitch on the final syllable, except in the case of an interrogative intonation (i.e. a 'yes-no' question, HM) in which case the final syllable has a falling pitch. Thus, when the antepenultimate syllable is a closed one, the intonation pattern is

/ \ / (statement),

/ _ \ (question),

for example,

/'taanárpìáq/, and /'taannárpiàq/.

However, since the closed syllable always takes stress, the stress accent does not always fall on the antepenultimate, but the intonation contour is unaffected by the existence of closed syllable(s) and remains unchanged. Thus Petersen affirms the priority of intonation as the distinctive feature of the last three syllables of the word.

---

1) As far as I can see in Petersen (op. cit.), stress and intonation is not so explicitly described as Collis will have it. Consequently I refer to the latter's description partly as his own and partly as Petersen's, i.e. as Collis/Petersen.

It is not certain whether the two intonation patterns described by Collis/Petersen are ones that occur in the same position in the sentence. The pattern which is said to be associated with "statement", i.e. the "rise-fall-rise" pattern, seems to be the phrase-final intonation defined in 2.2.3.

According to Collis/Petersen the tonal contours of the last three syllables of words serve to distinguish intonational patterns. However, as will be shown in the following section, it is actually the tonal contour of the last three (vowel) moras which is fixed, and not the contour of the last three syllables of the word.

2.2.3. Rischel's description of intonation

Rischel (1971 and personal communication) considers the single vowel segment rather than the syllable to be the unit of measure in West Greenlandic prosody. A long vowel is analysed as VV, i.e. a succession of two segments. He makes the following tentative analysis of the West Greenlandic intonation pattern in terms of terminal contours:[1]

(a) Phrase-internal contour: a succession of words belonging to one sentence may form a phrase. A word boundary which is non-final in a phrase, is signalled by high pitch on the last vowel segments (i.e. vowel moras), the penultimate one having in most cases a slightly higher pitch than the neighbouring ones ("raised" pitch).

---

1) A similar description of some of the intonation types is found in Petersen (1970). (Cf. 2.2.2.)

(b) Phrase-final contour: the penultimate vowel segment (i.e. vowel mora) of the word has a low pitch, whereas the antepenultimate and ultimate ones have a high pitch. For example, in /akiwuq/ and /akiwuŋa/ the underlined vowels are low-pitched. When the penultimate vocalic segment is part of a long vowel or of a diphthong /ai/ (the diphthong occurs only word-finally), the part in question has a low pitch. Thus, there is a falling pitch on the penultimate syllable of a word like /qaawuq/, and there is a rising pitch on the ultimate syllable of a word like /aŋiqaaq/.

(c) Yes-no question contour: the ultimate vowel segment of the word is low-pitched, the penultimate and antepenultimate vowel segments are high(er)-pitched, the tonal peak being on the antepenultimate one (except in some types of very short words). The relationship may be described as high-mid-low, or perhaps rather: raised-high-low. (If the penultimate vocalic segment is low-pitched, the word will presumably be perceived as having contour (e) below.) Examples of (c) are, schematically:

takuwaaŋā ?

takuwaaŋŋā ?

(d) Wh-question contour: a low pitch occurs on the penultimate vocalic segment, and a higher pitch occurs on the antepenultimate and ultimate vowel segments, for example,

kina takuwījuk ? ("kina" = "who").

It is not clear whether this contour exhibits some systematic difference from (b) above. In (d) the ultimate pitch may not be equal in height to the antepenultimate one.

(e) Absolutely final contour: the antepenultimate vowel segment has a high pitch, but the last two segments are low-pitched. The pattern of distribution of this contour is not well known, and it is difficult to distinguish rigidly between (b) and (e). Presumably the latter has a more marked status, i.e., (e) tends to be used only if finality is to be expressed explicitly. Schematically, the intonation is

—
takuwaāŋā,

—
takuwaa̅ŋ̅ŋā.

Other syllables than those involved in the contours mentioned in (a)-(e) have normally a neutral pitch, but three tendencies should be mentioned.
(I) Other conditions being equal, heavy syllables tend to be a little higher-pitched than light ones. (II) Long vowels tend to have less abrupt tone jumps than bisyllabic sequences. (III) There is a certain tendency for pitches over the utterance to go down gradually as the utterance goes on. But this gradual fall of pitches is not always observed.

In Rischel's description we understand that the tone base is definitely a vowel mora. His view is also summarized in Mase-Rischel (op. cit.):

> "the tonal contour of the word is closely bound to the vowel segments. For example, the typical contour before a non-final pause is characterized by nonlow tone on the antepenultimate and ultimate vowels, and low tone on the penultimate, no matter how they are distributed on syllables; schematically:
>
> (—)āawāa 'he fetches it' (—)ākiwāra 'I answer him'

> The tonal rules are as yet quite imperfectly understood, but there is evidence that the vowel segment (the "syllabic") plays at least as important a role as the syllable in prosodic rules." (p. 193)

It now seems evident that Thalbitzer's 'compound' (i.e. high-low-high) pattern and Collis/Petersen's intonation pattern for the statement (i.e. rise-fall-rise pattern) correspond to Rischel's phrase-final intonation, if and only if each of the last three syllables contains a short vowel.

2.3. Purpose of the present investigation

According to Rischel's scheme we should get the same type of tonal realization on the last three vowel moras of a word, irrespective of their distribution on syllables. For example, the phrase-final contour will appear as follows on three-mora words of three and two syllables:

i-kī-tit;	na-kā-taq;
tiī-tit (tii-tit);	kaā-taq (kaa-taq);
i-wīit (i-wiit);	a-māaq (a-maaq);

Likewise, we should get different pitch distributions on syllables of three-syllable words which have different numbers of moras.

For example,

na-kā-taq, and

ā-naa-wāa,

but not

*a-nāā-waa.

The first thing is to see how Rischel's terminal contours are manifested acoustically.

The next question is whether a consonant mora behaves more or less like a vowel mora. By way of definition, every syllable-final consonant is a mora.[1] Two kinds of consonant moras should be distinguished: (I) voiceless, and (II) voiced.

(I,a) Word-medial single versus double (= geminate) consonants: the pitch on the voiceless consonant mora is of course not realized. If, in word pairs such as

{katak / mattak} and {taqaq / qaqqaq},

we find that the timing of the tonal contour of /mattak/ and /qaqqaq/ with respect to the two vowel segments is different from that of /katak/ and /taqaq/ and is similar to that of, for example, /nakataq/, then we can say that the voiceless consonant mora counts the same as a vowel mora. If, on the other hand, the tonal contour of /mattak/ and /qaqqaq/ is realized in the same way as in /katak/ and /taqaq/, then we can say that the voiceless consonant mora is not counted as a tone base.

---

1) I.e., such consonants are here labelled "moras", not by reference to some potential or actual role in the realization of intonation contours, but on a distributional basis. The category may, however, be found useful both in connection with quantity (cf. Mase-Rischel 1971), stress, and intonation.

(I,b) Word-final consonant mora: Do /illu/ and /illut/ have the same or different tonal contours?

(II) Voiced consonant mora: The same question could be asked about the voiced consonant mora. In the type of material investigated here the word-medial nasal is the only type of voiced consonant mora.[1]

In words such as

1. maa<u>n</u>a,
2. ma<u>nn</u>a, and
3. maa<u>nn</u>a,

it is possible that a voiced consonant mora counts like a vowel mora, so that 1 and 2 are grouped together, or it may not, so that 1 and 3 are grouped together.

A priori, one would certainly consider it fairly probable that a nasal mora behaves in the same way as a vowel mora, whereas reference to voiceless consonant moras in the timing of intonation would seem a most improbable hypothesis. Both Collis' and Rischel's descriptions suggest that consonant moras altogether do not participate in regulating the intonation patterns.

The purpose of this investigation is to see how these things are realized acoustically.

3. Procedure in the acoustic-phonetic investigation

3.1. Subjects and recording

Three native, male speakers of central West Greenlandic (RP, AS, and GT) recorded the material during July and August

---

1) It must be mentioned that reduction phenomena, and their implications for tonal realizations, are not considered here. According to Petersen (1970) long (voiced) consonants may arise in connected speech by optional deletion of vowels between two like consonants. These long consonants would form a separate object of study from the point of view of intonation.

1971 in the sound treated studio of the Institute of Phonetics, University of Copenhagen. Each subject spoke each of two texts (see 3.2. below) six or seven times, so that twelve or thirteen recordings of each word token were obtained. The word lists were read distinctly at an even speed, but no further instructions were given.

3.2. Word list and text

A list of 90 wordforms (phonological words) was prepared.[1] In the text these words were arranged in random order, but, in order not to disturb the natural rhythm of speech, care was taken not to put next to each other words which contain drastically different numbers of syllables and/or moras, and words which, in sequence, might arouse some unusual or comical association of meaning. Two texts with different order of words were made, in such a way that a word which was put at the beginning or end of the line in one text was put in the middle of the line in the other text.

64 words with different numbers of syllables and moras were chosen for this investigation.[2] (Six five-mora words = nos. 86-91 were added after RP's recording was finished.) But due to difficulties in the precise segmentation, some of the words which include [j] (/j/), [w] (/w/)[3], [ɣ] (/g/)or [ʁ] (/r/) had to be omitted. Consequently, the number of words which are included in the following data is not the same among

---

1) I am very much obliged to Mr. Jørgen Rischel who was kind enough to make the original list.

2) The remaining 26 words contain various voiced continuants in intervocalic position and may be used later, particularly for the purpose of investigating the status of combinations of vowel+semivowel+vowel vis-à-vis long vowels on the one hand and sequences of vowel+fricative+vowel on the other.

3) Segmentation was not difficult when the phoneme /w/ was realized as a [v]- or [β]-like sound.

all three subjects. This explains why there are some missing tokens in the tables below. The word list is shown in table 3-1.

Each separate item of the word list was expected to be read with the terminal contour which is here called "phrase-final" in accordance with Rischel (see 2.2.3. above). It was rather easy to check whether this is actually the case. The phrase-final intonation is supposed to have a high-low-high pitch pattern on the last part of the word. The last vowel segments in the wh-question has a similar pattern, but it is uncertain whether this is phonologically the same intonation. The other patterns, according to Rischel, have descending pitches on the last two vowel moras, i.e. the penultimate vowel mora is higher than the ultimate one. With some exceptions which could be sorted out on a principled basis,[1] all words in the recordings were found to exhibit the first-mentioned relationship, i.e. a rise from the penultimate to the ultimate vowel mora. So, if there is any remaining mixture of intonations in the material of this investigation, it must be a confusion between phrase-final and wh-question intonations. However, no single question word is found in the text, so this possible source of variation can be disregarded.

3.3. Registration

All the material was registered on mingograms displaying a fundamental frequency curve, a duplex oscillogram, and four intensity curves (with an integration time of 5 msec) with different frequency filterings: (1) HP with cut-off frequency at

---

1) A few words which seem to have been spoken with absolutely final intonation because they occurred at the end of a line, were omitted from the measurements.

1000 or 1200 Hz, (2) HP at 500 Hz, (3) LP at 500 Hz, and (4) no filtering. Some wide-band spectrograms were taken to check the segmentation of the mingograms, but actually the difficulty of segmentation was the same both on the spectrogram and mingogram.

TABLE 3-1

List of words
(in phonemic notation)

No.	word	Nos. in texts	words to be compared with
1.	taaq	(18, 64)	
2.	puut	(80, 80)	20. puukka
3.	illu	(2, 79)	4. illut
4.	illut	(6, 72)	3. illu
5.	katak	(4, 78)	9. mattak, 19. kaataq
6.	masak	(7, 74)	7. nasaq, 10. aššak
7.	nasaq	(22, 59)	6. masak, 10. aššak
8.	taqaq	(24, 56)	12. qaqqaq
9.	mattak	(3, 76)	5. katak
10.	aššak	(9, 71)	6. masak, 11. aššaq
11.	aššaq	(20, 62)	7. nasaq, 10. aššak
12.	qaqqaq	(21, 58)	8. taqaq
13.	maniq	(26, 54)	{16. anniq, 17. marniq, 23. taaniq, 31. maanniq, 32. maarniq
14.	tuwit	(82, 83)	29. tuwikka
15.	manna	(84, 84)	22. maana, 30. maanna
16.	anniq	(29, 53)	See word 13.
17.	marniq	(44, 36)	See word 13.
18.	tiitit	(50, 28)	24. iwiit, 26. ikitit
19.	kaataq	(28, 52)	5. katak, 25. amaaq, 27. nakataq
20.	puukka	(81, 81)	2. puut
21.	quurqa	(85, 85)	36. quurqaa

TABLE 3-1
(continued)

No.	word	Nos. in texts	words to be compared with
22.	maana	(54, 29)	15. manna, 30. maanna
23.	taaniq	(52, 31)	See word 13.
24.	iwiit	(41, 41)	18. tiitit, 26. ikitit
25.	amaaq	(13, 70)	{33. ammaaq, 19. kaataq, 27. nakataq, 28. awataq
26.	ikitit	(25, 57)	18. tiitit, 24. iwiit
27.	nakataq	(42, 38)	19. kaataq, 25. amaaq, 28. awataq
28.	awataq	(47, 35)	{42. awataaq 19. kaataq, 25. amaaq, 27. nakataq
29.	tuwikka	(83, 82)	14. tuwit
30.	maanna	(19, 61)	See word 15.
31.	maanniq	(32, 48)	} See word 13.
32.	maarniq	(38, 42)	
33.	ammaaq	(16, 63)	25. amaaq
34.	aataa	(12, 69)	
35.	aappaa	(15, 67)	
36.	quurqaa	(35, 47)	21. quurqa
37.	tuurpara	(61, 18)	
38.	naalagaq	(43, 39)	
39.	kisiisa	(79, 2)	
40.	sukkuutit	(33, 49)	
41.	killuutit	(49, 33)	
42.	awataaq	(53, 30)	28. awataq
43.	naparutaq	(48, 32)	
44.	uqurluni	(36, 44)	
45.	iqqanarpuq	(66, 16)	
46.	iqqarsarpuq	(64, 17)	
49.	ammaqaaq	(89, 90)	
50.	anaawaa	(77, 4)	57. annaawaa

TABLE 3-1
(continued)

No.	word	Nos. in texts	words to be compared with
51.	tikiŋŋilaq	(88, 86)	
52.	ikusimmi	(91, 89)	
53.	aamaliwik	(39, 43)	
54.	amaaliwik	(46, 34)	
55.	aputituqaq	(86, 88)	
56.	akisimawuq	(87, 91)	
57.	annaawaa	(62, 20)	50. anaawaa
60.	iišaššaawuq	(67, 12)	63. ilišaššaawuq
62.	naluumasurtuq	(37, 45)	
63.	ilišaššaawuq	(75, 7)	60. iišaššaawuq
64.	ilutusimapput	(63, 21)	

3.4. Measurements

Only five recordings (= samples) of each word token by each informant were used in this investigation. If possible, these five samples were selected from the first two or three recordings of each text, but if a difficulty arose in these words, other recordings were used. One word, AS's No. 51 /tikiŋŋilaq/ has only four samples, because /i/ between the initial /t/ and the following /k/ was devoiced in all recordings except these four.[1] Other typical reasons for discarding a sample were: (a) straightforward problems of segmentation (see 3.4.1.), (b) extreme shortness of a vowel (after a voiceless consonant) causing a badly defined fundamental frequency, (c) a gradual onset of a word-initial vowel after a period of irregularity (glottal catch), which made it difficult to define the duration of the vowel proper, (d) other occasional occurrences of highly irregular F_o-curves (bad phonation?).

3.4.1. Duration

Segmentation was carried out according to conventions.[2] Accuracy of measurement is $\pm$ 0.25 cs.

---

1) This devoicing seems to have occurred due to strong affrication of the preceding /t/ ([t^s]), and perhaps partly due to devoicing of an unstressed high vowel between voiceless consonants.

2) As for the accuracy of measurement, the disadvantage of a mingogram without the "aid of supplementary broad band spectrograms" (Fant 1957, p. 62) seems to have been overcome to a high degree by the use of four intensity curves with different filtering frequencies.

Long vowels, i.e. two-mora vowels, occur in various consonantal environments, i.e. (-C)(C)_(C)(C-), and in various positions in the words. We cannot a priori decide where the mora boundary lies between two moras of a long vowel. Consequently, a long vowel was arbitrarily divided into two identical halves at the middle of the long segment. As for the long nasal, the first two thirds of the total duration was arbitrarily assigned as a mora-nasal and the last one third as the initial nasal consonant of the following syllable. This arbitrary decision was based on the observation that the minimal or maximal value of the fundamental frequency often occurs after a lapse of approximately two thirds of the total duration.

Initial and final consonants of words were not measured.

As mentioned in 3.2. it was not easy to delimit intervocalic [j], [w], [ɣ], and [ʁ]. In the transcriptions used here, /j, w/ after respectively /i, u/ stands for more or less audible glides. After other vowels /j, w/ are clearly distinct both from zero and from other fricatives. However, even when [j] was clearly heard, the change from [j] to the vowel was smooth and gradual on the acoustic curve. As a result, words containing /j/ were all omitted. [w] (/w/) was just as difficult to segment as [j], but when the phoneme was realized as [v] or [β], segmentation was not difficult. [ɣ] posed just the same problem as [j]. The uvular fricative [ʁ] showed a very low and often very irregular pitch, and the pitch of the adjacent vowel was very much influenced and became rather irregular. The influence was most conspicuous in words spoken by GT, who had a very deep voice, so that most of his words containing /r/ had to be discarded. (And, as shown later, words containing the consonants in question caused a certain irregularity in the results.)

Segmentation was also sometimes difficult in the case of nasal plus vowel or vowel plus nasal.

3.4.2. Fundamental frequency

Fundamental frequencies are measured at the following points: for a short vowel, the beginning and end of the segment; for a long vowel, the beginning, middle, and end of the segment; and for a mora nasal, the beginning, middle and end of the segment. As mentioned in 3.4.1., two thirds of the total duration of a long (i.e. geminate) nasal are assumed to represent a mora nasal, so the middle and end of the mora-segment correspond to the 1/3 and 2/3 points of the total duration of a long nasal, respectively. When a long vowel or a long nasal has a rise-fall or fall-rise pitch, more than three points were measured. Accuracy of measurement is $\pm$ 1.25 Hz.

As is generally known, the fundamental frequency curve of a vowel segment is sometimes distorted and shows some irregularity during the first and/or last one to two centiseconds of the segment, due to the influence of adjacent consonants (especially the preceding one). However, such irregularity might also arise as a consequence of the instrumental processing. In order to test the reliability of the frequency measuring device used for registration, a calibration with an intermittent sine wave of 125 Hz was carried out, and the result shows that the first and last cycles are registered a little lower than the rest.

The problems associated with these boundary phenomena were to some extent circumvented in the measurements: when any irregularities were found at the beginning and/or end of the segment, the tangent was drawn from the stable part and measured as the beginning and/or end. But it was sometimes difficult to decide whether the irregularity was an acoustic reality or an instrumental artifact. (Cf. section 5. and fig. 5-3.)

4. Results

4.1. Method of calculation

The original raw data were fed into a computer and run through a program which calculated the arithmetic mean and standard deviation[1] for each word token.[2] Each word token consists of five samples, except AS's word token No. 51, which has only four samples. Calculations were made for the duration, mean fundamental frequency, and slope of each tone base, and the difference of mean fundamental frequency between two tone bases adjacent to each other.

4.1.1. Mean fundamental frequency

The mean fundamental frequency of a tone base was calculated in the following way. [beg = beginning of a tone base, mid = mid point, end = end; V = vowel mora, N = nasal mora.]

1) short vowel: Mean = $(F_o(beg) + F_o(end))/2$,

---

1) The standard deviation as published in the tables below was calculated by the formula:

$$s = \sqrt{\frac{\Sigma(X-\bar{X})^2}{N}}$$

, which actually gives a somewhat too small estimate of the standard deviation in a large population because of the small number of samples of each token. Correction was made for the use of N instead of (N-1) in this formula, when the findings were tested for significance.

2) I am very much obliged to Mrs. B. Auld and Cand. polyt. Carl Ludvigsen. Mrs. Auld was kind enough to undertake the laborious work of punching the cards and to write the first part of the program, and Mr. Ludvigsen very kindly completed the program in a very short time.

2) long vowel:
i) when counted as one tone base: Mean = $(F_o(beg+mid+end))/3$,
ii) when counted as two tone bases: Mean = $F_o(beg + end)/2$, where for the first tone base, beg = beg, end = mid of a long vowel, and for the second tone base, beg = mid, end = end of a long vowel,

3) nasal mora: Mean = $F_o(beg + mid + end)/3$, where beg = beg, mid = 1/3 point, end = 2/3 point of a long nasal,

4) a vowel mora + a nasal mora = one tone base: Mean = $(VF_o(beg + end) + NF_o(mid + end))/4$.

In the data processed by the computer, the mean frequency values were calculated over three points of measurement for a long vowel, but a long vowel sometimes had a fall-rise or rise-fall contour, instead of a unidirectional rise or fall. For those long vowels which showed such rise-fall or fall-rise contours more than three points were measured and a hand-calculation was carried out to get the mean fundamental frequency value. (In the tables the values calculated by the latter method are shown in [ ].)

These values of mean fundamental frequencies of tone bases are compared in order to reveal any high-low relation between neighbouring tone bases. The reason why the mean values are compared is that, since the role of the direction and degree of pitch change of a tone base is not known, we cannot be sure whether a comparison reasonably should be made between beginnings and/or ends of two tone bases.

According to Rossi (1971), when one cannot hear a glissando during a (vowel) segment, it will be perceived as if it has a static pitch corresponding to the frequency at the transition between the second and third portions of the segment. Consequently, a comparison of mean fundamental frequencies seems to be reasonable at the first step, no matter whether a rise or fall is significant.

