THE REALISATION OF STOPPED-SYLLABLE TONES IN HUA SAI AND PAKPHANANG

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ABSTRACT - This paper examines the relationship between the acoustics of stopped and unstopped tones in two Southern Thai dialects with a high number of contour tone contrasts. It is shown that the realisation of stopped tones does not conform to a simple 'truncation' model.

INTRODUCTION

Most of the varieties of the three major tone languages of East and South East Asia -- Thai, Vietnamese and Chinese -- show apparent allotony conditioned by the phonological structure of the Rhyme. Most varieties show conditioning by specifically the absence or presence of a stop in the Coda. Some (e.g. varieties of Cantonese and Thai) also show conditioning by the length of the nuclear vowel. Stopped tones have not received much attention, beause the usually more compex unstopped tone system is considered more interesting and basic. This paper looks at the relationship between the stopped and unstopped syllable tones in two closely related varieties of Southern Thai: Hua Sai and Pakphanang. Pakphanang (PPN) is an old settlement dating from the 16th century. It is situated south of the Isthmus of Kra, about 25 kilometers E.S.E. of the provincial town of Nakon Sithammarat. Hua Sai (HS) is a medium sized town some 65 kilometers south of PPN. Both varieties are notable for having the large number of seven contrasting tones, and are thus members of the small number -- 15% -- of the world's tone languages with more than six tones.

As in most varieties of Tai, the number of surface tonal contrasts on citation monosyllables in PPN/HS depends on the structure of the Rhyme - specifically the absence or presence of a syllable-final stop (p, t, k) in the Coda. In addition to the seven-way contrast on unstopped syllables with phonologically at least two sonorants in the Rhyme, PPN/HS contrasts three tones on stopped syllables. The unstopped tones, which are fairly complicated, will be dealt with first.

UNSTOPPED TONES

The auditory characteristics of the seven PPN/HS unstopped citation tones are as follows. These are based on my transcriptions of recorded utterances of one female PPN speaker, and one male HS speaker. Both speakers have generally very similar pitch shapes. Differences are noted below. In the absence of data from many speakers of both varieties, it is not possible to say whether these differences reflect dialectal variation between HS and PPN, or individual variation, or both.

Tone 1 has convex pitch very high in the speaker's pitch range. In PPN the falling portion is a little more salient than the rising - $khaa^1$ *leg*. The voice quality is often falsetto, which is possibly a consequence of the very high pitch target. Tone 2 has level (PPN) or slightly falling (HS) pitch in the upper-mid pitch range - $khaa^2$ *kill*. Tone 3 has rising pitch in the lower half of the pitch range - kaa^3 *crow*. In an earlier recording of the same PPN speaker, this tone had a low convex pitch, which suggests that the falling part is optional in PPN, and may also be in HS. Tone 4 has level (PPN) or slightly falling (HS) pitch in mid pitch range - kaa^4 *mark*. Tone 5 has a relatively short level component in mid pitch range followed by a fall - $khaa^5$ *thatch grass*. Tone 6 has a fairly low dipping pitch rising just into the mid pitch range - $khaa^6$ *value*. Tone 7 in PPN has falling pitch in the low pitch range, and sounds longer than the other tones - $khaa^7$ *trade*. The corresponding HS tone differs slightly. It is low falling, but has the same contour as the high falling tone 5, with an initial level component.

A resonable characterisation of the PPN/HS unstopped tonal system described above would be that it comprises four distinctive pitch contours - rising, level, falling and concave - the first three of which each have a contrasting higher and lower value.

