Consonant-Tone Interaction in Thai: An OT Analysis

doi:10.6519/TJL.2006.4(2).1

Taiwan Journal of Linguistics, 4(2), 2006

臺灣語言學期刊, 4(2), 2006

作者/Author： Sugunya Ruangjaroon

頁數/Page： 1-66

出版日期/Publication Date：2006/12

Taiwan Journal of Linguistics
Vol. 4.2, 1-66, 2006

CONSONANT-TONE INTERACTION IN THAI: AN OT ANALYSIS*

Sugunya Ruangjaroon

ABSTRACT

Thai tones have traditionally been characterized in terms of a correlation between tones and syllable type (Gandour 1974, Tumtavitikul 1993, Intrasri 2001, Morin and Zsiga 2006). However, I show that a more interesting set of observations can be made on the distribution of Thai tones in which they can be explained as a consequence of consonant-tone interaction within an OT framework. The observations are that unaspirated stops are not compatible with a high tone vowel in the nucleus. An obstruent coda has the effect of shortening the vowel in the nucleus, something that is testable via phonetic experimentation. This shortening effect places a burden on either phonetic perception or production, so that the five-way contrast is neutralized to a two-way contrast. The shortening effect places an especially strong burden on contour tones, so these tones are preferably excluded from the two-way contrast. The best two-way contrast among the three level tones is a simple high-low contrast, which is more readily perceivable than a low-mid or high-mid contrast. I also show that unaspirated obstruents prefer to be adjacent to a non-high tone. Unaspirated coda are allowed to be adjacent to a preceding high tone in a short vowel, but a long vowel presents an opportunity to insert a low tone on the second tone bearing unit, thus producing a two-way contrast between low and falling tone instead. This insertion of a low tone is done in order to avoid a situation where a high tone vowel would be adjacent to the unaspirated consonant. A high-tone vowel- unaspirated coda sequence would result otherwise. It is argued that the attested patterns of consonant-tone interaction in Thai are captured by conjoining two markedness constraints in addition to the simple markedness constraints.

* I would like to express my thanks to Jeremy Perkins for his very insightful and helpful discussions and comments. This paper would not have turned out the way it did without his suggestions. I am especially grateful to the anonymous reviewers of the TJL journal. Thanks also to Patricia A. Shaw, Lisa Matthewson, Rose-Marie Déchaine, Gunnar Ólafur Hansson, Brian Gick, and Douglas Pulleyblank for their comments. I am, however, solely responsible for the content of the paper.

1. INTRODUCTION

In this paper, I adopt an Optimality Theoretic framework to provide an account for the restrictions on the distribution of Thai tones with a focus on vowel length and consonant-tone interaction. It is argued that the interaction of markedness constraints with faithfulness constraints (Prince & Smolensky 1993) provides a coherent explanation of such distributional restrictions within the Thai tonal system. I will first provide, in Section 2, an overview of Thai phonological structure and discuss theoretical issues in Thai tonology concerning how vowel length correlates with tone (Gandour 1974, Tumtavitikul 1993, Intrasri 2001, Morin and Zsiga 2006). Section 3 discusses how consonant-type interacts with tone and a further and particularly interesting set of observations is presented, adding the need for more constraints on the distribution of Thai tone. Section 4 provides an OT account of these restrictions. Section 5 discusses remaining issues.

2. THAI PHONOLOGY AND LEXICAL TONES

2.1 Thai Phonological Structures

In this section, I will introduce Thai phonology and discuss how vowel length and consonants are the major determinants of tones. The consonant and vowel inventories of Thai are given below.

(1) Consonant phoneme inventory

Consonantal	Bilabial	Labio-dental	Alveolar	Palatal	Velar	Glottal
Stop	p, p^h, b		t, t^h, d		k, k^h	ʔ
Affricate				c, c^h		
Fricative		f	s			h
Lateral			l			
Trill			r			
Nasal	m		n		ŋ	
Glide	w		y[1]			

[1] Phonetically, this sound is post-alveolar.

