A Preliminary Phonological Analysis of Huay Jo Khmu

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1. Introduction

This research was carried out under the sponsorship and support of the Payap Research and Development Institute of Payap University, Chiang Mai, Thailand. This is an abridged version of that research. A full version of this paper (including an appended wordlist) was previously published in PYU Working Papers in Linguistics, vol. 3, 1999, produced by the Graduate Linguistics Department of Payap University.

The research was conducted in the village of Huay Jo in the Wiang Kaen district of Chiang Rai province, northern Thailand. The dialect spoken in Huay Jo is very similar to the dialect referred to as "Kroong" ([krɔːŋ]), studied by Professor Suwilai Premsrirat of Mahidol University (1987, 1993).

This paper is limited to an analysis of the speech of a single person represented in a tape-recorded wordlist of 500 basic vocabulary items. This recording was later digitized using MacCECIL. MacCECIL was also used in acoustic analysis by comparing waveforms, pitch plots and sound spectrograms.

The native speaker who recorded the wordlist was Mrs. Khwiin Buncoeng, a 63-year-old woman. Her speech is particularly interesting, because she, along with her daughters and several other women of Huay Jo village, exhibit a falsetto voice quality in certain tense register syllables.

2. Words

The phonological word in Khmu Kroong is the domain of the minimal stress contour represented as follows:

$$PW = (S_r) + S_m$$

The phonological word (PW) consists of a main (fully stressed) syllable (S_m) optionally preceded by a reduced (weakly stressed) syllable (S_r). Thus, in general, phonological words are monosyllabic or "sesquisyllabic".

The phonological word (hereafter simply 'word') may be distinguished further as either tense or lax in phonation type. We represent tense phonation with an acute accent over the vowel of the main syllable (ú). A double acute accent (ű) marks tense forms that also exhibit falsetto voice quality. Lax phonation is represented by a grave accent (ù). Words of both types exhibit the same basic word structure as shown in these examples:

Tense:	**S_m** káp 'cut (hair)'	**$S_r + S_m$** pɨtéːʔ 'earth'
	S_m pűːt 'cloud'	**$S_r + S_m$** kɨműːl 'silver'
Lax:	**S_m** tàːŋ 'lizard'	**$S_r + S_m$** ləmtàːŋ 'eggplant'

As previously stated, in general, Khmu words are either monosyllabic or sesquisyllabic. However, there are some disyllabic words found in our data as well as three examples of words that appear to be trisyllabic words.

3. Syllables

3.1 Main Syllables

The structure of main syllables may be symbolized as:

$$S_m = (C)(C)V(C)$$

Initial consonants (C)(C) are optional and can be either a single simple consonant or a two-segment cluster. The syllable nucleus V can be a long vowel, a diphthong, or a short vowel. The optional final (-C) can only be a single consonant from a limited set. Each type of main syllable is exemplified below:

VC	ʔóm	'water'	(simple nucleus)
VC	ʔɯ́ːək	'drink'	(complex nucleus)
CV	nàː	'she'	
CCV	pʰɾɛ́ː	'cut grass'	
CVC	ɾɔ́ːt	'choke'	
CCVC	plɔ̀ːŋ	'rattan'	

The first element of an initial cluster can be /p/, /pʰ/, /t/, /c/, /k/, /kʰ/ and /s/. The second element of a cluster is either /l/ or /r/ (realized as a flap, [ɾ]). Table 1 shows all the clusters found in our data. Note that there are no clusters *tl, *cl or *sl.

pʰr			kʰr
pl			kl
pr	tr	cr	kr
	sr		

Table 1. Khmu Kroong consonant clusters

In some cases, the clusters /sr/ and /cr/ are ambiguous with a presyllable consisting of /s/ or /c/, followed by a main syllable with /r/ as an initial; there seems to be a transitional vowel between the initial and the /r/, as shown in the following (phonetic) examples:

tʃʰə̋ɾı̋ːl	'gold'
cçɨɾùːʔ	'deep'
tʃʰɨɾɛ́ːŋ	'gong'
tʃʰɨɾı̋ːh	'scrub'
tʃʰɨɾéːh	'sand'

The words for 'gold', 'sand' and 'deep' are found in Suksavang, Somseng, and Preisig (1994) with the clusters sr and cr respectively. Given this information and the fact that in our data there is no contrast between words with initial clusters and words with a single consonant presyllable preceding a liquid-initial main syllable, we conclude that the words above represent clusters phonemically.

3.2 Presyllables

The structure of presyllables may be represented in the following way:

$$S_r = \left\{ \begin{array}{c} \underset{\begin{bmatrix}+\text{nas}\\ +\text{syll}\end{bmatrix}}{C} \\ \\ \underset{[-\text{nas}]}{C} \quad v \left(\underset{[+\text{son}]}{C} \right) \end{array} \right\}$$

That is, the presyllable (S_r) consists of an obligatory consonant either nasal or non-nasal. If this consonant is a nasal, no other segments may be part of the presyllable and that nasal consonant is syllabic. If the obligatory consonant is not a nasal, a reduced vowel v is obligatorily epenthesized and there may be an optional sonorant final. Listed below are examples of the three presyllable types generated by our formula:

C	n̩tɯ̀p	'close'
Cv	ɾɨmɤ̀ːj	'ear'
CvC	pɨnsɯ̋m	'plant'

As shown by the formula, nasals never occur as initials in a closed presyllable, i.e. there are no forms such as the following: *nm, *ml, *ŋr etc. The following segments also do not occur as presyllable initials in the wordlist: /pʰ/, /kʰ/, /w/, and /j/. However, the aspirated stops are attested both by Suwilai (1993) and by data of our own apart from the wordlist. The approximants, on the other hand, appear to be disallowed as initials of presyllables.

