Laryngeal Features and Tone in Kyungsang Korean: a Phonetic Study[*]

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Kenstowicz, Michael and Chiyoun Park. 2006. Laryngeal Features and Tone in Kyungsang Korean: a Phonetic Study. *Studies in Phonetics, Phonology and Morphology*. Xx.x, xxx-xxx. F0 is one of the major phonetic correlates to the intensively studied lax-tense-aspirated contrast in Korean obstruents. Numerous investigations of the standard Seoul dialect have shown that the vowels following tense or aspirated consonants have higher F0 than vowels following a lax or nasal consonant at the beginning of a phonological phrase. Unlike the Seoul dialect, the Kyungsang dialects have preserved the H vs. L lexical tonal contrasts of Middle Korean. This study investigates the reflexes of the laryngeal contrast in the Kyungsang dialect, where the F0 space is shared for the realization of a high vs. low tonal contrast as well as a voiced vs. voiceless laryngeal contrast in the preceding consonant.

1. Introduction

It is well known that in many languages the [±voice] contrast in obstruents is accompanied by a difference in fundamental frequency (F0) at the onset of the following vowel. For example, Ohde (1984) reports a 20-30 Hz. increase in the first few of glottal periods after the release of a voiceless stop in comparison to a voiced stop in the speech of three American English speakers. Kingston & Diehl (1994) show diagrams indicating a c. 10 Hz difference for two male speakers of American English and a c. 25 Hz difference for a female speaker in comparable contexts. This phonetic difference is the basis for the frequent diachronic development (especially in Asian languages) of tonogenesis where the voicing distinction in the consonant is eliminated while the accompanying F0 difference in the vowel remains and becomes phonologized into a tonal contrast.

The phonetic correlates of the unusual three-way lax-tense-aspirated contrast in phrase-initial voiceless stops found in Korean have been intensively studied over the past forty years. For a recent comprehensive review see Cho et al. (2002) who cite the data in (1). We follow their transciption.

(1)

Lax	p	t	tʃ	k	s
Tense	p*	t*	tʃ*	k*	s*
Aspirated	p^h	t^h	$tʃ^h$	k^h	

paŋ	'room'	tal	'moon'
p*aŋ	'bread'	t*al	'daughter'
p^haŋ	'bang'	t^hal	'mask'

tʃata	'to sleep'	kæta	'to fold up'
tʃ*ata	'to squeeze'	k*æta	'to break'
$tʃ^h$ata	'to kick'	k^hæta	'to dig'

sata	'to buy'
s*ata	'to wrap'

This research has shown that an F0 difference in the following vowel is one of the major phonetic correlates as well as a perceptual cue to this contrast (Kim et al 2002). Vowels that follow a tense or aspirated consonant have higher F0 than vowels following a lax consonant. Figure (2) from Cho et al

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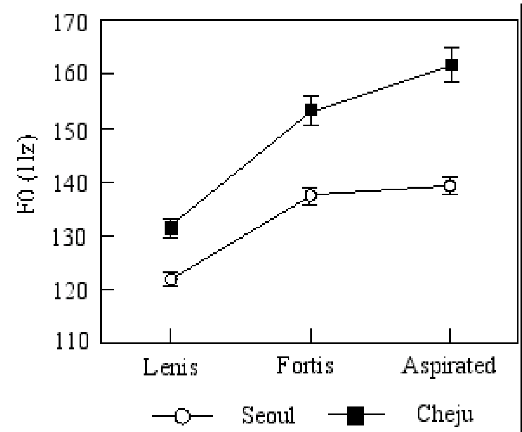
(2002) shows a c. 15 Hz difference between lax vs. tense or aspirated consonants for the Seoul dialect and an even greater difference for the Cheju dialect.

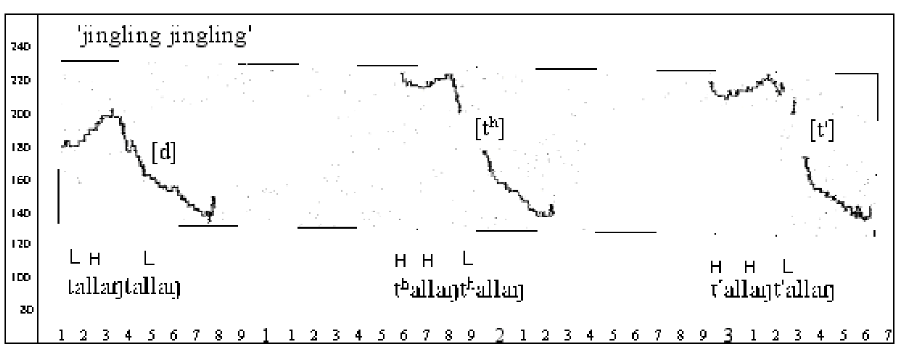
(2)



Since the Korean lax stops are normally voiced intervocalically but devoiced and accompanied by a significant VOT lag at the onset of the accentual phrase, the F0 difference is arguably a nascent (synchronic) tonogenesis that reflects the underlying voicing of the lax series (see Kim & Duanmu 2004 for recent discussion).