The absolute values of mean fundamental frequencies of tone bases may vary according to segmental constituents (and other factors). Thus, for example, the fundamental frequency of a penultimate vowel, which is lower than that of the antepenultimate in the same word, may be higher than that of the antepenultimate vowel in another word, which has the same relationship between the antepenultimate and penultimate vowels. This relation may also be seen among the samples within one and the same word token. In the following, our main concern is the difference in fundamental frequency between vowels.

Word tokens are classified not according to their vowel quality nor consonantal environment, but according to the numbers of syllables and/or moras.

4.1.2. Slope

A vowel or a nasal consonant has usually a rising or a falling pitch. That is, a certain fundamental frequency change or interval can be observed during a certain period of its duration. One question about this change is whether the absolute value of the frequency interval of the vowel (or the nasal consonant) is a constant, or whether it increases with increasing vowel duration.

Another question, which is of specific interest to the present investigation, is whether the direction of the fundamental frequency movement in a vowel is determined by the syllable or mora position.

To answer the first question the slope was calculated as:

$$\text{Slope} = (F_o(\text{end}) - F_o(\text{beg}))/\text{Duration}.$$

See the values of samples in the following word token used for illustration.

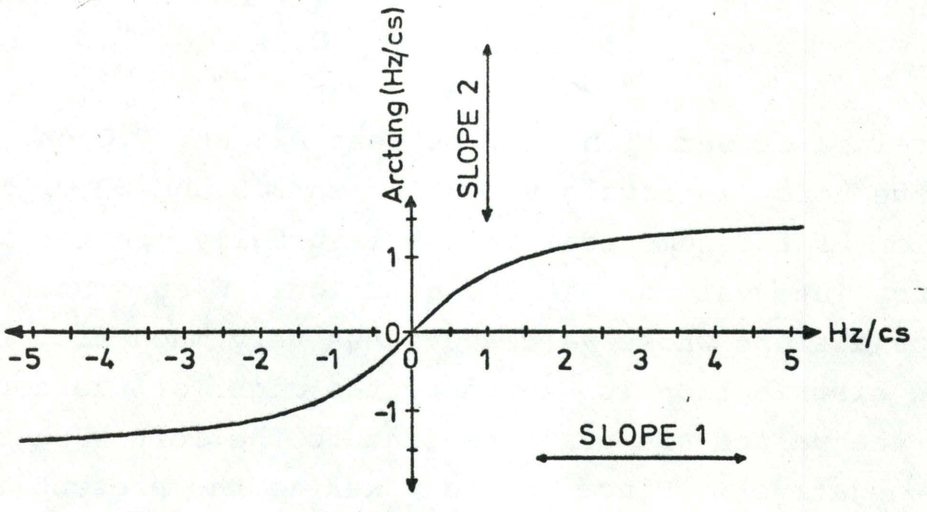
Sample [No.]	Dur. [cs]	Interv. [Hz]	Slope [Hz/cs]	Arctang(Slope) [radians]
1	5.5	12.5	2.27	1.19
2	5.5	2.5	0.46	0.43
3	5.0	20.0	4.00	1.33
4	7.0	5.0	0.71	0.62
5	4.5	5.0	1.11	0.84
$\overline{X}$	5.5	9.0	1.71	0.88
s	0.84	6.4	1.30	0.34

The values of duration vary between 4.5 and 7.0 cs, while the frequency intervals vary between 2.5 and 20.0 Hz. The variation of the numerical values is usually greater in the frequency interval than in the duration. When a sample (or two) has a slope whose value deviates very much from the others, the distribution is skewed to the right of the normal curve when the values are positive (and to the left when the values are negative). Since a word token in the present investigation has only five samples, this kind of deviation affects the results rather strongly.

But it is true that all five samples in the token shown above have positive slopes, i.e. they are all different from zero in positive direction. When the value of the slope is transformed to Arctangent(Slope), i.e. Arctangent(Hz/cs), the distribution of samples becomes less skewed. And we can see that this particular token has a slope whose mean value is significantly different from zero in positive direction. The figure on the next page shows the relation of values in (Hz/cs) and Arctang(Hz/cs).

In the following, the first slope (i.e. Hz/cs) will be called "slope 1" and the second transformed one (i.e. Arctang (Slope)) "slope 2". As for the slope, vowels are classified according to their position in the word and consonantal environments.

Relation between slopes 1 and 2



4.1.3. Other remarks

The position of the syllable or mora in the word is reckoned from the end of the word. Thus, the ultimate syllable or mora is called S1 or M1, the penultimate one S2 or M2, the antepenultimate one S3 or M3, and so on (where "S" and "M" stand for "syllable" and "mora" respectively).

Structurally a syllable or mora consists of (C)V(V)(C). But, since the consonants (except some mora consonants functioning as tone bases) are disregarded in the following, the vowels in S1, S2, M1, M2, etc. are often, for convenience, abbreviated as S1, S2, M1, M2, etc.

When a syllable is considered to be a tone base one vowel is counted as one tone base, whether it is long or short. When a mora is considered as a tone base, a short vowel and a nasal mora are counted as one base each, and a long vowel is counted as two bases.

4.2. Duration

4.2.1. Consonants

The statistic calculations were only carried out for short and long consonants in two-syllable, two-mora words and for all short and long nasal consonants.

As for short and long voiceless consonants in two-syllable, two-(vowel) mora words, a phonemically long consonant is phonetically longer than a phonemically short one in the same or a similar environment. The difference is significant at the 99% confidence level.

In this investigation, a "mora nasal" is arbitrarily considered as 2/3 of the total duration of a long nasal. In this case, a short nasal consonant is shorter than a mora nasal in the same or similar environment. The difference is significant at the 99% confidence level.

4.2.2. Vowels

No exhaustive comparison was attempted, since not all short and long vowels appear in (sub)minimal pairs or sets. It is not altogether certain whether the difference between short and long vowels is always significant at, say, the 95 or 99% confidence level. But the difference (i.e. a short vowel is shorter than a long one) is significant at the 99% level in some of the pairs or sets.

4.3. Mean fundamental frequency

It is assumed in this paper that the phrase-final intonation is signalled by a high-low-high pitch pattern on the last three tone bases. That is, with regard to the mean fundamental frequency, the tone base of S1 or M1 can be expected to be higher than that of S2 or M2, and that of S2 or M2 can be expected to be lower than that of S3 or M3. The tonal contours of the preceding tone bases (i.e. from S4 to S6, or from M4 to M6) are largely unknown.

4.3.1. Is the tonal pattern regulated on a syllable basis?

4.3.1.1. Words containing only short vowels

The number of words are:

["-s" = syllable]

	RP	AS	GT
2-s	14	15	15
3-s	3	4	4
4-s	3	6	4
5-s	0	1	2
6-s	1	1	1
total	21	27	26

See table 4-1.

(1) S2-S1: S2 will be lower than S1: The vowel of S2 is lower than that of S1, and the difference is statistically significant[1] in all the tokens of three speakers.

1) Hereafter, statistically significant means at the 95% confidence level.

(2) S3-S2: S3 will be higher than S2: All the vowels of S2 are lower than those of S3, and the difference is significant in all tokens.

(3) S4-S3: In all four tokens spoken by RP, S4 is lower than S3 in their mean values, but there are some samples where S4 is higher than S3. The result is that the difference between the two vowels cannot be shown to be significant. In all eight tokens spoken by AS, S4 is significantly lower than S3, and so it is in all seven tokens spoken by GT.

(4) S5-S4: In all six tokens (three persons pooled), S5 is lower than S4, and the difference is significant except in GT's token (56) akisimawuq.

(5) S6-S5: There is only one six-syllable word for each speaker. S6 of RP's token is significantly higher than S5, while S6 is significantly lower than S5 in the same tokens spoken by AS and GT.

The mean fundamental frequencies of vowels of both S3 and S1 can generally be expected to be rather high. S3 is generally lower than S1. The number of word tokens in which S3 is significantly lower than S1 is 5 out of 7 of RP's, 11 out of 12 of AS's, and 10 out of 11 of GT's words.

As a whole, the difference is smaller in RP's than in AS's and GT's words. This is due to the fact that the range of variation of the fundamental frequency is smallest in RP's words.

In the tokens where the differences between adjacent vowels are significant, the mean values of vowels which are assumed to be the higher ones are more than 5 Hz greater than those of the lower ones. One exception is AS's token (64) ilutusimapput, where the difference between S4 and S3 is 4.0 Hz.

In addition to the assumption on the pitches of the last three tone bases, when we tentatively assume that S3 is higher than S4, that S4 is higher than S5, and that S5 is higher than S6, the number of tokens where the differences between adjacent tone bases are significant is as follows. [The figure to the left of the slash indicates the number of tokens where the difference is significant; the figure to the right of the slash indicates the total number of tokens.]

	RP	AS	GT
S2 < S1	21/21	27/27	26/26
S3 > S2	7/7	12/12	11/11
S4 < S3	0/4	8/8	7/7
S5 < S4	1/1	2/2	2/3
S6 < S5	0/1	1/1	1/1

[NB : In RP's token S6 is significantly higher than S5.]

TABLE 4-1

Mean fundamental frequency values (in Hz), and the significance of differences of mean fundamental frequency values between adjacent vowels. The calculations are carried out on a "syllable" basis in words containing only "short" vowels.

(+: agrees significantly with the assumption,
-: differs significantly from the assumption,
O: no significance.)

Subject: RP	Mean fund. freq.				Significance		
	S4	S3	S2	S1	4<3	3>2	2<1
5. ka-tak			132.0	152.3			+
6. ma-sak			129.5	151.0			+
7. na-saq			135.5	154.0			+
8. ta-qaq			132.8	155.8			+
3. il-lu			140.5	157.5			+
4. il-lut			139.5	154.8			+
9. mat-tak			138.3	154.0			+
10. aš-šak			140.5	152.0			+
11. aš-šaq			144.8	150.8			+
12. qaq-qaq			135.8	147.8			+
13. ma-niq			138.0	157.5			+
15. man-niq			137.5	154.0			+
16. an-niq			143.3	150.5			+
17. mar-niq			136.5	150.8			+
26. i-ki-tit		151.3	139.3	159.5		+	+
27. na-ka-taq		143.5	133.0	153.5		+	+
28. a-wa-taq		141.8	131.0	156.3		+	+
44. u-qur-lu-ni	141.8	147.3	134.3	155.5	O	+	+
45. iq-qa-nar-puq	148.3	148.3	137.3	155.3	O	+	+
46. iq-qar-sar-puq	140.0	147.3	137.0	153.5	O	+	+
64. i-lu-tu-si-map-put	144.8	152.5	125.5	155.8	O	+	+
			S6	S5		6<5	5<4
64.			145.5	139.3		-	+

TABLE 4-1
(continued)

Subject: AS	Mean fund. freq.				Significance		
	S4	S3	S2	S1	4<3	3>2	2<1
5. ka-tak			125.3	159.5			+
6. ma-sak			117.8	159.5			+
7. na-saq			120.3	154.8			+
8. ta-qaq			120.3	157.3			+
3, il-lu			132.0	167.8			+
4. il-lut			137.3	167.8			+
9. mat-tak			126.8	164.8			+
10. aš-šak			129.5	164.0			+
11. aš-šaq			128.8	162.5			+
12. qaq-qaq			131.5	161.0			+
14. tu-wit			124.5	153.3			+
13. ma-niq			121.8	158.3			+
15. man-na			140.8	161.8			+
16. an-niq			129.8	155.8			+
17. mar-niq			128.0	156.8			+
26. i-ki-tit		142.5	128.0	167.3		+	+
27. na-ka-taq		138.8	121.8	157.8		+	+
28. a-wa-taq		130.5	121.5	156.3		+	+
29. tu-wik-ka		148.3	127.5	161.8		+	+
43. na-pa-ru-taq	126.0	138.3	117.0	153.0	+	+	+
44. u-qur-lu-ni	127.3	151.3	122.5	159.8	+	+	+
45. iq-qa-nar-puq	129.8	147.8	126.5	162.5	+	+	+
46. iq-qar-sar-puq	125.8	146.3	119.3	153.5	+	+	+
51. ti-kiŋ-ŋi-laq	138.1	152.5	118.4	148.8	+	+	+
52. i-ku-sim-mi	136.3	148.8	134.0	153.8	+	+	+
55. a-pu-ti-tu-qaq	143.5	150.3	126.3	158.5	+	+	+
64. i-lu-tu-si-map-put	145.0	149.0	124.5	159.5	+	+	+
			S6	S5		6<5	5<4
55.				128.3			+
64.			126.5	132.8		+	+

TABLE 4-1
(continued)

Subject: GT	Mean fund. freq.				Significance		
	S4	S3	S2	S1	4<3	3>2	2<1
5. ka-tak			100.0	138.0			+
6. ma-sak			101.3	139.8			+
7. na-saq			96.5	133.5			+
8. ta-qaq			98.3	130.3			+
3. il-lu			111.3	144.5			+
4. il-lut			114.0	144.3			+
9. mat-tak			101.8	138.5			+
10. aš-šak			106.8	141.5			+
11. aš-šaq			104.0	144.3			+
12. qaq-qaq			97.3	132.8			+
14. tu-wit			103.5	134.5			+
13. ma-niq			97.8	138.8			+
15. man-na			110.0	140.3			+
16. an-niq			103.8	134.0			+
17. mar-niq			101.8	142.0			+
26. i-ki-tit		120.8	107.8	144.0		+	+
27. na-ka-taq		109.8	97.3	130.5		+	+
28. a-wa-taq		110.0	96.8	135.5		+	+
29. tu-wik-ka		122.0	110.3	137.5		+	+
44. u-qur-lu-ni	102.0	130.8	105.0	139.3	+	+	+
45. iq-qa-nar-puq	105.0	120.3	107.5	147.8	+	+	+
51. ti-kiŋ-ŋi-laq	115.8	122.0	105.0	132.8	+	+	+
52. i-ku-sim-mi	109.8	127.0	121.3	140.5	+	+	+
55. a-pu-ti-tu-qaq	111.3	127.3	102.8	132.8	+	+	+
56. a-ki-si-ma-wuq	112.3	132.3	103.3	131.3	+	+	+
64. i-lu-tu-si-map-put	121.3	138.3	110.0	150.5	+	+	+

	S6	S5	6<5	5<4
55.		103.3		+
56.		108.3		0
64.	105.0	116.3	+	+

4.3.1.2. Words containing both short and long vowels

Table 4-2 shows the mean fundamental frequencies of the vowels and the differences of mean fundamental frequencies between the vowels.

The assumption on the pitches of the last three tone bases holds true of two-syllable words of the type VV-V and three-syllable words of the type VV-V-V (where VV is a long vowel and V is a short vowel, and a hyphen shows a syllable boundary, and consonants are disregarded). But in two- and three-syllable words of other types, the results are quite different.[1] Cf. fig. 4-1 which shows the values of the mean fundamental frequencies of vowels in adjacent syllables. The values of vowels which can be expected to be the higher ones are given on the y-axis and the one which can be expected to be the lower ones on the x-axis.

In two-syllable words of the V-VV type of words ((24) i-wiit, (25) a-maaq, and (33) am-maaq), S2 is either higher or lower than S1. This difference is significant in some cases, but not in other cases. In the VV-VV type of words ((34) aa-taa, (35) aap-paa, and (36) quur-qaa), no significant difference is seen between S2 and S1, except that in the tokens (36) spoken by RP and GT, S2 is significantly higher than S1.

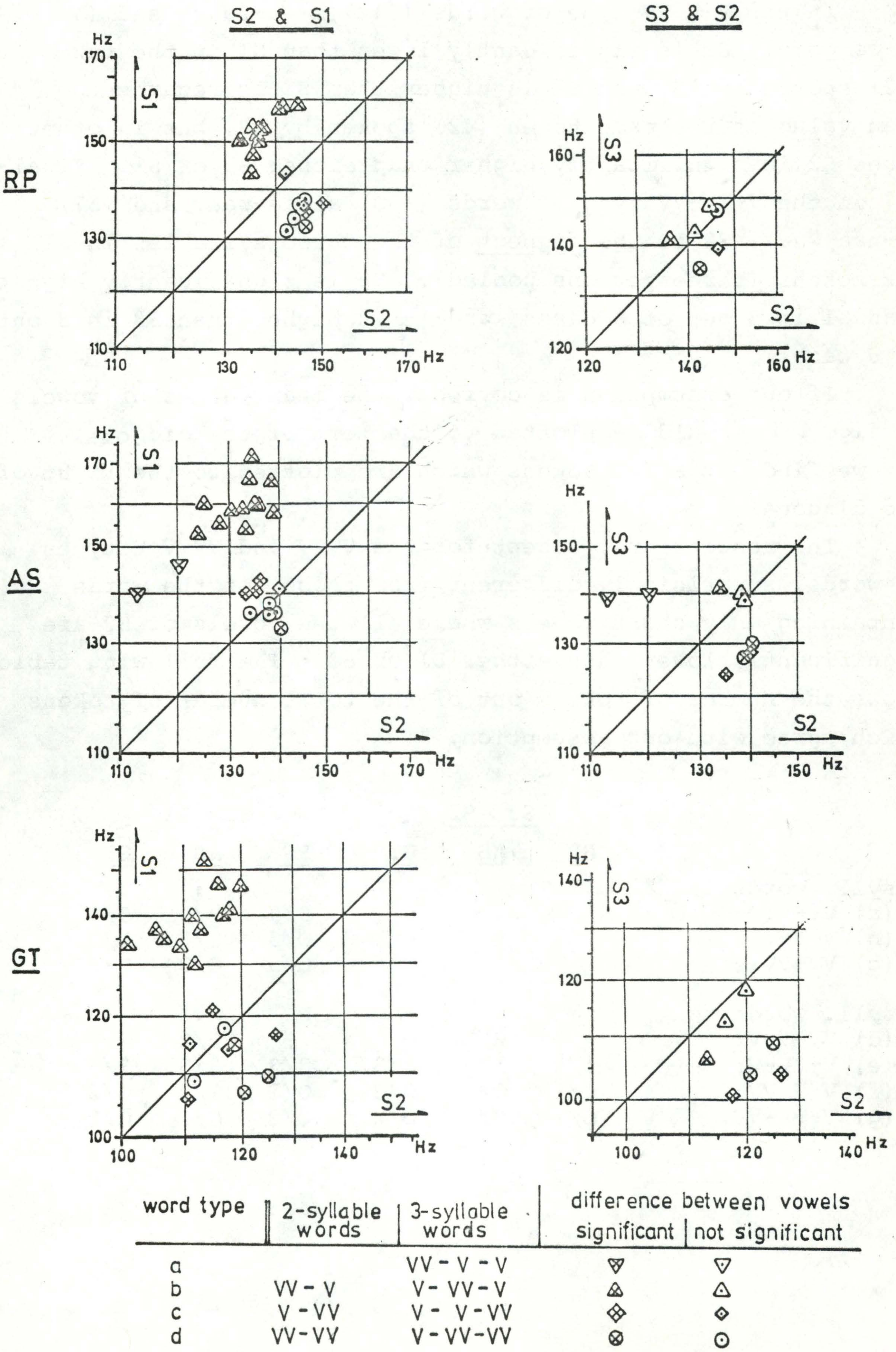
With regard to three-syllable words, in the V-VV-V type of words ((39) ki-sii-sa, (40) suk-kuu-tit, and (41) kil-luu-tit), S2 is significantly lower than S1, but S2 is either higher or lower than S3. That is, S2 is significantly

---

1) We have a few words which have more than four syllables (see table 3-1), but since the last three syllables of these words contain only short vowels, they are irrelevant to the present task of checking the pitches of the last three tone bases.

Fig. 4-1.

Values of mean fundamental frequencies of vowels in two adjacent syllables. [The values of vowels supposed to be the higher of the two are given on the y-axis, and the other supposed to be the lower on the x-axis.]



lower than S3 in the token (39) spoken by RP and in the token (41) spoken by AS. S2 is significantly higher than S3 in the token (39) spoken by GT. In other cases the difference between S3 and S2 is not significant.

In the V-V-VV type of words ((42) a-wa-taaq, and (49) am-ma-qaaq), S2 is significantly lower than S1 in the token (42) spoken by AS, and S2 is higher than S3 as regards the mean value of the same token (42) spoken by RP, but in other cases S2 is significantly higher than either S3 or S1. Finally, in the V-VV-VV type of words ((50) a-naa-waa, and (57) an-naa-waa), S2 is the highest of the three syllables in all six tokens (three persons pooled). S2 is significantly higher than S1 in 3 out of 6 cases, and it is higher than S3 in 5 out of 6 cases.

If our assumption is correct, the mean values of vowels in fig. 4-1 should be plotted to the left of the diagonal, but we find not a few tokens which are plotted to the right of the diagonal.

The results are, except for the VV-V and VV-V-V types of words, surprisingly different from those for the words containing only short vowels where all the vowels of S2 are significantly lower than either S1 or S3. The following table shows the number of tokens out of the total number of tokens which agree with our assumption.

	S3 > S2			S2 < S1		
	RP	AS	GT	RP	AS	GT
2-syll. words:						
(a) VV-V:				9/9	9/9	9/9
(b) V-VV:				0/3	2/2	1/3
(c) VV-VV:				0/3	0/3	0/3
3-syll. words:						
(d) VV-V-V:	-	2/2	-	-	2/2	-
(e) V-VV-V:	1/3	1/3	0/3	3/3	3/3	3/3
(f) V-V-VV:	0/1	0/2	0/2	0/1	1/2	0/2
(g) V-VV-VV:	0/2	0/2	0/2	0/2	0/2	0/2

TABLE 4-2

Mean fundamental frequency values (in Hz), and the significance of differences of mean fundamental frequency values between adjacent vowels. The calculations are carried out on a "syllable" basis in words containing both "short" and "long" vowels.

([ ] indicate values calculated over more than three points of measurements.
+: agrees significantly with the assumption,
-: differs significantly from the assumption,
O: no significance.)