Although other researchers (Suwilai 1993; Svantesson 1983:29) have found presyllables with stop finals, our data show only sonorants: /m/, /n/, /ŋ/, /l/, and /r/. See below for more discussion regarding the presyllable vowel.

4. Segments

4.1 Consonants

pʰ	tʰ		kʰ	
p	t	c	k	
(ʔm)	(ʔn)	(ʔj)		
m	n	ɲ	ŋ	
	r			
	s			h
	l			
w		j		

Table 2. Kroong initial consonants

p	t	c	k	ʔ
m	n	ɲ	ŋ	
	r			
				h
	l			
w		j̊ j		

Table 3. Kroong final consonants

As shown in Tables 2 and 3, there are no ordinary voiced stops in this variety of Khmu. However, there are sometimes audible differences between the initial stops of tense and lax syllables.

Also seen in these tables is the fact that the set of possible finals is more limited except for the inclusion of the two phonemes which only occur as finals, viz., /ʔ/ and /j̊/. These will be discussed in more detail below.

Unaspirated stops occur in all positions except as the coda of a presyllable (in our data). Aspirated stops on the other hand only occur syllable-initially and are relatively rare in our data with only two examples of /tʰ/, five examples of /kʰ/, nine of /pʰ/, and no palatal aspirated stops. Most forms with aspirate initials are loans from Tai languages (see Svantesson 1983:38).

Initial palatals, /c/ and /ɲ/ are palatalized (or affricated in the case of /c/): [cʲ] or [cç] and [ɲʲ].

Three other initials were found, which we have tentatively listed in Table 2: /ʔm/, /ʔn/, and /ʔj/. Below are all of the forms found in our data:

ʔméc	'indefinite'
ʔmáŋ	'bamboo tube for water'
ɗʌ̂:m	'look at'
ɗɯ́ŋ	'pull'
ʔjà:	'medicine'.

In the forms above, /ʔn/ is realized as [ɗ]. Similarly, data apart from the recorded wordlist shows that /ʔm/ can be phonetically realized as [ɓ] in free variation. Some researchers have included /ɓ/, /ɗ/, and /ʔj/ in their phonemic inventory, along with /ʔw/, which is not found in our wordlist (Svantesson 1983:13). Most words with glottalized initials are from Tai languages (Svantesson 1983:38), such as the latter two examples above.

Glottal stop is non-phonemic in initial position, where it occurs automatically before all vowel-initial syllables. However, it occurs contrastively in final position, as shown by the following forms:

pì:ʔ	'full, satisfied'	(cf. pì:h 'big')
ʔó:ʔ	'I'	(cf. ʔó:h 'sharp')
klɛ̀:ʔ	'husband'	(cf. klɛ̀:h 'chip off')
pà:ʔ	'all'	(cf. pà: '2nd sing. female')
kɔ́:ʔ	'wait'	(cf. kɔ́:k 'caterpillar')

In final position, stops are typically unreleased, although it is not uncommon to hear the palatal stop released with a bit of affrication.

Nasals occur initially in all syllables. As mentioned above, nasal initials in presyllables are syllabic. Such nasals are homorganic in place of articulation with the following stop (initial of main syllable), e.g. [m̩pó:ʔ] 'dream'.

All nasals are found in word-final position. In our data there are also examples of presyllables ending in each of the nasals except for the palatal nasal. Final nasals are often pronounced with slight homorganic prestopping, e.g. pű:^{d}n ‘lime’ (see additional examples below). This phenomenon is apparently due to a timing lag in opening the velum after the consonant is already articulated. Since Smalley also reported this occurring in Southern Khmu (1961:4), we conclude that this is not just an idiosyncrasy of Mrs. Khwiin’s speech. Perhaps not surprisingly, this prestopping phenomenon is more common when the syllable or word has a stop initial, and is infrequent with a nasal initial since the vowel is more likely to be at least slightly nasalized between two nasals segments. Below are some examples of these prestopped nasal finals:

ʔó^{b}m	‘water’
pi̋^{ɟ}ɲ	‘shoot’
klà:^{g}ŋ	‘stone’

There are only two fricatives, /s/ and /h/. /s/ only occurs syllable-initially, and may also occur in consonant clusters as in: /srú:ət/ (realized as [tʃ^{h}ɾú:ət]) ‘morning’. /s/ is manifested in three different ways phonetically: [s], [ʂ̥], and [tʃ^{h}], [ʂ̥] being the most common. There is free variation between all three allophones, although the aspirated affricate [tʃ^{h}] occurs most frequently preceding /r/. /h/ occurs in both syllable-initial and word-final positions, but not in consonant clusters.

There are two liquids: /r/ and /l/, which occur initially and finally in both syllable types. /r/ is realized as a flap, [ɾ], initially. As already mentioned, /r/ and /l/ also occur as the second element of a consonant cluster.

In word-final position, /r/ can be pronounced as [r], a trill, in free variation with [ɾl], flap followed by [l], when spoken in isolation. However, final /r/ is realized as [ɾ] when it is the coda of a presyllable or when followed by an utterance.

The two approximants /w/ and /j/ occur in initial position in main syllables; no instances of either occurring in presyllables were found. /j̊/ does not occur in initial position. Syllable-initially, /w/ is sometimes realized as [ʋ], a labiodental approximant.