All consonants can occur in onset position. Only TL[2] and Tw clusters are allowed in onset position. Coda position is subject to additional constraints. Only stops, nasals and glides can occur as a coda. In other words, fricatives, and the liquids, /l/ and /r/ cannot occur in coda position. Additionally, the contrast between unaspirated and aspirated stops is neutralized in coda position (see coda neutralization of aspiration in 38). Only unaspirated voiceless stops are allowed here. The pattern of coda neutralization is shown below in (2):

(2)	a.	*pʰápʰ	*pʰáb	pʰáp	'fold'
	b.	*cʰátʰ	*cʰád	cʰát	'clear'
	c.	*tàkʰ	*tàg	tàk	'dig in'

Consonant clusters are not allowed in coda position. An undominated constraint $*CC\#]_{\sigma}$ can account for this. Note that glides are not part of the nucleus in Thai. Evidence comes from the fact that *CVGR, *CVVGR, *CVGT and *CVVGT syllable types are never allowed. However, glides are allowed word-finally, thus indicating they are allowed in coda position.

(3)	way	'age, year'	*wayn	*wayp
	yaay	'grandmother'	*yaayn	*yaayt
	waaw	'sparkle, glitter'	*waawn	*waawk

(4) Vowel phoneme inventory

Vowel	Front Unrounded	Central Unrounded	Back Rounded
High	i iː	ɨ ɨː	u uː
Mid-high	e eː	ə əː	o oː
Mid-low	ɛ ɛː		ɔ ɔː
Low		a aː	

[2] Abbreviations are as follows: O = obstruent, R = sonorant, T = stop, L = liquid, N = nasal, G = glide and V = vowel.

(5) Syllables rhymes with glides

Vowel	Front Unrounded	Central Unrounded	Back Rounded
High	iw		uy
Mid-high	eːw	əːy	oːy
Mid-low	ɛːw		ɔːy
Low		ay aːy aw aːw	

Short and long vowels are contrastive. All front vowels can have [w] as a coda. As for the high front vowel, only the short vowel occurs with a [w], while the mid front and low front vowels allow only long vowels to occur with the glide. No *iːw, *ew, *ɛw are not allowed as rhymes in Thai. The back vowels, on the contrary, can only have [y] as a coda, and not [w]. *uːy, *oy, *ɔy are not allowed, and therefore they pattern the same way as the front vowels with respect to vowel length. The long mid central vowel can only occur with [y], while low central vowels can have both glides as a coda, and allow both short and long vowels. Note further that high central vowels are not compatible with a glide in coda position.

(6) Diphthong inventory

	Front	Central	Back
High	i iː	ɨː	u uː
Mid			
Low		a	

There are five diphthongs in Thai; ia, ɨa, ɨːa, ua, uːa. However, these short diphthongs are restricted to loanwords and onomatopoeia. These short diphthongs only occur with ʔ in coda position, as shown in (7). Diphthongs rise in sonority over their duration from the high vowels (i.e. i, ɨ and u) which are less sonorous, to the more sonorous low vowel [a].

(7) kía ʔ *kíak loanword from Chinese ‘wooden sandals’
yúa ʔ loanword from Chinese ‘angry’
pʰìa ʔ onomatopoeic ‘a sound like that of slapping’
pʰùa ʔ onomatopoeic ‘a sound like that of slapping’

Long vowel diphthongs such as [iːa], [ɨːa] and [uːa] allow all coda consonants that are legitimate codas including glides, but not ʔ.

(8)	pʰû:ak	*pʰû:aʔ	'all'
	rɨ̂:aʔ		'story'
	di:aw		'one, single'
	sŭ:ay		'beautiful'

Therefore, vowel length is not contrastive for diphthongs. It could also be that the coda is neutralized i.e., the coda-type is predictable based on the vowel length.

2.2 The Interaction of Thai Tones with Vowel Length

Thai has five contrastive lexical tones[3] but not all syllable shapes are allowed to have all five tones. The data in (9) gives an example of CVV long vowel syllables that can have all five tones.