Subject: RP	S4	S3	S2	S1	4<3	3>2	2<1
		Mean fund. freq.			Significance		
18. tii-tit			140.3	157.3			+
19. kaa-taq			134.8	146.8			+
20. puuk-ka			137.5	153.3			+
21. quur-qa			135.0	143.5			+
22. maa-na			132.5	150.3			+
23. taa-niq			132.7	150.3			+
30. maan-na			136.5	150.3			+
31. maan-niq			137.2	153.3			+
32. maar-niq			134.8	152.8			+
24. i-wiit			141.8	143.2			O
25. a-maaq			145.8	[136.3]			O
33. am-maaq			149.8	137.2			-
34. aa-taa			[144.7]	[136.7]			O
35. aap-paa			143.8	134.0			O
36. quur-qaa			146.5	[132.1]			-
39. ki-sii-sa		140.8	136.5	151.0		+	+
40. suk-kuu-tit		147.8	144.3	159.0		O	+
41. kil-luu-tit		142.3	141.3	158.0		O	+
42. a-wa-taaq		139.0	146.3	[135.0]		O	-
50. a-naa-waa		134.8	[142.3]	[131.3]		-	O
57. an-naa-waa		146.8	145.8	137.3		O	O
53. aa-ma-li-wik	142.5	144.3	134.8	156.3	O	+	+
54. a-maa-li-wik	142.8	145.2	133.5	151.8	O	+	+

TABLE 4-2
(continued)

Subject: AS	S4	S3	S2	S1	4<3	3>2	2<1
		Mean fund. freq.			Significance		
18. tii-tit			134.3	171.3			+
19. kaa-taq			[124.1]	152.8			+
20. puuk-ka			134.8	159.5			+
21. quur-qa			135.5	159.0			+
22. maa-na			[128.1]	155.3			+
23. taa-niq			125.2	159.8			+
30. maan-na			132.7	154.0			+
31. maan-niq			130.5	158.3			+
32. maar-niq			132.3	158.8			+
25. a-maaq			133.0	140.0			+
33. am-maaq			136.0	142.3			+
34. aa-taa			137.8	135.5			O
35. aap-paa			133.7	136.0			O
36. quur-qaa			138.2	137.7			O
37. tuur-pa-ra		139.0	112.8	139.8		+	+
38. naa-la-gaq		139.7	120.5	146.0		+	+
39. ki-sii-sa		138.5	138.8	157.8		O	+
40. suk-kuu-tit		140.0	138.5	165.5		O	+
41. kil-luu-tit		141.0	134.2	165.8		+	+
42. a-wa-taaq		124.0	135.0	[140.5]		-	+
49. am-ma-qaaq		127.8	139.8	140.7		-	O
50. a-naa-waa		127.0	[139.1]	[136.0]		-	O
57. an-naa-waa		130.0	[140.3]	[132.7]		-	-
53. aa-ma-li-wik	131.8	146.5	127.8	155.0	+	+	+
54. a-maa-li-wik	123.5	140.8	128.0	157.5	+	+	+
62. na-luu-ma-sur-tuq	138.8	148.0	128.3	161.5	+	+	+

	S5	5<4
62.	125.0	+

TABLE 4-2
(continued)

Subject: GT

	Mean fund. freq.				Significance		
	S4	S3	S2	S1	4<3	3>2	2<1
18. tii-tit			113.3	151.8			+
19. kaa-taq			101.2	133.8			+
20. puuk-ka			117.8	140.8			+
21. quur-qa			117.0	139.8			+
22. maa-na			[105.3]	136.8			+
23. taa-niq			106.7	134.8			+
30. maan-na			111.7	129.8			+
31. maan-niq			109.5	133.5			+
32. maar-niq			111.3	140.0			+
24. i-wiit			114.8	[120.9]			+
25. a-maaq			110.5	[105.7]			−
33. am-maaq			110.8	114.7			0
34. aa-taa			117.0	117.7			0
35. aap-paa			110.8	108.7			0
36. quur-qaa			118.7	115.2			−
39. ki-sii-sa		106.3	113.0	137.0		−	+
40. suk-kuu-tit		118.0	120.0	146.0		0	+
41. kil-luu-tit		112.5	116.0	146.5		0	+
42. a-wa-taaq		100.3	117.3	114.0		−	0
49. am-ma-qaaq		103.8	126.3	116.2		−	−
50. a-naa-waa		103.8	[120.4]	[106.8]		−	−
57. an-naa-waa		108.8	125.0	[109.4]		−	−
53. aa-ma-li-wik	105.5	126.0	104.0	137.3	+	+	+
54. a-maa-li-wik	106.5	122.0	106.0	137.3	+	+	+
60. ii-šaš-šaa-wuq	110.5	128.0	113.67	134.0	+	+	+
63. i-li-šaš-šaa-wuq	110.8	126.5	117.5	136.3	+	+	+

	S5	5<4
63.	103.8	+

4.3.2. Is the tonal pattern regulated on a mora basis?

4.3.2.1. The role of the voiceless consonant mora

In section 1., every syllable-final consonant was considered as a mora. If a word-final consonant is taken to count as a tone base, then in the (C)V-CVC type of words the vowel of the final syllable will be M2, and the vowel of the initial syllable will be M3. In this case, M2 is the mora which has the highest mean fundamental frequency. It is higher than that of M3, and this difference is significant! This is contrary to the assumption concerning phrase-final intonation. Further, in one pair of words, (3) illu and (4) illut, there is no significant difference of mean fundamental frequency between the final vowels of the two words. Consequently, the word-final consonant (which is always voiceless) should not be counted as a tone base.

If part of the word-medial voiceless consonant is taken as a tone base, the first vowel of (C)VC-CV(C) words will be M3, and the word-medial consonant mora will be M2. As is seen in table 4-1 , there is no difference of mean fundamental frequency between the vowel of M3 (= S2) in the (C)V-C-CV(C) type of words and that of M2 (= S2) in the (C)V-CV(C) type.

Consequently, in the following a voiceless consonant mora is not taken as a tone base. The behaviour of a voiced consonant mora, i.e. a nasal mora, will be taken up later in 4.3.2.4.

4.3.2.2. Words containing only short vowels (and no long nasal)

Since a voiceless consonant mora is not taken as a tone base, the results are the same as those obtained for words with short vowels on a syllable basis, except that words containing a long nasal are, for the time being, not included.

4.3.2.3. Words containing both short and long vowels (and no long nasal)

Here a short vowel is counted as one mora vowel, and a long vowel is counted as two mora vowels. See table 4-3.

(1) M2-M1: M2 will be lower than M1: The numbers of tokens are 20 for RP, 22 for AS, and 22 for GT. In all the tokens M2 is significantly lower than M1.

(2) M3-M2: M3 will be higher than M2: The numbers of tokens are 18 for RP, 20 for AS, and 20 for GT. In all the tokens M3 is significantly higher than M2.

(3) M4-M3: The numbers of tokens are 10 for RP, 13 for AS, and 12 for GT. In five tokens spoken by RP, M4 is significantly lower than M3. In three tokens of the same person M4 is lower than M3, but the difference is not significant. Two tokens of his ((39) kisiisa, and (40) sukkuutit) have significantly higher M4. In the tokens spoken by AS, 11 out of 13 tokens have significantly lower M4. Two tokens ((40) sukkuutit, and (41) killuutit) have either higher or lower M4. In the tokens spoken by GT, M4 is significantly lower than M3 in four- and five-mora words (10 tokens). But in two six-mora words the result is different. In (60) iišaššaawuq, M4 is significantly higher than M3, and in (63) ilišaššaawuq, M4 is either higher or lower than M3. (These six-mora words are found only in GT's list.)

(4) M5-M4: In the token (50) anaawaa spoken by RP, M5 is significantly lower than M4, but in two other tokens spoken by the same person the difference is not significant. In AS's four tokens and in GT's five tokens, M5 is significantly lower than M4.

(5) M6-M5: The numbers of tokens are 1 for AS and 2 for GT. M6 is significantly lower than M5.

As for M3 and M1, M3 is significantly lower than M1 in 12 out of 18 tokens of the material spoken by RP, in 17 out of 20 tokens by AS, and in 14 out of 20 tokens by GT.

The number of tokens which agree with our assumption is as follows. [The figure to the left of the slash indicates the number of tokens in which the difference is significant; the figure to the right of the slash indicates the total number of tokens.]

	RP	AS	GT
M2 < M1	20/20	22/22	22/22
M3 > M2	18/18	20/20	20/20
M4 < M3	5/10	11/13	10/12
M5 < M4	1/3	4/4	5/5
M6 < M5	-	1/1	2/2

[NB: In RP's (39) and (40) M4 is significantly higher than M3; in GT's (60) M4 is significantly higher than M3.]

When words containing only short vowels or both short and long vowels are put together, but words containing long nasals are omitted, the number of tokens which agree with our assumption on the mora basis is as follows.

	RP	AS	GT
M2 < M1	38/38	44/44	43/43
M3 > M2	25/25	30/30	29/29
M4 < M3	5/14	17/19	15/17
M5 < M4	2/4	6/6	7/8
M6 < M5	0/1	2/2	3/3

In the tokens in which the differences between adjacent moras are significant, the following tokens have values of less than 5.0 Hz difference. [Values in Hz.]

M3 > M2:

AS:	(42)	awataaq	(4.3)
GT:	(22)	maana	(5.0)
	(24)	iwiit	(5.0)

M4 < M3:

RP:	(35)	aappaa	(4.2)
	(36)	quurqaa	(4.2)
	(50)	anaawaa	(3.0)
	(53)	aamaliwik	(4.3)

M5 < M4:

GT:	(53)	aamaliwik	(5.0)

M6 < M5:

GT:	(60)	iišaššaawuq	(3.0)

TABLE 4-3

Mean fundamental frequency values (in Hz), and the significance of differences of mean fundamental frequency values between adjacent vowel moras. The calculations are carried out on a "mora" basis in words containing both "short" and "long" vowels (and no long nasal).

([ ]: indicates values calculated over more than two points of measurement,
+: agrees significantly with the assumption,
-: differs significantly from the assumption,
O: no significance.)

Subject: RP	Mean fund. freq.				Significance		
	M4	M3	M2	M1	4<3	3>2	2<1
1. ta-aq			[127.8]	[140.3]			+
2. pu-ut			142.3	156.3			+
18. ti-i-tit		141.5	135.5	157.3		+	+
19. ka-a-taq		134.8	126.3	146.8		+	+
20. pu-uk-ka		141.3	133.8	153.3		+	+
21. qu-ur-qa		135.8	130.5	143.5		+	+
22. ma-a-na		132.5	125.5	150.3		+	+
23. ta-a-niq		133.8	126.5	150.3		+	+
24. i-wi-it		141.8	134.3	147.5		+	+
25. a-ma-aq		145.8	[132.2]	[145.2]		+	+
34. a-a-ta-a	[140.8]	[148.5]	[128.7]	142.5	+	+	+
35. a-ap-pa-a	140.8	145.0	126.3	135.0	+	+	+
36. qu-ur-qa-a	141.3	145.5	[126.3]	[136.2]	+	+	+
39. ki-si-i-sa	140.8	136.5	130.0	151.0	-	+	+
40. suk-ku-u-tit	147.8	144.0	138.3	159.0	-	+	+
41. kil-lu-u-tit	142.3	142.8	135.0	158.0	O	+	+
42. a-wa-ta-aq	139.0	146.3	[129.8]	143.5	O	+	+
50. a-na-a-wa-a	140.3	[143.3]	[126.5]	138.0	+	+	+
53. a-a-ma-li-wik	140.0	144.3	134.8	156.3	+	+	+
54. a-ma-a-li-wik	142.8	144.3	133.5	151.8	O	+	+
				M5			5<4
50.				134.8			+
53.				141.8			O
54.				142.8			O

TABLE 4-3
(continued)

Subject: AS	Mean fund. freq.				Significance		
	M4	M3	M2	M1	4<3	3>2	2<1
1. ta-aq			125.3	145.0			+
2. pu-ut			136.0	154.8			+
18. ti-i-tit		141.3	126.8	171.3		+	+
19. ka-a-taq		[130.5]	[115.5]	152.8		+	+
20. pu-uk-ka		140.3	125.5	159.5		+	+
21. qu-ur-qa		140.0	127.0	159.0		+	+
22. ma-a-na		[131.3]	122.8	155.3		+	+
23. ta-a-niq		129.0	118.5	159.8		+	+
25. a-ma-aq		133.0	125.5	150.8		+	+
34. a-a-ta-a	130.0	143.5	120.8	142.8	+	+	+
35. a-ap-pa-a	126.5	136.5	123.0	146.0	+	+	+
36. qu-ur-qa-a	132.8	140.3	122.8	143.8	+	+	+
37. tu-ur-pa-ra	134.3	139.5	112.8	139.8	+	+	+
38. na-a-la-gaq	133.3	140.8	120.5	146.0	+	+	+
39. ki-si-i-sa	138.5	145.0	127.0	157.8	+	+	+
40. suk-ku-u-tit	140.0	141.0	127.3	165.5	O	+	+
41. kil-lu-u-tit	141.0	139.5	124.3	165.8	O	+	+
42. a-wa-ta-aq	124.0	135.5	[131.2]	153.8	+	+	+
50. a-na-a-wa-a	136.0	[142.2]	[125.7]	150.5	+	+	+
53. a-a-ma-li-wik	134.3	146.5	127.8	155.5	+	+	+
54. a-ma-a-li-wik	136.3	144.0	128.0	157.5	+	+	+
62. na-lu-u-ma-sur-tuq	140.3	148.0	128.3	161.5	+	+	+

			M6	M5		6<5	5<4
50.				127.0			+
53.				125.8			+
54.				123.5			+
62.			125.0	133.5		+	+

TABLE 4-3
(continued)

Subject: GT	Mean fund. freq.				Significance		
	M4	M3	M2	M1	4<3	3>2	2<1
1. ta-aq			96.0	119.3			+
2. pu-ut			113.3	134.5			+
18. ti-i-tit		118.3	108.3	151.8		+	+
19. ka-a-taq		107.5	97.3	133.8		+	+
20. pu-uk-ka		122.0	114.0	140.8		+	+
21. qu-ur-qa		118.5	110.8	139.8		+	+
22. ma-a-na		106.0	101.0	136.8		+	+
23. ta-a-niq		107.5	100.3	134.8		+	+
24. i-wi-it		114.8	[109.8]	133.3		+	+
25. a-ma-aq		110.5	[96.4]	120.5		+	+
34. a-a-ta-a	109.8	123.8	103.3	121.8	+	+	+
35. a-ap-pa-a	103.0	118.3	95.5	115.8	+	+	+
36. qu-ur-qa-a	110.8	126.0	101.3	121.3	+	+	+
39. ki-si-i-sa	106.3	118.5	106.8	137.0	+	+	+
40. suk-ku-u-tit	118.0	127.0	110.0	146.0	+	+	+
41. kil-lu-u-tit	112.5	122.8	106.0	146.5	+	+	+
42. a-wa-ta-aq	100.3	117.3	[98.0]	121.8	+	+	+
50. a-na-a-wa-a	116.5	[124.2]	[99.2]	116.0	+	+	+
53. a-a-ma-li-wik	107.0	126.0	104.0	137.3	+	+	+
54. a-ma-a-li-wik	117.0	126.3	106.0	137.3	+	+	+
60. i-i-šaš-ša-a-wuq	128.0	119.3	103.3	134.0	-	+	+
63. i-li-šaš-ša-a-wuq	126.5	123.8	106.5	136.3	0	+	+
			M6	M5		6<5	5<4
50.				103.8			+
53.				102.0			+
54.				106.5			+
60.			108.0	111.0		+	+
63.			103.8	110.8		+	+

4.3.2.4. Words containing a long nasal

In 4.3.2.1. it was mentioned that a voiceless consonant mora is not a tone base. A nasal mora, on the other hand, may behave differently, since this is a voiced sound with a well-defined fundamental frequency throughout its duration. Three hypotheses should be tested concerning the role of a nasal mora as a tone base: (a) a nasal mora is not a tone base, (b) a vowel mora and the following nasal mora form a single compound tone base, and (c) a nasal mora is an independent tone base.

It should be remembered that a nasal mora is arbitrarily assigned two thirds of the total duration of a long nasal.

As for the results, see table 4-4.

In words in which the nasal mora /N/ occurs as M2 or M3 when counted as a tone base, the results are as follows:

(a) When /N/ is completely omitted, the difference between mean values of M3 and mean values of M2 in (30) maanna, (31) maanniq, and (32) maarniq is less than 5.0 Hz, except in AS's token (32).

(b) When /V/ + /N/ is counted as a compound tone base, our assumption holds true of all the tokens. That is, the differences between M2 and M1, and M3 and M2 are significant, and the mean values of the higher tone base are more than 5.0 Hz higher than those of the lower.

(c) When /N/ is counted as an independent tone base, M2 is significantly lower than M1. But the difference between M3 and M2 is not significant in GT's token (15) manna. And the mean values of M3 are higher than those of M2, but are less than 5.0 Hz higher than those of M2 in RP's tokens (30), (31), and (32), and GT's tokens (32) and (17) marniq. Notice here that M2 is a nasal mora and M3 is a vowel mora. The difference between M4 and M3 is contrary to the assumption in most of the cases. In the following tokens M4 is significantly higher than M3: for RP, (31); for AS, (30), (31), (51) tikiŋ-ŋilaq, and (52) ikusimmi; for GT, (32) and (52). In the rest of the tokens the difference is not significant, except in GT's (33) a-m-maaq, in which M3 (= /N/) is significantly higher than M4.[1]

---

1) In the transcription used here it should be remembered that /rn/ stands for a long nasal with an initial uvular component. Hence /r/ may be referred to as a nasal mora.

TABLE 4-4

Mean fundamental frequency value (in Hz), and the significance of differences of mean fundamental frequency values between adjacent moras in words containing a long nasal.

(tb = tone base)

Subject: RP	Mean fund. freq. M4	M3	M2	M1	Significance 4<3	3>2	2<1
N ≠ tb							
15. ma(n)-na			137.5	154.0			+
16. a(n)-niq			143.3	150.5			+
17. ma(r)-niq			136.5	150.8			+
30. ma-a(n)-na		136.0	133.3	150.3		0	+
31. ma-a(n)-niq		139.8	134.8	153.3		+	+
32. ma-a(r)-niq		135.0	131.3	152.8		0	+
33. a(m)-ma-aq		149.8	131.3	141.3		+	+
57. a(n)-na-a-wa-a	145.0	144.3	128.3	139.3	0	+	+
				M5			5<4
57.				146.8			0
V+N = tb							
15. man-na			131.6	154.0			+
16. an-niq			136.5	150.5			+
17. mar-niq			131.9	150.8			+
30. ma-an-na		136.0	130.5	150.3		+	+
31. ma-an-niq		139.8	132.5	153.3		+	+
32. ma-ar-niq		135.0	130.8	152.8		0	+
33. am-ma-aq		147.0	131.3	141.3		+	+
57. an-na-a-wa-a	M5 (/an/) = 144.6, "5 < 4" = 0.						
N = tb							
15. ma-n̲-na		137.5	128.3	154.0		+	+
16. a-n̲-niq		143.3	133.3	150.5		+	+
17. ma-r̲-niq		136.5	129.7	150.8		+	+
30. ma-a-n̲-na	136.0	133.3	129.0	150.3	0	+	+
31. ma-a-n̲-niq	139.8	134.8	130.8	153.3	-	+	+
32. ma-a-r̲-niq	135.0	131.3	129.3	152.8	0	+	+
33. a-m̲-ma-aq	149.8	145.7	131.3	141.3	0	+	+
57. a-n̲-na-a-wa-a	M6 = 146.8, M5 (/N/) = 143.7, "6 < 5" = 0, "5 < 4" = 0.						

TABLE 4-4
(continued)

Subject: AS	Mean fund. freq.				Significance		
	M4	M3	M2	M1	4<3	3>2	2<1
N ≠ tb							
15. ma(n)-na			140.8	161.8			+
16. a(n)-niq			129.8	155.8			+
17. ma(r)-niq			128.0	156.8			+
30. ma-a(n)-na		133.8	130.5	154.0		+	+
31. ma-a(n)-niq		132.8	130.8	158.3		O	+
32. ma-a(r)-niq		136.0	130.0	158.8		+	+
52. i-ku-si(m)-mi	136.3	148.8	134.0	153.8	+	+	+
33. a(m)-ma-aq		136.0	127.8	150.5	+	+	+
51. ti-ki(ŋ)-ŋi-laq	138.1	152.5	118.4	148.8	+	+	+
49. a(m)-ma-qa-aq	127.8	139.8	129.3	145.5	+	+	+
57. a(n)-na-a-wa-a	140.5	[141.9]	[123.3]	144.8	O	+	+
				M5			5<4
57.				130.0			+
V+N = tb							
15. man-na			133.3	161.8			+
16. an-niq			123.0	155.8			+
17. mar-niq			123.3	156.8			+
30. ma-an-na		133.8	123.6	154.0		+	+
31. ma-an-niq		132.8	124.4	158.3		+	+
32. ma-ar-niq		136.0	124.5	158.8		+	+
52. i-ku-sim-mi	136.3	148.8	125.8	153.8	+	+	+
33. am-ma-aq		137.8	127.8	150.5		+	+
51. ti-kiŋ-ŋi-laq	138.1	146.9	118.4	148.8	+	+	+
49. am-ma-qa-aq	130.1	139.8	129.3	145.5	+	+	+
57. an-na-a-wa-a	M5 (/an/) = 131.9, "5 < 4" = +.						