All three approximates occur in word-final position. We analyze /j̊/ as a single phoneme rather than the sequence /jh/ because it patterns with unambiguous syllables where there are no instances of a final consonant sequence.

4.2 Vowels

4.2.1 Quality

The qualities of the vowels of Khmu Kroong of Huay Jo are relatively straightforward and are quite similar to those of Thai and other Southeast Asian languages. Those that we have written as unrounded back vowels tend to be a bit more central than fully back. The close-mid and open-mid vowels (/e/ and /o/, /ɛ/ and /ɔ/ respectively) are both slightly closer than the corresponding IPA Cardinal vowels. This is especially noticeable for the open-mid vowels as compared, say, with the open-mid vowels in Thai, which are significantly more open.

iː		ɯː	uː
eː		ɤː	oː
ɛː		(ʌː)	ɔː
	aː		
iːə		ɯːə	uːə

Table 4. Long vowels and diphthongs

i		ɯ	ụ
e			o
ɛ			
	a		

Table 5. Short vowels

Comparing Tables 4 and 5, we see that there are more long vowel phonemes than short. The absence of /ɔ/ and /ɤ/ is possibly due to insufficient data.

In Table 4 one vowel, (ʌː), is only tentatively listed. In our data there are only two instances: n̩tʌ́ːl 'shallow'; ɗʌ̂ːm 'look at'. Suwilai 1987:13 lists /ʌː/ as a phoneme, but says it is rather rare, as do Lindell, Svantesson, and Tayanin (1981:47).

The diphthongs all consist of high nuclear vowels which are relatively long followed by a schwa-like off-glide. In careful speech this offglide can be more open, approaching [ɐ]. Diphthongs only occur in main syllables. One form which seems to contain an aberrant type of diphthong is ɾìeh 'root'. In a seven-dialect vocabulary list, Lindell, Svantesson, and Tayanin (1981) cite 'root' as rias or riaç, derived from Proto-Khmu (PK) *rias. Other PK forms with *s final are realized as /j̊/ in Khmu Kroong, so it may be that phonologically this word is /riːəj̊/, thus eliminating a phonemic diphthong /ie/.

Phonetically, it is plausible that the palatality of /j̊/ could raise and front the [ə] to [e].

4.2.2 Length

Vowel length is contrastive in main syllables except among diphthongs, open syllables or syllables with final /ʔ/ or /h/. Long vowels occur in main syllables in all contexts. Short vowels occur in main syllables in all contexts except those just mentioned. Below are examples exhibiting the length contrast.

màr	'snake'	màːr	'salt'
múm	'little girl'	mùːm	'bathe'
tɯ̋r	'scatter'	tɯ́ːr	'fly'
wɛ̀r	'turn around'	wɛ̀ːl	'knife'
lóŋ	'forget'	róːŋ	'musical instrument'
pʰɨ̋t	'wrong'	pɨnpìːt	'extinguish (fire)'

Other researchers have analyzed syllables with the glottal finals /h/ and /ʔ/ as having underlyingly short vowels (Smalley 1961:5; Svantesson 1983:14; Suwilai 1987:17). It is true that there is no phonemic contrast in vowel length before these finals. However, measuring the lengths of vowels in long and short syllables of all types (open, sonorant-final, stop-final, tense and lax) indicates that the those before final /h/ and final /ʔ/ pattern with the long vowel forms rather than the short.

The vowel in long syllables of all types has an average length of about 350 msec while the average vowel length for all types of short syllables is about 100 msec. So, on the average, long vowels are at least three times as long as short vowels.

We find that vowel length in syllables with a final glottal stop clearly pattern with other stop-final syllables. The ranges are quite similar (230-370 msec for the stop-finals, 250-370 msec for ʔ-finals) and the overall average length of ʔ-final syllables (312 msec) is actually longer than that of the stop-finals (285 msec).

The average vowel lengths for h-final are not quite as long as other long-vowel syllables closed in a sonorant (267 msec for the former but 340 msec for the latter). However, the ranges show that even the shortest vowel in an h-final form (190 msec) is longer than the longest examples of short vowels (170 msec). In other words, there is no overlap between the length range of h-final forms (190-350 msec) with the length range of short vowels (80-170 msec) while there is a significant overlap with the length range of long vowels (230-560 msec).

One point to consider is that most of our data consists of citation forms, usually spoken in isolation. Suwilai observes that

"In isolation and at the final position a word containing a vowel and final /ʔ/ will be heard as a long vowel but in connected speech it is short" (1987:17). Instrumental measurement of vowel length in connected speech would be a topic for further research.

4.2.3 Presyllable Vowels

The presyllable vowel is not a full vowel, but a reduced vowel—reduced in vowel quality contrast and in length. In general it is realized as an extra short close central vowel, [ɨ̆], particularly when there is no presyllable final, where it only represents the transition between the presyllable initial and the main syllable initial. However, when there is any vowel quality in the presyllable that is distinguishable, it often reflects some vowel harmony with the vowel of the main stressed syllable of the word. This harmony may be manifested in one or more of the three standard parameters of vowel quality: height, front/backness and lip-rounding. Harmony in height seems to be the most common but harmony that includes lip-rounding and/or front/backness can also be seen. There are even instances when the presyllable vowel shows complete harmony with the vowel of the main syllable.

5. Prosodics

It is common in Mon-Khmer languages to find the contrastive prosodic phenomenon that Eugénie Henderson first referred to as "register" in her description of the pronunciation of contrastive syllables in Khmer (1952). This phenomenon is usually seen as a result of historical sound change.