(9)	a mid tone	[pʰɛ:]	'a raft'
	a low tone	[pʰɛ̀:]	'to spread'
	a falling tone	[pʰ(r)[4]ɛ̂:	'to broadcast'
	a high tone	[pʰɛ́:]	'to lose'
	a rising tone	[pʰ(l)ɛ̌:]	'a wound'

Thai tones show a restriction on the co-occurrence between certain groups of tones and types of syllables. Syllables with two or three vowels can have five contrastive tones while those with one vowel can only have two possible tones: low or high. This suggests that there is a correlation between tonal contour and vowel length. That is, contour tones occur only in syllables with, minimally, two tone bearing units (TBUs). TBUs are defined in this paper as moras that are linked to a sonorant segment occurring in the rhyme of a syllable, assuming that long vowels and diphthongs constitute two segments.

Since all five tones can occur on vowels in CVV and CVR syllable types and only high and low tones occur on CVT syllable types, this suggests that codas play a crucial role with respect to restrictions on tone. Apparently, the former syllable types do allow contour tones,

[3] A word may have more than one meaning. For convenience, I gloss only one meaning.
[4] A segment in brackets is defined as optional. Some people do not pronounce it in informal speech.

suggests that sonorant codas are TBUs if we assume that contour tones are sequences of level tones (Pulleyblank 1997). The fact that the latter syllable type only can carry level tones implies that obstruent codas are not TBUs. Assuming that the moras is the unit to which tones link, we still need take into account that tone does not seem to link to a moraic obstruent coda. Therefore, I define a TBU simply as any mora in the rhyme that is not linked to an obstruent coda. The constraint *obstruent must be undominated, in order to enforce this.

tone

This is structurally illustrated below. Note that the structure below also applies for the other values of tones. I use the low tone as an arbitrary example to illustrate this.

(10) Short vowels
Level tones

```
C V  V          C V R          C V T
 |   |           | |            |
TBU[5] TBU       TBU  TBU       TBU
  \ /             \ /            |
   L               L             L
```

Contour tones

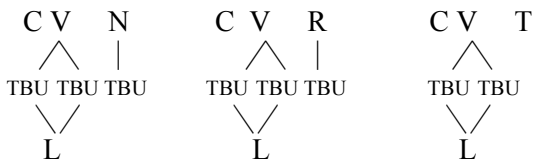
```
                C V  V          C V R          *C V T         *C V T
                   | |            | |             |              |
                 TBU TBU        TBU TBU          TBU            TBU
                  | |            | |             /\              |
Falling:          H L            H L            H L            H L
Rising:           L H            L H            L H            L H
```

Therefore, there is maximally one tonal autosegment per TBU. As for long vowels as shown in (11), sonorant codas do not link to any level tone. Two TBUs, on the other hand, are permitted to share the first level

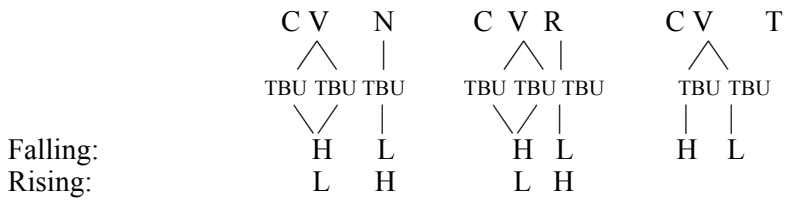
[5] Note that a TBU is a mora structurally. I simply use the notation "TBU" to highlight the fact that only sonorant moraic segments are able to have tones.

tone and sonorant codas link to the second tone composing a contour tone.

(11) Long vowels
Level tones



Contour tones



Short vowel diphthongs (ia and ua) only occur with the default [ʔ] coda (*Cia and *Cua). Only high and low tones are allowed on Ciaʔ and Cuaʔ syllable types. Additionally, they always surface with a ʔ coda. The restriction of level tones on short vowel diphthongs thus suggests that short vowel diphthongs are represented by one TBU. Long vowel diphthongs, in contrast, would contain two TBUs.

