PHONETIC PROPERTIES OF VIETNAMESE TONES ACROSS DIALECTS

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0. INTRODUCTION[1]

Although Vietnamese tones have been extensively studied in quite a few works, the more detailed phonetic descriptions based on instrumental analysis have all concentrated on Northern Vietnamese (henceforward NV), e.g. Lê Văn Lý (1948), Andreev and Gordina (1957), Nguyên Hàm Dương (1962), Han (1969), Han and Kim (1972) and Earle (1975), while Central Vietnamese and Southern Vietnamese (henceforward CV and SV) have had fewer and mainly impressionistic descriptions, with the exception of Trần Huong Mai (1969) which was only partially based on instrumental records. Mine is an attempt to provide a more comprehensive description of Vietnamese tones by presenting data from all three major dialects in their various aspects.

1. AN OVERVIEW OF VIETNAMESE TONES

The official spelling recognises six tones in Vietnamese, which represent what can be termed the underlying phonological tones of standard literary Vietnamese and also of NV, which is regarded as a prestige dialect. Table 1 summarises the system in three dialects. The English labels, taken from Han (1969) and preferred to others because they are short and suggestive of the basic contours of each tone, and the phonological notations, taken from official spelling diacritics with the addition of the macron for the level tone, will be used throughout this work. The phonetic notations, a modified version of Chao's (1930), was first based on auditory impressions and later readjusted in some cases by taking pitch values calculated from the data through various normalisation and conversion procedures described elsewhere (Vũ Thanh Phương 1981).

TABLE 1

THE TONES OF VIETNAMESE

Number	1	2	3	3B	4	4B	5	6
Vietnamese Names	ngang	huyền	sắc	sắc (tắc)	nặng	nặng (tắc)	hỏi	ngã
English Labels*	level tone	falling tone	rising tone	stopped rising tone	drop tone	stopped drop tone	curve tone	broken tone
Phonological Notations*	/-/	/\`/	/ˊ/	/ˊs/**	/./	/.s/**	/ˀ/	/~/
Phonetic Notations*								
NV	[33]	[21]	[35]	[45s]**	[21]**	[21s]**	[212]	[325]**
CV	[55]	[42]	[24]	[34s]**	[31]	[31s]**	[312]**	
SV	[33]	[21]	[35]	[35s]**	[212]	[21s]**	[214]	
Examples	/hāj/	/hàj/	/háj/	/hát/	/hạj/	/hạt/	/hảj/	/hãj/
	'two'	*'slipper'*	*'to pick (fruit)'*	*'to sing'*	*'harm'*	*'grain'*	*'sea'*	*'scared'*
							(in compounds only)	

* See comments in the text.

** s represents the syllable-final voiceless stop which conditions the occurrence of the tone.

═ marks the laryngealisation characteristic of the tone.

2. PROCEDURES

2.1. *INFORMANTS*

This study was based on the recorded voices of thirty-four native speakers of Vietnamese (11 NV, 12 CV and 11 SV), whose home towns are indicated on Map 1 (p.58). They included 14 females and 20 males, respectively represented by F and M and numbered in increasing order in the southward direction within each sex group and each dialect. Being mostly university students or staff, they spoke an educated and standardised variety of their respective dialects.

2.2. *WORD LISTS*

In order to pinpoint dialectal variations of tones in similar phonetic environments, I decided on a restricted number of syllables in two word lists. One consisted of five syllables

/ta/ /t^{h}a/ /da/ /na/ /sa/

occurring with all the six tones (five in CV and SV), and

/tak/ /t^{h}ak/ /dak/ /nak/ /sak/

occurring with the two stopped tones.

The other consisted of the syllables /ta/ (for non-stopped tones), and /tak/ (for stopped tones), each repeated three times after a frame sentence.

The idea was to minimise possible perturbations caused by consonants and vowels of various types which might differ phonetically in the three dialects. Comparison with data from Han (1969) and Earle (1975), which included a greater variety of syllables, showed that the tone shapes obtained from my material were essentially the same as theirs.