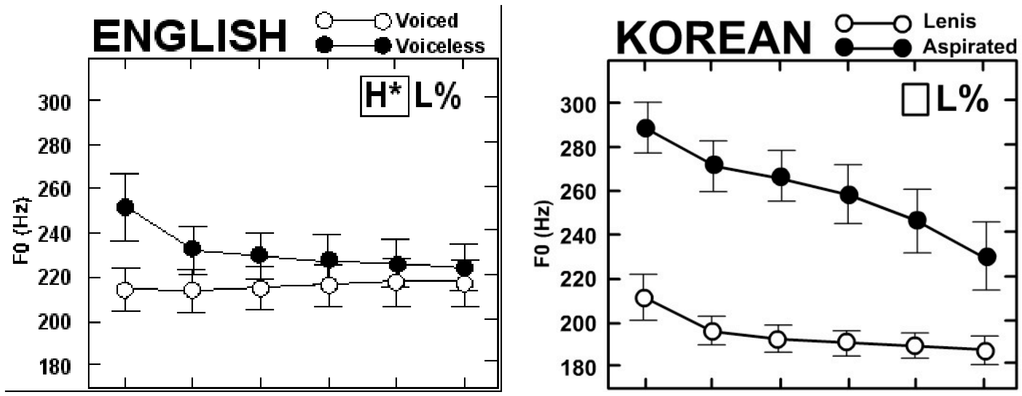
In her study of phonological phrasing in Korean, Jun (1993) proposed that the F0 difference has been phonologized in the Seoul and Chonnam dialects at the level of the accentual phrase. In particular, she finds that a LH..L(H) intonation contour is replaced by HH…L(H) after a tense or aspirated consonant, as indicated by the pitch contours in (3) that are associated with the three contrasting ideophones *tallaŋ-tallaŋ* (lax), *thallaŋ-thallaŋ* (aspirated), and *t*allaŋ-t*allaŋ* (tense).

(3)



In a follow-up study, Jun (1996) demonstrated that the F0 difference found at the release of the consonant and onset of the following vowel persists well into the articulation of the syllable. In this respect Korean differs from English and French, where the F0 difference decays rapidly after the release of the stop consonant. Compare the figures in (4) from Jun (1996) showing F0 measurement points at 20 ms. intervals.

(4)



This finding suggests that the first syllable in the Korean Accentual Phrase has a different tonal target H vs. L, depending on the underlying laryngeal state of the phrase-initial consonant. It could be formalized in the grammar by a rule (5) spreading the feature [±stiff vocal folds] (Halle and Stevens 1971) from the consonant to the vowel. As Halle and Stevens note, the acoustic correlate of stiffening/slackening the vocal folds in the articulation of a vowel is a relative increase/decrease in the rate of vibration of the folds and hence a change in pitch.

(5) C V
|
[±stiff vf]

In their evolution from Middle Korean, the Seoul, Chonnam, and Cheju dialects have lost the lexical F0 contrasts that characterized the pitch accent system of earlier stages of the language. However, lexical pitch contrasts are preserved in the Kyungsang (as well as in the Hamgyong) dialects. In disyllables Kyungsang distinguishes the three contrasting tonal patterns shown in (6a). In monosyllables (6b) the Southern Kyungsang variety (Pusan region) preserves a high vs. rising contrast that corresponds to a short vs. long contrast in the Northern Kyungsang dialects (Taegu region). See Ramsey (1978) for discussion of the diachronic development of the Korean tones.

(6) a. HL kácì 'kind'
HH ká:cí 'branch'
LH kàcí 'eggplant'

b. mál 'horse'
mǎl 'speech' (Pusan)
má:l 'speech' (Taegu)

The Kyungsang dialects have also preserved the three-way lax-tense-aspirated contrast in stops; however, for many speakers the contrast has been eliminated in fricatives. Since F0 is used for lexical tonal contrasts in Kyungsang, the question naturally arises as to whether the laryngeal contrast has different phonetic correlates in this dialect as compared to nontonal dialects such as Seoul. Is F0 still a correlate of the laryngeal contrast in stops in Kyungsang? If so, how is it deployed? We might imagine two scenarios here. First, since the language contrasts H and L tones, the F0 correlates of the laryngeal contrast might be confined to the onset of the vowel, comparable to what is found in English (cf. (4) above). Alternatively, if the H vs. L contrast is implemented via a tonal feature that divides the pitch space into an upper and lower register, then Kyungsang could have the same process (5) that spreads [±stiff vf] as in the Seoul and Chonnam dialects. Under this scenario the F0 for the vowel would express two separate features: a basic [±Upper] tonal contrast (H vs. L) and a modulating effect of [±stiff vf] (which itself reflects the underlying voicing contrast in obstruents). Finally, if one thinks of F0 space as a resource that must be shared between different phonological contrasts, then since the H vs. L tonal contrast has a prior claim on the space, one might expect the magnitude of the F0 correlate of the laryngeal distinction to diminish with a possibly compensating increase in the contribution of the other phonetic correlates of the voicing contrast such as VOT and voice quality (open quotient). To the best of our knowledge, this topic has not been addressed before in Korean linguistics. In sum, our study was designed to investigate the way F0 is utilized to implement the tonal and laryngeal contrasts in Kyungsang Korean and to see if the scope and magnitude of other phonetic correlates to the lax-tense-aspirated distinction are comparable to those reported for Seoul and Cheju speech in (Cho et al 2002).