Khmu is particularly interesting in this regard since there are coexisting dialects which manifest the proposed historical picture. That is, there are dialects of Khmu which have phonologically contrastive voiced and voiceless initial consonants and there are dialects of Khmu where the cognate sets of contrasting words contrast only in prosodic features.[1] In fact, it is commonly agreed that the highest order of subgrouping within Khmu is based on exactly this difference. The larger, "Southern" group of dialects maintain a series of voiced initials (see Smalley 1961) while the "Northern" group of dialects have voiceless initials corresponding to that series and manifest a two-way system of lexical prosodic contrast.

The Huay Jo dialect is clearly a Northern Khmu dialect as there are essentially no voiced initials (as discussed above) and numerous instances of minimal pairs of words different only in prosodic features. Lindell, Svantesson and Tayanin (1981) and

Svantesson (1983) conclude in their research of the Northern Khmu dialect, Yuan, that the contrastive prosodic system in that dialect is primarily a contrast in pitch: "...the fundamental frequency difference alone is a sufficient cue for differentiation between high and low tone words" (Svantesson 1983:15). In other words, they consider Yuan to be a true tonal language.

The prosodic features of the Huay Jo dialect include pitch but also involve voice quality features. We conclude, therefore, that this dialect is a 'register language' as opposed to being a purely tonal language. Suwilai (1987) presents a similar analysis and reports the same type of phenomena in the Khmu Kroong dialect she researched. We follow her and others in referring to the two contrasting series of this register system 'tense' and 'lax'. The data in our wordlist show 26 pairs of words that contrast only in register. Here are a few examples:

Tense		Lax	
kéc	'cut hair'	kèc	'sow rice'
kɔ́:k	'caterpillar'	kɔ̀:k	'carry over shoulder'
cɯ́:əŋ	'Khmu hero'	cɯ̀:əŋ	'foot'
plɔ́:ŋ	'calf'	plɔ̀:ŋ	'rattan'
lóŋ	'forget'	lòŋ	'branch'
lá:ʔ	'leaf'	là:ʔ	'go out (for fun)'
pĩ́h	'lead by hand'	pìh	'big'

Notice that the last pair involves the falsetto manifestation of tense register. In eight of the 26 register minimal pairs the tense word is falsetto. We discuss falsetto in more detail below.

Laver (1980) also uses the terms 'tense' and 'lax' but his usage is specifically describing overall muscular tension throughout the vocal tract. Although our usage of the terms is more broad (including pitch and phonation type), the characteristics of muscular tension discussed by Laver are also features in the registers of Khmu Kroong. Not every one of these characteristics is (clearly) part of the registers in Khmu Kroong, but there is a set of features commonly associated with each of the registers in the speech of Mrs. Khwiin. While these features are not always manifested on every form, they are frequent enough to be listed as descriptive of the two registers. Obviously, the features are interrelated and interdependent to some extent. Including pitch and phonatory features, these are the characteristics that the registers tend to have.

Tense Register	Lax Register
creaky or "choked" voice	breathy or "hollow" voice
"fortis" initial	"lenis" initial
greater intensity (amplitude)	lower intensity (amplitude)
slightly shorter duration	slightly longer duration
higher pitch	lower pitch
falling contour	rising contour
falsetto (on high vowels)	

5.1 Creaky or Choked vs. Breathy or Hollow

A creaky voice quality versus a breathy one is fairly straightforward as a common opposition in Mon-Khmer register systems. However, in our data neither is sufficient as a definitive feature of a register since they are not always present and when they are, they vary in degree from only weakly present to quite clearly present. It is true, however, that tense forms never manifest breathiness and lax forms almost never manifest creakiness. We say 'almost never' as creakiness in particular is not that useful in identifying registers in this data since Mrs. Khwiin tends towards having a slight creak as a permanent phonetic setting. Even so, there are clearly recognizable differences in the degree of creakiness between the two registers.

The "choked" versus "hollow" or "resonant" distinction is a bit different from creaky vs. breathy and may be due to such articulatory characteristics as raised or lowered larynx, degrees of pharyngeal constriction, etc.

5.2 Fortis vs. Lenis Initials

We use the terms "fortis" and "lenis" in a more or less traditional way and consider that they are convenient cover terms for Laver's degrees of "radial movement" of the constricted, convex or relaxed, flat tongue cited above.[2] In addition to those details of articulation we add weak aspiration and/or partial voicing as part of the lenis articulation. This lenis feature, when present, can be seen in the waveform of the word in question. In the set of Figures below, waveforms are given for velar stop initials. Each Figure covers a total of 80 milliseconds (msec) of the beginning of the syllable in question, including 5 msec before the release of the initial. A phonetic transcription corresponding to the waveform can be seen across the top of each figure.