2.3. *INSTRUMENTS*

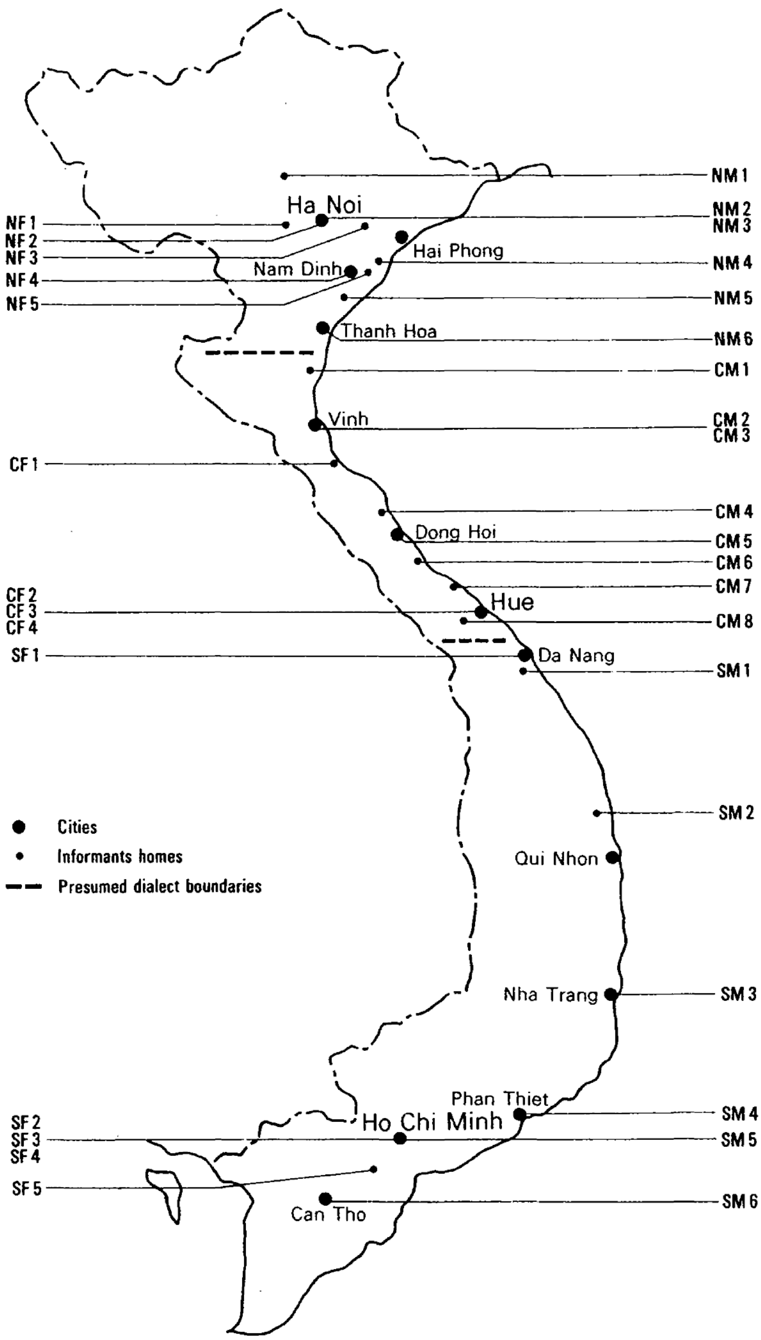
Recordings were made at various times in Canberra, Sydney, Hanoi, Hue and Ho Chi Minh City through a UHER 4000 Report IC Recorder with reel-to-reel BASF tapes. Mingograms were made through the use of an F-J Fundamental Frequency Meter, an F-J Intensity Meter, a Sony 8-Channel Mixer and an Elema-Schonander Mingograf, and spectrograms were made from a Voiceprint Spectrograph, at the Phonetics Laboratory of the Department of Linguistics, The Faculties, Australian National University.

2.4. *MEASUREMENTS*

After I decided to look at four parameters that appeared to characterise Vietnamese tones, namely Fo, intensity, duration and

MAP 1

DISTRIBUTION OF INFORMANTS' NATIVE PLACES IN VIET NAM



laryngealisation, measurements were made manually from mingograms, supplemented by spectrograms only in cases of unclear traces.

Fo values were measured at six timepoints for non-stopped tones designated P1, P2, P3, P4, P5, and P6, corresponding respectively to vowel onset, 10% (after onset), 37% (midpoint 1), 63% (midpoint 2), 90% (before endpoint) and endpoint. For the stopped tones, P1, P2, P3 and P4 were defined as onset, midpoint 1, midpoint 2 and endpoint, because with their much shorter duration, values at 10% after onset and before endpoint would not alter their Fo contours. For syllables beginning with voiced consonants, vowel onsets started later as the Fo values for consonant onsets were ignored, because they could cause deviations from the typical Fo contours of the tones.

Intensity was measured at four timepoints, I1, I2, I3 and I4, corresponding to P2, P3, P4 and P5 of the Fo measurements, and on the same syllables /ta/ and /tak/ for the various tones.

Duration was measured in centiseconds and the determination of onset and endpoint was made in the same way as for Fo and intensity.

As I know of no tested method of measuring laryngealisation, I studied the tones auditorily, noted the occurrence of breathy voice, creaky voice and glottal closure in various tones, and referred back to places in mingograms and spectrograms where they were supposed to occur and measured their rough duration in centiseconds.