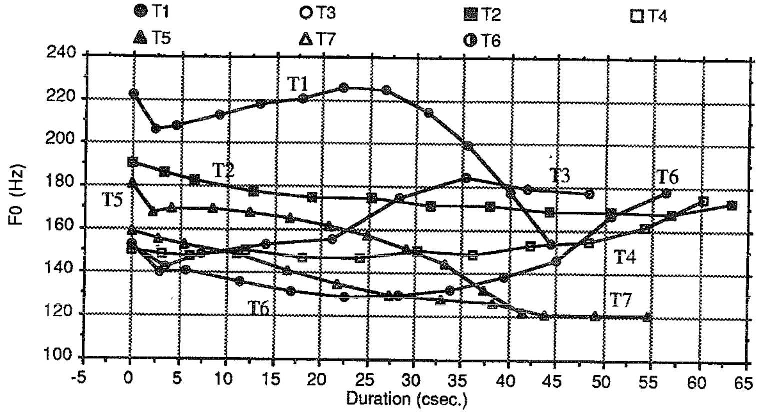

Figure 1a. Mean F0 shapes for PPN unstopped tones

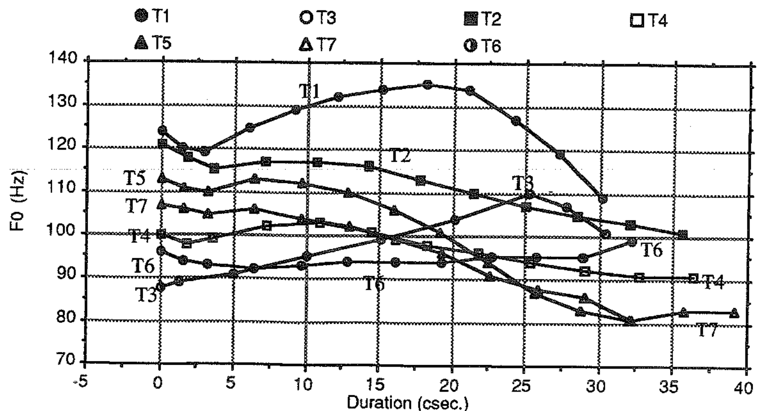

Figure 1b. Mean F0 shapes for HS unstopped tones

PPN/HS tones 1 and 3, and 2 and 4 are in complementary distribution with respect to syllable-initial obstruents: tones 1 and 2 co-occur with voiceless aspirated stops and fricatives, and tones 3 and 4 with voiceless unaspirated stops. There are, however, minimal and sub-minimal pairs on syllables with the initial palatal glide y- to demonstrate a tonemic contrast between tones 1 and 3, and 2 and 4.

Figure 1 shows raw mean F0 shapes for the unstopped PPN and HS tones plotted as a function of absolute duration. These plots are based on recordings made by Dr. Tony Diller in 1989 in Songklaa in southern Thailand. The two speakers -- a 54 year old female PPN peaker, and an old male HS speaker -- were recorded at the same sitting. The corpus consisted of unstopped tones with CVV structure, and stopped tones with CV(V)C structure, where V was /a/. Initial C for both stopped and unstopped tones was a grave /kh, k or p/. Final C was /p t or k/. n was 6 in each case for HS, and generally less (3) for PPN. The PPN corpus also included an additional 2 unstopped T1 and 1 T2 tokens with -au. Rose (1994, & forthcoming) contain a detailed acoustic description of the PPN female speaker's unstopped tones on -aa and -uu syllables from another recording made eight years previously.

Table 1. Means and standard deviations (X, sd) for F0 (Hz) and duration (D, csec.) in 7 unstopped and 4 stopped Hua Sai tones (male speaker). SP = sampling point. DP = duration to F0 peak.