(12) Short vowel diphthongs (ia and ua) with default ʔ coda

(13) Long vowel diphthongs (iːa, ɨːa and uːa) with codas.
Level tones

```
C  iː a   R                    C  iː a    T
   | |    |                       | |
 TBU TBU TBU                    TBU TBU
   \ / /                          \ /
    L                              L
```

Contour tones

```
          C  iː a   R     C  iː a   R     *C  iː a   R     C  iː a   T
             | |    |        | |    |        /\     |        /\
          TBU TBU TBU     TBU TBU TBU     TBU TBU TBU     TBU TBU
            \ /    |        |   \ /        |   |   |        |   |
Falling:     H     L        H    L         H   L   H        H   L
Rising:      L     H        L    H         L   H   L        L   H
```

I assume that both $[H\ L\ H]_\sigma$ or $[L\ H\ L]_\sigma$ violate an OCP-Tone constraint. This OCP-Tone constraint does not allow a syllable to contain two identical tonal autosegments whether they are adjacent or not. The constraint *obstruent-tone enforces that tones do not link to obstruent codas. There must also be a constraint that does not allow a TBU that links to two tonal autosegments. These two constraints are inviolable and must rank above the constraints that allow a single tone to link to a TBU or two TBUs. The faith-tone constraint accounts for the fact that tonal autosegments that are in the input tend to be preserved on the surface. The constraint ranking is as follows:

(14) *Obstruent, OCP-Tone, *TBU >> Faith-tone

```
      |                  /\
    Tone               T   T
```

So far, we have seen that the distribution of Thai tones is restricted by vowel length. All five tones can occur on CVV and CV(V)(V)R syllable types. Only high and low tones can occur on CVT and CVʔ syllable types. Low and falling tones occur on CVVT syllable types. These generalizations are summarized in the table below. Note that "+"

means that the phenomena is attested in Thai syllables, while "–" means it is not attested in Thai syllables.

(15) Tonal distribution (Gandour 1974, Tumtavitikul 1993)

Syllable types	Mid	Low	Falling	High	Rising
CVV / CV(V)(V)R	+	+	+	+	+
CVT / CVʔ	-	+	-	+	-
CVVT	-	+	+	-	-

Mid tones do not surface in CVT/CVʔ and CVVT syllable types which is unexpected given that mid is a level tone. I assume that the low tone is the default tone in stressed syllables since low tones surface in every syllable type as shown in table 15, while the mid tone is the default in unstressed syllables. I will not present an analysis of unstressed syllables in this paper but it is an important fact that should be taken into account in a complete analysis. The next section shows how consonant-type has an effect on the tone of both the preceding and the following vowels.

3. THE INTERACTION OF THAI TONE WITH CONSONANT-TYPE

Consonants in Thai have been classified into three classes (Chotikasathian 1991, Tumtavitikul 1993) which correspond to aspirated voiceless obstruents (henceforth C_1), unaspirated voiceless and voiced stops (C_2) and sonorants (C_3).

(16) Consonant-type

Consonant classes	Bilabial	Labio-dental	Alveolar	Palatal	Velar	Glottal
C_1 = [sg]	p^h	f	t^h, s	c^h	k^h	h
C_2 = [cg][6]	p, b		t, d	c	k	ʔ
C_3 = R	m, w		n, l, r, y		ŋ	

The authors (Chotikasathian 1991, Tumtavitikul 1993) have suggested the pattern of tone splitting has resulted from historical sound

[6] Ladefoged and Maddieson (1996) note that voiced stops are "stiff".