3. RESULTS

The Fo, intensity and duration values obtained from measurements described above were treated statistically by calculating the arithmetical means and standard deviations. They are given in tabular forms in the following pages. Tables 2 to 4 present the Fo data, Tables 5 to 7 the intensity data, Table 8 the duration data and Table 9 the laryngealisation data.

TABLE 2

MEAN Fo IN HERTZ AND STANDARD DEVIATIONS OF NV TONES AT SIX TIMEPOINTS (FOUR TIMEPOINTS FOR STOPPED TONES)*

Tone	n	P1	P2	P3	P4	P5	P6
Level /-/	72	212 55	212 56	212 55	210 55	207 54	202 53
Falling /\`/	72	178 45	175 46	171 45	163 43	159 44	155 43
Rising /'/	72	198 52	194 51	197 51	217 51	246 54	257 56
St. Ris. /'s/	72	221 61	232 59	250 57	268 60		
Drop /./	72	189 47	186 47	180 45	165 43	162 44	163 47
St. Drop /.s/	72	182 45	174 43	167 41	158 43		
Curve /'/	72	176 45	170 46	157 42	140 37	155 38	166 38
Broken /~/	72	202 55	196 54	169 47	211 55	244 55	245 58

*Data from nine NV informants: NF1, NF2, NF3, NF4, NM1, NM2, NM3, NM4 and NM6.

For each tone, mean Fo values on first line, SD on second line.

TABLE 3

MEAN Fo IN HERTZ AND STANDARD DEVIATIONS OF CV TONES
AT SIX TIMEPOINTS (FOUR TIMEPOINTS FOR STOPPED TONES)*

Tone	n	P1	P2	P3	P4	P5	P6
Level /-/	96	184 53	182 50	185 50	187 50	188 52	186 52
Falling /\`/	96	174 49	171 48	167 47	162 46	159 45	156 44
Rising /'/	96	158 43	153 39	150 37	162 37	177 47	181 52
St. Ris. /'s/	96	163 42	159 39	166 39	179 46		
Drop /./	96	163 42	158 40	153 38	148 39	148 39	149 40
St. Drop /.s/	96	169 43	161 39	155 39	150 39		
Curve /'/	96	166 45	163 43	156 41	148 42	153 46	156 48

*Data from twelve CV informants: CF1, CF2, CF3, CF4, CM1, CM2, CM3, CM4, CM5, CM6, CM7 and CM8.
For each tone, mean Fo values on first line, SD on second line.

TABLE 4

MEAN Fo IN HERTZ AND STANDARD DEVIATIONS OF SV TONES AT SIX TIMEPOINTS (FOUR TIMEPOINTS FOR STOPPED TONES)*

Tone	n	P1	P2	P3	P4	P5	P6
Level /-/	72	191 61	191 60	192 61	191 60	189 61	185 61
Falling /\/	72	166 52	161 52	155 51	151 50	149 51	149 54
Rising /'/	72	194 63	192 60	201 61	224 68	250 80	255 84
St. Ris. /'s/	72	201 67	208 66	228 71	256 86		
Drop /./	72	166 57	157 52	148 49	150 51	162 55	166 56
St. Drop /.s/	72	170 56	159 52	155 49	160 52		
Curve /'/	72	173 61	162 56	149 48	175 54	219 66	224 71

*Data from nine SV informants: SF1, SF2, SF3, SF5, SM1, SM2, SM4, SM5, and SM6.

For each tone, mean Fo values on first line, SD on second line.

TABLE 5

MEAN INTENSITY IN dB AND STANDARD DEVIATIONS OF
NV TONES ON SAME SYLLABLES AT FOUR TIMEPOINTS*

Tone	n	I1	SD	I2	SD	I3	SD	I4	SD
Level /-/	32	7.1	2.1	6.3	1.1	5.4	1.6	2.0	1.8
Falling /ˋ/	32	5.1	2.1	4.5	1.5	3.5	1.7	1.1	0.2
Rising /'/	32	5.5	1.5	4.6	1.3	5.4	2.5	1.6	1.1
St. Ris. /'s/	32	5.6	2.0	5.0	1.6	4.5	2.1	1.5	1.3
Drop /./	32	4.5	1.3	4.1	1.5	2.3	1.0	0.8	0.2
St. Drop /.s/	32	5.0	2.1	4.4	1.8	3.6	1.6	1.0	0.05
Curve /’/	32	4.4	1.5	3.2	1.2	2.5	1.2	1.4	0.5
Broken /~/	32	5.2	1.9	2.4	0.9	4.8	2.3	1.4	0.5

*Data from 8 NV informants: NF1, NF2, NF5, NM1, NM3, NM4, NM5 and NM6. The syllables were /ta/ and /tak/ for sonorant-ending and stopped tones respectively.