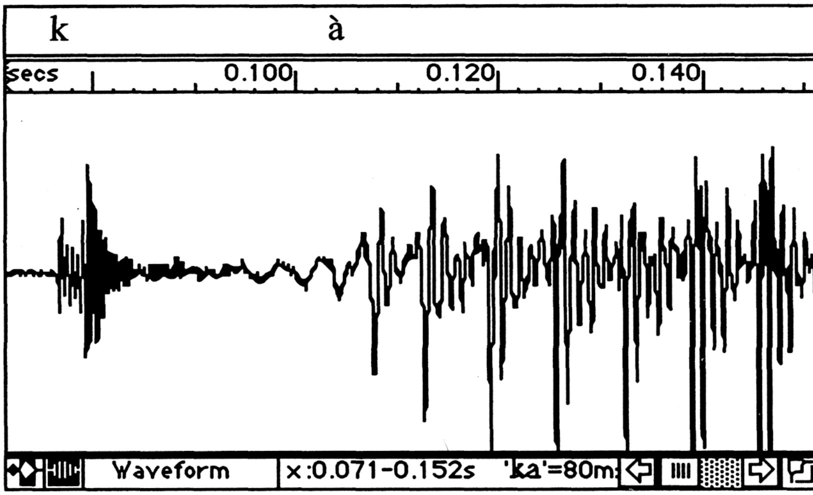

Figure 1. Waveform of the beginning of kà:ŋ 'house'

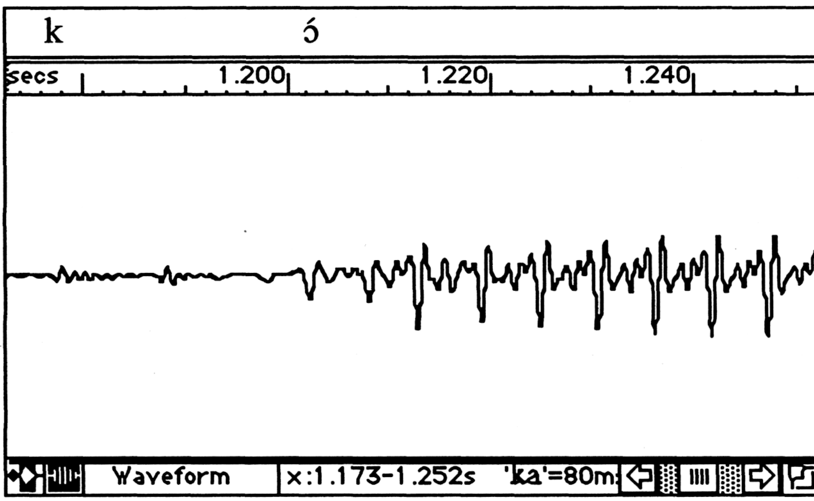

Figure 2. Waveform of the beginning of kɔ́:n 'child'

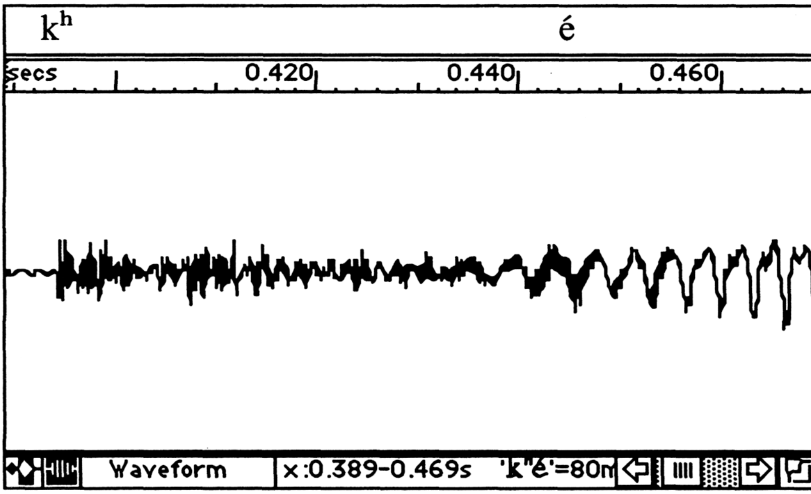

Figure 3. Beginning of the last syllable in cɨləkʰé: 'crocodile'

Figures 1 and 2 show the differences in waveforms for velar initials in lax and tense forms respectively. There is a striking difference between the lax and tense initials. There is almost nothing to be seen in the release of the tense initial while the lax initial has a relatively large burst with a small amount of friction noise before the vowel begins. A waveform of an aspirated velar initial is also given in Figure 3 for comparison. A much greater amount of friction over a longer period of time is seen in this 'normal' aspirated stop.

Overall, a greater amount of acoustic energy can be seen in the release of the lax initials. More energy in a lax form might seem counterintuitive at first, but if it is considered as weak aspiration resulting from breathiness over the entire syllable, then it fits in with the general phonetic characteristics of lax forms.

5.3 Differences in Intensity

Differences in intensity (as shown in the amplitude of the waveform) between the two registers are due to general muscular tension and the relative force of articulation. Sound-waves of the lax forms do not broadcast as efficiently as do those of the tense forms because the relaxed muscles of the vocal tract absorb rather than reflect the sound waves. This damping effect is one of the main features of lax voice in the literature (see especially Laver 1980:143ff). Since our wordlist was elicited item by item, it is not helpful to compare the separate sound files of two items, e.g. minimal pairs, since they were not produced in the same context and thus may have differing intensities for any number of reasons other than difference in register. However, there are numerous examples where the subject provided some context for the word at hand. These contexts provide nice frames for comparing features such as intensity and pitch between words of different registers. One good example is given in Figure 4 below.

