THE EFFECT ON F_0 OF THE LINGUISTIC USE OF PHONATION TYPE

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ABSTRACT

Phoneticians generally expect that laxer adjustments of the vocal cords will produce lower F_0. Hence, languages with phonological contrasts between syllables with tense (somewhat creaky) and lax (somewhat breathy) phonation would be expected to show a difference in pitch between them. We measured F_0 in several minority languages of China with contrasts that have been described as tense vs lax. Our results show that a pitch difference is only sometimes present. The patterns are, in part, explicable in terms of different phonetic realizations and different diachronic sources of the tense/lax contrast, and in terms of its phonological function.

A tendency for different phonatory settings to be associated with pitch differences has been noted by many observers. For example, Laver (1980), in his discussion of laryngeal tension settings, remarks that "there is a strong possibility that in tense voice the pitch range will be higher than in lax voice". Later he comments that "lax voice tends to be accompanied by a low pitch-range". But he goes on to note that there is nothing necessary about the association of laryngeal tension with pitch, commenting that "it is certainly possible to compensate for these tendencies."

Laver is discussing tense and lax laryngeal settings as attributes of individal voice quality. However, a number of languages use tense and lax phonation for linguistic contrast between vowels. This phenomenon is quite common among languages spoken in Southwestern China and adjoining parts of Southeast Asia. We have been conducting studies of the phonation type contrast in several of these languages, and have reported some of our results elsewhere (Maddieson & Ladefoged 1985, Maddieson & Hess 1986). In the present paper we focus on the relation between F_0 and phonatory tension in five of the languages in question. We hypothesized that pitch would correlate with tension, following the tendency noted by Laver, in languages which did not also have tonal contrasts. In languages with tonal contrasts with a high functional load and phonological systems in which phonatory tension is not an aspect of particular tones, we anticipated that the need to maintain the separation of tonal registers would inhibit this tendency. Instead, speakers would draw on the compensatory mechanisms available to counteract it.

Our data consists of measurements of F_0 from 5 languages - Wa, Jingpho, Yi, Lahu, and Lisu. Wa is a non-tonal language of the Mon-Khmer family (Diffloth 1980, Qiu, Li & Nie 1980). The others are Sino-Tibetan languages with tonal systems with a high functional load. Yi (Liangshang dialect, Li & Ma 1983) and Jingpho (of Yunnan, Lu 1984) have similar tone systems, distinguishing high, mid and low-falling tones. In these two languages the phonatory contrast is independent of the tone system, although it is limited to particular syllabic nuclei in Yi. Lisu is usually analyzed as having a 6-tone system in which tense phonation is characteristic of two of the tones (Mu & Duan 1983). These two tones are mid-level and mid-falling, and can be matched with two of the "lax" tones, also mid-level and mid-falling. Mu and Duan transcribe the pitch height of the tense tones as 44 and 42, and the paired lax tones as 33 and 31, implying that the "tense" tones are indeed higher. Lahu has a system of seven tones, two of which are variously described as being checked by a glottal stop (Matisoff 1973), or having tense vowels (Ma 1984). These two tones, high-falling and low-falling, can be matched with two of the tones that occur non-checked or lax. Whereas Matisoff gives the same pitch values for tense and lax tones, Ma transcribes the tense tones as 54 and 21 but the lax tones as 53 and 31, indicating a smaller pitch range for the tense ones.

3 speakers of each language were recorded with the assistance of Ren Hongmo. The speakers read a wordlist containing 8-10 pairs of monosyllabic words with a minimal tense/lax contrast. Each list was read twice, giving 48-60 examples of each contrast (except for Lahu where only one repetition was recorded, giving 30 cases). F_0 was measured at the onset and offset of the vowel from narrow-band spectrograms. If a more extreme value of F_0 occurred after the vowel onset that value was also measured.

The F_0 measurements in each language were examined in a 3-way analysis of variance, specifying speaker, word pair and tension as main effects. In Table 1 the mean onset and offset F_0 values are shown for the tense and lax vowels in each language. Significant differences (at the .0001 level) are printed bold. All other tense/lax differences are not significant (fall below the .05 level). Measurements of the peak F_0 value did not show a different pattern from those made at the onset, hence these measures are not reported.

Table 1. F_0 measures on tense and lax vowels.