For each tone, mean intensity values on first line, SD on second line.

TABLE 6

MEAN INTENSITY IN dB AND STANDARD DEVIATIONS OF CV TONES ON SAME SYLLABLES AT FOUR TIMEPOINTS*

Tone	n	I1	SD	I2	SD	I3	SD	I4	SD
Level /-/	32	8.0	2.5	7.2	1.1	5.5	1.8	2.7	1.3
Falling /\`/	32	8.4	2.7	6.5	1.8	4.1	1.6	1.9	0.6
Rising /'/	32	5.9	2.8	5.0	1.8	5.1	1.8	2.3	1.2
St. Ris. /'s/	32	5.3	2.6	4.9	2.1	4.6	1.8	1.6	0.5
Drop /./	32	6.5	3.1	4.7	1.5	3.1	1.9	1.7	0.9
St. Drop /.s/	32	6.6	3.2	5.3	1.5	3.8	1.3	1.4	0.8
Curve /'/	32	7.3	2.7	5.8	2.2	3.2	1.6	1.4	0.7

*Data from 8 CV informants: CF1, CF2, CF4, CM1, CM4, CM5, CM7 and CM8. The syllables were /ta/ and /tak/ for sonorant-ending and stopped tones respectively.

For each tone, mean intensity values on first line, SD on second line.

TABLE 7

MEAN INTENSITY IN dB AND STANDARD DEVIATIONS OF SV TONES ON SAME SYLLABLES AT FOUR TIMEPOINTS*

Tone	n	I1	SD	I2	SD	I3	SD	I4	SD
Level /-/	32	4.9	2.0	5.8	1.4	4.1	1.3	2.3	1.7
Falling /\`/	32	3.5	1.3	3.8	0.9	2.4	0.8	1.2	0.6
Rising /'/	32	4.4	1.8	4.9	1.3	4.2	2.2	2.5	2.3
St. Ris. /'s/	32	4.2	2.3	5.8	2.0	5.0	1.5	2.4	1.7
Drop /./	32	3.2	1.3	2.9	1.1	2.0	0.8	1.2	0.4
St. Drop /.s/	32	3.9	1.2	3.7	1.2	2.7	0.3	1.2	0.4
Curve /ʾ/	32	3.6	1.5	2.5	0.9	3.0	1.0	2.0	1.7

*Data from 8 SV informants: SF1, SF4, SF5, SM1, SM3, SM4, SM5 and SM6. The syllables were /ta/ and /tak/ for sonorant-ending and stopped tones respectively.

For each tone, mean intensity values on first line, SD on second line.

TABLE 8

MEAN DURATION IN CENTISECONDS AND STANDARD DEVIATIONS OF NV, CV AND SV TONES ON SAME SYLLABLES*

Dialect & Tone	n	$\bar{D}$	SD	Dmax	Dmin**
NV Level /-/	36	25	6	36	12
Falling /\/	32	25	6	38	12
Rising /'/	32	25	5	38	14
St. Rising /'s/	32	15	3	22	10
Drop /./	32	20	4	30	14
St. Drop /.s/	32	15	3	22	8
Curve /ʾ/	32	26	6	40	16
Broken /~/	32	25	4	32	14
CV Level /-/	32	26	5	40	16
Falling /\/	32	28	5	40	16
Rising /'/	32	26	5	40	18
St. Rising /'s/	32	16	3	26	10
Drop /./	32	28	7	50	18
St. Drop /.s/	32	17	3	26	10
Curve /ʾ/	32	24	5	40	15
SV Level /-/	32	30	8	50	16
Falling /\/	32	29	6	44	18
Rising /'/	32	28	6	40	15
St. Rising /'s/	32	18	4	28	12
Drop /./	32	28	5	40	18
St. Drop /.s/	32	17	4	24	10
Curve /ʾ/	32	30	6	42	20

*Data from same syllables and same informants as for intensity data in Tables 5 to 7.

**Dmax and Dmin are the longest and shortest tokens found in each tone sample.

TABLE 9

LARYNGEALISATION IN NV, CV AND SV TONES*

Dialect and Tone	Degree (a)	Duration (b)	Timing (c)
NV Level /-/. Rising /ʹ/, St. Rising /ʹs/ and St. Drop /.s/	0		
Falling /ˋ/	0 (1)	(i)	(E)
Drop /./	2 (3)	4.5	E
Curve /ʾ/	0 (1)	(i)	(M,E)
Broken /˜/	2 (3)	3.7	M
CV Level /-/, Falling /ˋ/, St. Rising /ʹs/ and St. Drop /.s/	0		
Rising /ʹ/	0 (1)	(i)	(M)
Drop /./	0 (1,2)	(i)	(E)
Curve /ʾ/	2 (1)	4.6	E
SV Level /-/, Rising /ʹ/, St. Rising /ʹs/ and St. Drop /.s/	0		
Falling /ˋ/	0 (1)	(i)	(E)
Drop /./	0 (1,2)	(i)	(E)
Curve /ʾ/	0 (1)	(i)	(M)

*Based on auditory and acoustic studies on same syllables and same informants as for intensity data in Tables 5 to 7.

