INTRINSIC EFFECTS OF VOICED AND VOICELESS UNASPIRATED PREVOCALIC STOPS ON FUNDAMENTAL FREQUENCY IN LUANG PRABANG LAO

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ABSTRACT - Three tones, of two native speakers of the Luang Prabang variety of Lao, are investigated as to the effects of the voicing or voicelessness of the initial consonant of a syllable on the fundamental frequency of the following vowel. Three vowels are used, and the intrinsic effect of vowel height on fundamental frequency observed. The results from this investigation support the hypothesis that the intrinsic effect of lowering of fundamental frequency after voiced consonants is minimised in tonal languages.

INTRODUCTION (1)

There is evidence to suggest that the fundamental frequency (F_0) of a vowel following a voiced initial consonant is intrinsically lower than that following a voiceless initial consonant (Lea, 1973; Hombert, 1978). There have been experiments done in both non-tonal languages such as English and French (Hombert,1978) and in the tonal languages Yoruba (Hombert, 1978) and Thai (Gandour, 1974). Hombert hypothesises from these experiments that the intrinsic effect of lowering the F_0 of a following vowel when the initial consonant is voiced is of a shorter duration in tonal languages than in non-tonal languages. This makes sense when one considers the fact that tonal languages have the phenomenon of lexically contrastive pitch. The aim of this investigation is to look at another tonal language, to see whether the perturbations to the F_0 of the vowel resulting from the type of initial consonant are minimised as seems to be the case in the two tonal languages investigated to date.

THE LUANG PRABANG VARIETY OF LAO

Initial Consonants

Lao is a member of the Tai language family. In common with most members of this family, it has a three way contrast as far as initial stops are concerned. There are voiced, unaspirated voiceless and aspirated voiceless stops. In this investigation, only voiced and unaspirated voiceless stops are considered.

There are four distinctive places of articulation for stops in Lao, viz. bilabial, dentalveolar, palatal and velar. The voiced palatal and velar stop phonemes are not present in Lao, so any investigation of voiced versus voiceless unaspirated stops needs to be restricted to bilabial and dentalveolar stops. In this investigation, only bilabial stops were examined.

Vowels

Luang Prabang Lao has nine contrastive monophthongs. In this investigation, only three of these are considered, viz. [aa], [ii] and [uu]. These were chosen because they are the vowels that would be expected to show most clearly the well known intrinsic F_0 differences associated with vowel height. Lao has both long and short vowels. In this investigation only long vowels and only open syllables (i.e. syllables not ending in a consonant) are considered. One reason for only using long vowels is that short vowels in open syllables tend to be followed by glottal stops, and glottal stops produce a differential effect on F_0 (Rose, 1987).

Tones

The Luang Prabang variety of Lao has six phonemic tones. Only three of these tones allow a contrast between initial voiced and voiceless unaspirated stops where the syllable contains a long open vowel. All of these three tones are phonologically level and, for historical reasons, will be referred to as M0, M1 and M2. The tone M2 has a higher pitch than the tone M1, which itself has a higher pitch than the tone M0.

METHOD

Two native speakers of the Luang Prabang variety of Lao took part in this investigation. One is male (BM) and the other is female (VM). Both are in their late thirties and have lived in Australia for about a decade.

Eighteen different syllables were investigated. For each of the three tones, both voiced and voiceless unaspirated initial consonants followed by each of three vowels were used. The tone of a syllable can be ascertained from the orthography, so it is possible for informants to read syllables, even when these syllables have no meaning. In fact, about half of the eighteen syllables used do have meaning in Lao. Each of these eighteen syllables was said by the informants a number of times within a frame. The frame used was, using fairly broad phonetic transcription,

ຄຳວ່າ X ---- ນີ້ ມີ ຄວາມໝາຍຫຍັງແດ່

k^{h}am wāā tua X nīi, mii k^{h}waam mǎaj jǎŋ dɛ̄ɛ

This can be roughly translated as "this word X, does it have meaning?" With this frame, the sentence makes sense, even when nonsense syllables are being used.

The eighteen tokens were given to the informants in random order, and each informant was recorded on a Nagra tape recorder, in a soundproofed room situated in the phonetics laboratory of the A.N.U. Linguistics Department. BM spoke each of the framed tokens a total of 20 times, of which ten of each have been processed to date. VM spoke each of the tokens a total of 15 times, of which ten of each have also been processed. Some of VM's tokens were spoken with creaky voice, which gave a F_0 of about half that expected. These were rejected from analysis.