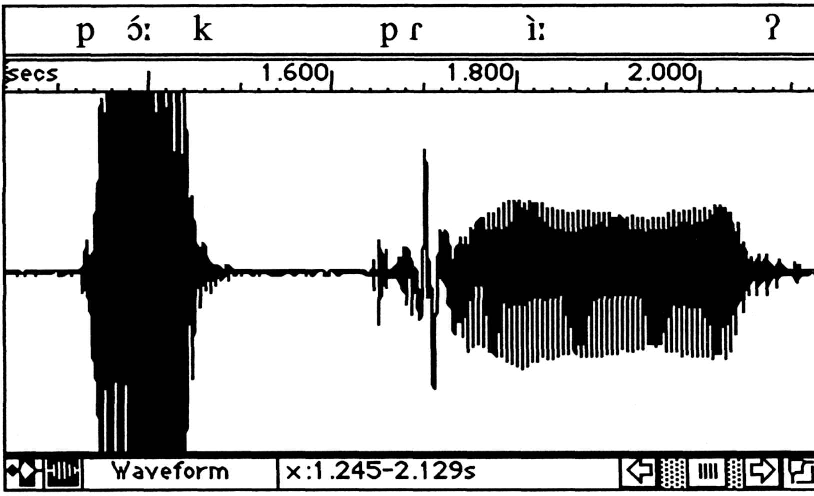

Figure 4. Waveform of the phrase pɔ́:k prì:ʔ 'burn the forest'

Figure 4 illustrates how in a single phrase the tense word has a much greater intensity than the lax word. Normal phrase intonation in Khmu (Suwilai 1987:24 as well as personal observation) shows an increase of pitch and stress on final elements, so the difference in intensity here is not likely to be a by-product of any intonational phenomena.

5.4 Differences in Duration

Another point of interest is the difference in duration between the two registers. Laver (1994:417ff) states that lax segments tend to be shorter whereas tense segments are longer. However, Theraphan (1987:36) cites research in other languages where breathy vowels are longer than clear vowels. Our measurements show that, in general, Kroong lax words tend to be of longer duration than tense words, particularly among those with lexically long vowels. (This tendency does not override phonologically contrastive length of course.)

5.5 Differences in Pitch

There are two significant differences between the pitches of tense and lax registers (excluding falsetto phonation): 1) pitch height and 2) pitch contour. We consider each in its turn.

5.5.1 Pitch Height

There is a fairly consistent difference in pitch between the two series, with the tense forms manifesting a higher pitch and the lax forms a lower pitch. In general, the difference between the pitches of the two registers is about 50 Hz but it seems to range quite a bit.

The average pitch on lax forms ranges from 140 - 275 Hz. The overall average pitch for lax forms is about 200 Hz. Average pitches on tense forms range from about 170 - 350 Hz. The average pitch on tense forms is about 250 Hz. The pitches for tense forms just barely overlap with falsettos (see below). There is a large overlap, however, with the lax forms where the lowest tense pitch is only slightly higher than the lowest lax pitch. But the upper ranges differ more between the two with lax pitches (usually) a fair bit below 300 Hz, while tense pitches in the low to mid 300s are quite common. Falsetto averages range from about 350 to over 500 Hz[3] and the overall average pitch for falsetto is about 440 Hz. A summary of this pitch information is shown in Table 5 below.

	Lax	Tense	
		Non-Falsetto	Falsetto
Range:	140-270 Hz	170-350 Hz	350-500+ Hz
Average:	200 Hz	250 Hz	440 Hz

Table 5. Pitch ranges and averages of Lax and Tense registers.

An average difference of 50 Hz is significantly greater than the pitch difference between the high and low tones proposed for Yuan. Svantesson says of the high and low tones in Yuan that "the difference between them is rather small (20-30 Hz for male speakers)" (1989:62). Gårding and Lindell also say the largest difference is 30 Hz (1977:325). Since neither study gives any data regarding the average ranges of the high and low tones, we are unable to make any comparison in that area.

Our data show a varied range of differences between the pitches of tense and lax forms. The following Figures show pitch plots of minimal pairs with varying pitch differences.

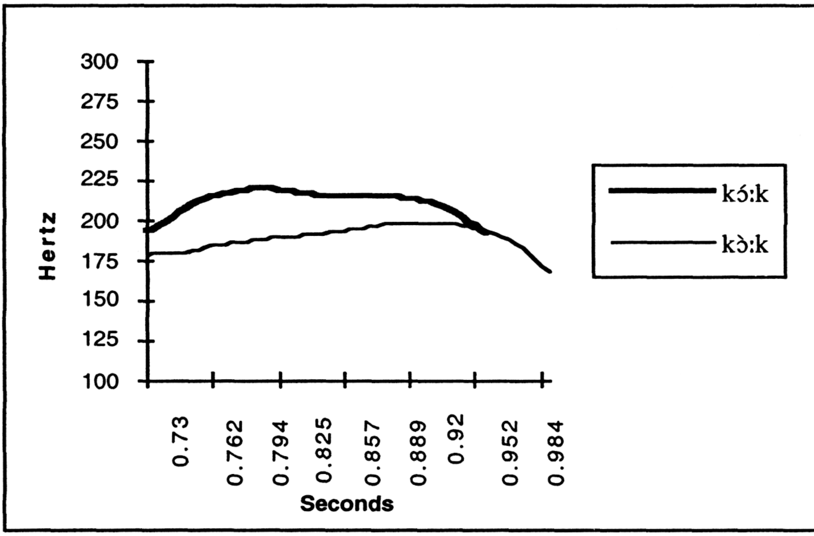

Figure 5. Pitch plots for kɔ́:k 'caterpillar' and kɔ̀:k 'carry slung over shoulder'