changes, which their synchronic analysis is not taken into account here. I, however, assume that this is not the case and that a synchronic analysis is valid. I, as a native speaker of the language, have observed the more refined generalization that a level high tone does not occur when a C_2 is in onset position. In other words, with respect to onsets a full five-way tonal contrast is seen except when the onset is C_2. Additionally, with respect to codas, if the coda is an obstruent, then the five-way contrast is neutralized to a two-way contrast except when the onset is a C_2 segment, in which case only the low tone is permitted. If the vowel is short, then this contrast is between the low tone and the high tone. If the vowel is long, then this contrast is between the low tone and the falling tone. As mentioned above, only high and low tones occur in CVT syllable types; and yet, high tones still do not occur when a C_2 segment is in onset position. As for $C_{1/3}$VVT syllable types, only the low and falling tones can occur. In this case, it can be observed that the falling tone does not occur when a C_2 is in onset position (*C_2ûvvT). In addition to this, [h] behaves more like a C_2. The high tone does not occur when [h] is in the onset. But more interestingly, falling tones do surface. Falling tones are also realized on vowels in C_2VV and C_2VR syllable types. These generalizations[7] are shown in (17) and all monosyllabic words are listed in the appendices.

(17)

Syllable types	Mid	**Low**	Falling	High	Rising
$C_{1/3}$VV / $C_{1/3}$V(V)(V)R	+	+	+	+	+
C_2VV / C_2VR	+	+	+	–	+
$C_{1/3}$VT	–	+	-	+	-
C_2VT	–	+	-	–	-
$C_{1/3}$VVT	–	+	+	-	–
C_2VVT	–	+	–	–	–

[7] Note that Thai speakers only allow high tones in onomatopoeia, loanwords and proper names (i.e., nicknames) when C_2 segments are onsets. These onsets are not used in the nativized Thai lexicon. In order to capture this pattern as a property of the Thai lexicon, we must constrain it to exclude the high tone in these environments. The data is shown in the appendices.

In addition to empirical evidence (see the appendices), there is also evidence from a word game. The high tone does not usually occur on *C_2 v́vw syllable types. Additionally, morphemes in Thai are usually monosyllabic. When a monosyllabic word combines with another monosyllabic word to form a bisyllabic word, the tones do not change. The word games shown below reveal that bisyllabic or trisyllabic words conform to the monosyllabic generalization because they consist of two or three morphemes. The onsets are never switched. The rhymes of the second syllable are reversed with those of the first syllable. Tones can either remain stable or can be reversed along with the rhymes. The data is shown below.

(18)						WG_1	WG_2	
a.	pʰǒm	'hair'	sân	'short'	pʰǒm.sân	pʰân.som	pʰan.sôm	'short hair'
b.	kʰàp	'to drive'	rót	'car'	kʰàp.rót	kʰót.ràp	kʰòt.ráp	'to drive a car'
c.	tʰɔ̌:n	'to pull out'	cay	'heart'	tʰɔ̌:n.cay	tʰay.cɔ̌:n	tʰay.cɔ:n	'to sigh'

However, the data in (19) show that when rhymes are switched and carry their original tone along that the last syllable ends up creating a *C_2v́vw syllable type. The reversed tones yield unacceptable outputs according to native speakers playing the game because high tones are not allowed on *C_2v́vw syllable types.

(19)						WG_1	WG_2	
a.	cʰá:w	'morning'	bà:y	'afternoon'	cʰá:w.bà:y	*cʰà:y.bá:w	cʰá:y.bà:w	'morning (and) afternoon'
b.	lɛ́:w	'already'	kan	'self'	lɛ́:w.kan	*lan.kɛ́:w	lán.kɛ:w	'what a nuisance'
c.	kʰíw	'eyebrows'	kòŋ	'arched'	kʰíw.kòŋ	*kʰòŋ.kíw	kʰóŋ.kìw	'arched eyebrows'
d.	kɛ̂:w	'glass'	rá:w	'crack'	kɛ̂:w.rá:w	*ká:w.rɛ̂:w	kâ:w.rɛ́:w	'a cracked glass'

The next section shows an optimality theoretic account of Thai tone with respect to vowel-length and consonant-type.

4. OT ANALYSIS OF THAI TONES

4.1 OT Constraints

The fact that a low tone surfaces in every syllable type suggests that the low tone is the default tone in stressed syllables. It is therefore unmarked. Mid tone, on the other hand, is more marked than low tone in stressed syllables because it is not allowed in many syllable types. In this paper, I argue that the high tone is marked when it occurs in a syllable where an unaspirated stop occurs as an onset or a coda. I show that unaspirated stops have an effect on tone and that the effect involves either the obligatory presence of a low tone or the avoidance of a high tone.