UNSTOPPED TONES n=6

	T1		T2		T4		T6		T7		T5			T3	
SP %	X	sd	X	sd	X	sd	X	sd	X	sd	X	sd	SP	X	sd
0	124	6	121	6	100	6	96	3	107	5	113	2	0	88	4
5	120	8	118	4	98	4	94	3	106	3	111	3	5	89	4
10	119	6	115	3	99	5	93	3	105	4	110	4	20	91	5
20	125	5	117	4	102	6	92	4	106	5	113	4	40	95	5
30	129	4	117	3	103	6	93	3	104	4	112	5	60	99	6
40	132	4	116	2	101	7	94	3	102	3	110	4	80	104	5
50	134	3	113	2	98	8	94	3	99	3	106	5	peak	110	5
60	135	4	110	1	96	7	94	3	96	3	101	5	DP	25.2	2.6
70	134	4	107	2	94	6	95	3	91	3	94	4	50	107	5
80	127	3	105	2	92	8	95	3	88	2	87	5	100	101	5
90	119	3	103	3	91	6	95	4	86	2	83	4	D	30.4	2.0
100	109	4	101	5	91	6	99	3	81	6	81	3			
D	30.2	2.5	35.6	1.4	36.3	2.9	32.1	5.9	32.2	0.8	32.0	3.1			

STOPPED TONES n=6

	T1		T2		T4		T6		T7		T3	
SP %	X	sd	X	sd	X	sd	X	sd	X	sd	X	sd
0	130	8	126	3	97	7	90	5	102	6	103	7
10	-	-	120	5	98	7	88	4	-	-	-	-
20	124	8	123	7	100	5	89	3	98	5	101	5
40	127	9	123	9	101	5	92	5	97	5	102	5
60	131	10	117	8	102	6	94	5	96	5	106	5
80	133	12	111	7	100	7	94	6	93	5	108	6
90	-	-	-	-	-	-	95	5	-	-	-	-
100	132	10	106	9	97	7	98	6	89	6	110	7
D	10.1	0.7	21.8	0.7	23.4	1.7	21.6	1.7	11.2	0.7	10.6	0.8

Measurement of F0 and duration was essentially the same as described in Rose (1994). The duration of the Rhyme (unstopped syllables) and Nucleus (stopped syllables) was first determined from wide band spectrograms with their good time-domain resolution. F0 was then sampled at percentage points of this duration from aligned expanded narrow band spectrograms. A sampling frequency was used high enough to resolve the details of the F0 time course. Slightly diffferent duration bases were used for tones 3 and 6. The mean values plotted in figure 1 are given, together with standard deviations, in tables 1 and 2. In table 1 it can be seen for example that the mean duration of HS tone1 was 30.2 csec., and that at 60% of duration (csec. 18.1), the mean F0 was 135 Hz, with 4 Hz standard deviation.

The raw mean F0 curves of the unstopped tones in figure 1 show typical between-sex differences conditioned presumably by sexual dimorphism in cord mass and length. There are large differences in absolute range. The female range of 105 Hz is almost twice that of the male (55 Hz). The HS configuration also lies amost totally lower than the PPN: the ranges (80 - 135 Hz male, 120 - 225 Hz, female) barely overlap. Another, probably not sex-linked difference is in duration, with the male tones having about two-thirds the duration of the female tones. Despite these differences, both configurations are conspicuous for a shared skewness in tonal F0 distribution, with all except the the high convex tone 1 squashed into the lower part of the speakers' F0 range. In the female speaker it is the lower half of the range, from 120 Hz to ca. 180 Hz; in the male the lower two-thirds, from 80 Hz to ca.115 Hz, which contains most of the tones.

STOPPED TONES

On syllables with final stops, PPN/HS contrasts three tones. The pitch of these tones is dependent on nuclear complexity. In syllables with long vowels, i.e. with two V's in the CV skeleton, the values of the three-way contrast are as follows. Level pitch in the upper-mid pitch range - khaat^{2} *to tear*, level pitch in the mid pitch range - kaat^{4} *mustard* ; and level, then slightly rising pitch in low pitch range - khaat^{6} *to guess*. In syllables with one V, the values of the three-way contrast are: short rising pitch high in the speaker's pitch range - khat^{1} *to polish*; short level (PPN) or rising (HS) pitch in mid pitch range - kat[3] *to bite* ; short level or falling pitch in low pitch range - khat[7] *to select*.