2. Methods

Seven Kyungsang speakers were recruited as subjects for the study. Three originate from the Southern Kyungsang area near Pusan and four from the Northern Kyungsang area near Taegu. Five of the subjects were females and two were males. Subjects ranged in age from their mid twenties to mid forties. Our corpus consists of disyllabic words (mostly nouns) drawn from each of the three contrasting HL, HH, and LH tonal patterns in which the initial consonant has been systematically varied along several dimensions. First, we collected lexical items containing an initial plosive (labial, dental, palatal, dorsal) belonging to the lax-tense-aspirated categories for a total of 36 words. The corpus also contains six words beginning with the nasals [m] and [n], which served as controls. Finally, we also recorded six items with initial [s]--three cognates to the lax [s] and three cognates to the tense [s*] of the Seoul dialect. The overall corpus thus consists of 48 words. We attempted to maintain the same vowels so most of our lexical items contain the vowel [a] in the first syllable. Not all possible tonal plus consonant combinations occurred as disyllables in the Korean lexicon. In these cases we used monosyllables followed by the nominative case particle (*ka* after a vowel and *i* after a consonant) to fill in the gaps. (See Appendix A for the list of words).

The subjects were recorded pronouncing these 48 words in a sentential frame. The words in the list were randomized; each subject read the list twice for a total of 96 utterances per subject. The utterances were recorded in a soundproof booth and analyzed using Pratt or Klatt Tools. A number of measurements were taken including VOT as well as open quotient (H1-H2) and F0 at four points: at the onset of the first vowel shortly after the release of the preceding consonant, at the mid point of the first vowel, at the onset of the second vowel, and at the mid point of the second vowel.

3. Results

3.1 VOT

Cho et al (2002) report the VOT measurements in (7a) for their Seoul (four male subjects) and Cheju (eight male subjects) speakers. Our results are indicated in (7b). While the values for the fortis/tense series are comparable, the values for the lax and aspirated stops are smaller than those in the Cho et al study. Some of the differences are attributable to the fact that their words were elicited in isolation while ours were embedded in a sentence. Cho et al (2002) also comment on the difference between Seoul and Cheju dialects, citing observations of Silva (1992) and N. Han (1998) that VOT values for lax and aspirated stops have increased over the past 50 years; they remark that Cheju speech may be conservative and Seoul more dynamic for this as well other factors.

(7)		Tense	Lax	Aspirated
a.	Seoul	20 ms.	70 ms.	120 ms.
	Cheju	20	45	105
b.	Kyungsang	22	50	81

3.2 Open Quotient

Cho et al (2002) report the results depicted in figure (8) for the H1-H2 open quotient for the Seoul and Cheju dialects. Although there is some speaker variation, the lax and tense stops appear at opposite poles for this measure of voice quality, with the aspirate and control sonorant falling in between.

(8)

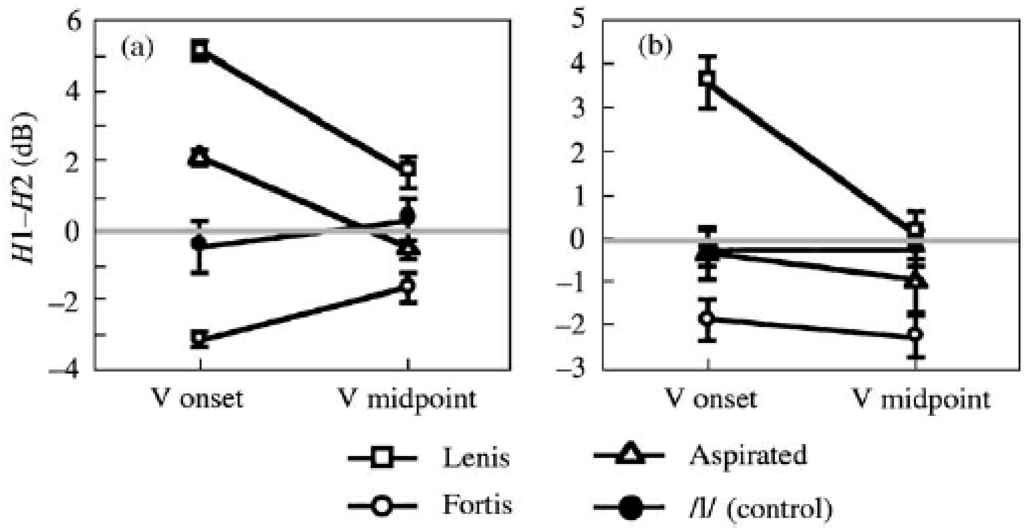
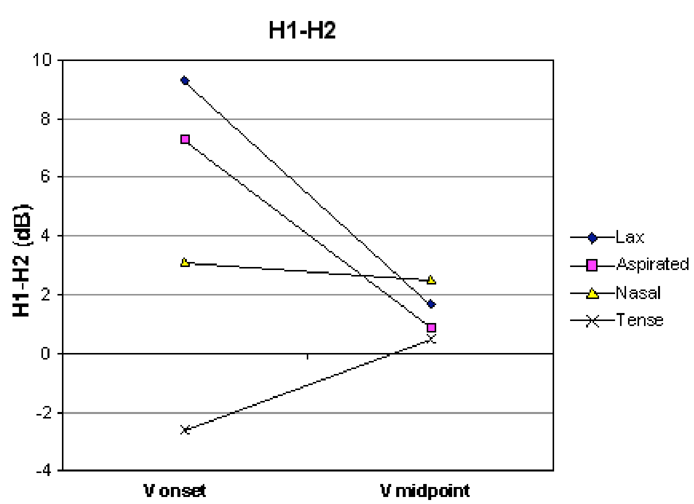