(a) 0:regular voicing; 1:breathy voice; 2:creaky voice; 3:glottal closure. () indicates alternative occurrences with some speakers and in some contexts only.

(b) Number indicates mean duration of laryngealised part in centiseconds; (i) indicates irregular durations.

(c) Laryngealisation may occur at the middle (M) or end (E) of the syllable.

4. DISCUSSION

4.1. *PHYSICAL PHONETIC PARAMETERS IN NORMALISED VALUES*

To understand and evaluate the common characteristics of Vietnamese tones and their variations across dialects, it is necessary to make the data comparable by using the same sets of parameters in describing them. However, the absolute and mean values given for those parameters as the results of direct measurements do not always make meaningful generalisations possible, because of the wide range of variations in non-linguistic parameters such as different Fo ranges between male and female speakers, differences in speech tempo or the power of their voices, etc. Therefore some normalisation procedures are proposed below to bring the data presented in 3. into directly conparable forms.

For comparison of Fo data, I devised a method of normalisation involving the notion of Fo Differential in function of the mean $\bar{F}$, or FD($\bar{F}$), expressed in percent in the following formula:

$$FD(\bar{F}) = Itg\ (\frac{Fi - \bar{F}}{\bar{F}} \times 100)$$

where Fi is any individual Fo value, $\bar{F}$ is the mean Fo of a sample, used as a reference level, and Itg stands for integer, i.e. the FD will be expressed in integer digits, any decimals being automatically dropped off.

The intensity and duration data were normalised according to two similar formulae:

$$I = Itg\ (\frac{Ii \times 10}{\bar{I}max} + 0.9)$$

$$D = Itg\ \ \frac{Di \times 10}{\bar{D}max} + 0.9)$$

where Ii and Di are any individual intensity and duration values to be normalised,

$\bar{I}$max and $\bar{D}$ max are the highest mean values of I and D in the samples in question, and 0.9 is a correcting factor.

These formulae will give normalised values for I and D in decimal scales where only integers are retained.

The application of the foregoing formulae gives results in Table 10 and is illustrated in Figures 1, 2 and 3. Table 10 gives the normalised values for the physical phonetic parameters of NV, CV and SV tones in their standard forms. Figure 1 gives diagrams of these tones in actual mean Fo plotted against mean duration, for comparison with Figure 2 where Fo in FD($\bar{F}$) percent of the same tones were plotted against normalised duration, and Figure 3 presents normalised intensity plotted against normalised duration.

TABLE 10

PHYSICAL PHONETIC PARAMETERS (Fo, L, I & D IN NORMALISED VALUES) OF NV, CV AND SV TONES*

Dialect & Tone	Fo in FD($\overline{F}$) Percent						Laryng.**			Intensity				Duration
	P1	P2	P3	P4	P5	P6	a	b	c	I1	I2	I3	I4	
NV /-/	9	9	9	8	7	4	0			10	9	8	3	10
/`/	-7	-9	-10	-15	-17	-19	0			8	7	5	2	10
/'/	2	0	2	12	27	33	0			8	7	8	3	10
/'s/	14	20	29	38			0			8	7	7	3	6
/./	-2	-3	-6	-14	-16	-15	2	2	E	7	6	4	2	8
/.s/	-5	-9	-13	-17			0			7	7	5	2	6
/’/	-8	-11	-18	-26	-19	-13	0			7	5	4	2	10
/~/	4	1	-12	9	26	26	2	2	M	8	4	7	2	10
CV /-/	12	10	12	14	14	13	0			10	9	7	4	10
/`/	6	4	1	-1	-3	-4	0			10	8	5	3	10
/'/	-3	-6	-8	-1	7	10	0			7	6	6	3	10
/'s/	0	-3	1	9			0			7	6	6	2	6
/./	0	-3	-6	-9	-9	-9	0			8	6	4	2	10
/.s/	3	-1	-5	-8			0			8	7	5	2	6
/’/	1	0	-4	-9	-6	-4	2	2	E	9	7	4	2	9
SV /-/	4	4	4	4	3	1	0			9	10	7	4	10
/`/	-9	-12	-14	-17	-18	-18	0			6	7	5	2	10
/'/	6	4	9	22	36	39	0			8	9	8	5	10
/'s/	9	13	24	39			0			8	10	9	5	6
/./	-9	-14	-19	-18	-11	-9	0			6	5	4	2	10
/.s/	-7	-13	-15	-12			0			7	7	5	2	6
/’/	-5	-12	-18	-4	19	22	0			7	5	6	4	10

*Calculated from data in Tables 2 to 9.