TABLE 4-4

(continued)

Subject: AS

	Mean fund. freq.				Significance		
	M4	M3	M2	M1	4<3	3>2	2<1
N = tb							
15. ma-n-na		140.8	130.0	161.8		+	+
16. a-n-niq		129.8	120.3	155.8		+	+
17. ma-r-niq		128.0	119.5	156.8		+	+
30. ma-a-n-na	133.8	130.5	119.3	154.0	-	+	+
31. ma-a-n-niq	132.8	130.8	120.7	158.3	0	+	+
32. ma-a-r-niq	136.0	130.0	121.0	158.8	-	+	+
52. i-ku-si-m-mi	148.8	134.0	121.7	153.8	-	+	+
33. a-m-ma-aq	136.0	140.0	127.8	150.5	0	+	+
51. ti-ki-ŋ-ŋi-laq	152.5	144.6	118.4	148.8	-	+	+
49. a-m-ma-qa-aq	131.2	139.8	129.3	145.5	+	+	+
57. a-n-na-a-wa-a	140.5	[141.9]	[123.3]	144.8	0	+	+

	M6	M5	6<5	5<4
52.		136.3		+
51.		138.1		+
49.		127.8		0
57.	130.0	132.7	0	+

TABLE 4-4
(continued)

Subject: GT

	Mean fund. freq.				Significance		
	M4	M3	M2	M1	4<3	3>2	2<1
N ≠ tb							
15. ma(n)-na			110.0	140.3			+
16. a(n)-niq			103.8	134.0			+
17. ma(r)-niq			101.8	142.0			+
30. ma-a(n)-na		112.3	109.3	129.8		o	+
31. ma-a(n)-niq		110.8	108.5	133.5		o	+
32. ma-a(r)-niq		109.5	106.0	140.0		+	+
52. i-ku-si(m)-mi	109.8	127.0	121.3	140.5	+	+	+
33. a(m)-ma-aq		110.8	101.5	121.3		+	+
51. ti-ki(ŋ)-ŋi-laq	115.8	122.0	105.0	132.8	+	+	+
49. a(m)-ma-qa-aq	103.8	126.3	102.8	122.3	+	+	+
57. a(n)-na-a-wa-a	122.0	127.3	[101.2]	118.0	+	+	+
				M5			5<4
57.				108.8			+

V+N = tb							
15. man-na			108.8	140.3			+
16. an-niq			99.0	134.0			+
17. mar-niq			100.1	142.0			+
30. ma-an-na		112.3	102.8	129.8		+	+
31. ma-an-niq		110.8	103.1	133.5		+	+
32. ma-ar-niq		109.5	103.2	140.0		+	+
52. i-ku-sim-mi	109.8	127.0	113.5	140.5	+	+	+
33. am-ma-aq		116.4	101.5	121.3		+	+
51. ti-kiŋ-ŋi-laq	115.8	124.5	105.0	132.8	+	+	+
49. am-ma-qa-aq	106.6	126.3	102.8	122.3	+	+	+
57. an-na-a-wa-a	M5 (/an/)= 110.4, "5 < 4" = +.						

TABLE 4-4

(continued)

Subject: GT	Mean fund. freq. M4	M3	M2	M1	Significance 4<3	3>2	2<1
N = tb							
15. ma-n-na		110.0	108.3	140.3		0	+
16. a-n-niq		103.8	97.2	134.0		+	+
17. ma-r-niq		101.8	99.2	142.0		+	+
30. ma-a-n-na	112.3	109.0	99.2	129.8	0	+	+
31. ma-a-n-niq	110.8	108.5	99.2	133.5	0	+	+
32. ma-a-r-niq	109.5	106.0	101.3	140.0	-	+	+
52. i-ku-si-m-mi	127.0	121.3	109.2	140.5	-	+	+
33. a-m-ma-aq	110.8	119.3	101.5	121.3	+	+	+
51. ti-ki-ŋ-ŋi-laq	122.0	124.8	105.0	132.8	0	+	+
49. a-m-ma-qa-aq	108.0	126.3	102.8	122.3	+	+	+
57. a-n-na-a-wa-a	122.0	127.3	[101.2]	118.0	+	+	+

	M6	M5	6<5	5<4
52.		109.8		+
51.		115.8		+
49.		103.8		+
57.	108.8	111.0	0	+

4.4. Slope

4.4.1. Slope of short vowels (on a syllable basis)

See 4.4.3. below.

4.4.2. Slope 1 of vowels (on a syllable basis)

Table 4-5 shows the slope 1 (i.e. [Hz/cs]) of vowels in words containing both short and long vowels and containing no long nasal.[1] Both long and short vowels are counted as one vowel segment. Is the slope of the vowel fixed according to the syllable position? The results show that except for the slope of S1, there is no definite tendency. The vowel of S1 has a positive slope. Notice that there are some tokens in which the vowel of S2 has a significantly positive slope.

---

1) Notice that "+" and "-" are used here in a different way than in the presentation of differences of mean fundamental frequency values.

TABLE 4-5

Slope 1 (Hz/cs) of vowels in two- and three-"syllable" words containing both "short" and "long" vowels.

($\overline{X}$ = mean, s = standard deviation)
("+" at the upper right of the X value: slope 1 is significant)

Subject: RP	S3 $\overline{X}$	S3 s	S2 $\overline{X}$	S2 s	S1 $\overline{X}$	S1 s
18. tii-tit			-0.6^{+}	0.2	0.1	0.5
19. kaa-taq			-0.4	0.3	-0.5	1.0
20. puuk-ka			-0.6^{+}	0.4	-0.8	0.9
21. quur-qa			-0.5^{+}	0.2	-0.7	1.3
22. maa-na			-0.2^{+}	0.1	1.2^{+}	0.7
23. taa-niq			-0.2^{+}	0.1	2.2^{+}	0.7
24. i-wiit			-1.6^{+}	0.3	1.9^{+}	0.2
25. a-maaq			-0.6^{+}	0.3	1.2^{+}	0.4
34. aa-taa			0.6^{+}	0.4	1.4^{+}	0.4
35. aap-paa			0.4	0.4	1.2^{+}	0.3
36. quur-qaa			0.4^{+}	0.2	1.1^{+}	0.2
39. ki-sii-sa	-2.0^{+}	0.4	-0.4^{+}	0.2	-0.7	1.3
40. suk-kuu-tit	-0.3	0.8	-0.3	0.3	-0.6	1.0
41. kil-luu-tit	-1.6^{+}	1.1	-0.4^{+}	0.1	0.0	0.0
42. a-wa-taaq	-1.1	0.8	0.9^{+}	0.5	0.9^{+}	0.2
50. a-naa-waa	-0.7	0.9	-0.3^{+}	0.2	1.3^{+}	0.3
57. an-naa-waa	-0.6	1.0	-0.3^{+}	0.1	1.0^{+}	0.3

TABLE 4-5
(continued)

Subject: AS	S3 $\overline{X}$	S3 s	S2 $\overline{X}$	S2 s	S1 $\overline{X}$	S1 s
18. tii-tit			-1.2^+	0.3	0.3	0.5
19. kaa-taq			-0.5^+	0.3	1.6^+	0.5
20. puuk-ka			-1.7^+	0.4	1.5^+	0.6
21. quur-qa			-1.7^+	0.3	1.9^+	0.4
22. maa-na			-0.7^+	0.2	3.4^+	0.9
23. taa-niq			-0.4^+	0.1	3.8^+	0.8
25. a-maaq			0.7	0.6	1.8^+	0.3
34. aa-taa			0.9^+	0.3	1.9^+	0.2
35. aap-paa			1.1^+	0.3	2.0^+	0.1
36. quur-qaa			0.5	0.4	1.9^+	0.2
37. tuur-pa-ra	0.5^+	0.3	-0.3	0.4	3.7^+	0.6
38. naa-la-gaq	0.3	0.2	0.0	0.3	3.9^+	0.1
39. ki-sii-sa	-2.5^+	0.9	-1.2^+	0.2	1.7^+	0.3
40. suk-kuu-tit	-2.2^+	0.7	-0.8^+	0.1	-0.8	1.2
41. kil-luu-tit	-2.0^+	0.4	-0.9^+	0.1	0.1	0.6
42. a-wa-taaq	0.0	0.6	1.6^+	0.4	1.9^+	0.2
50. a-naa-waa	0.2	0.3	-0.1	0.3	1.9^+	0.4
57. an-naa-waa	0.2	0.3	-0.6^+	0.2	1.9^+	0.2

TABLE 4-5
(continued)

Subject: GT	S3 $\overline{X}$	S3 s	S2 $\overline{X}$	S2 s	S1 $\overline{X}$	S1 s
18. tii-tit			-0.6^{+}	0.1	1.1	0.8
19. kaa-taq			-0.6^{+}	0.2	1.3^{+}	0.6
20. puuk-ka			-0.9^{+}	0.1	1.3^{+}	0.5
21. quur-qa			-0.7^{+}	0.1	1.6^{+}	0.5
22. maa-na			-0.3^{+}	0.0	3.4^{+}	0.5
23. taa-niq			-0.3^{+}	0.1	3.6^{+}	0.6
24. i-wiit			0.3^{+}	0.2	1.4^{+}	0.3
25. a-maaq			1.0^{+}	0.4	1.7^{+}	0.1
34. aa-taa			0.4^{+}	0.2	1.3^{+}	0.2
35. aap-paa			1.1^{+}	0.2	1.5^{+}	0.3
36. quur-qaa			1.0^{+}	0.2	1.4^{+}	0.2
39. ki-sii-sa	-1.2^{+}	0.3	-0.7^{+}	0.2	1.5^{+}	0.4
40. suk-kuu-tit	-1.6^{+}	0.3	-0.8^{+}	0.1	1.1^{+}	0.7
41. kil-luu-tit	-1.1^{+}	0.5	-0.7^{+}	0.2	1.6^{+}	0.9
42. a-wa-taaq	0.6^{+}	0.3	1.0^{+}	0.2	1.8^{+}	0.2
50. a-naa-waa	0.4	0.5	-0.1	0.1	1.2^{+}	0.2
57. an-naa-waa	0.1	0.1	0.1	0.1	1.5^{+}	0.2

4.4.3. Slope of short vowels (on a mora basis)

Based on the results in the preceding section 4.3., we tentatively assume that the tonal pattern is regulated on a mora basis. (NB: When a word contains only short vowels, the results obtained on a mora basis are equal to those obtained on a syllable basis. And short vowels of M2 and M1 are always equal to those of S2 and S1.) A nasal mora is not an independent tone base, but it is uncertain as yet whether a vowel before a nasal mora forms a tone base with or without help of the following nasal mora. Therefore, vowels immediately before a nasal mora will not be included here.

As for the results of slope 1 ([Hz/cs]) and slope 2 ([Arctang (Hz/cs)]), see table 4-6. Fig. 4-2 shows the number of significant tokens.

In this section only the significance of the direction of the slope is considered. But in section 5. the degree of the slope and relations between the slope and the mean fundamental frequency and the consonantal environment will be discussed.

The direction of the slope is not clear except for the vowels of M1 and M2. In M1 there is a general tendency for the slope to be positive, i.e. the pitch is rising. When the slope is not significantly positive, the vowel is always preceded by a voiceless consonant. In M2 the slope is generally negative, i.e. the pitch is falling. The slope of M3 shows no clear tendency common to the three persons. Further, in half of all these cases, the slope does not differ significantly from zero. In RP's and AS's tokens, the slope tends to be negative, while in GT's tokens it tends to be positive. In M4 there is no case where either slope 1 or 2 is significantly positive, except in one of GT's tokens (i.e. (42) <u>a</u>wataaq), in which the slope is significantly positive. The slopes of M5 and M6 have, as a whole, no significant direction.

Fig. 4-2.

Slopes of short vowels in each mora position.

- Number of significant tokens -

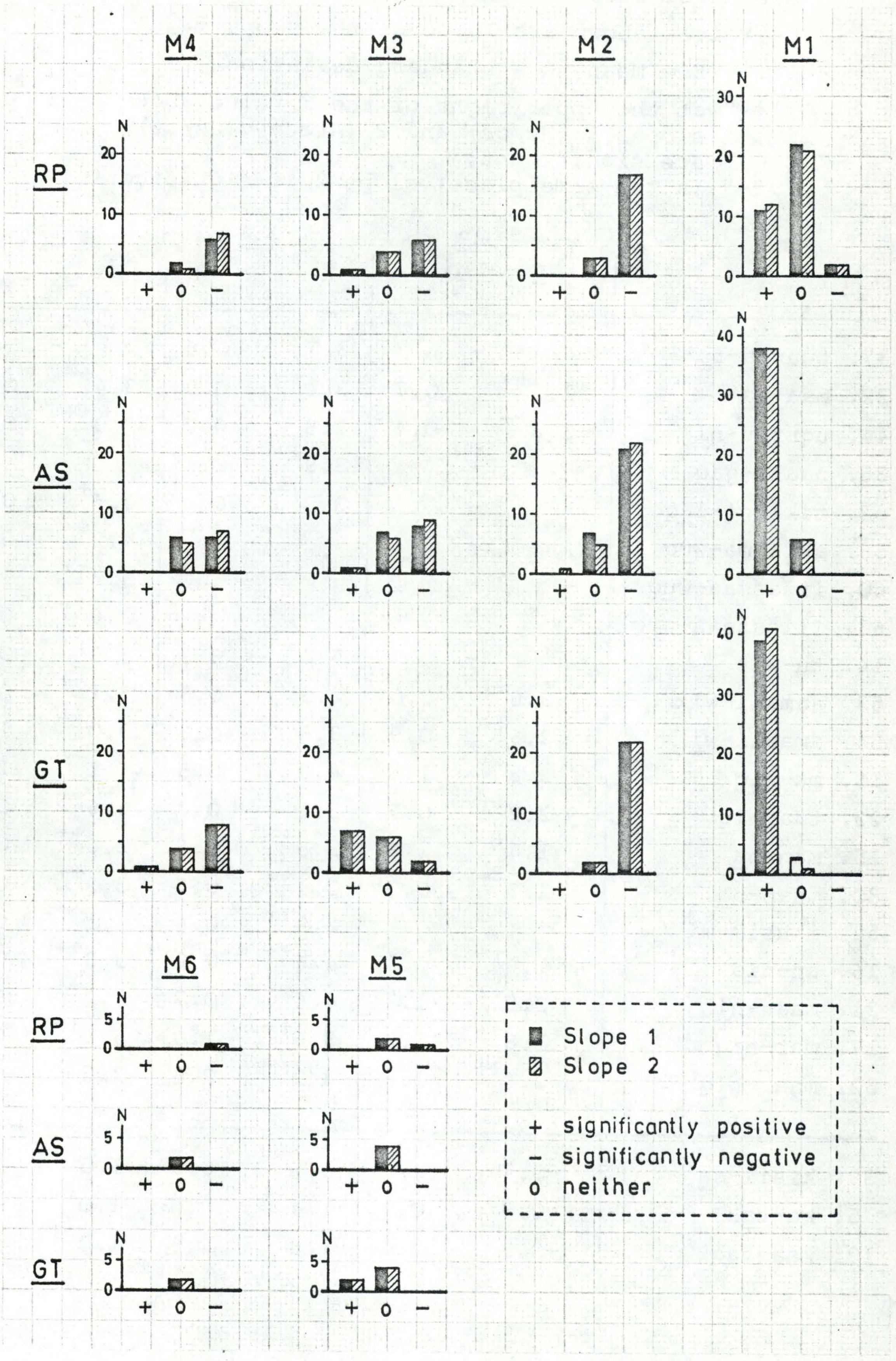


TABLE 4-6

Slopes of short vowels in each mora position.

[Values shown are those of the slope 1.]

($\overline{X}$ = mean, s = standard deviation)

("++" at the upper right of the $\overline{X}$ value: both slopes 1 (Hz/cs) and 2 (Arctang(Hz/cs)) are significant;
"+" in the same place: slope 2 is significant.)

M1	RP $\overline{X}$	RP s	AS $\overline{X}$	AS s	GT $\overline{X}$	GT s
37. tuurpa-ra	-		3.7++	0.6	-	
22. maa-na	1.2++	0.7	3.4++	0.9	3.4++	0.5
44. uqurlu-ni	1.3++	0.4	2.8++	0.7	2.9++	0.6
38. naala-gaq	-		3.9++	0.1	-	
51. tikiŋŋi-laq	-		3.3++	0.8	3.4++	0.4
56. akisima-wuq	-		-		4.2++	0.9
60. iišaššaa-wuq	-		-		3.7++	1.2
63. ilišaššaa-wuq	-		-		3.6++	0.8
14. tu-wit	-		5.0++	0.5	3.3++	0.8
53. aamali-wik	3.6++	2.0	3.9++	0.3	3.1++	0.7
54. amaali-wik	2.6++	0.9	3.3++	0.6	3.0++	1.2
13. ma-niq	2.8++	1.5	4.8++	0.5	4.1++	1.0
23. taa-niq	2.2++	0.7	3.8++	0.8	3.6++	0.6
15. man-na	1.7+	1.3	3.5++	0.6	2.6++	0.5
30. maan-na	1.3++	0.7	3.1++	0.6	3.3++	0.4
52. ikusim-mi	-		2.9++	0.6	3.1++	0.5
16. an-niq	1.6++	0.8	4.6++	0.9	3.3++	0.5
31. maan-niq	2.5++	1.1	4.6++	0.7	3.2++	0.8
17. mar-niq	1.8++	1.2	3.6++	1.0	3.1++	0.5
32. maar-niq	2.4++	0.3	3.9++	0.5	3.5++	0.4
39. kisii-sa	-0.7	1.3	1.7++	0.3	1.5++	0.4
5. ka-tak	-0.5	0.8	1.4++	0.5	1.0++	0.5
19. kaa-taq	-0.5	1.0	1.6++	0.5	1.3++	0.6

TABLE 4-6
(continued)

M1	RP $\overline{X}$	RP s	AS $\overline{X}$	AS s	GT $\overline{X}$	GT s
27. naka-t<u>a</u>q	-0.5	0.7	1.6^{++}	0.5	1.2^{++}	0.7
28. awa-t<u>a</u>q	0.1	0.7	1.0^{++}	0.6	2.3^{++}	0.4
43. naparu-t<u>a</u>q	-		0.7^{++}	0.4	-	
8. ta-q<u>a</u>q	1.3	1.4	1.3^{++}	0.6	2.2^{++}	0.6
55. aputitu-q<u>a</u>q	-		1.0^{++}	0.5	2.5^{++}	0.6
6. ma-s<u>a</u>k	0.0	0.6	1.9^{++}	0.6	1.3^{++}	0.6
7. na-s<u>a</u>q	-0.8	0.8	1.7^{++}	0.6	1.8^{++}	0.3
18. tii-t<u>i</u>t	0.1	0.5	0.3	0.5	1.1^{+}	0.8
26. iki-t<u>i</u>t	-0.6	0.7	0.9^{++}	0.6	1.3^{++}	0.4
40. killuu-t<u>i</u>t	-0.6	1.0	-0.8	1.2	1.1^{++}	0.7
41. sukkuu-t<u>i</u>t	0.0	0.0	0.1	0.6	1.6^{++}	0.9
20. puuk-k<u>a</u>	-0.8	0.9	1.5^{++}	0.6	1.3^{++}	0.5
29. tuwik-k<u>a</u>	-		0.9^{++}	0.5	2.7^{++}	0.3
21. quur-q<u>a</u>	-0.7	1.3	1.9^{++}	0.4	1.6^{++}	0.5
3. il-l<u>u</u>	-0.6	1.3	1.3^{++}	0.6	1.0^{++}	0.7
9. mat-t<u>a</u>k	0.0	0.6	1.2^{++}	0.2	0.2	0.3
12. qaq-q<u>a</u>q	-0.2	1.0	1.8^{++}	0.2	1.6^{++}	0.5
10. aš-š<u>a</u>k	0.2	1.0	1.1^{++}	0.3	0.4^{+}	0.3
11. aš-š<u>a</u>q	0.1	0.4	1.5^{++}	0.5	0.6^{++}	0.4
64. ilutusimap-p<u>u</u>t	-0.7	0.6	0.7^{++}	0.5	1.9^{++}	1.2
45. iqqanar-p<u>u</u>q	-1.5^{++}	0.8	1.0	0.9	1.7^{++}	0.8
46. iqqarsar-p<u>u</u>q	-1.3^{++}	0.2	-0.2	0.6	-	
62. naluumasur-t<u>u</u>q	-		0.0	0.0	-	
4. il-l<u>u</u>t	-0.2	1.1	1.9^{++}	0.8	1.1^{++}	0.6

TABLE 4-6
(continued)

M2	RP $\bar{X}$	RP s	AS $\bar{X}$	AS s	GT $\bar{X}$	GT s
10. aš-šak	-2.7^{++}	1.0	-0.9^{++}	0.6	-0.3	0.5
11. aš-šaq	-2.1^{++}	0.8	-1.4^{++}	0.4	-0.2	0.4
3. il-lu	-2.6^{++}	0.9	-1.4^{+}	1.1	-1.6^{++}	0.5
4. il-lut	-1.1^{++}	0.2	-2.1^{++}	0.7	-2.1^{++}	0.4
38. naa-la-gaq	-		0.0	0.3	-	
56. akisi-ma-wuq	-		-		-0.7^{++}	0.5
13. ma-niq	-0.8^{++}	0.4	-0.7^{++}	0.4	-0.3^{++}	0.2
53. aama-li-wik	0.2	0.4	0.4^{+}	0.3	-0.4^{++}	0.1
54. amaa-li-wik	0.1	0.7	0.2	0.3	-0.3^{++}	0.2
28. a-wa-taq	-0.9^{++}	0.5	-1.1^{++}	0.2	-1.4^{++}	0.5
6. ma-sak	-1.2^{++}	0.8	-0.7^{++}	0.4	-0.8^{++}	0.5
7. na-saq	-1.1^{++}	0.5	-1.7^{++}	0.4	-1.0^{++}	0.4
43. napa-ru-taq	-		-0.5^{++}	0.3	-	
64. ilutusi-map-put	-1.8^{++}	0.4	-2.9^{++}	0.4	-2.9^{++}	0.4
9. mat-tak	-0.9	0.8	-1.5^{++}	0.3	-0.6^{++}	0.4
45. iqqa-nar-puq	-1.5^{++}	0.3	-3.8^{++}	0.8	-2.2^{++}	0.6
29. tu-wik-ka	-		-1.9^{++}	0.4	-1.5^{++}	0.6
51. tikiŋ-ŋi-laq	-		-0.1	0.4	-1.5^{++}	0.2
14. tu-wit	-		-2.4^{++}	0.5	-0.7^{++}	0.4
8. ta-qaq	-2.5^{++}	0.7	-1.3^{++}	0.6	-1.0^{++}	0.6
5. ka-taq	-2.1^{++}	0.5	-1.6^{++}	0.5	-1.1^{++}	0.6
27. na-ka-taq	-1.8^{++}	0.6	-1.6^{++}	0.2	-1.0^{++}	0.5
55. aputi-tu-qaq	-		-2.3^{++}	0.6	-1.6^{++}	0.4
26. i-ki-tit	-1.6^{++}	0.5	-2.2^{++}	0.4	-1.7^{++}	0.6
12. qaq-qaq	-2.1^{++}	0.6	-2.2^{++}	0.4	-1.3^{++}	0.2
62. naluuma-sur-tuq	-		-1.6^{++}	0.3	-	
37. tuur-pa-ra	-		-0.3	0.4	-	
44. uqur-lu-ni	-1.9^{++}	0.6	-0.5	0.5	-0.9^{++}	0.3
46. iqqar-sar-puq	-2.5^{++}	0.8	-2.0^{++}	0.6	-	