Figure 6. Difference between the amplitudes (dB) of the first harmonic ($H1$) and the second harmonic ($H2$) for different stop categories and /l/. Error bars indicate standard errors. (a) Seoul and (b) Cheju.

Our data (9) show a similar tense < nasal < aspirated < lax ordering with good separation at V-Onset and a significant reduction by the time the middle of the vowel is reached. Nevertheless even at V-Mid point the average value for tense is lower than for lax for all speakers. Another point worth mentioning is that the magnitude of the difference between the tense and lax categories is c. 11 db while the values reported for Seoul (8 db) and for Cheju (6 db) are significantly smaller.

(9)



The table below summarizes the statistics for the Open Quotient correlates of the tense vs. lax contrast in Korean stops. The difference is highly significant at V-Onset but loses significance by the V-Mid point.

(10) Repeated Measures ANOVA for H1-H2 for tense vs. lax stops

	df	F	p > F
V-Onset	(1,6)	49.53	0.0000
V-Mid	(1,6)	2.86	0.1191

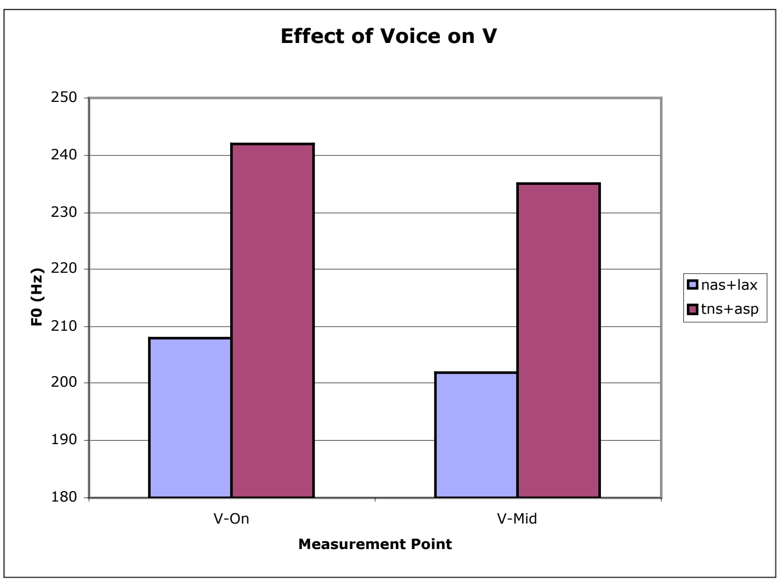
3.3 F0

Since absolute F0 values differ between male and female speakers, we separated out the data from our male subjects and added an additional female for a total of eight subjects, six female and two male. We report here the results for the female subjects. Both male speakers exhibited comparable data and distinctions.

Figure (11) shows the effect of the laryngeal category of voicing ([±stiff vf]) on the F0 value of the initial syllable at both V-Onset and V-Mid points for the six female subjects. As in the Seoul and Chonnam dialects, the tense and aspirated stops boost the F0 value in both V-Onset as well as V-Mid positions as compared to the nasal and lax stops. The effect is slightly stronger at V-Onset. The fact that the V-Mid difference is comparable to the V-Onset one thus supports the second hypothesis that the underlying [±stiff vf] feature has spread from the onset consonant to the vowel, just as in Seoul and Chonnam. For the Cho et al (2002) study, where a phrasal tonal contrast was presumably not at play (words recorded in isolation), the F0 difference was on the order of 15 Hz. But for Jun (1996), where an effect on tonal category was in play (i.e. the LH…LH vs. HH…LH phrasal contour), the difference was much greater: 70-80 at V-Onset and 40-50 at V-mid. Our results are intermediate with a c. 30 Hz. difference at both V-Onset and V-Mid.