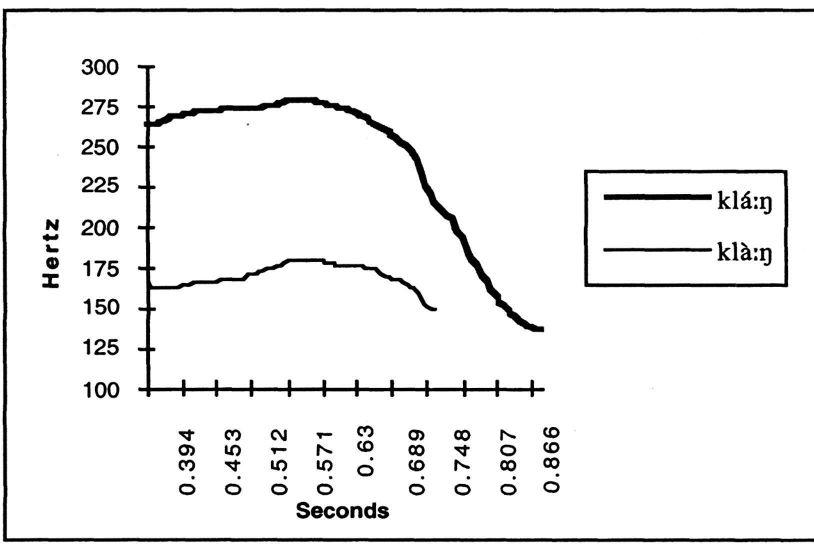

Figure 6. Pitch plots for klá:ŋ 'eagle' and klà:ŋ 'stone'

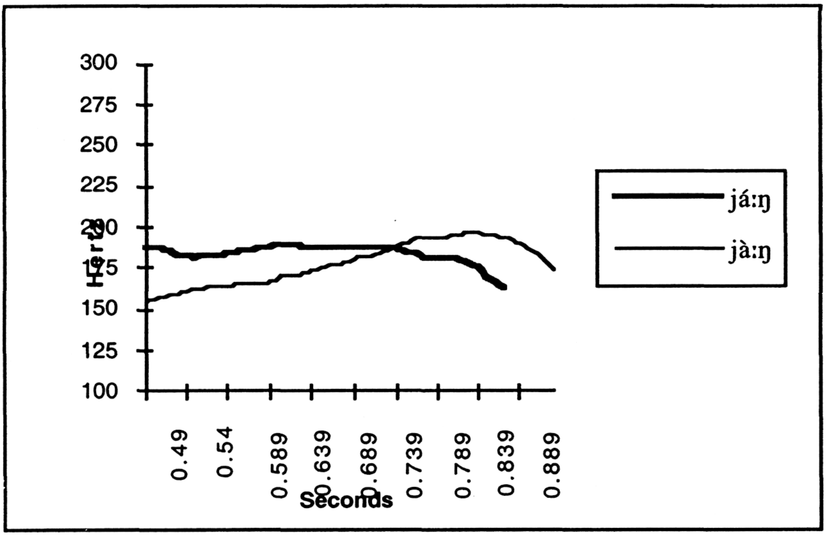

Figure 7. Plots for já:ŋ 'female animal' and jà:ŋ 'chicken coop'

Comparing the peaks of each pitch contour, the pair of words in Figure 5 differ by only about 20 Hz while the pair shown in Figure 6 differ by about 100 Hz. One immediate explanation for such differences has already been briefly mentioned and that is that the words were elicited separately. That is, none of the minimal pairs we have were elicited as a pair. So, as with details of intensity being potentially different for reasons other than register differences, the pitches in these cases may also be different for other reasons. In Figure 7 however, we see that the peak of the lax form is about 7.5 Hz higher than that of the peak of the tense form! More detailed investigation into these and other sets of minimal pairs needs to be carried out.

5.5.2 Pitch Contour

One of the most interesting characteristics about the pitch differences between tense and lax forms is the distinct pitch contours. The lax forms very consistently show a relatively rising contour while the tense forms show more of a falling contour. Careful measurements of where the contour peaks occur turn up some interesting and fairly consistent results. In general, the pitch of tense forms tends to peak around 35-40% through the vowel while lax form pitches tend to peak around 70% through the vowel. In terms of pitch alone, this distinction between pitch contours appears to be a more regular difference in our data than distinctions in pitch height. The different contours can be clearly seen in the pitch plots shown below.

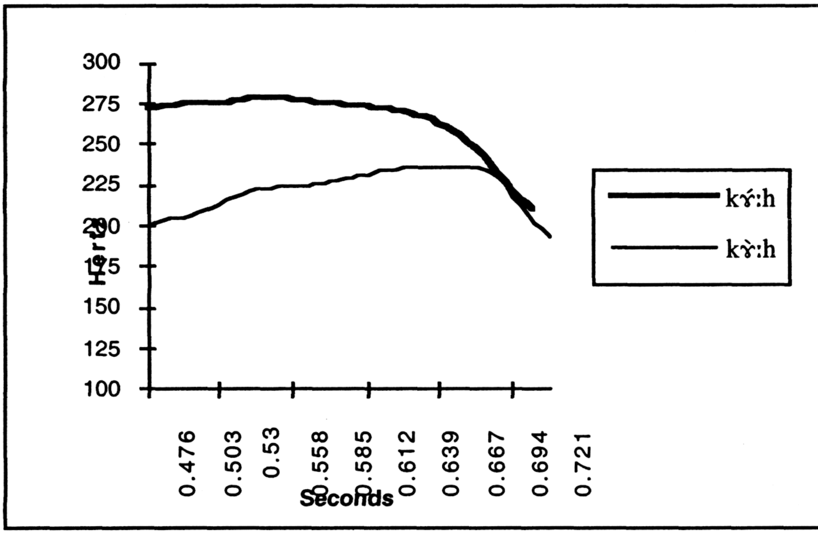

Figure 8. Plots for kɤ́:h 'pour slowly' and kɤ̀:h 'blaze up'