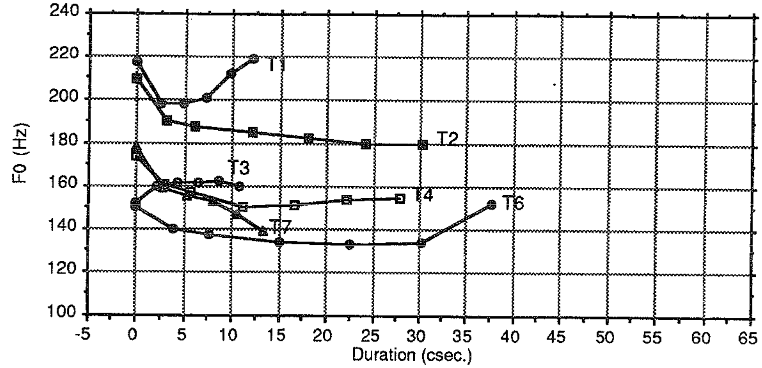

Figure 2a. Mean F0 shapes on PPN stopped tones (T1, 3, 7 -VC; T2, 4, 6 -VVC)

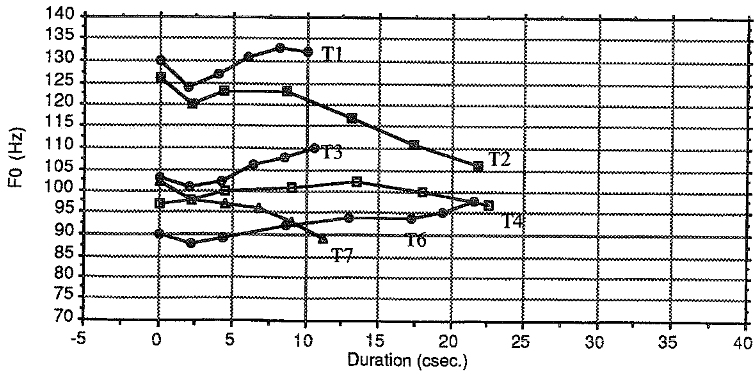

Figure 2b. Mean F0 shapes on HS stopped tones (T1, 3, 7 -VC, T2, 4, 6 -VVC)

On the basis of similarity in pitch height and contour, it is clear that the three long stopped tones are allotones of tones /2, 4 and 6/. On the basis of plausibility of allotonic conditioning by vowel length, at least in two out of three cases, the three short stopped tones can likewise be identified as allotones of tones /1, 3 and 7/, since their pitch is phonetically similar to that on the initial part of the long unstopped tones. Note that this analysis is strengthened by the same complementary distribution between tone and aspiration of the syllable-initial consonant as in the unstopped tones (exemplified in the stopped tone examples above). From a structuralist perspective, then, PPN/HS has seven tonemes. All except /5/ can occur on both stopped and unstopped syllables. In stopped syllables, long vowels are in complementary distribution with short vowels, conditioned by the toneme. In stopped syllables, tonemes /1 3 and 7/ have Rhymes with short vowels, and tonemes /2 4 and 6/ have Rhymes with long vowels. For each of the tonemes except /5/ the pitch shape occurring on stopped syllables represents a presumably intrinsic allotone plausibly conditioned by the duration of the nucleus. This allows identification of the toneme involved.

Tables 1 and 2 also contain the means and standard deviations for F0 and duration of the PPN/HS stopped tones. It should be remembered that the duration values given are not of the Rhyme, as in the unstopped tones, but of the nucleus (V, VV) only. The duration of the final stop could not be measured since it is unreleased, and the citation forms were not elicited with any following material.

Table 2. Means and standard deviations (X, sd) for F0 (Hz) and duration (D, csec.) in 7 unstopped and 4 stopped Pakphanang tones (female speaker). SP = sampling point. DP = duration to F0 peak.