The framed tokens were then processed using the ILS computer package. The recordings were digitised at a sampling frequency of 10 kHz and analysed using the ILS API command (this uses the linear predictive method of analysis with autocorrelation). The start and end of the vowel were ascertained by examination of the displayed speech wave, and were taken as the 0% and 100% points of duration of the vowel, respectively. F_0 was sampled at each 5% point, up to the 30% point, and at 10% points thereafter.

RESULTS

Tables 1 and 2 give the mean and standard deviations values for F_0 at various percentage points of duration. Figures 1 and 2 show plots of the mean F_0 for the vowel [aa]. The plots obtained for the other vowels are similar in pattern, although the extracted F_0 values are higher. This illustrates the intrinsic effect that vowel height has on F_0, where high vowels tend to have higher F_0 values. The values for [ii] are of the order of 10 Hz higher than the values for [aa], and the values for [uu] are slightly higher than those for [ii].

Figure 1 - Plots of Fundamental Frequency vs. Vowel Duration for BM's tones M0, M1 and M2, where the vowel is [aa]

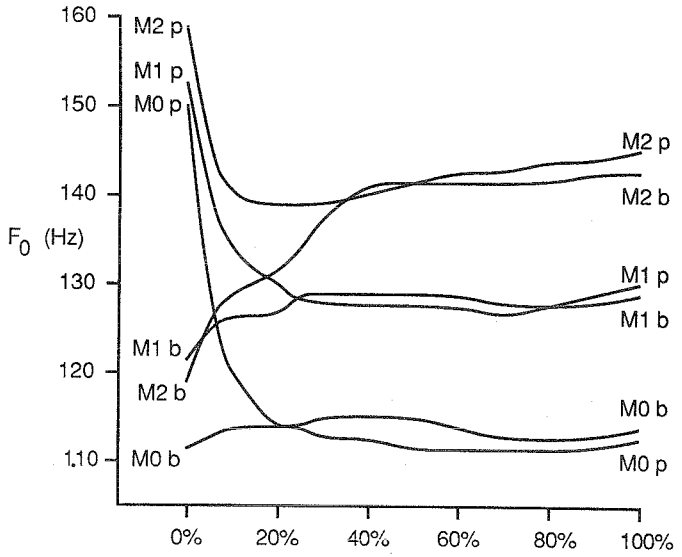

Figure 2 - Plots of Fundamental Frequency vs. Vowel Duration for VM's tones M0, M1 and M2, where the vowel is [aa]

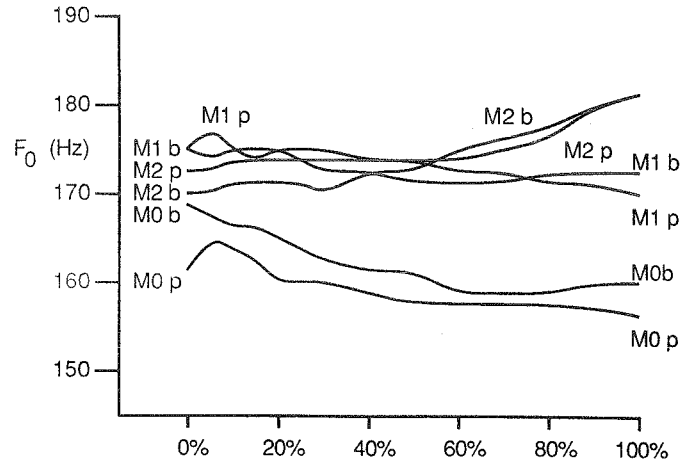

Table 1 - Number of tokens (n) & means and standard deviations ($\bar{x}$,s) for vowel duration (csec) and for F_0 (Hz) at various points of duration, for informant BM

	Tone M0			Tone M1			Tone M2		
	[baa]	[bii]	[buu]	[baa]	[bii]	[buu]	[baa]	[bii]	[buu]
n	10	10	10	10	10	10	10	10	10
0%	111,2	120,2	123,4	122,5*	131,3	133,4	119,5*	129,4	132,5
5%	113,3	121,2	124,3	125,5	133,2	135,4	126,4	133,5	135,5
10%	114,3	122,2	125,4	126,5	135,3	138,5	128,4	135,5	138,5
15%	114,3	122,3	126,3	126,5	136,3	139,5	130,5	138,5	141,6
20%	114,3	122,3	126,4	126,4	137,3	141,5	132,5	140,6	144,6
25%	114,3	122,3	125,4	128,4	138,3	141,5	134,5	143,6	146,7
30%	115,2	122,2	125,4	128,4	138,4	141,5	137,5	145,6	147,7
40%	115,3	121,3	124,4	129,5	139,4	141,5	140,5	147,6	149,6
50%	115,4	120,3	122,3	129,4	137,3	141,4	141,5	149,6	151,6
60%	114,4	119,2	122,4	129,4	137,3	140,4	141,5	151,7	152,6
70%	113,3	120,2	121,2	128,4	136,2	139,3	141,5	152,7	152,5
80%	112,3	120,2	120,2	128,4	136,2	139,3	141,5	153,7	152,5
90%	112,2	120,2	119,2	128,4	136,2	139,3	143,6	153,7	152,5
100%	113,3	117,3	120,3***	129,4	133,2	139,4	143,7	152,8	153,6
Duration	28,2	25,2	27,2	28,3	26,2	27,4	28,2	25,3	26,3