These are the following constraints:

Observation 1: Unaspirated (both voiced and voiceless) stops in onset position are not compatible with a high tone vowel in the nucleus.

(20) *[-SG]∞[8][v́]: When an onset is [-SG], no high tones are allowed on a following TBU. The two features do not have to be immediately adjacent but do need to be in the same syllable in order for there to be a violation.

Observation 2: All else being equal, an unaspirated obstruent can only be adjacent to a non-high tone. Due to observation 1, I assume that this force is present in both directions. While the coda must tolerate a preceding high tone in a short vowel, a long vowel presents an opportunity to a low tone on the second vowel, thus producing a 2-way contrast between low and falling instead. This insertion of a low tone is done in order to avoid the high-tone vowel-[-SG] coda sequence that would otherwise result.

(21) *[v́] [-SG]: If the coda is an obstruent, a high tone autosegment incurs one violation if it immediately precedes this obstruent (note that this constraint is violable if the vowel is short).

[8] See tableau (32) for reasons for the "∞" condition.

Observation 3: An obstruent coda has the effect of shortening the vowel in the nucleus (this is testable via phonetic experimentation).

3a. This shortening effect places a burden on either phonetic perception or production, so that the 5-way contrast is neutralized to a 2-way contrast.

3b. The shortening effect places an especially strong burden on contour tones, so these tones are preferably excluded from the 2-way contrast.

3c. The best 2-way contrast among the 3 level tones is a simple high-low contrast, which is more readily perceivable than a low-mid or a high-mid contrast, because the pitch difference is maximized in this pair. These observations and hypotheses account in the markedness constraint below:

(22) *[v̄]-[-SG]: If the coda is an obstruent, mid tones are not allowed on an immediately preceding segment.

Observation 4: Since high tones are more marked than mid tones, *H is ranked higher than *M. The ranking *H >> *M. takes this into account (I assume that since the low tone is the least marked tone, there is no *L constraint. If this constraint exists at all, it is inactive.

(23) *High tone (henceforth *H): Each high tone vowel violates this constraint once.

(24) *Mid tone (henceforth *M): Each mid tone vowel violates this constraint once.

Observation 5: Since high, low and mid tones are permissible in Thai, faithfulness constraints (McCarthy & Prince 1993) are required for tones to surface in the output.

(25) Max-H: Every high tone in the input must have a correspondent in the output.

IO-Faith (tone): The tonal autosegment that is linked to an input segment must also be linked to that segment in its output correspondent and vice versa.

Max-L is not active because markedness constraints against high and mid tone alone are enough to ensure low tone surfaces preferably.

Observation 6: Because tautosyllabic tone sequences are allowed with one-to-one TBU association in Thai, we need a constraint that is able to preserve the underlying linear ordering of H and L autosegments. Linearity-IO ensures that the outputs will be faithful to the linear ordering in the inputs.

(26) Linearity-IO: The output reflects the precedence structure of the input, and vice versa.

4.2 Rankings of Constraints

I will now show how each case can be accounted for by these constraints and their relative rankings. The fact that high tones do not occur when C_2 segments are in onset position suggests that the two markedness constraints *[-SG]8[v́] and *[v́] [-SG] must rank above IO-faith (Tone) as shown in tableau (27). Even though the input is specified as being high tone, candidate (27a) with a low tone is selected optimally[9].

[9] Notice also a candidate with a mid tone might possibly win if *M outranks *L because there is no overt evidence that these two constraints are crucially ranked with respect to each other. It makes no difference though since both are possible attested Thai outputs.

(27) pòn ‘grounded’

p o n | | | [-sg] TBU TBU \╱ H	*[-SG]∞[v́]	*[v́] [-SG]	IO-Faith (Tone)	*H	*M
a. ☞ p o n | | | [-sg] TBU TBU \╱ L			*		
b. p o n | | | [-sg] TBU TBU \╱ H	*!			*	
c. p o n | | | [-sg] TBU TBU \╱ M			*		*!