TABLE 4-6
(continued)

M3	RP $\bar{X}$	RP s	AS $\bar{X}$	AS s	GT $\bar{X}$	GT s
28. a-wataq	-1.1	1.2	0.6	0.5	0.9^{++}	0.1
25. a-maaq	-0.6^{++}	0.3	0.7	0.6	1.0^{++}	0.4
24. i-wiit	-1.6^{++}	0.3	-		0.3^{++}	0.2
26. i-kitit	-2.2^{++}	0.5	0.7	0.7	-0.4	1.1
53. aa-ma-liwik	-0.8^{++}	0.5	0.0	0.0	0.7	0.6
42. a-wa-taaq	0.9^{++}	0.5	1.6^{++}	0.4	1.0^{++}	0.2
27. na-kataq	0.0	0.7	0.3	0.3	0.6^{++}	0.2
62. naluu-ma-surtuq	-		-1.5^{++}	0.4	-	
49. am-ma-qaaq	-		-0.8^{++}	0.3	1.2^{++}	0.5
43. na-pa-rutaq	-		-1.3^{++}	0.6	-	
29. tu-wikka	-		-1.0^{++}	0.2	-0.3	0.8
56. aki-si-mawuq	-		-		-0.7^{++}	0.2
64. ilutu-si-mapput	-0.7	0.6	-2.1^{++}	1.2	-0.3	0.4
52. i-ku-simmi	-		-1.6^{++}	0.5	0.1	0.4
55. apu-ti-tuqaq	-		-1.4	1.1	-0.9^{++}	0.4
44. u-qur-luni	-1.0^{++}	0.7	-1.0^{++}	0.6	1.1^{++}	0.7
45. iq-qa-narpuq	-0.8	0.9	-0.7^{++}	0.5	0.7	1.0
46. iq-qar-sarpuq	-1.4^{++}	0.7	-1.2^{+}	0.9	-	

TABLE 4-6
(continued)

M4	RP $\bar{X}$	RP s	AS $\bar{X}$	AS s	GT $\bar{X}$	GT s
42. a-wataaq	-1.1^{+}	0.8	0.0	0.6	0.6^{++}	0.3
44. u-qurluni	-1.4^{++}	0.6	-0.5	1.2	-0.8	0.7
52. i-kusimmi	-		-0.7	0.8	-1.7^{++}	0.7
45. iq-qanarpuq	-1.9^{++}	0.9	0.1	0.9	0.2	0.8
46. iq-qarsarpuq	-1.6^{++}	0.8	-0.4	0.7	-	
43. na-parutaq	-		-1.3^{++}	0.4	-	
55. a-pu-tituqaq	-		-0.5^{++}	0.3	0.3	0.7
64. ilu-tu-simapput	-1.9^{++}	0.5	-1.7^{++}	1.2	-0.9^{++}	0.2
51. ti-kiŋŋilaq	-		-1.6^{+}	1.2	-1.9^{++}	1.2
39. ki-siisa	-2.0^{++}	0.4	-2.5^{++}	0.9	-1.2^{++}	0.3
56. a-ki-simawuq	-		-		-0.7^{++}	0.3
60. ii-šaš-šaawuq	-		-		-0.5^{++}	0.2
63. ili-šaš-šaawuq	-		-		-0.4	0.3
40. suk-kuutit	-0.3	0.8	-2.2^{++}	0.7	-1.6^{++}	0.3
41. kil-luutit	-1.6^{++}	1.1	-2.0^{++}	0.4	-1.1^{++}	0.5
M5						
54. a-maaliwik	-1.6^{++}	0.6	0.5	0.5	0.0	0.3
50. a-naawaa	-0.7	0.9	0.2	0.3	0.4	0.5
55. a-putituqaq	-		0.3	1.2	-0.2	0.3
56. a-kisimawuq	-		-		-0.1	0.1
64. i-lu-tusimapput	0.1	0.8	0.4	0.3	0.7^{++}	0.3
63. i-li-šaššaawuq	-		-		0.6^{++}	0.4
M6						
64. i-lutusimapput	-1.2^{++}	0.2	0.4	0.5	0.2	0.4
63. i-lišaššaawuq	-		-		0.4	0.4
62. na-luumasurtuq	-		-0.3	0.3	-	

4.4.4. Slope of long vowels (on a mora basis)

As opposed to the slopes of the short vowels, the slopes of long vowels seem to have rather fixed directions, depending on the mora positions of their occurrences in the word. See fig. 4-3. Generally, a long vowel of M2 and M1 (i.e. a long vowel which forms M2 and M1) has a positive slope, that of M3 and M2 a negative slope, that of M4 and M3 a positive slope. But the slopes of long vowels forming M5 and M4, and M6 and M5 are not clear. This is due to the fact that the change of fundamental frequency is smaller in the positions of M6, M5, and M4, and that there are only a few examples in the material of this investigation.

When there is a rise-fall or fall-rise during one mora portion of a long vowel, the slope is not significant, since the slope in this case is multidirectional. In fig. 4-3 and table 4-7 slopes which are not significant include both unidirectional ones (i.e. either a rise or a fall) and multidirectional ones (i.e. a rise-fall or a fall-rise). Notice here that the vowel mora in M3 position has a positive slope when it forms the second half of a long vowel, while it has a negative slope (though often not significantly negative) when it forms the first half of a long vowel. The vowel mora in M2 position has a negative slope when it forms the second half of a long vowel, while its slope is positive (though often not significantly positive) when it forms the first half of a long vowel.

Fig. 4-3.

Slopes of long vowels in the last four mora positions.

- Number of significant tokens -

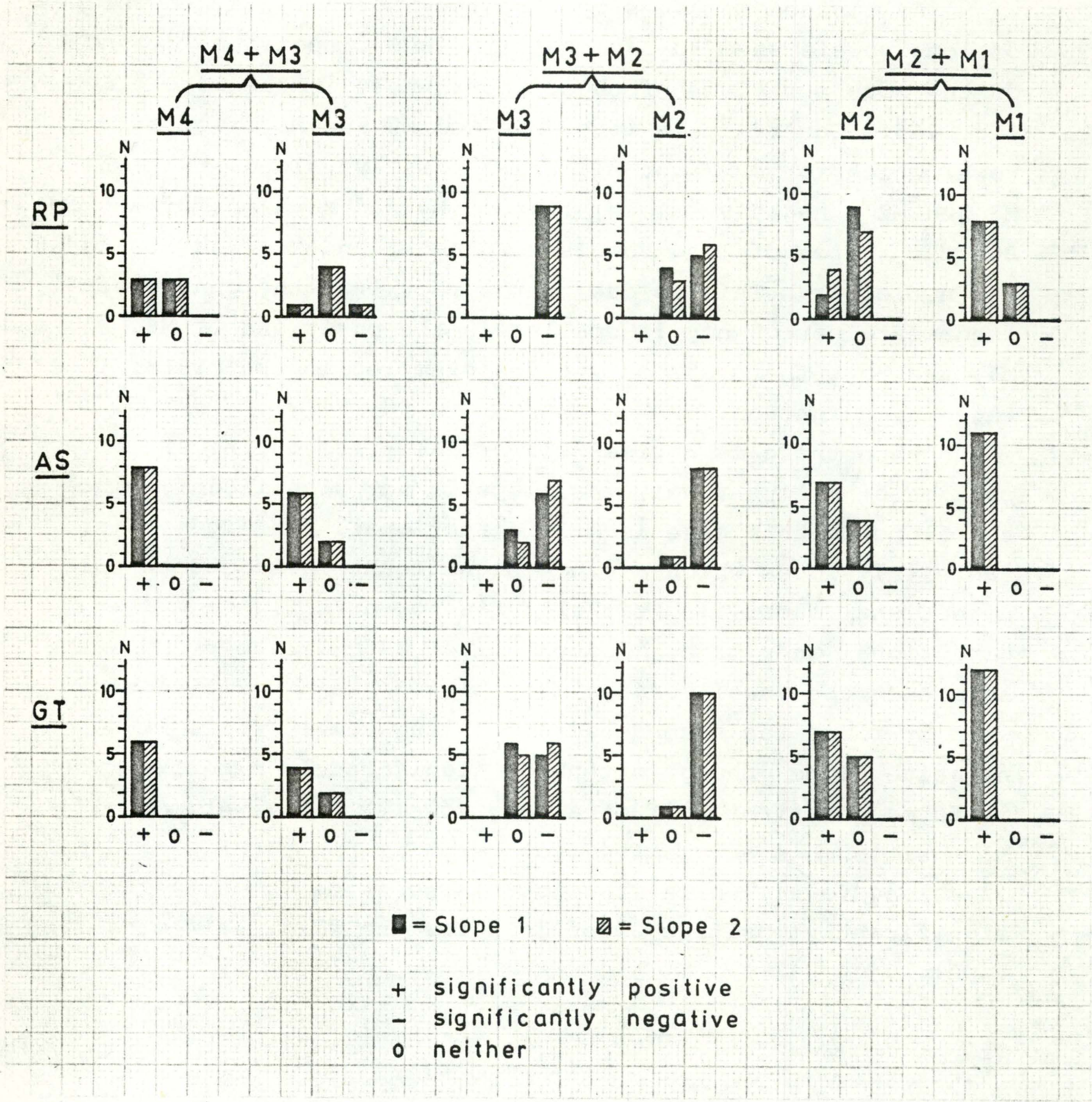


TABLE 4-7

Slopes of long vowels in each mora position

[Values shown are those of the slope 1]

($\overline{X}$ = mean, s = standard deviation)

("...": the pitch of the mora is multidirectional; "++" at the upper right of the $\overline{X}$ value: both slopes 1 and 2 are significant; "+" in the same place: the slope 2 is significant.)

M2+M1		RP		AS		GT	
		M2	M1	M2	M1	M2	M1
50. anaa-waa	$\overline{X}$	...	2.7^{++}	...	3.8^{++}	...	2.4^{++}
	s		0.7		0.7		0.4
57. annaa-waa	$\overline{X}$	1.1^{+}	2.1^{++}	...	3.8^{++}	...	3.0^{++}
	s	0.8	0.5		0.4		0.3
24. i-wiit	$\overline{X}$	1.0^{++}	3.8^{++}	-	-	...	2.8^{++}
	s	0.4	0.4				0.7
25. a-maaq	$\overline{X}$	...	...	2.4^{++}	3.7^{++}	...	3.4^{++}
	s			0.6	0.5		0.2
33. am-maaq	$\overline{X}$	0.7^{++}	2.3^{++}	1.8^{++}	3.6^{++}	0.6^{++}	3.2^{++}
	s	0.5	0.3	0.5	0.4	0.4	0.5
34. aa-taa	$\overline{X}$	...	2.8^{++}	1.3^{++}	3.8^{++}	0.5^{++}	2.6^{++}
	s		0.8	0.4	0.4	0.2	0.3
1. taaq	$\overline{X}$	...	...	0.9^{++}	3.1^{++}	0.9^{++}	3.2^{++}
	s			0.5	0.5	0.4	0.2
42. awa-taaq	$\overline{X}$	...	1.9^{++}	...	3.7^{++}	...	3.5^{++}
	s		0.4		0.4		0.5
49. amma-qaaq	$\overline{X}$	-	-	1.3^{++}	3.6^{++}	1.1^{++}	3.3^{++}
	s			0.5	0.5	0.2	0.9
2. puut	$\overline{X}$	1.0^{+}	3.3^{++}	1.0	4.0^{++}	1.8^{++}	2.5^{++}
	s	0.8	1.1	0.8	1.1	0.5	0.3
35. aap-paa	$\overline{X}$	0.0	2.3^{++}	1.7^{++}	3.9^{++}	0.8^{++}	3.1^{++}
	s	1.1	0.5	0.6	0.3	0.3	0.7
36. quur-qaa	$\overline{X}$	...	...	1.6^{++}	3.7^{++}	0.8^{++}	2.8^{++}
	s			0.4	0.5	0.2	0.5

TABLE 4-7
(continued)

M3+M2		RP M3	RP M2	AS M3	AS M2	GT M3	GT M2
22. maa-na	$\bar{X}$	-1.1^{++}	-0.4	...	-1.3^{++}	-0.0	-0.6^{++}
	s	0.2	0.3		0.3	0.4	0.1
23. taa-niq	$\bar{X}$	-1.0^{++}	-0.4	-1.3^{++}	-0.8^{++}	-0.4^{+}	-0.5^{++}
	s	0.2	0.3	0.2	0.3	0.3	0.2
19. kaa-taq	$\bar{X}$	-1.3^{++}	-0.8^{+}	...	...	-0.2	-1.2^{++}
	s	0.5	0.6			0.3	0.5
18. tii-tit	$\bar{X}$	-0.9^{++}	-1.2^{++}	-1.5^{++}	-2.5^{++}	-0.3	-1.2^{++}
	s	0.4	0.3	0.6	0.5	0.3	0.1
39. ki-sii-sa	$\bar{X}$	-1.2^{++}	-0.8^{++}	-2.2^{++}	-2.5^{++}	-0.7	-1.4^{++}
	s	0.3	0.4	0.6	0.4	0.5	0.3
20. puuk-ka	$\bar{X}$	-1.2^{++}	-1.3^{++}	-1.3^{++}	-3.4^{++}	-0.1	-1.8^{++}
	s	0.5	0.7	0.7	0.7	0.2	0.2
21. quur-qa	$\bar{X}$	-0.8^{++}	-1.0^{++}	-1.2^{+}	-3.4^{++}	-0.5^{++}	-1.3^{++}
	s	0.3	0.4	0.9	0.6	0.3	0.3
60. iišaš-šaa-wuq	$\bar{X}$	-	-	-	-	-1.6^{++}	-0.5^{++}
	s					0.6	0.2
63. ilišaš-šaa-wuq	$\bar{X}$	-	-	-	-	-1.8^{++}	-0.7
	s					0.2	0.4
40. suk-kuu-tit	$\bar{X}$	-1.0^{++}	-0.6	-2.1^{++}	-1.5^{++}	-1.1^{++}	-1.6^{++}
	s	0.4	0.5	0.7	0.2	0.4	0.2
41. kil-luu-tit	$\bar{X}$	-1.5^{++}	-0.7^{++}	-2.3^{++}	-1.8^{++}	-1.1^{++}	-1.4^{++}
	s	0.3	0.2	0.4	0.3	0.4	0.4
30. maan-na	$\bar{X}$	-0.3	-0.6	0.8^{++}	-1.8^{++}	-0.2	-0.8
	s	0.4	0.5	0.4	0.6	0.2	0.8
31. maan-niq	$\bar{X}$	-0.7^{++}	-0.9^{++}	0.8^{++}	-1.4^{++}	0.4^{++}	-0.9^{++}
	s	0.2	0.3	0.5	0.2	0.2	0.3
32. maar-niq	$\bar{X}$	-0.3	-0.8^{++}	-0.3	-1.4^{++}	-0.1	-0.5^{++}
	s	0.3	0.5	0.5	0.1	0.4	0.1

TABLE 4-7
(continued)

		RP		AS		GT	
M4+M3		M4	M3	M4	M3	M4	M3
34. aa-taa	$\bar{X}$	...	...	1.6^{++}	1.7^{++}	1.6^{++}	0.8^{++}
	s			0.6	0.6	0.1	0.3
35. aap-paa	$\bar{X}$	0.9^{++}	0.8	1.8^{++}	2.2^{++}	1.9^{++}	2.2^{++}
	s	0.5	0.8	0.4	0.6	0.3	0.3
54. a-maa-liwik	$\bar{X}$	0.5^{++}	-0.1	1.2^{++}	0.8^{++}	1.2^{++}	0.5^{++}
	s	0.3	0.4	0.5	0.2	0.2	0.3
38. naa-lagaq	$\bar{X}$	-	-	1.2^{++}	0.7^{++}	-	-
	s			0.2	0.3		
50. a-naa-waa	$\bar{X}$	1.2^{++}	...	1.4^{++}	...	1.0^{++}	...
	s	0.6		0.4		0.2	
57. an-naa-waa	$\bar{X}$	0.4	-0.6^{++}	1.1^{++}	...	0.7^{++}	...
	s	0.4	0.2	0.3		0.3	
37. tuur-para	$\bar{X}$	-	-	0.8^{++}	1.0^{++}	-	-
	s			0.4	0.7		
36. quur-qaa	$\bar{X}$	0.6	0.9^{++}	1.7^{++}	1.0^{++}	1.6^{++}	2.0^{++}
	s	0.8	0.5	0.7	0.7	0.6	0.4
M5+M4		M5	M4	M5	M4	M5	M4
53. aa-maliwik	$\bar{X}$	-0.8	0.3	1.2^{++}	0.9	0.4	0.4^{++}
	s	0.7	0.7	0.7	0.8	0.4	0.2
62. na-luu-masurtuq	$\bar{X}$	-	-	1.4^{++}	1.3^{++}	-	-
	s			0.3	0.7		
M6+M5						M6	M5
60. ii-šaššaa-wuq	$\bar{X}$	-	-	-	-	0.3^{++}	0.3^{++}
	s					0.2	0.2

5. Discussion

In this section the question of syllable or mora basis will be taken up first. Then the nasal mora, the slope, and the difference of mean fundamental frequency will be considered, in that order.

5.1. Syllable or mora basis

The phrase-final intonation is not regulated on a syllable basis. As for differences of mean fundamental frequency the assumption often works when the last syllable contains no long vowel, but once it has a long one, the situation is chaotic. That is, when the last syllable has a long vowel, the penultimate syllable (i.e. S2) of a word often has the highest value of mean fundamental frequency; thus the high-low-high relation is exactly the opposite of the relation observed in words containing only short vowels. This is due to the fact that the syllable which contains the penultimate vowel mora (i.e. M2) tends to take the lowest value of mean fundamental frequency. A typical example is a three-syllable word, (50) a-naa-waa. For all three persons the penultimate syllable has the highest mean fundamental frequency in the word.

The slope does not support the syllable basis theory, either. When both S1 and S2 have long vowels, both of them have a positive slope, and the vowel of S2 often ends with a pitch higher than that of S1. Examples are (34) aa-taa, (35) aap-paa, and (36) quur-qaa. Further, if the slope of the vowel is fixed according to the syllable position, there can be no explanation of why S2 of the token (21) quurqa has a negative slope, while that of (36) quurqaa has a positive slope.

Consequently, the syllable is no useful candidate as tone base. So the following discussion will be concentrated on the mora basis.

5.2. The role of the nasal mora

No completely clear picture is seen concerning the role of the nasal mora in forming the phrase-final intonation pattern. This fact may be partly due to the arbitrary assignment of two thirds of a long nasal as a mora nasal. But, disregarding this source of uncertainty about the interpretation, acoustic results favour the assumption that a vowel mora and the following nasal mora form a single tone base.

When the nasal mora is totally disregarded as part of the tone base, the relation between M3 and M2 becomes inconsistent. In some cases the result is that the difference between M3 and M2 is not significant, and further, there are a few samples (recordings) where M2 is higher than M3. This is observed in the following tokens of all three persons: (30) maanna, (31) maanniq, and (32) maarniq. It also holds true of GT's token (52) ikusimmi. In word tokens containing no nasal mora, M3 is always significantly higher than M2.

If, instead, a nasal mora is counted as an independent tone base, the pattern is likewise obscured because the difference between a vowel occurring as M3 and a nasal occurring as M2 is very small (this seems to be due to the fact that both moras are low pitched). Moreover, the relationship between M4 and M3 in AS's and GT's tokens tends to be different in words with and without a nasal mora: in most tokens without a long nasal M4 is significantly lower than M3, whereas it is significantly higher than M3 in most tokens with a long nasal. (RP has a general tendency to have a higher M4.) These findings speak against the assumption of a separate nasal tone base.

When a vowel mora and the following nasal mora are taken to form a compound tone base, the relations of pitch difference between adjacent vowels are clear, and the results agree with the assumption on the phrase-final pitch pattern. M2 is lower than M3 and M1. (The difference between M3 and M2 is not significant in RP's token (32) maarniq, but this lack of significance seems to be caused by other factors than the existence of the nasal, see 5.3.)

The slope of long vowels forming M3 and M2 (i.e. in (30) maanna, (31) maanniq, and (32) maarniq) is similar to that observed in (22) maana, and (23) taaniq.

When we count /V+N/ as one tone base, the numbers of tokens which agree with the assumption are as follows:

	RP	AS	GT
M2 < M1	8/8	11/11	11/11
M3 > M2	4/5	8/8	8/8
M4 < M3	0/1	3/4	4/4
M5 < M4	0/1	1/1	1/1

5.3. Slope and mean fundamental frequency

Quite a few tokens show slopes which are not found to be significantly different from zero. However, the slopes of the vowels, especially those of the last three vowel moras, are hardly quite arbitrary, although the direction of the slope in a vowel mora consisting of a short vowel may differ from the first part of a long vowel.