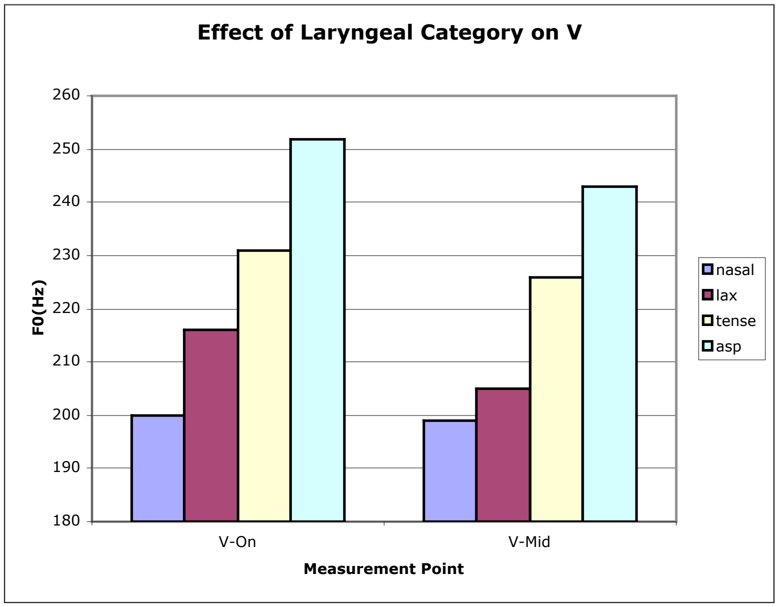
One possible explanation for the discrepancy in scaling is that in Kyungsang the F0 space is being shared for the realization of both a lexical tonal as well as a laryngeal contrast while in the Chonnam and Seoul dialects the entire space is available for expressing the [±stiff vf] laryngeal distinction.

(11)



Within the [±stiff vf] voiced vs. voiceless categories there is a further differentiation that is noteworthy. Figure (12) shows that at both measurement points the F0 values for the lax and aspirated categories are boosted relative to the nasal and tense categories. Once again the values are slightly higher at V-Onset. It is well known that the lax series has a significant degree of breathiness in phrase-initial position, as reflected in the voice quality (open quotient) as well as the VOT meaures. Our data suggest that this feature as well is shaping the F0 values--to a smaller but still not insignificant degree.

(12)



The statistical results of repeated measures ANOVA for the categories of voice (nasal and lax vs. tense and aspirated) and breathiness (nasal and tense vs. lax and aspirated) at both the V-Onset and V-Mid points are summarized in (13). Following the suggestion of a reviewer, we separate out the results for each of the three tonal patterns. The data indicate that the laryngeal category of the onset consonant has a systematic effect on the F0 value of the following vowel that is highly significant at both the onset and middle of the vowel. All three tonal patterns are affected. The effect of voice is greater than breathiness.

(13) **Repeated Measures ANOVA**

a. HL tonal pattern

V-Onset	df	F	p > F
voice	(1,5)	114.43	0.0001
breathiness	(1,5)	8.22	0.0351

V-Mid	df	F	p > F
voice	(1,5)	57.28	0.0006
breathiness	(1,5)	21.74	0.0055

b. HH tonal pattern

V-Onset	df	F	p > F
voice	(1,5)	66.07	0.0005
breathiness	(1,5)	8.50	0.0332

V-Mid	df	F	p > F
voice	(1,5)	45.97	0.0011
breathiness	(1,5)	7.11	0.0446

c. LH tonal pattern

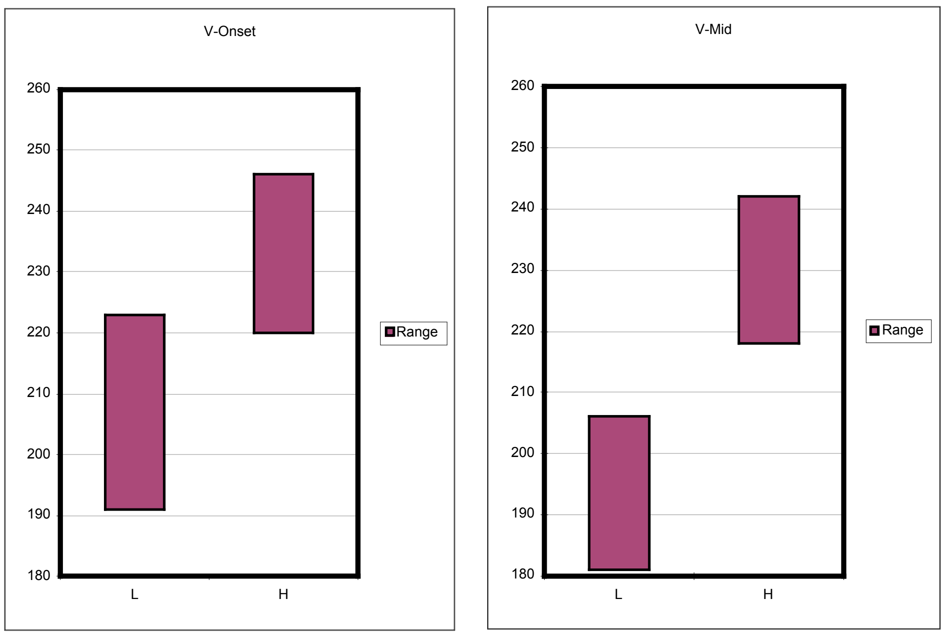
V-Onset	df	F	p > F
voice	(1,5)	26.30	0.0037
breathiness	(1,5)	9.76	0.0261