	[paa]	[pii]	[puu]	[paa]	[pii]	[puu]	[paa]	[pii]	[puu]
n	10	10	10	10	10	10	10	10	10
0%	150,18	152,15	139,7*	152,12	161,12	156,11*	158,15	155,9	152,5
5%	124,3	133,3	135,4	138,3	146,5	148,7	143,7	149,5	150,4
10%	120,3	130,2	133,4	134,3	143,4	146,6	140,7	147,4	148,4
15%	116,3	128,3	131,3	132,3	141,4	144,6	138,6	146,4	148,4
20%	114,3	126,3	129,3	131,4	139,3	142,6	138,7	145,4	148,5
25%	114,2	124,3	127,3	128,3	138,3	141,7	138,7	144,4	147,5
30%	113,2	123,3	126,3	128,3	137,3	139,6	138,6	144,4	147,5
40%	113,2	120,3	124,3	128,3	135,3	138,6	139,6	144,3	148,4
50%	112,2	119,3	122,2	128,3	134,3	137,6	141,6	145,4	148,4
60%	111,2	118,3	120,2	128,3	133,3	136,6	142,6	147,4	149,4
70%	111,3	118,3	120,2	127,4	133,3	135,6	143,5	149,4	151,4
80%	111,3	118,3	120,3	128,4	133,3	135,6	144,5	151,4	152,5
90%	111,2	118,3	121,3	129,4	134,3	136,6	144,5	152,4	153,5
100%	112,3	114,5	120,2*	130,4	132,3	137,7	145,6	152,3	154,8
Duration	28,2	25,2	26,2	28,2	25,2	26,2	28,2	23,1	25,3

At some points of duration for some tokens F_0 was not able to be extracted. This was particularly so for the 0% and 100% points of duration, i.e. at the start and end points of the vowel. It also occurred at the 5% point of duration for one of VM's tokens. When F_0 extraction is not possible, there is a reduction in the sample size, n, for that point of duration. In both tables 1 and 2, this reduction in sample size is indicated as follows.

* The sample size, n, is one less than stated.
** The sample size, n, is two less than stated.
*** The sample size, n, is three less than stated.
\+ The sample size, n, is four less than stated.

Table 2 - Number of tokens (n) & means and standard deviations ($\bar{x}$,s) for vowel duration (csec) and for F_0 (Hz) at various points of duration, for informant VM