**In the Laryngealisation parameter,

(a) indicates degree,

(b) duration (same scale as for whole tone), and

(c) timing.

Intensity and duration values are in decimal scales.

4.2. *COMMON CHARACTERISTICS AND DIFFERENCES*

A number of observations can be made about the similarities and differences between NV, CV and SV tones from the data thus processed.

First, one can see that across dialects, all but one of the tones have basically similar Fo contours (level, falling, rising or concave), while varying in relative Fo level (high, mid or low) and in the presence or absence of laryngealisation, and the remaining one, the drop tone, displays difference in Fo contour in one dialect only, namely SV, as laryngealisation marks the contrast between the other two dialects. This suggests the primacy of Fo contour over other parameters as a major feature for differentiating tones in the Vietnamese system, and this fact is borne out in the analysis of tone perception by native speakers, as I reported elsewhere (1979, 1981). Together with the fact that Vietnamese has only one level tone out of the seven or eight phonetic tones in each dialect, Vietnamese can be typologically classified as a "contour tone language with register overlap" as defined by Pike (1948). This is further supported by analysis of subdialectal and individual variations, which showed that Fo contour is mainly characterised by the general direction of the Fo change, while great differences could occur in Fo slopes and Fo ranges. For example, the mean Fo differential between onset and endpoint of the NV rising tone is only 18% with Informant NM6 and as great as 53% with Informant NM1. It is also interesting to note that beside the expected difference in Fo ranges between male and female speakers, the use of Fo ranges differs markedly between CV and the other two dialects (see Figures 1 and 2).

Second, intensity shows no great differences between dialects, and correlation coefficients calculated for Fo and intensity values at the same timepoints indicate a fair degree of correlation. Duration is not significantly different between sonorant-ending tones, except for the creaky-ending NV drop tone and CV curve tone, which are significantly shorter by 20% and 10% respectively, and for the stopped tones where duration is 40% shorter in all three dialects. I take this to mean that duration is not an independent factor in tone production but is conditioned by the presence of laryngealisation or the voiceless final stop at syllable endings, which cause the shortening. Both intensity and duration may thus be characterised as independent parameters at the physical phonetic level only, and would become redundant at higher levels of analysis.

FIGURE 1

Mean Fo of NV, CV and SV Tones Plotted Against Mean Duration
(Data from 9 NV, 12 CV and 9 SV Informants)