V-Mid	df	F	p > F
voice	(1,5)	24.72	0.0042
breathiness	(1,5)	7.66	0.0395

In sum, the laryngeal state of the onset consonant has a significant effect on the F0 values of the following vowel--not just at its onset but also deep inside the syllable. This is expected if rule (5) is also operative in the Kyungsang dialects.

But what about the actual H vs. L tonal contrast itself? How does rule (5) divide the tonal space? Figure (14) shows the range of average F0 values across the six female subjects. The L tone category spans a range from 191 to 223 Hz at V-Onset and the H from 220 to 246 Hz. Thus, at V-Onset the voiceless and H tone and voiced and L tone combinations are well separated while the H tone voiced and L tone voiceless combinations overlap considerably. The latter pair separates out a bit more at V-Mid where L spans a range from 181 to 206 and the H from 218 to 242.

(14)



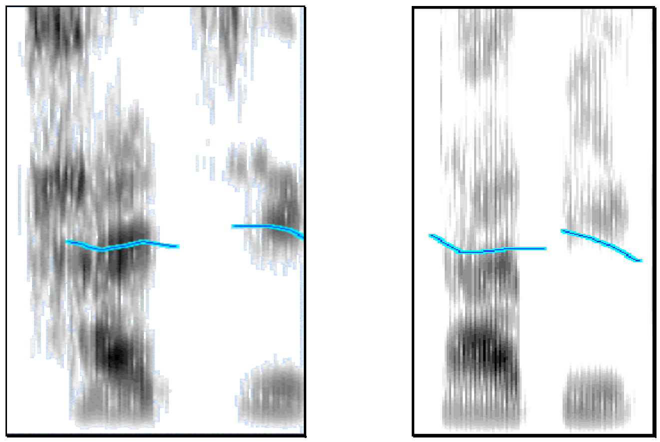
The discussion so far indicates that the effect of [±stiff vf] originating in the onset consonant spreads to the following vowel and thus overlays the basic H vs. L [±upper] tonal contrast. This results in four possible feature combinations that divide the F0 space into four regions or levels indicated in (15).

(15)

(1)	[+upper, +stiff vf]	p^há, p*á
	[+upper, -stiff vf]	pá < /bá/, má
	[-upper, +stiff vf]	p^hà, p*à
	[-upper, -stiff vf]	pà < /bà/, mà

However, for a couple of Northern Kyungsang speakers the peaks in the HL and HH categories are consistently delayed into the onset of the following syllable when the phrase-initial onset consonant is nasal or lax. Figure (16) shows two examples (*pácì* 'pants' and *nápì* 'butterfly'). For these speakers it appears that the F0 effects of [-stiff vf] and H tone are sequenced rather than overlaid. The voiced consonants lower the F0 delaying the realization of the peak until the onset of the following syllable. The restriction of this phenomenon to H tones after the [-stiff vf] nasal and lax consonants ([má] and [pá] < /bá/) suggests that it may be a strategy to eliminate overlapping of the two interior F0 zones in (15).

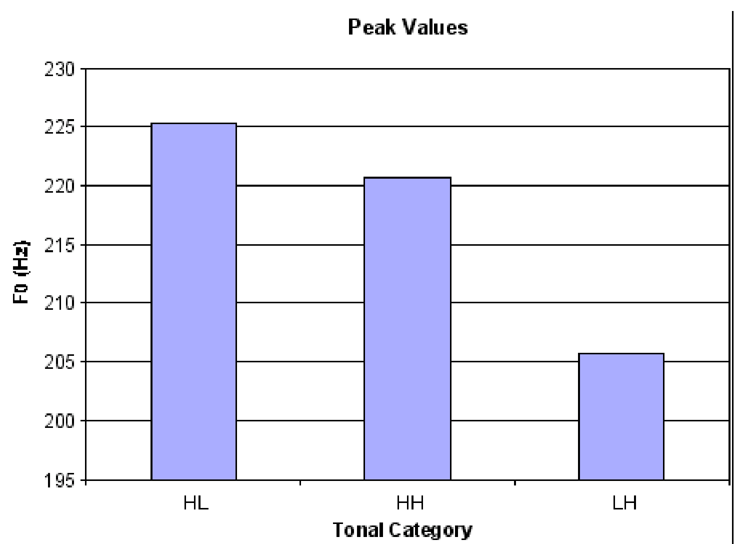
(16)