With this ranking, when the candidate is specified for the H tone, it violates the markedness constraints *[-SG]∞[v́] and *H. Candidate (27c) is ruled out because it violates *M even though these two candidates tie with respect to faithfulness constraint violations. This is an emergence of the unmarked effect because the low tone emerges rather than mid tone which is the least marked.

Due to the observation above in tableau (27), we expect that high tones will not occur on C_2VT. Likewise, we also observed that mid tones are not allowed in a short vowel syllable. Tableau (28) illustrates that *[v̄]-[-SG] can account for this observation. Though the input is specified with a mid tone, it is not selected because of a fatal *[v̄]-[-SG] constraint violation. By ranking *[v̄]-[-SG] above IO-Faith (Tone), candidate (28b) with a low tone is still selected optimally.

(28) pìt ‘close’

p i t | | | [-sg] TBU [-sg] | M	*[-SG]8[v́]	*[v́] [-SG]	*[v̄]-[-SG]	IO-Faith (Tone)	*H	*M
a. p i t | | | [-sg] TBU [-sg] | M			*!			*
b. ☞ p i t | | | [-sg] TBU [-sg] | L				*		
c. p i t | | | [-sg] TBU [-sg] | H	*!	*		*	*	

Tableau (29), on the other hand, illustrates the case where falling tones occur on either a C_2VV or C_2VR syllable types. We would expect the absence of falling tones (HL) on these syllables with C_2 onsets (e.g., C_2VV and C_2VR). This is because the falling tone is a H-L sequence, and therefore C_2v̂v would violate *[-SG]∞[v́][10].

In order to capture this, we need the Max-H constraint to be ranked above the markedness constraints.

[10] Note that *[-SG]8[v́] is applied at a distance. The reason that the “8” condition is needed is shown in tableau (32).

(29) kɛ̂ː 'fix' Unexpected falling contours occur in C_2VV

k ε | ∧ [-sg] TBU TBU | | H L	Max-H	*[-SG]∞[v́]	IO-Faith (Tone)	*H	*M	Linearity-IO
a. k ε | ∧ [-sg] TBU TBU ∨ L	*!		*			
b. k ε | ∧ [-sg] TBU TBU ∨ H		**!	*	*		
c. k ε | ∧ [-sg] TBU TBU ∨ M	*!		**		*	
d. k ε | ∧ [-sg] TBU TBU | | L H		*		*		*!
e. ☞ k ε | ∧ [-sg] TBU TBU | | H L		*		*		

Both candidates (29a) and (29c) fatally violate Max-H once. Candidates (29b) fatally violates *[-SG]∞[v́], while candidate (29d) violates Linearity-IO. However, both candidate (29d) and (29e) tie in violating the markedness constraint *[-SG]∞[v́] and *H. However, (29e) wins because of the linearity constraint. Therefore, it surfaces as the optimal output.

Candidate (29d) on the other hand is unfaithful to its tonal input with respect to its linear order and so is eliminated.

The next tableau confirms that Max-H must outrank *[-SG]∞[v́] because the high tone is allowed to surface on $C_{1/3}$VT syllable types. As observed, only high and low tones surface in $C_{1/3}$VT syllable types. But when an input $C_{1/3}$VT syllable type is specified for a high tone, *[v́] [-SG] militates against the optimal output with the high tone. Thus, it is because of the Max-H constraint that the optimal candidate (30b) is selected optimally as shown in tableau (30).

(30) p^hét 'diamond'

p^h e t [+sg] TBU [-sg] H	Max-H	*[-SG]∞[v́]	*[v́] [-SG]	IO-Faith (Tone)	*H	*M
a. p^h e t [+sg] TBU [-sg] L	*!			*		
b. ☞ p^h e t [+sg] TBU [-sg] H			*		*	
c. p^h e t [+sg] TBU [-sg] M	*!			*		*

We encounter another problem, however, in that if the Max-H constraint is ranked above *[-SG]∞[v́], this would potentially allow an input with a high tone to surface on C_2VV syllable types-a phenomena which is unattested in Thai. Additionally, falling and rising tones do occur on C_2VV syllable types. In order to allow HL and LH sequences to

surface but not H, we need a distant parameter on the markedness constraint *[-SG]∞[v́]. This is shown in tableau (31).