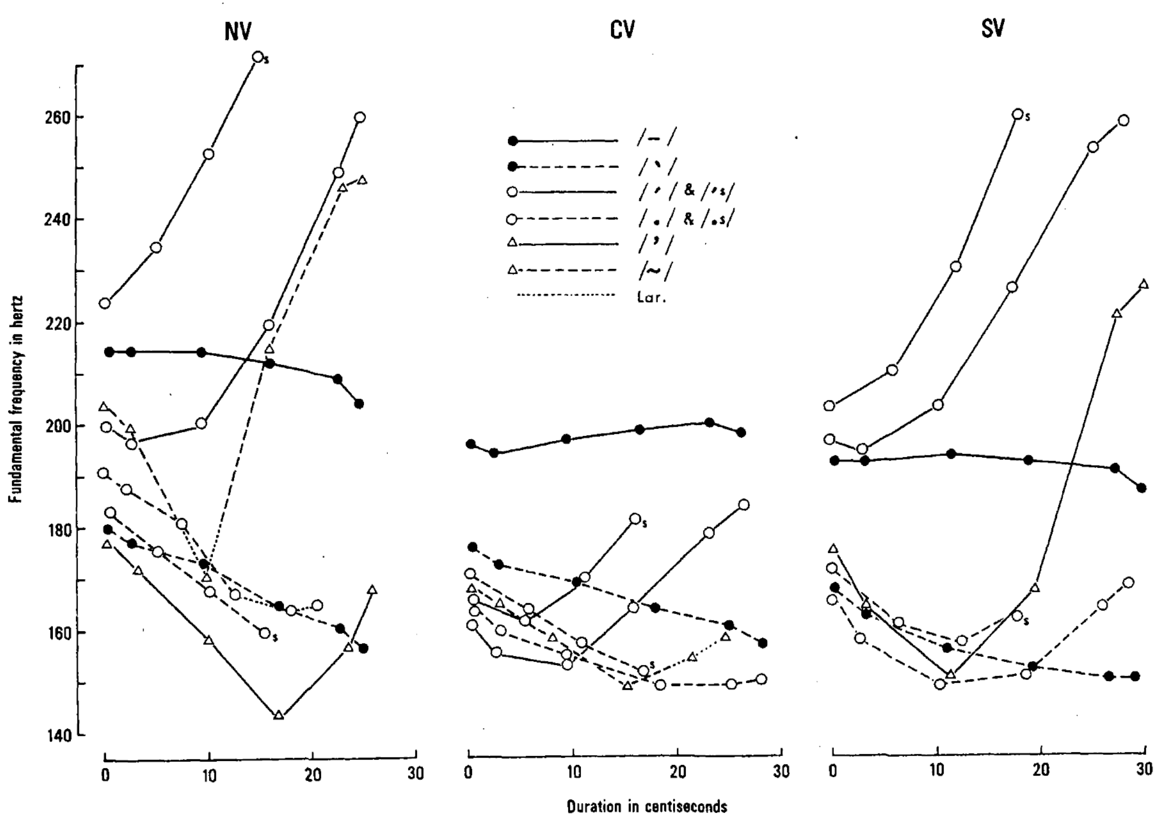


FIGURE 2

Normalised Mean Fo in FD($\overline{F}$) Percent of NV, CV and SV Tones Plotted Against Normalised Duration

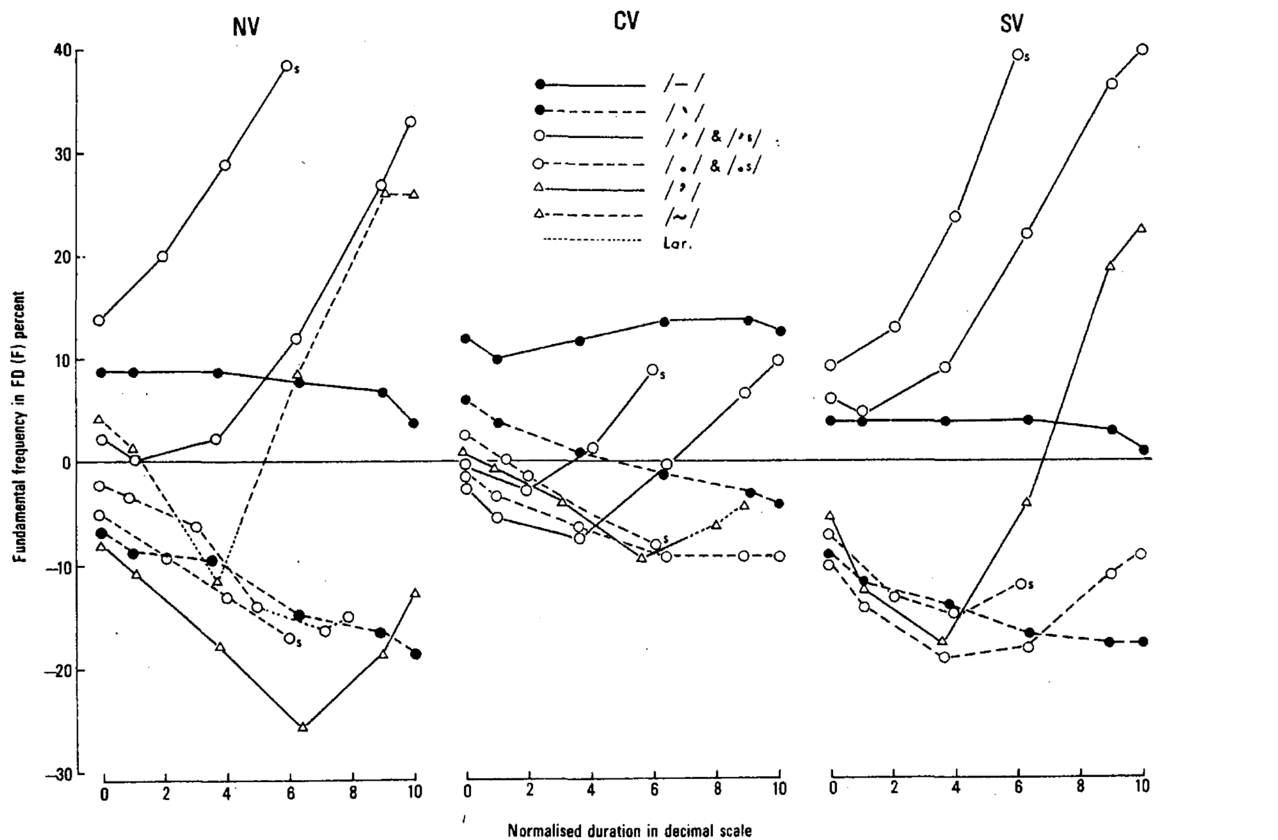
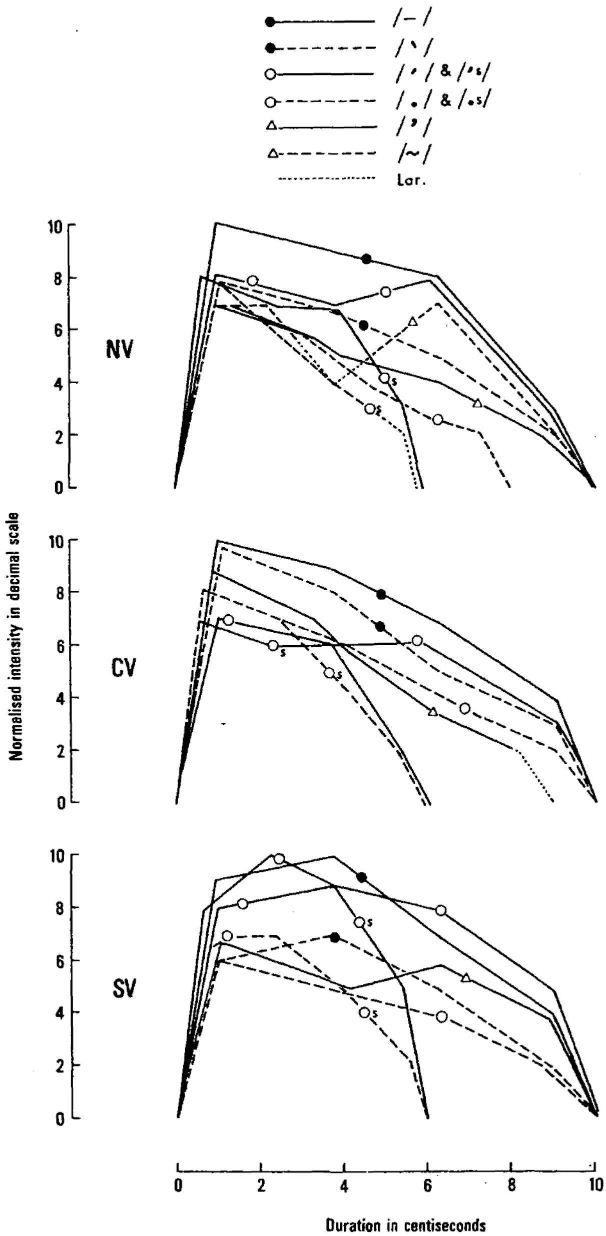