pácì nápì

Figure (17) shows the average F0 values for the H peaks in the three tonal categories: HL, HH, and LH. There is a small but consistent difference of c. 5 Hz between HL and HH and a somewhat larger difference of c. 15 Hz between the peak values in HH vs. LH. These differences make sense given what is known about tonal scaling cross-linguistically. It has been shown that a H tone is implemented at a higher F0 value when followed by a L tone in Hausa (Maddieson 1977), Mandarin (Xu 1993), Yoruba (Laniran 1992), and many other languages. This is presumably the reason for the boost in the peak of the HL tonal pattern relative to the HH one. Also, H tones are frequently downstepped after an L in many African languages as well as Japanese (Pierrehumbert and Beckman 1988). This plausibly explains the relatively depressed peaks in the LH category.

(17)



There is another way that we can test for the effect of a L on a preceding H. Monosyllables occur in three different morphophonemic categories in Kyungsang, as shown by the table in (18). The F0 realizations of the HL and HH categories are virtually identical for monosyllables in isolation but differentiate themselves when another syllable follows.[1] The rising tone category occurs in Pusan while Taegu has a long vowel.

(18)

category	isolation	noun + nom. case		
HL	súl	súl-ì	'wine'	
HH	múl	múl-í	'water'	
LH	thǎl	thàl-í	'mask'	Pusan
HH	tháal	tháal-í	'mask'	Taegu

The nouns in the HL pattern allow us to test the values for the peak in isolation and compare it with the result when the low tone suffix is added. If L boosts a preceding H then the difference should be comparable to that observed between the peak values in the HL vs. HH disyllables. A list of ten HL nouns (see Appendix B) were recorded by two speakers in isolation as well as embedded in a phrase. For one speaker the F0 difference between the H stem by itself and when followed by the nominative suffix was of comparable magnitude to that shown in figure (17) (viz. c. 7 Hz at V-Mid) while for the other speaker it was much larger (c. 35 Hz).

(19)

	H		**H+L**	
speaker	V-Onset	V-Mid	V-Onset	V-Mid
YP	170	155	167	162
HS	234	215	257	251

3.4 s* vs. s

Kyungsang speakers are notorious for failing to distinguish between tense [s*] and lax [s] in their speech, indicating an s* > s sound change. The lax [s] is aspirated in Seoul Korean in initial position but lacks this aspiration word-medially (paralleling the medial voicing of lax stops). The tense [s*] is longer in medial position (like all tense consonants). We were curious to see to what extent these differences are reflected in our speakers. Being highly educated they might be expected to retain or import the [s] vs. [s*] distinction of the standard Seoul dialect into their speech.

As far as the H1 - H2 measure is concerned, our subjects retain this contrast in both V-Onset as well as V-Mid points. While the average difference between [s] and [s*] is slightly smaller than between lax and tense stops at V-Onset, it is on average both greater and more reliable at V-Mid.

(20) H1 - H2

	[s]	[s*]	df	F	p > F
V-Onset	8.3	-1.50	(1,6)	34.27	0.0001
V-Mid	3.2	-0.18	(1,6)	23.44	0.0005

	[p]	[p*]	df	F	p > F
V-Onset	9.3	-2.6	(1,6)	49.53	0.0000
V-Mid	1.7	0.5	(1,6)	2.86	0.1191

As far as F0 is concerned, Cho et al (2002) report speaker variation as to whether or not the tense [s*] raises F0 with respect to lax [s] comparable to the way other tense consonants raise F0 relative to lax ones. In particular, the mean F0 value of 137 Hz for lax [s] falls between the lax stops (125 Hz) and the aspirated (147 Hz.). The mean F0 following a tense [s*] (145 Hz) was similar to that following a tense stop (144 Hz).

[1] The earlier literature (e.g. Martin 1992:35) reports a three-way High, Mid, Low distinction for the monosyllabic realization of the stems belong to the HL, HH, and LH classes, respectively. Our speakers have merged the first two categories in the isolation form.

In our data there was speaker variation on this point as well. Four of the seven subjects had no reliable distinction between [s*] and [s] as far as its effect on F0 was concerned. For these speakers the F0 value for the [s*] and [s] fricatives lies closest to the aspirated stop and is quite distinct from the lax stop value. For the remaining three subjects, lax [s] is associated with a c. 10 Hz increase in F0 over tense [s*] in the following vowel. For these speakers as well the [s] was closest to the aspirated stops, which it will be recalled elevate the F0 value the most. Thus, as far as its effect on F0 is concerned, the Kyungsang [s] is squarely in the aspirated category. In this respect our results differ from Cho et al (2002) who report higher F0 after the tense [s*] as compared to the lax [s].

In sum, the [s] vs. [s*] contrast is both robustly and reliably expressed by our subjects in terms of voice quality but not in terms of pitch, showing that these are separately controlled enhancement gestures.