	Wa		Jingpho	
	onset	offset	onset	offset
"tense"	146	112	**157**	128
"lax"	145	115	**145**	126
	Lisu		**Lahu**	
	onset	offset	onset	offset
"tense"	147	119	213	**195**
"lax"	148	122	214	**126**
	Yi			
	onset	offset		
"tense"	**157**	153		
"lax"	**152**	154		

In Wa, words in citation form are spoken with a falling intonation. No pitch difference between tense and lax vowels was observed at either the onset or offset of the vowel. On the other hand, in Jingpho, a significant pitch difference at the vowel onset was observed. The Jingpho wordlist includes pairs of words with all three tones, but pairs with low-falling tone predominate (6 out of 10). Because of this, the mean offset value is low. The word pairs examined in Yi were all mid-level tone, hence onset and offset values are close. The onset F_0 differs between tense and lax syllables by a small but highly significant amount in Yi. In Lisu there is no significant difference at either onset or offset, despite Mu & Duan's indication to the contrary. Since phonatory tension is a property of particular tones in this language we had expected no effort to avoid a pitch distinction. Lahu shows a significant difference in F_0 at the vowel offset. The mean offset value in the two lax falling tones is considerably lower than in the tense tones.

Our results are thus generally counter to our hypothesis, which predicted that an F_0

difference would occur in the nontonal language Wa, and in Lisu and Lahu where phonation type is an aspect of tone, but not in Jingpho or Yi where phonation type is independent of tone.

Are there historical or synchronic facts about these particular languages which enable us to understand this result? Jingpho and Wa share a similar historical origin for the tense/lax contrast, namely, the somewhat breathy lax syllables are those which used to have initial voiced consonants. However, synchronically, the phonation type contrast is more salient in Jingpho than it is in Wa. We have used the difference in amplitude between the second harmonic and the fundamental, $H_2 - F_0$, as our measure of phonation type. This measure has a higher value for tenser phonation than for laxer phonation (Maddieson & Ladefoged 1985). In Wa the mean difference in the $H_2 - F_0$ measure between lax and tense vowels is just under 2 dB, whereas in Jingpho it is just over 7 dB. In addition, the tense/lax contrast in Wa is accompanied by some vowel quality difference: tense vowels have a higher first formant than lax ones, i.e. they are lower in the perceptual vowel space. In Jingpho, vowels in tense and lax syllables do not differ. It may therefore be the case that in Wa the small pitch difference that might have been expected from the not-very-salient phonation type contrast is counteracted by the effect of vowel lowering in tense syllables. In Jingpho on the other hand, the phonation type contrast is made salient enough so that the conditioning environment for any allotonic variation can be readily recognized.

Lisu developed tense phonation in syllables which were originally checked (i.e. stop-final). In Lisu we found that the mean difference in the H_2-F_0 measure between tense and lax was about 3 dB, confirming the existence of a moderately salient phonation type difference. Since there is no pitch difference, this suggests that the system should be reinterpreted as one with four tones in which a phonation type contrast operates within two of the tones, rather than as one with six tones, two of which have a marked phonation type.

Lahu shows no reliable evidence of a phonation type difference based on the measure we have used, nor is there usually any auditory impression of one. Instead, in the historically checked syllables, a final glottal stop usually occurs and the vowel is considerably abbreviated (about 275ms shorter than in "lax" syllables). The much lower offset pitch in the two falling "lax" tones seems simply due to their much greater length; the pitch continues to fall and reaches a much lower level. In Lahu, phonation type is only marginally involved in syllabic contrasts. Duration, extent of pitch change and glottal stop are more central to the contrast which has been described as "tense" vs "lax". Matisoff's representation of the "tense" syllables as having a final glottal stop is more accurate than Ma's account, though Ma correctly indicates the greater pitch range of the "lax" (unchecked) syllables (cf Hombert 1983).

Yi is again somewhat different. Although the difference between "tense" and "lax" vowel pairs is quite distinctive, with an auditorily "harsher" quality for the tense members, the $H_2 - F_0$ measure does not distinguish them. Perhaps this measurement is simply not appropriate for detecting phonatory differences in the rather unusual range of "fricative vowel" segments found in Yi. We think that it is more likely that the tense/lax contrast is produced in a different way here. We speculate that the "tense" vowels employ a supralaryngeal mechanism like that used in the "strident" vowels found in some of the Khoisan languages, which involves a narrowing between the base of the epiglottis and the upper part of the arytenoid cartilages. The use of this mechanism in !Xoo has been described in some detail by Traill (1985). Traill has listened to our Yi recordings and agrees that there is an auditory similarity between the strident vowels of !Xóõ and the tense vowels of Yi. However, in !Xóõ, strident vowels have somewhat lowered pitch, rather than the slightly higher pitch found in Yi "tense" vowels.

In the meantime, we find that, particularly in the data from Jingpho, we have provided a phonetic basis for a different hypothesis. This is the diachronic hypothesis that tonogenesis and splitting of tones in tone languages can arise from phonation type contrasts on vowels, as has been proposed by Pulleyblank (1978, 1984) for Chinese. Previous work has concentrated on consonantal sources for tones, and the effect of contrasts on vowels has largely been ignored. We now see that such effects can be significant. However, as data from Wa and Lisu demonstrate, phonation type may be contrastive in vowels without any accompanying pitch differences.

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