The phrase-final intonation should be distinguished from other patterns by a combination of high-low-high tones on the last three vowel moras, if the initial assumption is correct. In order to characterize the phrase-final intonation, the penultimate vowel mora should have a low tone, and the final vowel mora should have a high tone. When the vowel mora starts at a lower tone it will reach a high tone at the end. When a short-vowel mora starts at a high tone, it will not necessarily end with a still higher tone. Actually, it may fall a little, but the amount of fall should not be so great that it may be perceived as another intonation pattern. The penultimate vowel mora should have a low tone. When a short-vowel mora in this position starts with a higher tone, it should have a falling tone and end with a lower tone. When it starts low, it will stay low or rise a little, but the rise must be small in order to avoid confusion with the higher tone of the final or antepenultimate vowel mora.

When the last two vowel moras consist of a long vowel, the tone of the long segment should be rising, otherwise it will be perceived as other patterns. When M3 and M2 are formed by one long vowel, the tone of the long segment should be falling and be followed by a noticeable rise or a high tone of M1, otherwise it will be perceived as other patterns.

In the light of this presupposition, the slope of the vowel in each mora position will be discussed. It should now be possible to explain the interference on the fundamental frequency from various phonetic factors. Such interference may for instance be caused by vowel quality and quantity, consonant quality and quantity, stress, or the degree of assimilation present (especially regressive assimilation) in connection with open and close contact. Some of these influential factors may be of a universal character, and others may be specific to Greenlandic. But notice that if it is true that the direction of the slope is rather fixed, this factor might be able to dominate to such a degree as to minimize the influence from various phonetic factors.

When all the influential factors mentioned above are taken into account, a normalization should be possible. Unfortunately, however, the material of the present investigation is not suitable for such an attempt, since the material is too inhomogeneous. Thus, the following account is more like an informal speculation on the factors which may possibly influence the fundamental frequency of the vowel in a particular position. It should be remembered that the accuracy of measurement may be one of the factors which should be taken into account.

The problems concerning the slope of long vowels are less complicated than those concerning short vowels, so this point will be taken up first. The slope of a long vowel segment in M2+M1 position will be positive. The slope of M2 (i.e. the first half of the vowel) is not significantly different from zero in RP's words, and it is significantly positive in half of AS's and GT's words, while the slope of M1 (i.e. the second half of the vowel) is always significantly positive. This means that the tone stays low during the first half of the vowel and rises steeply during the second half of the vowel. A fall-rise is often observed in the first half.

The slope of a long vowel forming M3 and M2 will be negative. In RP's words the fundamental frequency falls during the first half and falls again or stays low during the second half of the vowel. In AS's and GT's words the fundamental frequency falls all the way through the long vowel, or it stays rather high during the first half and falls steeply during the second half of the vowel. A delayed fall is often observed in GT's words.

Thus, the slope of M3 of RP's words is significantly negative, while that of AS's and GT's words is significantly negative only in half of the total set of tokens, and the slope of M2 is sometimes not significantly negative in RP's words, whereas it is significantly negative in the great majority of AS's and GT's words.

The slope of a long vowel forming M4 and M3 will be positive. In RP's words a rise is certainly observed, but the rise is small. In half of all cases it is true of both M4 and M3 that they do not show significantly positive slopes. In AS's and GT's tokens, on the other hand, the tone movement during the long segment is either a simple rise or rise-and-stay-high. Thus, the slope of M4 is significantly positive, but in some cases that of M3 is not significantly different from zero.

The slope of a long vowel forming M5 and M4 is not well-defined, since the change is small, and the number of examples is limited. As for the word token (53) <u>aa</u>-maliwik, which is the only word common to all three persons, there is either a rise or a rise-fall in RP's token, a rise or a rise-and-stay-high in AS's token, and a small rise in GT's token. As for AS's (62) na-l<u>uu</u>-masurtuq, the slope of the long vowel is positive. As for the slope of a long vowel forming M6+M5, the only word we have is GT's (60) <u>ii</u>-šaššaa-wuq. Here the slope of the long vowel is positive, though the rise is small.

Rischel[1] assumes that a long (homosyllabic) vowel tends to have less pitch inflection than a sequence of two heterosyllabic vowels. Although the auditive pitch impression is not equal to acoustic fact, this tendency toward even pitch may be observed in the present material when a long vowel occurs in the positions of M4 to M6. Long vowels of either M4 and M3 or M3 and M2 sometimes have a very small change,

---

1) Personal communication (also mentioned in Rischel (1971)).

but they are seldom quite level. Since they take part in the contour signalling phrase-final intonation, they will exhibit some inflection.

There may be some influence of surrounding consonants on the slope. If there is any, it may be of the same kind as observed in the short vowels. This will be taken up below.

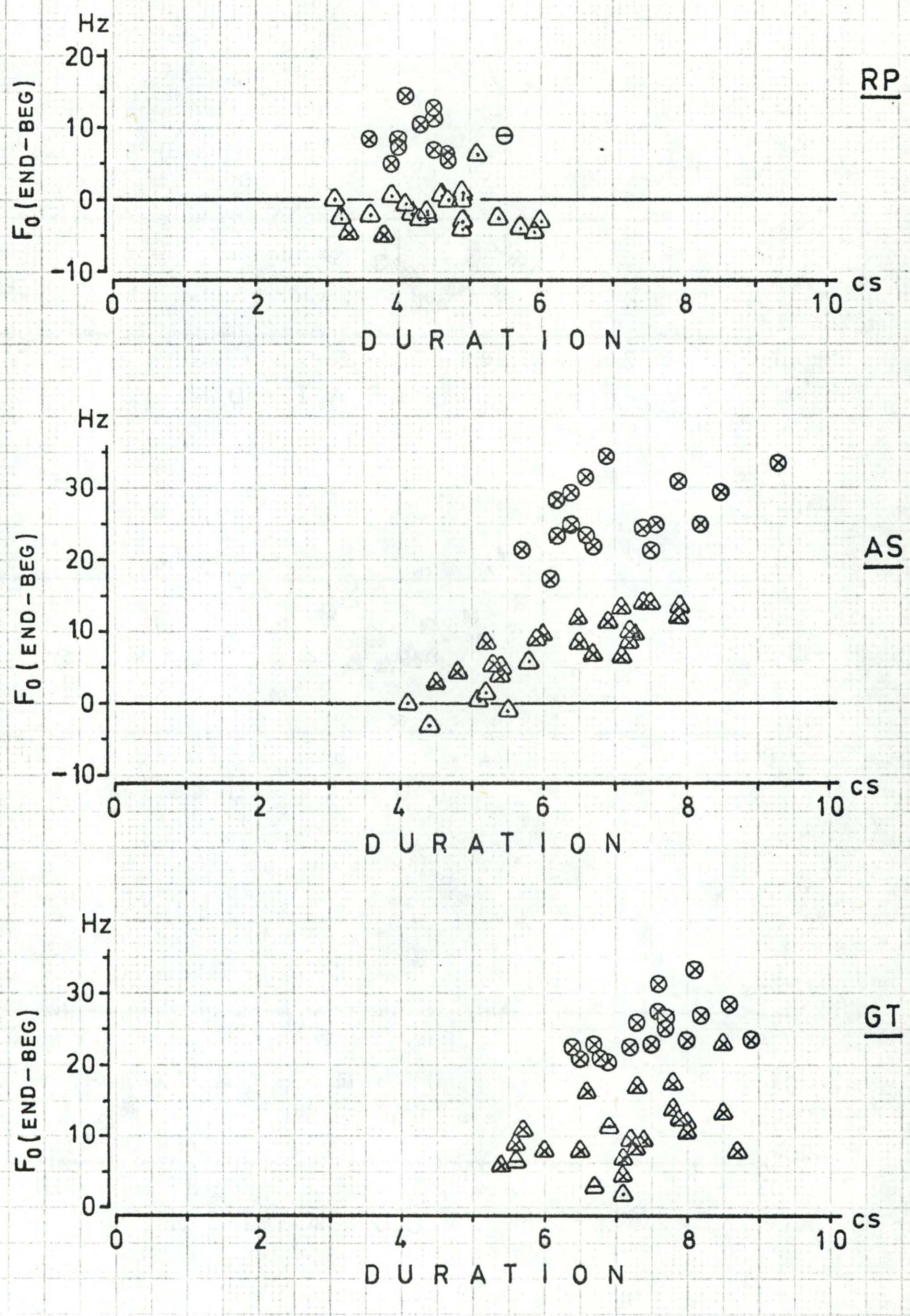
The general outline of the slope of short vowels is as follows. Fig. 5-1,a,b,c shows the relation between duration and amount of fundamental frequency change of vowels in the last three moras classified according to whether the preceding consonant[1] is voiced, voiceless, or zero. Fig. 5-2,a,b shows the relation between the slope and the mean fundamental frequency of the vowel.

The slope of M1 is positive in the majority of cases. When a vowel of M1 has a positive slope there is a certain correlation between duration and amount of fundamental frequency rise. When the preceding consonant is voiced, both slopes 1 and 2 are significantly positive, no matter whether the vowel occurs in an open or closed syllable. When the preceding consonant is voiceless, the situation is different. Of 23 tokens of RP's, none has a slope which is significantly positive. Two tokens (i.e. (45) iqqanar-pu̲q, and (46) iqqarsar-pu̲q) have significantly negative slopes. In AS's and GT's tokens there are some whose slopes are not significantly different from zero. As a whole, the amount of change

1) "Preceding" and "following" consonants are not always the same as "initial" and "final" consonants of the syllable. When a preceding consonant is short, it is the initial consonant of the same syllable, but when it is long, i.e. geminate, it is final in the preceding syllable as well as initial in the syllable in question. A "following" long consonant is final in the syllable and at the same time initial in the following syllable, and a "following" short consonant is initial in the following syllable.

Fig. 5-1a.

Intervals of duration and frequency between the beginning and the end of a short vowel in M1 position.



preceding cons.

C̬_	C̥_	Ø_	
⊗	◬	⊠	: slopes 1 and 2 are significantly different from zero,
⊖	△	⊟	: slope 2 is significantly different from zero,
⊙	△	⊡	: neither of the above two cases.

Fig. 5-1b.

Intervals of duration and frequency between the beginning and the end of a short vowel in M2 position.
(As for symbols, see Fig. 5-1a.)

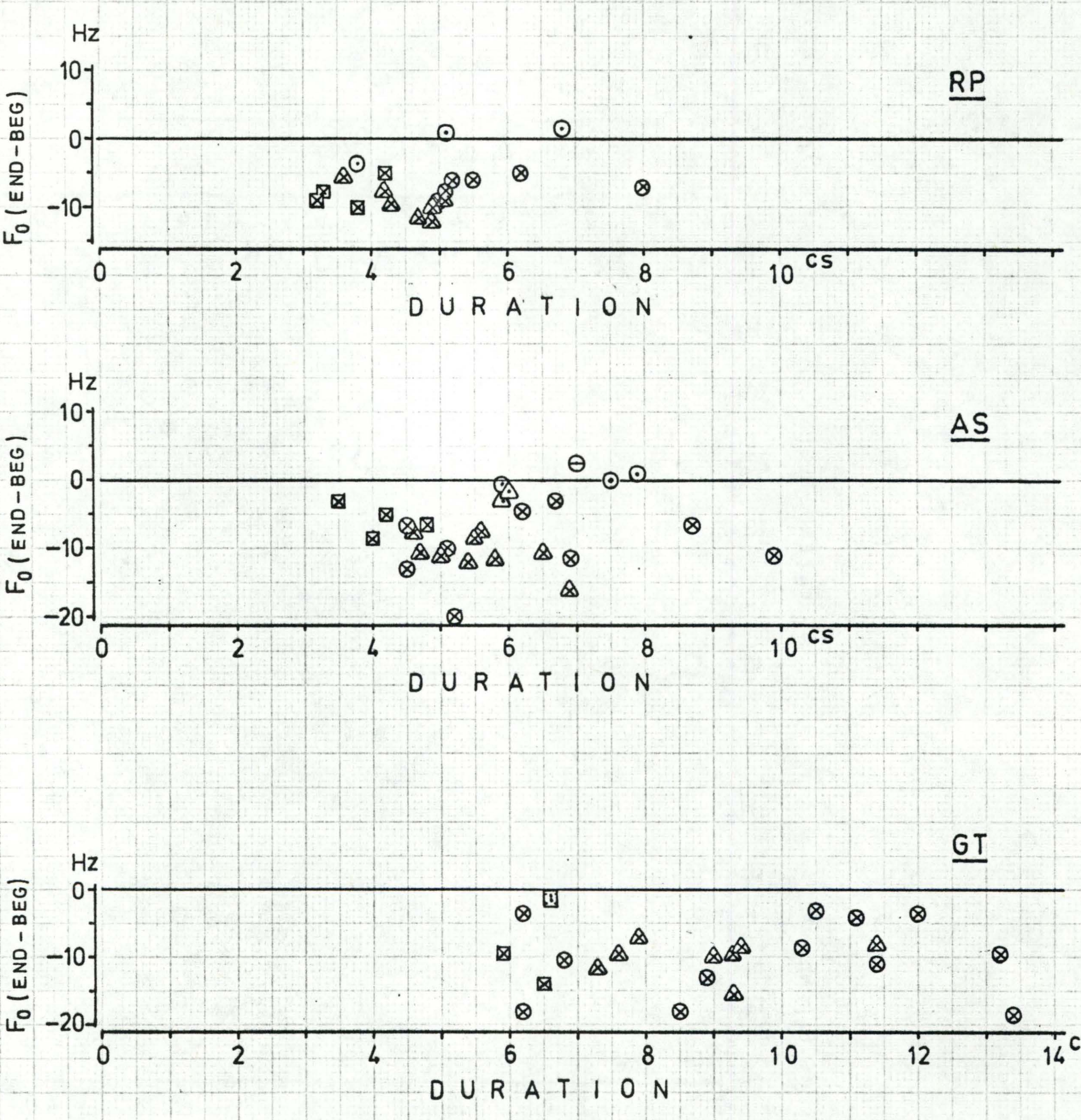


Fig. 5-1c.

Intervals of duration and frequency between the beginning and the end of a short vowel in M3 position.
(As for symbols, see Fig. 5-1a.)

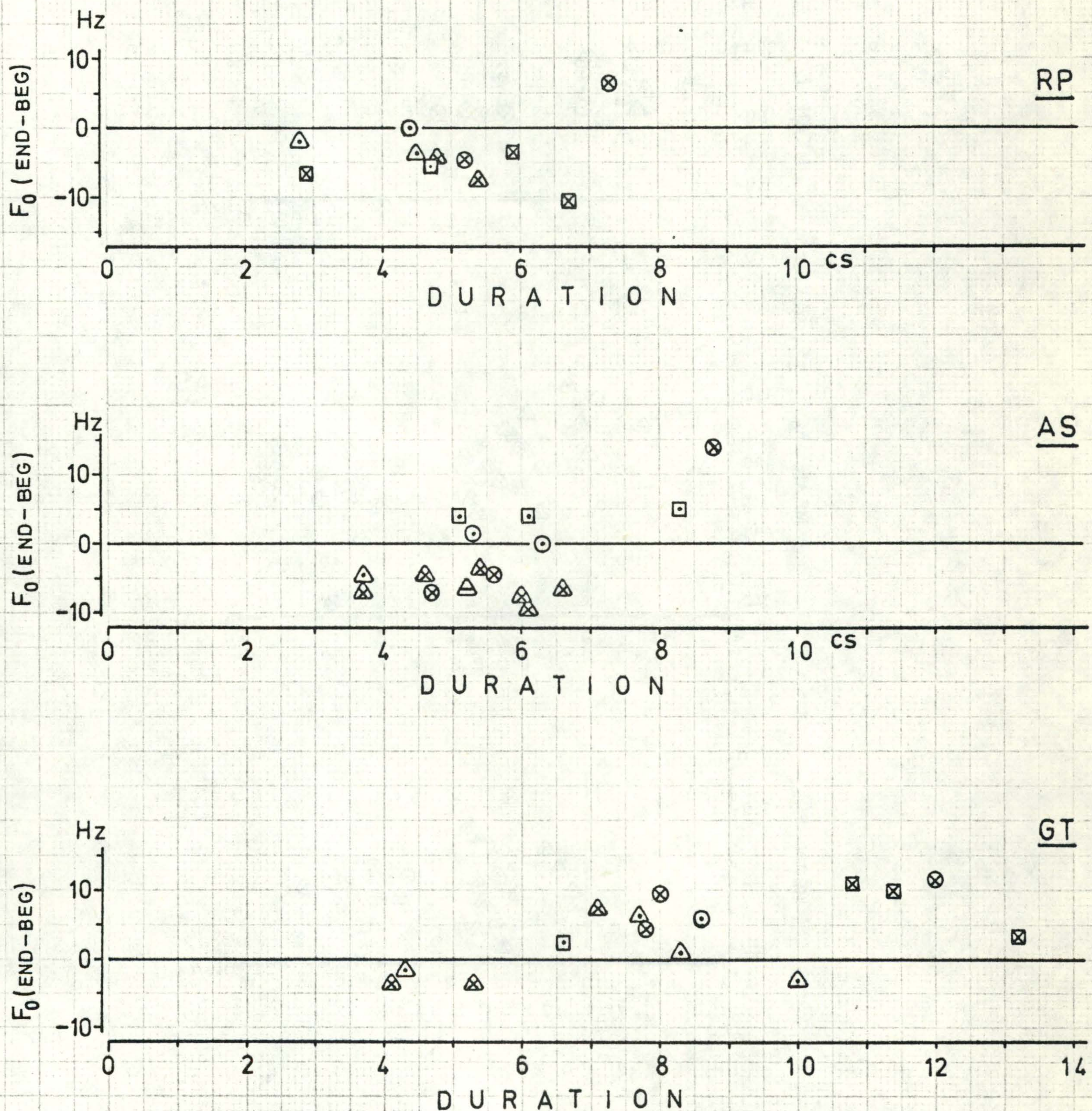
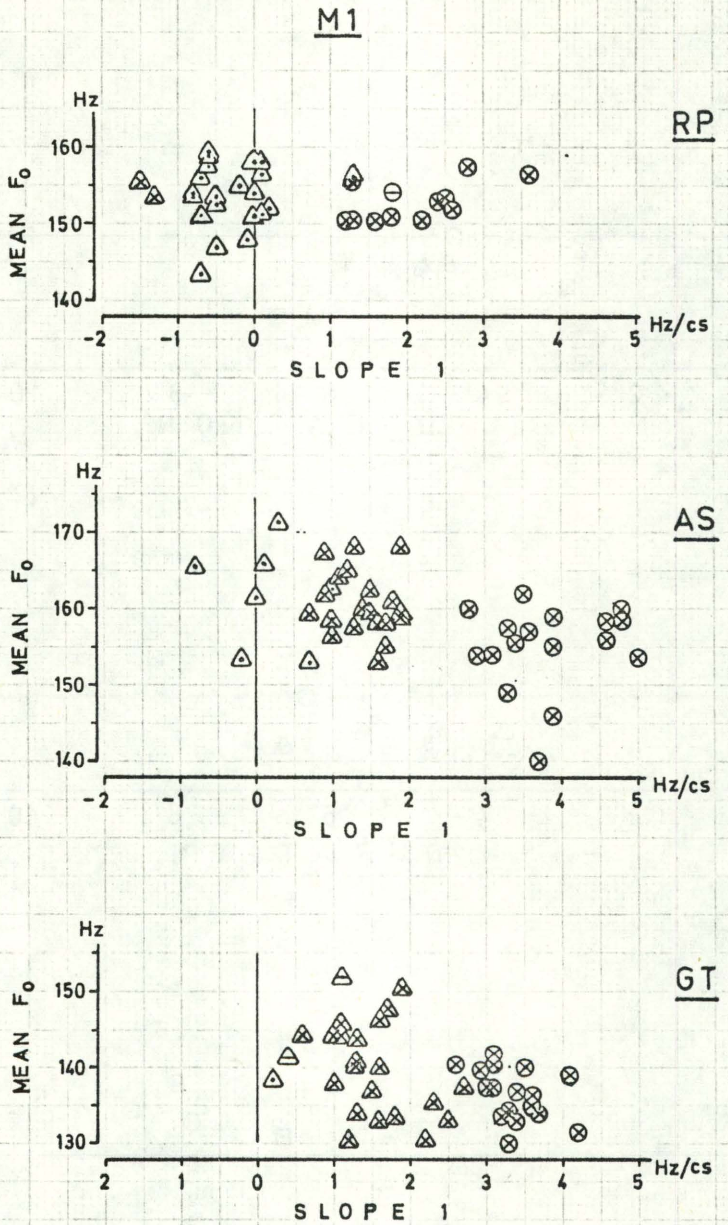


Fig. 5-2a.

Slopes and mean fundamental frequencies of short vowels in M1 position.