FIGURE 3

Normalised Mean Intensity of NV, CV and SV Tones Plotted Against Normalised Duration (Data from Table 10)



Third, laryngealisation or creaky voice, a characteristic of the NV drop tone and broken tone, and of the CV curve tone, is not a regular feature of any SV tone. While breathy voice and glottal closure may occur with some tones in all three dialects, they are not a regular characteristic of any, and can best be regarded as alternatives in free variation for some standard forms. It is interesting to note that what is auditorily perceived as creaky voice may be realised differently in acoustic terms. For example, three NV informants display marked differences in the broken tone: NF3: heavy laryngealisation, sharp drop in Fo and in intensity at middle; NM3: no laryngealisation, sharp drop in Fo and slight drop in intensity at middle; and NM4: no laryngealisation, no sharp drop in Fo but only sharp drop in intensity at middle. For Informant NM4 it appears that the Fo curves of the rising and broken tones are similar; only the intensity contours differ sharply.

This fact is of potential relevance for both the historical evolution and the physiological production of tone in Vietnamese: it might explain how creaky voice developed in different tones in NV and CV, and why creaky voice and glottal closure occur alternatively in some tones. This was the point I made earlier (1980) and discussed in more detail in my thesis (1981).

5. CONCLUSION

The results of my investigations into the physical phonetic properties of Vietnamese tones in the three major dialects have shown that NV, CV and SV tones display both similarities and differences and can be characterised by four parameters: Fo, intensity, duration and laryngealisation.

Fo contours appear to be the most important factor that unites the same phonological tones in the three dialects, below the surface differences which concern mainly relative Fo level, and presence or absence of laryngealisation in some tones. This suggests that Vietnamese can be classified as a "contour tone language with register overlap" (Pike 1948).

Intensity and duration are found to be phonetic parameters characterising some tones but not independently; they are probably conditioned respectively by Fo and segmental environment or laryngealisation.

Apart from breathy voice and glottal closure which occur irregularly as free variations, laryngealisation or creaky voice is a distinctive feature of some NV and CV tones. Its auditory quality may be the effect of different acoustic realisations and this fact might have implications for historical tone evolution in Vietnamese.

NOTES

1. This is an abridged version of a chapter from my thesis on Vietnamese tones. I am gratefully indebted to my successive supervisors, Dr David Bradley (now at the University of Melbourne), Dr Tim Shopen and Mr Phil Rose, of the Department of Linguistics, The Faculties, Australian National University, for their valuable advice in my research.

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