UNSTOPPED TONES n = 7 (T1), 5 (T2), otherwise 3															
	T1		T2		T4		T6		T7		T5			T3	
SP %	X	sd	X	sd	X	sd	X	sd	X	sd	X	sd	SP	X	sd
0	223	15	190	19	150	6	153	5	159	3	181	10	0	152	2
5	206	11	186	6	149	5	140	6	156	11	168	4	10	143	5
10	208	9	183	4	148	4	141	2	153	13	170	4	20	149	8
20	213	7	177	8	150	2	136	3	149	13	170	3	40	153	11
30	218	7	175	11	147	5	131	5	141	15	168	4	60	156	16
40	221	9	175	11	147	2	129	8	135	14	165	4	80	175	10
50	226	12	171	11	150	4	130	11	130	14	162	6	peak	184	10
60	225	8	171	12	149	3	132	12	128	13	157	6	DP	35.3	4.1
70	215	10	169	12	153	11	138	13	126	13	151	3	50	179	12
80	199	21	169	11	155	11	146	16	121	12	144	3	100	177	23
90	177	20	168	8	162	11	167	10	121	13	132	6	D	48.3	7.5
100	154	8	173	12	175	14	178	8	121	13	122	6			
D	44.4	4.0	63.2	3.9	60.2	3.0	56.3	3.4	54.6	2.6	41.3	1.9			

STOPPED TONES n = 4 (T5,7), otherwise 3												
	T1		T2		T4		T6		T7		T3	
SP %	X	sd	X	sd	X	sd	X	sd	X	sd	X	sd
0	217	14	210	4	174	18	150	12	178	17	152	14
10			190	12	161	25	140	6				
20	198	10	188	12	157	8	137	7	159	9	160	15
40	198	10	185	10	150	3	134	7	156	10	162	16
60	201	14	183	9	151	5	133	6	153	7	162	14
80	212	11	180	8	154	6	134	5	147	5	163	14
100	219	14	180	7	155	4	152	8	139	2	160	16
D	12.1	0.2	30.2	0.7	27.8	1.9	37.6	2.4	13.2	2.8	10.7	0.3

Figure 2 shows the mean F0 of the stopped tones of the two speakers plotted as a function of absolute duration, as in figure 1. In figure 2, the short stopped tones show three distinct high (T1) mid (T3) and low (T7) F0 shapes of about the same duration. The shapes for tones 3 and 7 appear to share the same origin, with T1 located higher. If onset perturbations are discounted, the high shape (T1) is rising, the lowest (T7) is falling, and the middle (T3) differs between the two speakers: level (PPN) and rising (HS). There are greater differences between HS and PPN in the F0 shapes of the long stopped tones 2, 4 and 6. Both varieties have three distinct upper (T2) middle (T4) and lower (T6) shapes. In PPN, the upper two are level, and the lower is level, with a slight rise at the end. In HS, although the upper two, like PPN, are roughly parallel, their shape is mildly convex. Unlike PPN, the shape of HS tone 6 rises gradually, but, like PPN, it shows an increase in rate of rise at the end. In both varieties, tones 6 and 4 have effectively the same offset value.

RELATIONSHIP BETWEEN STOPPED AND UNSTOPPED TONES.

The relationship between the acoustics of the stopped and unstopped tones is interesting, for two reasons. Firstly, it is of interest to see to what extent the phonetics are consistent with the structural tonemic analysis above which claims allotony between long stopped tones and unstopped tones 2, 4, and 6, and between short stopped tones and unstopped tones 1, 3, and 7. Secondly, the phonetic realisation of the stopped tones is of interest in the light of a theoretical claim by Hombert et al. (1979, 49) that a tonal contour can be truncated by a postvocalic voiceless consonant. In their model (ibid. fig. B) the truncated portion is realised congruently with the first portion of the contour representing the 'underlying' tonal contour, or the tonal contour before a voiced sonorant. However, there are other realisational possibilities. The F0 contour found in unstopped syllables could, for example, be time-warped so as to be distributed over the shorter duration of the tone-bearing segment(s). This question can only be examined where dynamic unstopped tones are involved, which, fortunately, applies to most of the cases in PPN/HS. For reasons of space, discussion will focus here on the PPN tones, because they are somewhat less complex.