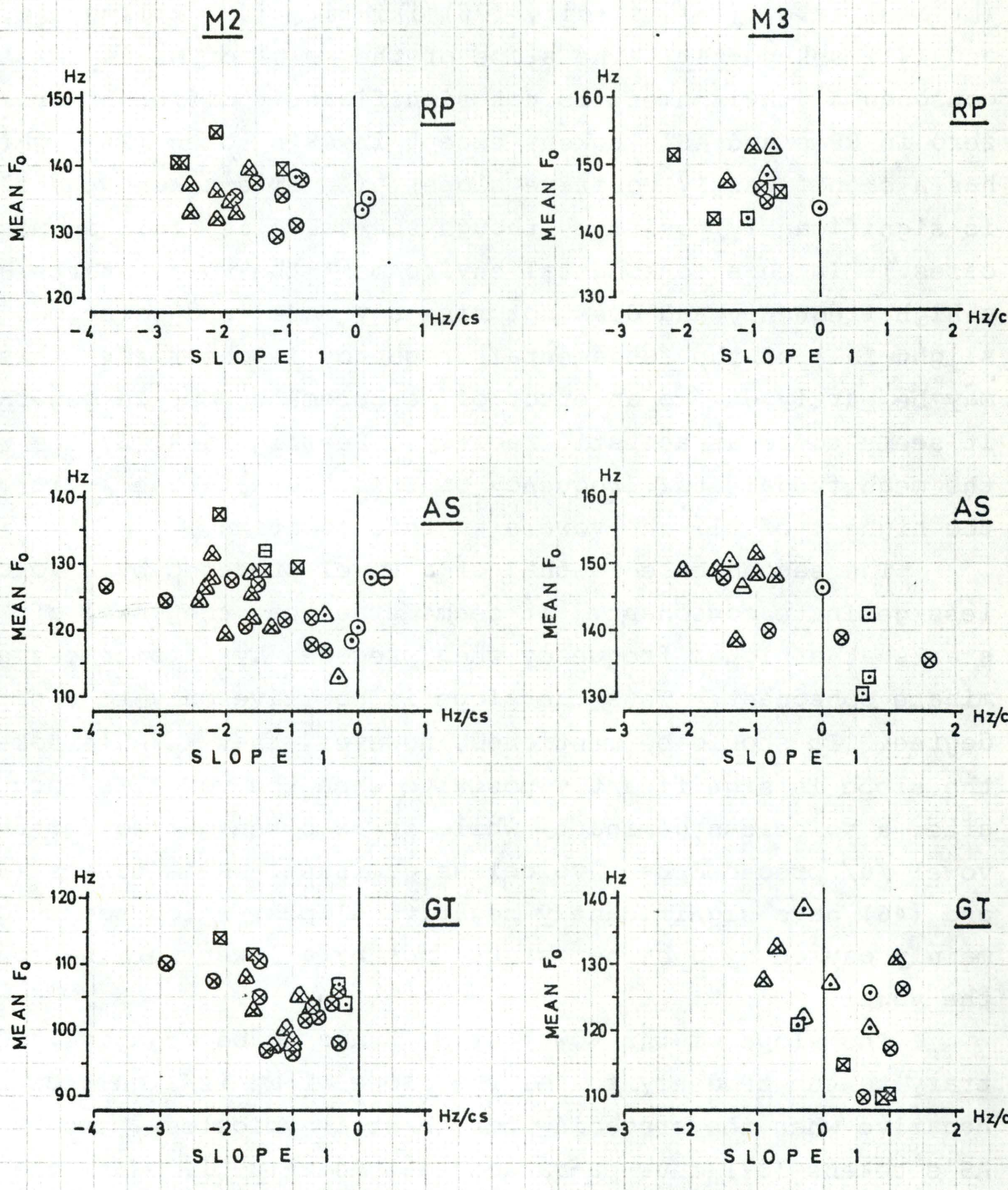


preceding cons.

Ç_	C̥_	Ø_	
⊗	⊗△	⊠	: slopes 1 and 2 are significantly different from zero,
⊖	△	⊟	: slope 2 is significantly different from zero,
⊙	△	⊡	: neither of the above two cases.

Fig. 5-2b.

Slopes and mean fundamental frequencies of short vowels in M2 position (left column) and in M3 position (right column).
(As for symbols, see 5-2a.)



is smaller in vowels preceded by voiceless consonants than in vowels preceded by voiced ones. But this does not necessarily mean that the mean fundamental frequency is lower in the former case than in the latter; it is rather the other way round.

There are four tokens in which M1 consists of -tit ([t^sit]), i.e. (18) tii-tit, (26) iki-tit, (40) killuu-tit, and (41) sukkuu-tit. The slope of the vowel of M1 in this consonantal environment is not significantly different from zero in RP's and AS's tokens except in AS's token (26), which has a significantly positive slope. (In GT's tokens the slope is significantly positive, though the value is small in most cases.) In this consonantal environment the vowel starts at a high frequency and does not rise any more, and sometimes a slight fall of the fundamental frequency is observed. This may be partly due to an error of measurement, but in general it seems to be an acoustic reality. See fig. 5-3.(By the way, the mean fundamental frequency of this "level"-tone /-tit/ is the highest of all the vowels in this position.)

The second case is that of a vowel preceded by a voiceless geminate consonant. It seems true that the vowel of M1 starts at a higher frequency when preceded by a voiceless geminate consonant. Thus the slope is positive only to a small degree. It should be mentioned, however, that in AS's tokens the slope is significantly positive when the vowel /a/ occurs after a voiceless geminate, while it is often not so for the vowel /u/ preceded by a voiceless geminate. RP's tokens (45) and (46) have significantly negative slopes, which seems to be mainly caused by a higher start, not by a lower termination of the vowel.

The slope of the vowel of M2 tends to be negative. Contrary to the tendency for M1 the slope of M2 is significantly negative when the preceding consonant is voiceless, except in AS's tokens (37) tuur-pa-ra and (44) uqur-lu-ni. When the

Fig. 5-3a.

Narrow-band spectrograms with a frequency expanded scale, and mingograms (traces from top to bottom: two intensity curves, fundamental frequency curve, and duplex oscillogram).

Words: /taqaq/ and /ikitit/. Speaker: RP.

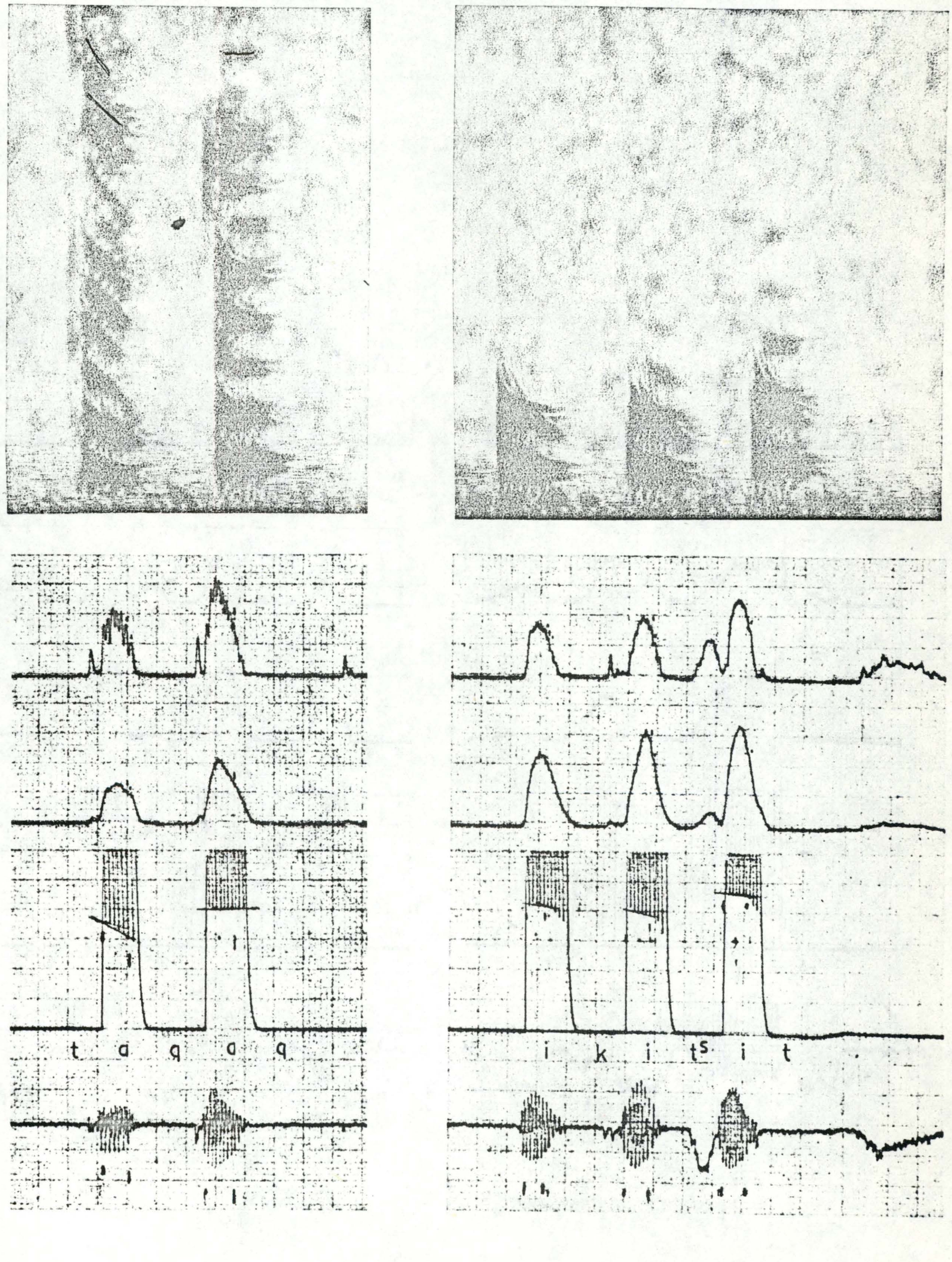
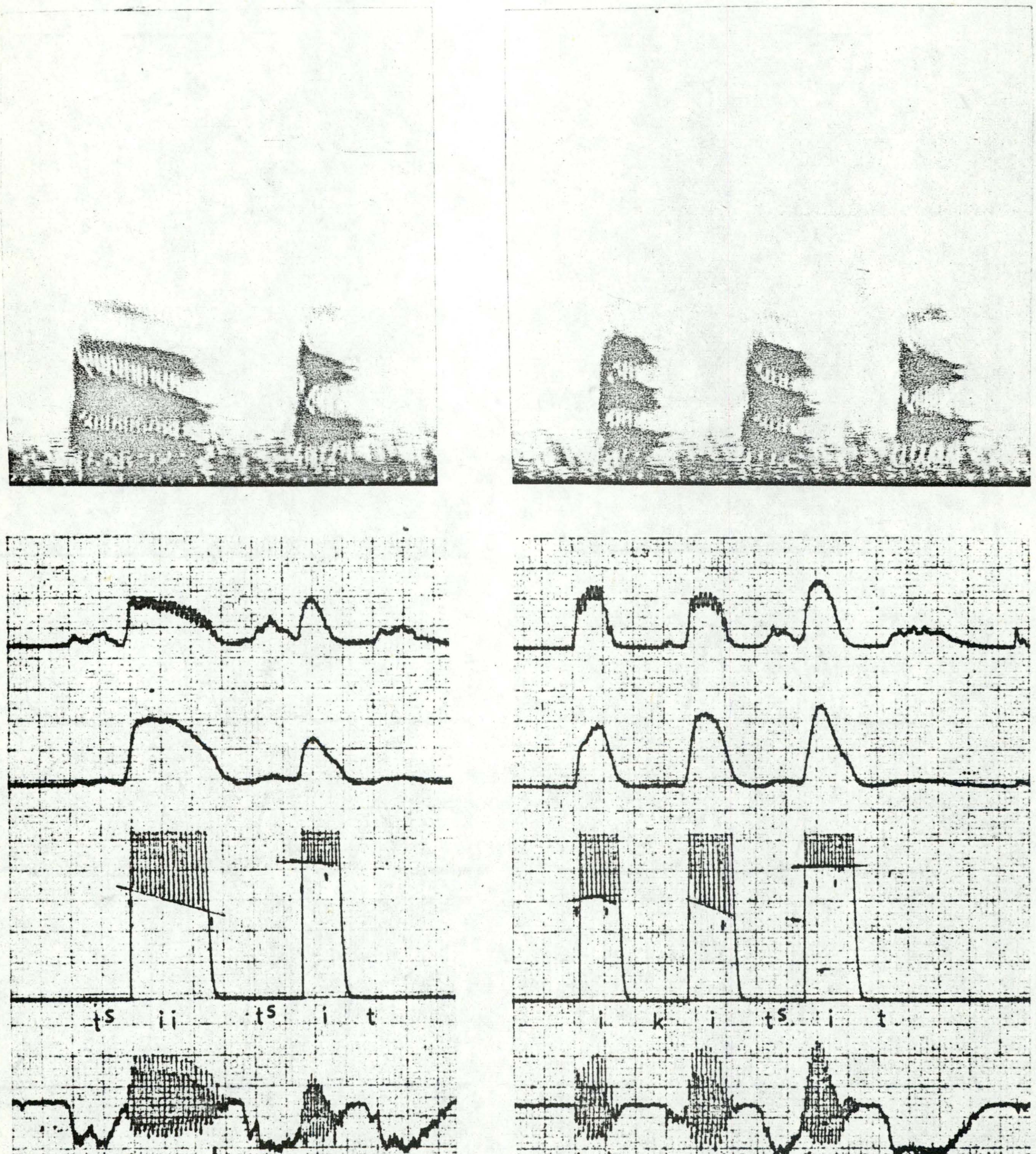


Fig. 5-3b.

Narrow-band spectrograms with a frequency expanded scale, and mingograms (as for traces, see Fig. 5-3a).

Words: /tiitit/ and /ikitit/. Speaker: AS.



slope is not significantly different from zero the preceding consonant is voiced, or the vowel is preceded by no (initial) consonant and followed by a voiceless geminate (no initial consonant in the case of two-syllable, two-(vowel) mora words). The tokens (53) aama-l<u>i</u>-wik, and (54) amaa-l<u>i</u>-wik spoken by RP and AS are the only ones in which the slope is slightly positive.

When all the tokens of three persons are pooled, there are 10 cases where the vowel of M2 is preceded by a short voiced consonant and followed by a short voiceless consonant, and there are 12 cases where the vowel of M2 occurs between a short voiced consonant and a long voiceless consonant. In all, except one, of these 22 cases, the vowel of M2 has a significantly negative slope. This may mean that the following consonant is not so influential as the preceding one upon the direction of the slope.

The results for the slope of M2 show that when the vowel of M2 starts higher, as it does after a voiceless consonant, the fundamental frequency of the vowel should be lowered in order to achieve a relatively low mean value. As the results show, the mean fundamental frequencies of vowels are not significantly different, whether the slopes are significant or not.

Whereas M1 and M2 show a rather clear tendency, the remaining moras do not. The first question is whether there is a fixed direction of the slope for the vowels from M3 to M6. <u>M3</u> is the least promising one; there are too many tokens in which the slope is not significantly different from zero. But a weak tendency for the slope to be negative is seen in RP's and AS's tokens, and a weak positive tendency is observed in GT's tokens. The token (42) a-w<u>a</u>-taaq is the only case in which the slope of M3 is significantly positive for all the three persons. This is the only one among RP's tokens in which the slope is positive, and it is the only one among AS's tokens in which the slope is significantly positive. No consistent influence from surrounding consonants can be observed.

The slope of M4 will be negative, since there is no case where the slope is significantly positive, except for GT's (42) a-wataaq, though the change here is small. The slopes of M5 and of M6 are not clear, since the number of tokens is small and since the change becomes smaller. The influence from surrounding consonants and the influence of stress will be greater here.

Mohr (1971) says that in vowels spoken with an "intended" level pitch,[1] the following results were obtained:

> "After voiceless consonants, onset frequencies are slightly higher than offset frequencies. After voiced consonants, onset frequencies are more than 15 cps below offset frequencies, for CVC syllables. For VCV sequences, onset frequencies are only about 5 cps lower than offset frequencies in the case of obstruents, and less than 2 cps lower in the case of liquids." (p. 7o-71)

---

1) B. Mohr made a study of the (acoustic) intrinsic variations in F_0 and the durations of vowels (/a i u/) and consonants (/p t k b d g f v l r ? h/). Three speakers of different languages (a Chinese, a Russian, and a German) with "sufficient experience in English" spoke "language-independent" nonsense CVC syllables and VCV sequences. "Speakers were instructed to read the lists at normal speed and uniform pitch. All syllables were to have level and equal stress." (p. 67)

If these vowels with "intended" level pitches are perceived as level pitched,[1] our results will be as follows. A slight rise in fundamental frequency of the vowel of M1 after a voiceless consonant may correspond to an auditively more rising pitch, and a slightly falling fundamental frequency may correspond to an auditively level pitch. A great rise in the vowel of M1 after a voiced consonant will be not so great auditively. In the case of the vowel of M2, a falling fundamental frequency after a voiceless consonant may not be auditively very noticeable, and the (almost) level frequency of a vowel after a voiced consonant may be perceived as falling pitch. But we have not carried out any perception test. The only thing we know is that the words of the present investigation sounded normal to the ears of the native speakers.

---

1) It is not explicitly mentioned in Mohr whether the vowels were perceived to be level pitched. But it is true that the author carried out a perception test using the same stimuli. The procedure of the test is not completely clear to me, but anyway, the author's concern is the distinction of "voiced" and "voiceless" categories of consonants and/or the "naturalness" of the pitch contour of the vowel after a certain consonant, but not the pitch perception of the vowel in a certain consonantal environment. We can interpret the results as follows. A vowel preceded by a voiceless consonant sounded "natural" if the vowel had a (slight) falling contour, while a vowel preceded by a voiced consonant sounded natural if the vowel had a rising contour. (cf. Mohr, p. 85 ff.)

As for the pitch change of the nasal consonant, the author says: "Kyungnyun Kim (1968) found that the average pitch level of nasals is lower than that of vowels, but that the pitch contour during the nasal is rising" (p. 8o).

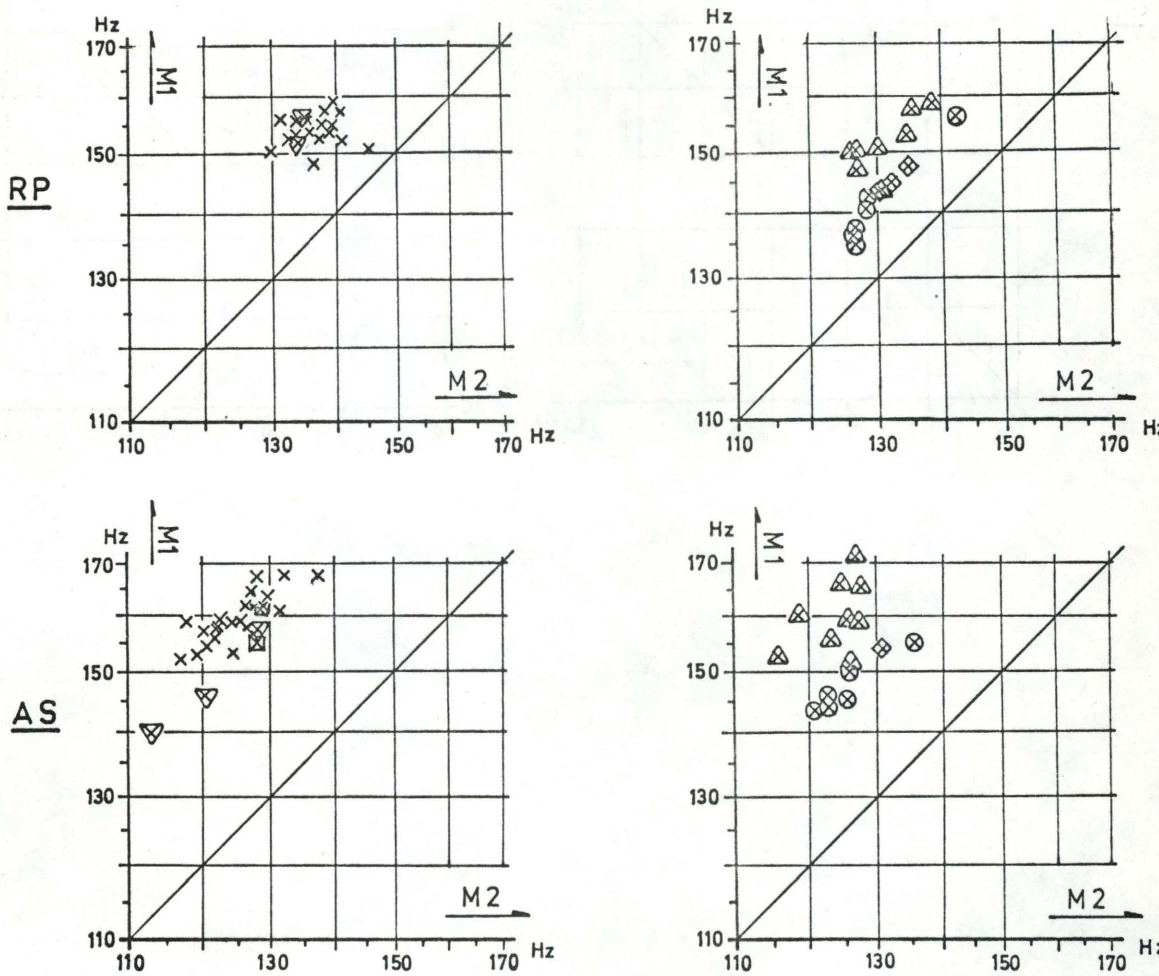
In their research on Swedish Accent 2, Erikson-Alstermark (1972) report that if an accented vowel (with a falling fundamental frequency) varies in duration, the value of the (negative) slope is constant, and the vowel truncation occurs at the final part of the vowel. Thus, the shorter the vowel is, the higher the F_o value at the end of the vowel. This is called the "truncation" type, as against the "rate adjustment" type, by which is meant that the value of frequency interval is constant without regard to the vowel duration.

In our case, the vowel of M1 has generally a positive slope. If the direction of change is relevant, the vowel of M1 will be more like the "truncation" type than the "rate adjustment" type. The truncation occurs at the beginning of the vowel. Thus, if there is any difference of mean fundamental frequencies between the vowels after voiceless and voiced consonants, the values after a voiceless consonant are a little higher than those after a voiced consonant. But generally there is no significant difference. This means that the longer duration of the vowel after the voiced consonant is necessary to get a sufficiently high mean fundamental frequency, no matter whether the longer duration of the vowel is physiologically conditioned or not.

Now we proceed to the question of the mean fundamental frequency. From the above discussion, it will be fairly clear that the fundamental frequency of the vowel may vary according to the particular consonantal environment. In addition to this factor, the difference of mean fundamental frequency values between adjacent vowel moras may vary according to the distribution of short and long vowels in a word. Fig. 5-4,a,b,c shows the mean fundamental frequencies of adjacent vowel moras. Both absolute values and differences between adjacent vowel moras are often great when both of the moras are short vowels. This is especially true of short vowels in M2-M1 and M3-M2 positions.