	Tone M0			Tone M1			Tone M2		
	[baa]	[bii]	[buu]	[baa]	[bii]	[buu]	[baa]	[bii]	[buu]
n	10	10	10	10	10	10	10	10	10
0%	168,5	171,4	167,4	175,5	178,3	173,3**	169,6	178,4	173,6*
5%	167,3	172,4	167,4	174,5	179,4	173,4	170,4	180,4	173,5
10%	166,3	172,3	168,4	175,5	180,5	175,4	171,4	181,3	174,5
15%	166,3	172,3	168,4	175,5	179,5	176,4	171,4	181,4	176,6
20%	165,3	171,4	168,5	175,4	179,5	177,4	171,4	181,4	177,6
25%	164,3	170,4	168,5	174,3	178,6	177,3	171,4	181,4	178,6
30%	163,4	169,4	167,5	173,3	177,5	177,3	170,4	181,4	179,6
40%	162,4	168,4	166,5	173,3	177,5	178,2	172,5	182,4	180,6
50%	161,5	166,3	165,5	172,4	178,5	176,3	173,5	185,4	182,7
60%	159,4	166,4	163,4	172,4	178,5	175,3	175,5	187,4	184,6
70%	159,4	165,4	163,4	172,4	178,5	175,3	176,5	189,4	185,6
80%	159,4	165,3	164,4	173,4	178,4	176,3	178,4	190,3	188,7
90%	160,3	164,3	165,4	173,4	177,4	176,3	180,4	191,3	190,7
100%	160,4	161,4***	163,3*	173,4	171,3**	176,3*	181,2	186,6***	189,7**
Duration	29,2	24,2	26,3	32,2	28,2	31,3	32,3	28,4	29,2
	[paa]	[pii]	[puu]	[paa]	[pii]	[puu]	[paa]	[pii]	[puu]
n	8	8	10	10	8	10	9	8	10
0%	161,6	175,12	171,8	175,10	180,5	173,3	172,3**	173,9**	173,7*
5%	165,6	171,4	168,3	177,5*	180,5	173,4	172,5	179,5	173,5
10%	164,6	170,4	168,3	175,5	181,5	174,3	173,6	182,5	174,5
15%	163,6	169,3	168,3	174,5	179,4	175,3	173,6	183,4	175,5
20%	160,6	169,3	169,2	175,5	179,3	176,3	173,6	183,4	177,4
25%	160,6	167,3	168,3	175,5	179,3	177,3	173,6	182,4	177,5
30%	160,6	166,3	168,3	175,5	178,2	178,3	173,6	182,5	179,5
40%	159,7	164,3	167,4	174,6	177,3	179,4	174,6	182,6	179,5
50%	158,6	163,3	165,3	174,5	178,3	178,4	174,6	182,5	179,5
60%	158,6	163,3	164,3	173,6	177,4	178,4	174,6	183,6	180,4
70%	158,5	165,2	163,3	173,6	177,4	177,4	175,6	186,7	182,5
80%	158,5	165,3	163,4	172,6	177,5	177,4	177,6	188,5	186,3
90%	158,5	163,3	165,3	172,5	177,4	178,4	180,5	190,5	188,4
100%	157,4*	158,4*	165,3	171,4	168,5+	178,5	181,4	185,6***	189,4*
Duration	27,3	23,3	26,3	32,3	28,5	31,3	28,2	25,3	28,4

ANALYSIS OF RESULTS

From the data for BM, it is of interest to note that the 0% points of duration have roughly equal F_0 values for tones M1 and M2 when the syllable begins with a voiced consonant. The F_0 value for the tone M0 is about 10 Hz lower. However, the curves representing F_0 for the tones M0 and M2 for voiced initial consonants may begin from a common locus, somewhat lower than the locus for the tone M1. Also, the initial values of F_0 for syllables beginning with unaspirated voiceless initial consonants have much higher frequencies at the 0% point of duration than at subsequent points. (Perhaps the intrinsic effect could be regarded as a heightening of the F_0 of a vowel following a voiceless unaspirated stop, rather than a lowering of the F_0 after a voiced stop.) However, this does not occur for all tokens, which accounts for the higher values of standard deviations for these values. None of these effects occurs for VM's data.

T-tests show that there may be some significant difference in the F_0 of vowels following voiced and

unaspirated voiceless initial consonants for the data obtained from BM, but not for that obtained from VM. For VM there is no significant difference in the values of F_0 for a vowel following a voiced initial consonant as opposed to that following a voiceless initial consonant. In fact, in some cases the mean value of F_0, for some points of duration, is lower when the vowel follows a voiceless initial consonant.

For the data obtained from BM, there does seem to be an initial difference in F_0, with the vowel following a voiced consonant having significantly lower F_0, but never beyond the 20% point of duration. (This 20% point of duration can be regarded as having an approximate absolute value of 5 or 6 csecs., taking into account the mean values for duration obtained above.) This compares well with the results for the other two tonal languages cited by Hombert, and is much less than the values obtained for non-tonal languages. It thus provides further evidence that the intrinsic lowering of F_0 after voiced consonants does not have as large an effect in tonal languages, compared with non-tonal languages. Another interesting point, emerging from the results of BM's data, is that there appears to be some inertial overshoot effect occurring, in that after the 30 or 40% point of duration, the value of F_0 is higher after the voiced initial than after the voiceless initial. However, this effect begins to dissipate shortly after the 30 or 40% point of duration. Although differences after the 30% point of duration are not statistically significant, this pattern occurs for all three vowels.

CONCLUSION

It appears that Luang Prabang Lao does show similar effects to the other tonal languages investigated to date, insofar as the minimisation of the intrinsic effect of lowering of F_0 after voiced consonants is concerned. In fact, for one informant it would seem that the effect of F_0 lowering has been minimised to such an extent that there is no significant difference at all, and for the other there was no significant difference after the 20% point of duration of the vowel.

More work needs to be done in this area of research both in Lao and in other tonal languages. Other informants should be investigated, to see how they compare with the rather different results obtained from the two informants in this study. In addition, the effects of voiced and unaspirated voiceless initial consonants should be compared with that of aspirated voiceless consonants.

NOTE

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