Both allotones of the low dipping tone /6/ have clearly congruent F0 contours over the first 30 csec. of duration. After this point, however, the F0 of the stopped tone diverges upwards from that of the unstopped tone, but does not rise as high as the peak value in the unstopped tone. The rise in F0 on the stopped tone is likely to be extrinsic, and not a function of the following consonant, for the following reasons. Firstly, no F0 perturbation is noted for the other two long stopped tones, which do clearly involve an unambiguously level target. Secondly, although small relative to the speaker's overall F0 range, the 20 Hz rise in F0 before closure presumably signals the pitch rise audible on this allotone. Hence it must be supposed that the F0 rise is part of the tone target on the stopped syllable. (It is also possible that the small F0 rise is perceived as a proportionately greater pitch rise because of the intrinsic truncatory effect of the following consonant). It is the case, therefore, that neither the time-warp model nor the truncation model is appropriate on its own for describing the relationship between the F0 shapes on these tone /6/ allotones. The tone on the stopped syllable is clearly not truncated in the Hombert et al. sense; nor yet is it fully realised: it does not reach the same peak value as in the unstopped tone. However, because of the rise on the stopped allotone, both allotones must be understood as aiming for the same tonal target (whether this is conceived of as a sequence of LH tones, or a low dipping contour). The fact that the same peak target is not reached in the stopped tone is presumably due to the final stop.

As far as the short stopped tones are concerned, the acoustics are consistent with allotony contracted between the high, mid and low short stopped tones on the one hand and the unstopped tones /1 3 and 7/, as posited above. This is indicated by the high degree of similarity between the F0 shapes of the high and low short stopped tones and the contours of the initial part of the corresponding unstopped allotones 1 and 7. Assignment of these short stopped shapes to unstopped tones /2 and 6/ is also effectively precluded on statistical grounds: t tests show them to be significantly different. Note, however, the assignment of the middle short stopped tone is not clear from its F0 alone. The F0 of this tone lies about 12 Hz non-significantly higher than the F0 of both unstopped tones 4 and 3, and on the basis of its essentially level shape, too, it could be allotonically related to either tone /4/ or tone /3/. This appears to be a case, then, where the phonetics are ambiguous as to phonology, and analysis rests on considerations of patterning of the unambiguous relations between unstopped and stopped tones. Since each unstopped tone (except tone 5 whch doesn't have a stopped counterpart) patterns with one stopped tone only, the mid short tone must be assigned to the low convex tone /3/, since tone /4/ already has a (long) stopped allotone.

The vowels on the short stopped tones have between 20% and 30% of the duration of the corresponding unstopped tones. The clear general similarity in contour between the short stopped and unstopped tones during this period had been noted. There is evidence, however, as with the stopped tone /6/ allotone just discussed, that the F0 contours on the high and low short stopped tones are not simply truncated versions of the unstopped tones, but embody realisations of tonal targets. This is most clear on the high short tone, where the F0 parallels that on unstopped tone 1 for about the first 7 centiseconds, but then rises abruptly at a much higher rate. Not quite so salient, but consistent with the targeting of a low tonal value, is the fall at the the end of the F0 on the low stopped tone, which again is at a greater rate than the corresponding unstopped tone 7. It seems that, were these tones to have a simply truncated realisation, their duration would be insufficiently long to achieve an F0 glide perceptially salient enough to be perceived as a rise/fall in pitch. Hence the greater F0 derivative than unstopped tones. It is clear, however, that the high short stopped tone aims at a rising pitch target, which can be equated with the pitch target of the first (rising) branch of tone 1, and the low short stopped tone aims at the same low falling pitch target as unstopped low falling tone 7. The case of the short stopped mid tone 3 is not analogous, at least in PPN, since its F0 does not rise like that of its unstopped counterpart tone 3. Presumably it realises a non-dynamic low target -- the same target as unstopped tone 3's onset.

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