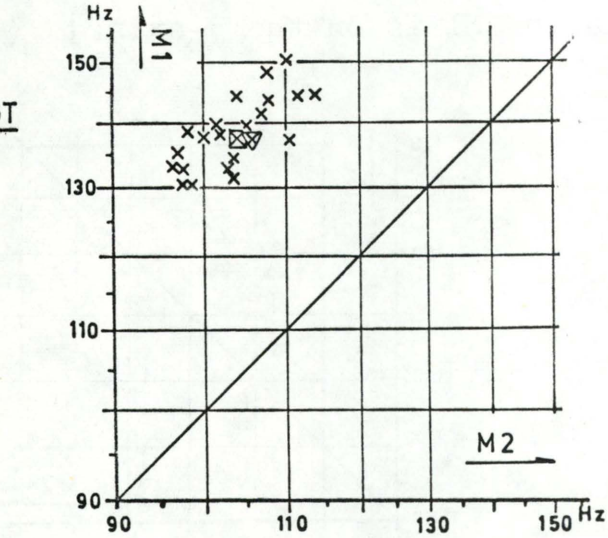
Fig. 5-4a.

Values of mean fundamental frequencies of two adjacent vowel moras. [The value of the vowel mora of M2 is on the x-axis, and that of M1 is on the y-axis.]



Vowel distribution in words (– = syllable boundary) (long vowels in [ ])	M4 M3 M2 M1	difference between moras: significant	difference between moras: not significant
Type 1:	(–) V – V – V – V	×	•
" 2:	(–[V) V] – V – V – V	⊠	⊡
" 3:	(–) [V V] – V – V	▽×	▽·
" 4:	(–) V – [V V] – V	△×	△·
" 5:	(–) V – V – [V V]	◇×	⟐
" 6:	(–) [V V] – [V V]	⊗	⊙

Fig. 5-4a.
(continued)



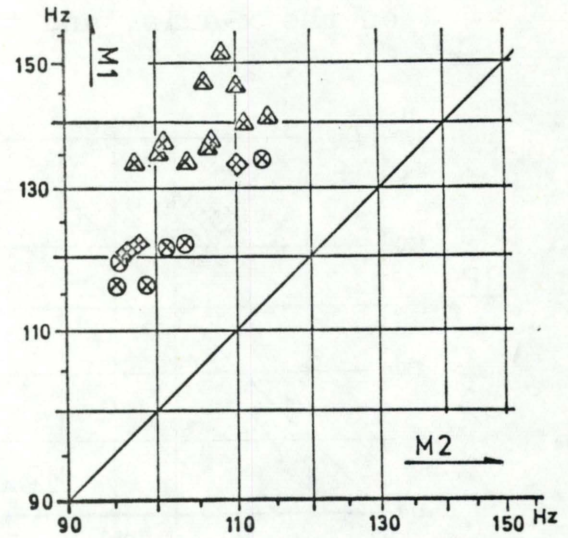


Fig. 5-4b.

Values of mean fundamental frequencies of two adjacent vowel moras. [The value of the vowel mora of M2 is on the x-axis, and that of M3 is on the y-axis.] (As for symbols, see Fig. 5-4a.)

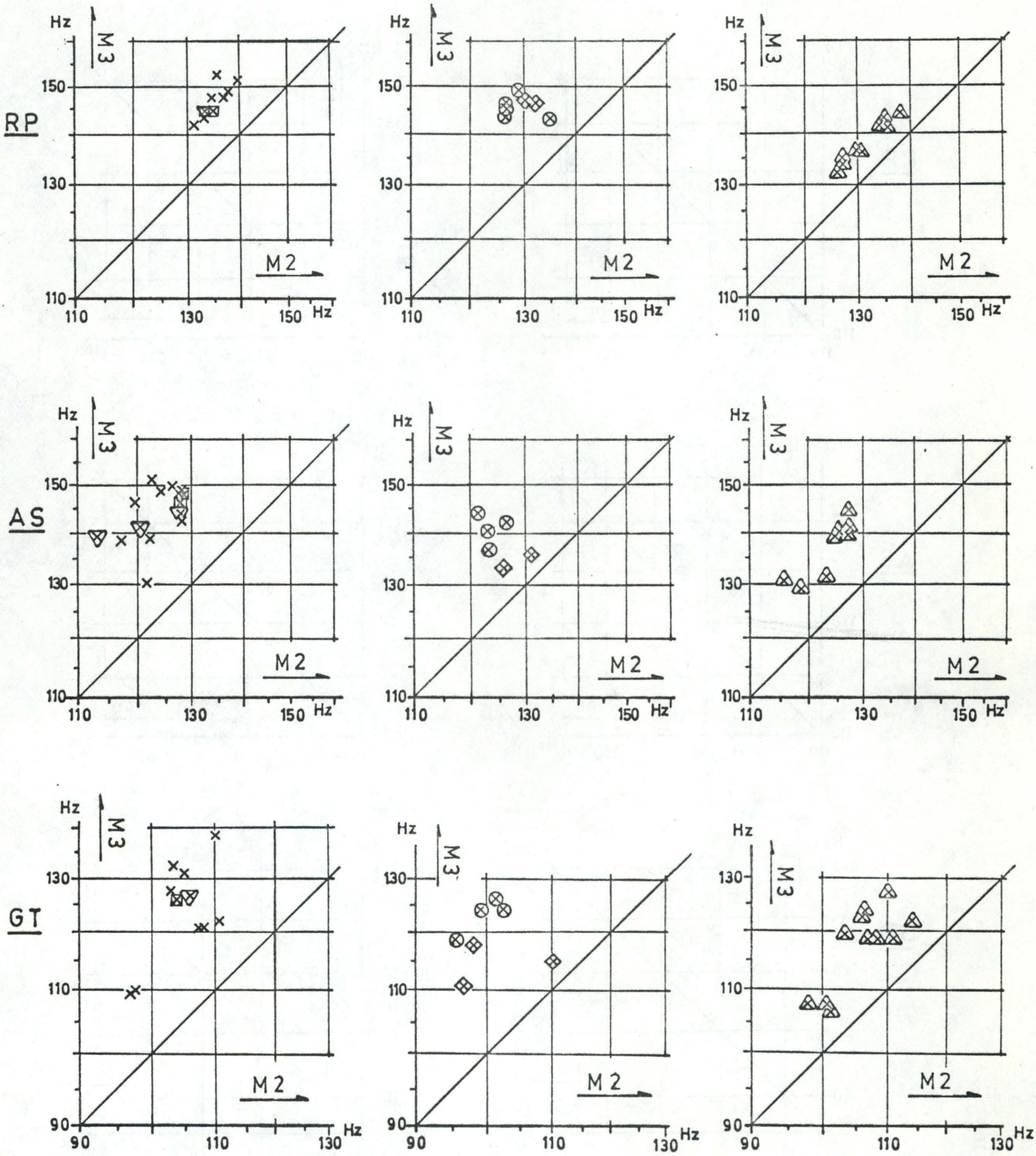
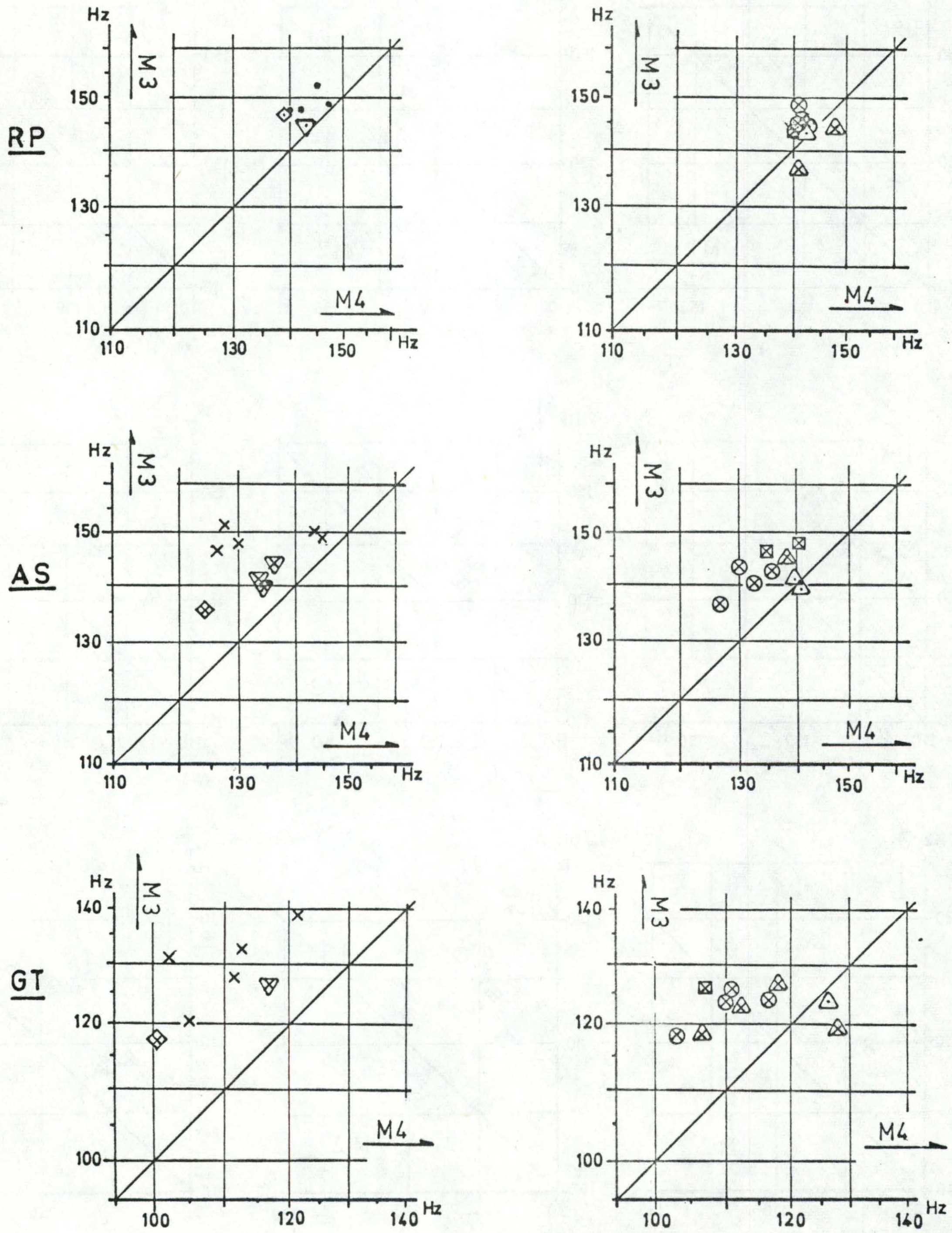


Fig. 5-4c.
Values of mean fundamental frequencies of two adjacent vowel moras. [The value of the vowel mora of M4 is on the x-axis, and that of M3 is on the y-axis.] (As for symbols, see Fig. 5-4a.)



Both absolute values of M1 and the difference between M2 and M1 are great when M2 is the second half of a long vowel and the vowel of M1 is short. On the other hand, both absolute values and the difference are smaller in M2-M1 position when the two vowel moras consist of a long vowel.

Another fact emerges from fig. 5-4,a,b,c. Though the absolute values of the mean fundamental frequency vary among the words depending upon the vowel quality, the quality and duration of surrounding consonants, the differences of mean fundamental frequency values are rather constant among words which have the same distribution of short and long vowels.

The relation between M4 and M3 is that M4 is generally lower than M3, but this is not true of three-syllable, four-mora words of the type CV(C)-CVV-CV(C), if the consonants are voiceless. In RP's tokens (39) ki-si-i-sa and (40) suk-ku-u-tit M4 is significantly higher than M3; in the token (41) kil-lu-u-tit of the same person and in AS's tokens (40) and (41), the difference between M4 and M3 is not significant. In the same tokens spoken by GT, M4 is significantly lower than M3. It is different with his two six-mora words, i.e. (60) ii-šaš-ša-a-wuq, and (63) ili-šaš-ša-a-wuq (these tokens occur only in the material spoken by GT): M4 is significantly higher in the former, and it is either higher or lower in the latter. The vowel qualities of M4 and M3 are almost the same here. The choice of dividing a long vowel into two moras of equal length may not have been appropriate. It is very regrettable that the factor of duration was not taken up in this paper, and is completely left to be analysed.

In words of AS and GT, except in the tokens above mentioned, M4 is always lower than M3. On the other hand, in RP's tokens there are only 5 out of 14 tokens in which M4 is significantly lower than M3. Thus, it may be one of the characteristics of his words that there is no significant difference between M4 and M3. In his words the initial mora of the word is often comparatively high-pitched. This fact may have some connection with stress.

As for the differences between M5 and M4, and M6 and M5, a given mora will be lower than the following one, though the difference is small.

Almost all the way through we have been discussing the high-low relations between tone bases or moras, but we have only briefly touched upon the absolute values of the differences. Since the measurements ought to be normalized with respect to various factors the values shown in the tables in section 4. do not necessarily correspond to the auditive distances between tone bases. As mentioned before, the values of the differences between M2 and M1, and between M3 and M2 are usually more than 20 Hz and 10 Hz, respectively. The values of the differences between tone bases from M3 to M6 are smaller than those found between M2 and M1 and between M3 and M2. But all values vary according to the consonantal environment and the distribution of short and long vowels in the words.

Summing up the above discussion, the slope is not as important as the mean fundamental frequency. A large change in a short vowel will be required only if the fundamental frequency starts higher or lower than the target mean.[1]

---

1) If our speculation on possible consonant influence upon adjacent vowels is right, the particular example of phrase-final intonation in Collis (1970) will get, as he describes, a rise-fall-rise pattern.
Collis (1971, p. 142) shows pitch shapes of vowels in different segmental environments. It seems that in this latter work Collis is inclined to say that the direction of pitch change depends upon the segmental environment. However, the pitch shapes shown in the work do not agree with the tendencies of frequency change observed in the material of the present investigation. This discrepancy cannot be due to the fact that in the present investigation only two points (i.e. beginning and end) are taken into account to measure the values of fundamental frequency.

In the cases of long vowels, the directions of the slopes are rather fixed according to the mora positions. M2 as part of a long vowel, for example, has a positive slope when it is the first half of a long vowel, and it has a negative slope when it is the second half of a long vowel. M3 as part of a long vowel has a positive slope when it is formed by the second half of a long vowel, while it has a negative slope when it is the first half of a long vowel.

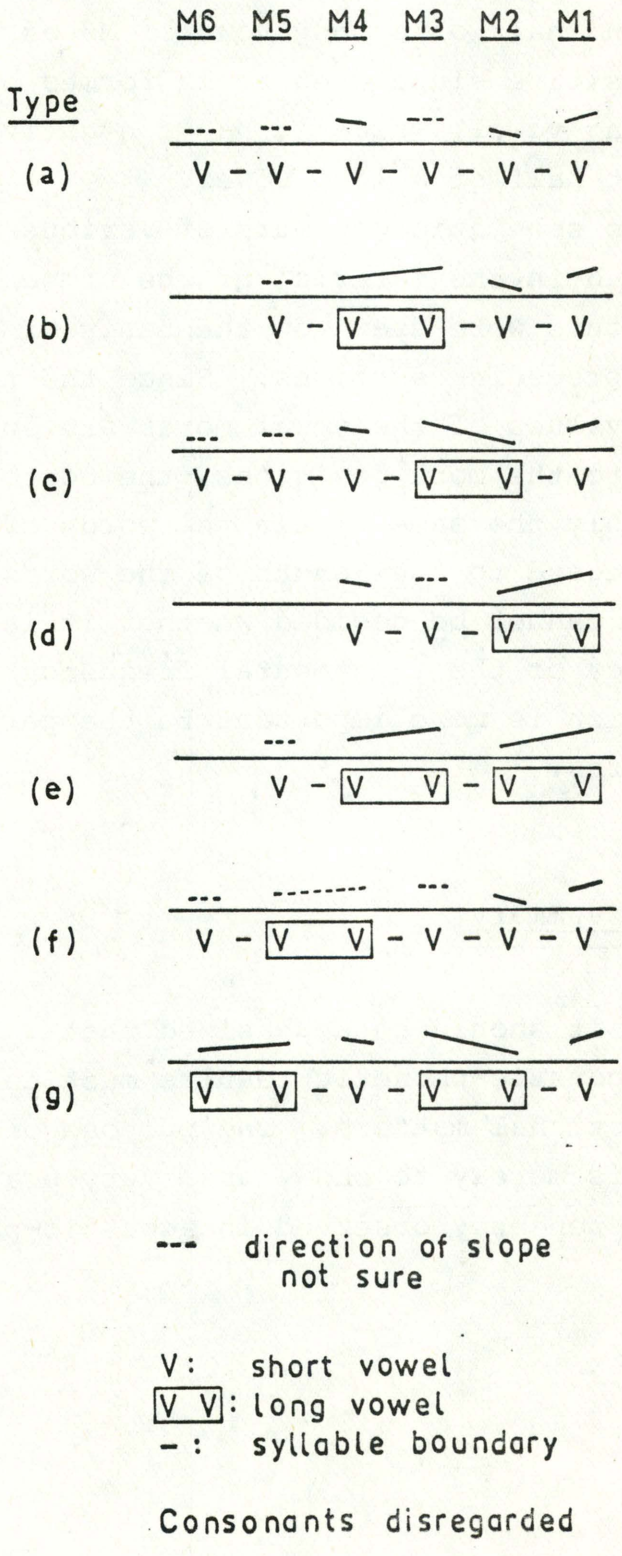
Fig. 5-5 shows schematic contours of various types of words which are found in the material of the present investigation. These contours were drawn on the basis of the results shown in the preceding sections. Since the target fundamental frequency values of the vowel moras are supposed to be fixed according to the mora positions, the contours are supposed to be roughly the same within the words of one contour type without regard to the length of the words.

At present it cannot be decided whether it is the mean fundamental frequency or the fundamental frequency at the end of the vowel which is more important to the perception of intonation patterns.

6. Final remarks - summary

First of all, it should be emphasized that I have no illusion that the acoustic-phonetic results must decide on phonological or functional matters. The purpose of the present investigation is merely to show, as a very preliminary research, a certain tendency observed in acoustic-phonetic results.

Fig. 5-5.
Schematic pitch contours of vowel moras in each mora position.



Though there are many unsolved and unclear points in the results of this investigation, the argument that tone is regulated not on a syllable basis but with reference to vowel moras - is supported on various grounds.

The phrase-final intonation is signalled by a "high-low-high" pattern on the last three vowel moras, since a comparison of the mean fundamental frequencies shows that the second vowel mora from the end has a lower frequency than the first and the third in all the tokens of three speakers. (If we say that it is not the mean fundamental frequency but the fundamental frequency at the end of the vowel mora which signals the phrase-final intonation, we can at least say that M2 is lower than M1.) Thus, the instrumental results here agree with what Rischel's phonological analysis shows. The relations between the vowel moras from M3 to M6 are not so clear, which may be partly due to the fact that they do not contribute to characterize the phrase-final intonation, and partly due to the fact that the influences of surrounding consonants and stress (if any) will be comparatively great here, since the fixed movements are smaller. But it is quite probable that in the positions from M3 to M6, the preceding vowel mora is lower than the following one.

With regard to the consonants, a voiceless consonant mora cannot be a tone base, though it may have a certain influence upon the pitch of adjacent vowels. A nasal mora cannot be a tone base, either. But if the nasal mora is completely disregarded, the tonal pattern of words containing a long nasal does not fit well with the patterns of other words which do not contain a long nasal. The first (= syllable-final) portion of a long nasal seems to form one compound tone base together with a preceding vowel mora.

References

Collis, Dermot R.F. 1970: "Etudes philologiques et linguistiques des langages esquimaux", Internord N° 11, p. 263-282

Collis, Dermot R.F. 1971: Pour une sémiologie de l'esquimau (Paris)

Erikson, Y. and M. Altermark 1972: "Fundamental frequency correlates of the grave word accent in Swedish: The effect of vowel duration", STL-QPSR 2-3, p. 53-60

Fant, Gunnar 1958: Modern instruments and methods for acoustic studies of speech (Oslo)

Flanagan, J.L. and M.G. Saslow 1958: "Pitch discrimination for synthetic vowels", JASA 30, p. 435-442

Hadding-Koch, Kerstin 1961: Acoustico-phonetic studies in the intonation of southern Swedish (Lund)

Holtved, Erik 1964: Kleinschmidts Briefe an Theodor Bourquin = Meddelelser om Grønland 140, 3

Lehiste, I. and G.E. Peterson 1961: "Some basic considerations in the analysis of intonation", JASA 33, p. 419-425

Lehiste, Ilse 1970: Suprasegmentals (Cambridge, Mass.)

Mase, H. and J. Rischel 1971: "A study of consonant quantity in West Greenlandic", ARIPUC 5, p. 175-247

Mohr, B. 1971: "Intrinsic variations in the speech signal", Phonetica 23, p. 65-93

Petersen, Robert 1970: "On phonological length in the Eastern Eskimo dialects", Folk 11-12, p. 329-344

Rischel, Jørgen 1971: Lecture notes, esp. "Udkast til formuleringer af nogle regler vedrørende grønlandsk intonation" (København, 4 pp)

Rossi, M. 1971: "Le seuil de glissando ou seuil de perception des variations tonales pour les sons de la parole", Phonetica 23, p. 1-33

Thalbitzer, W.A. 1904: A phonetical study of the Eskimo language = Meddelelser om Grønland 31

Editors' note:

The editing of this paper for ARIPUC was not finished when Mr. Mase left for Japan. With his consent a final revision has been made by the editors.

There are some essential changes in the sections dealing with Rischel's phonological analysis, to the extent that this presentation was based on "personal communication": the terminology in Rischel's analysis has been modified in accordance with the most recent formalization (to appear in Rischel's forthcoming monograph on West Greenlandic phonology). These modifications do not affect the theoretical issues of Mr. Mase's paper.