5.6 Falsetto

The first and most obvious feature of falsetto phonation is the very high pitch. Other details concerning the production of falsetto voice are given by Laver:

> In producing falsetto, the vocal folds are stretched longitudinally from front to back, so that they become relatively thin in cross-section, with the glottal margins of the folds being particularly thin-edged. The glottis is often left very slightly open, and this has several results. Firstly, falsetto phonation is often accompanied by a slight whisperiness, as the pulmonic airflow is able to escape continuously through the glottal gap. Secondly, the sub-glottal pressure is characteristically lower than in ordinary voiced phonation, partly because of the continuous transglottal leakage. (1994:197)

Since we lack the equipment necessary to examine the exact laryngeal workings or to measure sub-glottal air pressure, we can only assume that these features are indeed concomitant with what we hear as falsetto. The only measurements we have pertaining to falsetto are of pitches which are conspicuously high. Besides these instrumental measurements, one can also distinctly hear the "slight whisperiness" described by Laver.

That the forms which manifest falsetto are tense forms (as opposed to lax forms) is clear for two reasons. First, there are cases where the data show free variation on certain words between falsetto and non-falsetto. The non-falsetto versions of these cases are clearly tense. Second, comparison with cognate forms in Southern Khmu provides further evidence in that the cognates have voiceless initials.

While it is clear that the forms which are produced with falsetto voice are tense, what is less clear is why this might be so. That both tense and falsetto forms have higher pitch is plain, but is there any other overlap between the features of tense and those of falsetto? On at least one count, yes. Falsetto is produced with greater muscular tension (particularly among these laryngeal muscles: interarytenoid, lateral cricoarytenoid, thyroarytenoid, and cricothyroid (Laver 1980:118)). So higher pitch and an increase of muscular tension would support falsetto being a potential realization of tense voice.

However there are two other points that appear to run counter to this. These are two of the points in Laver's description of falsetto above, namely, the "slight whisperiness" and the "characteristically lower sub-glottal pressure". These two features were previously mentioned in connection with lax voice. In Laver's detailed description of the characteristics of tense and lax voice given above, "breathy or whispery phonation" was one of the characteristics of lax voice, as was "lower sub-glottal air pressure" (1980:155). However, both of these characteristics of falsetto phonation can be reconciled with tense voice. The whispery aspect is due to the glottis remaining slightly open and is more accurately associated specifically with whispery phonation rather than with breathiness (Laver 1980:119). Since whispery voice involves a "greater degree of laryngeal effort" while breathy voice involves a "low degree of laryngeal effort" (Laver 1980:134), we can still associate this aspect of falsetto with tense voice.

As for lower sub-glottal air pressure, this is the case because less air is needed for phonatory vibration in falsetto voice since the glottal edge is under strong tension and quite thin and "only the thin margins of the vocal folds [are] participating in phonatory vibration" (Laver 1980:119). The lower air pressure is simply due to a much smaller demand for air pressure in producing falsetto, not due to any laxness in production per se.

The most interesting thing about tense forms produced with falsetto voice in our data is that falsetto production *regularly corresponds* to vowel quality. That is, tense forms with close vowels, [i ɯ u], tend to be produced with falsetto voice. This is a strong tendency for Mrs. Khwiin, but there is free variation. Some forms were consistently produced with falsetto voice while others exhibited free variation. Other vowels and diphthongs are not produced with falsetto voice (even though diphthongs include close vowels). Below are a few examples of falsetto forms from our data. If there is a minimal pair partner for the form, it is also listed:

ti̋:ŋ	‘fall over’	tì:ŋ	‘water container’
hi̋c	‘pound rice’		
cɯ̋	‘remember’	cɯ̀	‘name’
pɯ̋k	‘hold near fire’	pɯ̀k	‘middle beam’
pɯ̋:c	‘take off clothing’	pɯ̀:c	‘liquor’
tɯ̋k	‘tie’		

Laver states that “falsetto is not used systematically for contrastive phonological purposes [but it can be] used paralinguistically” (1994:197-8). This makes our data all the more interesting. The use of falsetto is not universally contrastive in itself in Mrs. Khwiin’s Kroong, but it is a regular, conditioned, allophonic realization of contrastive register in this system. Mrs. Khwiin consistently uses falsetto for these forms in both words elicited in isolation as well as in her natural conversational speech. One might think it was only a paralinguistic signal or style of speech with sociolinguistic significance if it were not so predictable on an unconscious level. We do not discount however, the role(s) that sociolinguistic factors may play in this phenomenon.

In addition to the needs for further study mentioned throughout the paper, use of falsetto voice especially needs further study regarding these sociolinguistic factors and the interactions of intonation in connected speech.

Endnotes

[i] There may even be dialects where both types of contrast are employed redundantly but none have been attested.

[2] The actual facts concerning the movement and muscular constriction of the subject’s tongue as well degrees of sub-glottal air pressure, acoustic correlates of a raised or lowered larynx, degrees of muscular constriction in the larynx and pharynx etc. are all elements that we were unable to observe

for lack of the necessary equipment. Further and more detailed instrumental study is necessary to discover if these further characteristics also play a part in the registers of Khmu Kroong.

[3] We are unable to say exactly what the highest pitch in a falsetto form is because the maximum pitch measurement MacCECIL can make is 500 Hz. However, we do not think it is significantly higher than 500 Hz.

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