4. Summary and Conclusion

In this study we have identified several factors that determine the scaling of the F0 values for the initial syllable of an accentual phrase in the Kyungsang dialect of Korean. First, there is the basic H vs. L tonal contrast. Second, our major finding is that just as in the Seoul and Chonnam dialects, F0 in Kyungsang is boosted after underlying voiceless consonants relative to underlying voiced ones. This difference appears not just in the first few periods following the release of the consonant but deep inside the syllable as well. We formalized this effect as a spreading of the Halle and Stevens (1971) feature [±stiff vf] to the vowel. Since the lax consonants are voiceless and relatively aspirated/breathy in phrase-initial position, this process reflects their underlying voicing and hence is a form of synchronic tonogenesis. Third, the aspirated and lax (breathy) consonants increase the F0 of the following vowel relative to the nasals and tense consonants, respectively. However, this effect is not as strong or reliable as the effect of voice. Finally, the surrounding tonal environment also influences the scaling of the H tones. In particular, the following L raises the peak of the HL pattern relative to HH while the peak of the LH pattern is lowered relative to HH. Both reflect common cross-linguistic effects of low tones on neighboring high tones. In terms of trade-off relations, we suggested that the scaling differences between the Kyungsang and Seoul dialects might reflect the fact that in the former dialect F0 expresses two phonological distinctions (tone and voicing) while in the latter it just expresses voicing. The larger differences between tense and lax consonants for the H1-H2 measure in the Kyungsang dialect as compared to Seoul could be a compensating factor. Finally, we also saw that our subjects preserve a distinction between tense and lax [s] as far as the effect of voice quality on the following vowel is concerned. However, there was no comparable difference in F0 in the vowel. Here is another case where the F0 correlate of the laryngeal contrast is diminished, arguably because F0 is primarily utilized to express a tonal contrast in Kyungsang.

Appendix A

Pusan		Taegu	
kácì	'kind'	káwì	'scissors'
kácí	'branch'	kák-í	'angle'
kàcí	'eggplant'	kàm-í	'persimmon'
k*ángì	'unyielding courage'	k*óch-ì	'flower'
k*ákí	'peeling'	k*é ká	'sesame'
k*àpúl	'naughtiness'	k*àmáng	'black'
k^{h}án-ì	'partition'	k^{h}átɨ	'card'
k^{h}ál-í	'knife' + nom.	k^{h}élól	'carrol'
k^{h}òíl	'coil'	k^{h}àllyúm	'Kalium'
pán-ì	'class'	pácì	'trousers'
pál-í	'foot'	páp-í	'rice'
pə̀lî	'barley'	pàm-í	'chestnut'
p*áng-ì	'jail'	p*ángk*ù	'puncture'
p*áng-í	'jail'	p*átá	'butter'

p*àlɨ́m	'being fast'	p*àllé	'laundry'
p^{h}ál-ì	'arm'	p^{h}áthì	'party'
p^{h}án-í	'board'	p^{h}á-ká	'onion'
p^{h}àcú	name of city	p^{h}àsán	'bankruptcy'
mál-ì	'horse'	mákè	'cap'
mál-í	'unit of measure'	más-í	'taste'
màlú	'floor'	màtí	'joint'
cáng-ì	'market'	cálì	'seat'
cám-í	'sleep'	cá ká	'ruler'
càngmí	'rose'	càsé	'pose'
c*ák-ì	'pair'	c*ákà	'imitation'
c*ákí	'to squeeze'	c*ím-í	'to steam'
c*àcáng	'black sauce'	c*àlís	'shock'
c^{h}á-kà	'car'	c^{h}âì	'difference'
c^{h}ám-í	'truth'	c^{h}ó-ká	'candle'
c^{h}àpí	'fare'	c^{h}àkí	'next term'
ták-ì	'chicken'	ték-ì	'home'
tál-í	'moon'	tám-í	'fence'
tàlí	'leg'	tàyáng	'diverse'
t*ákwì	'slap in the face'	t*ákcì	'label'
t*ál-í	'daughter'	t*ál-í	'daughter'
t*àlɨ́m	'following'	t*àlkí	'strawberry'
t^{h}ám-ì	'desire'	t^{h}élə̀	'terror'
t^{h}ál-í	'mask'	t^{h}óng-í	'can'
t^{h}ə̀lə́k	'hair'	t^{h}àlák	'corruption'
nán-ì	'orchid'	nápì	'butterfly'
nám-í	'other person'	nám-í	'stranger'
nàmú	'tree'	nàgwí	'donkey'
s*ák-ì	'bud'	s*áùm	'quarrel'
s*ál-í	'rice'	s*úk-í	'mugwort'
s*àlí	'bush'	s*àngbáng	'both'
sáng-ì	'table'	sán-ì	'mountain'
sáang-í	'prize'	sál-í	'skin'
sàngá	'ivory'	sàláng	'love'

Appendix B

k^{h}óng	'bean'
p^{h}ál	'arm'
sán	'mountain'
t^{h}ə́k	'chin'
k^{h}án	'partition'
pát	'field'
t*óng	'manure'
páng	'room'
táng	'sugar'
káng	'river'

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