(31) kɛ̂ː 'fix'

k ε | ∧ [-sg] TBU TBU \ / H	Max-H	*[-SG]∞ [v́]	IO-Faith (Tone)	*H	*M
a. k ε | ∧ [-sg] TBU TBU \ / H		**![11]		*	
b. ☞ k ε | ∧ [-sg] TBU TBU | | L H		*	*	*	
c. ☞ k ε | ∧ [-sg] TBU TBU | | H L		*	*	*	
d. k ε | ∧ [-sg] TBU TBU \ / L	*!		*		

Because of the distance condition on the markedness constraint, candidate (31a) with the two TBUs that are linked to the single high tone autosegment violates *[-SG]∞[v́] twice. Therefore, it is eliminated. Candidate (31d) fatally violates Max-H and it is therefore ruled out. Candidate (31b) and (31c), on the other hand, tie on all constraints. With

[11] Crucially, *[-SG]∞[v́] counts each TBU that is H, not each H-autosegment. If it counted each H-autosegment, then (31a) would actually win.

this constraint ranking, either can surface faithfully[12]. Some low- ranking will presumably decide between these two candidates, but it does not matter which will win, since both are attested Thai outputs. There is however one case where a high tone can never occur in a C_2VT syllable type. But the analysis so far predicts it can surface as shown in tableau (32).

(32) *C_2íT

p i t [-sg] TBU [-sg] H	Max-H	*[-SG]∞[ý]	IO-Faith (Tone)	*H	*M
a. p i t [-sg] TBU [-sg] M	*!		*		*
b.☹ p i t [-sg] TBU [-sg] H		*		*	
c.☺ p i t [-sg] TBU [-sg] L	*!		*		

Candidate (32c) with a low tone cannot surface faithfully because Max-H is ranked above *[-SG]∞[ý]. One way to capture this problematic case is to use a conjoined version (Smolensky 1997) of the two markedness constraints *[-SG]∞[ý] & *[ý]∞[-SG]. The conjoin version is such that both members can occur at a distance: *[-SG]∞[ý] & *[ý]∞[-SG]. This conjoined constraint will not be violated if both of the

[12] This is unresolved which is fine. How could one ever tell which is selected optimally? Clearly, linearity prefers /LH/ → [LH] and /HL/ → [HL] but it has nothing to say on /H/ → [LH] or [HL].

constraints are not violated. Therefore, candidates that violate exactly one of the conjoined constraints will not be ruled out by it. This conjoined constraint must outrank both the simple markedness constraints and also the faithfulness constraint in order to allow the optimal candidate to surface faithfully. This is illustrated below.

(33) *C_2íT

p i t [-sg] TBU [-sg] H	*[-SG]∞[v́] & *[v́]∞[-SG]	Max-H	*[-SG]∞[v́]	*[v́] [-SG]	IO-Faith (Tone)	*H	*M
a. p i t [-sg] TBU [-sg] M		*			*		*!
b. p i t [-sg] TBU [-sg] H	*!		*	*		*	
c. ☞ p i t [-sg] TBU [-sg] L		*			*		

The candidate with a low tone, (33c), is saved by ranking the conjoined constraint above Max-H. Candidate (33b) however violates the conjoined constraint which results in a fatal violation. Candidate (33c) becomes the optimal candidate since it does not violate *M, while (33a) does. Thus, the proposed constraint ranking succeeds in selecting the optimal candidate.

Let us now look at the case of C_2VVT where only a low tone can surface. No high, rising or falling tone is allowed here.

(34) p̀i:k ‘wing’

p i k | ⋀ | [-sg]TBU TBU [-sg] ⋁ H	*[-SG]∞[v́] & *[v́]∞[-SG]	Max-H	*[-SG]∞[v́]	*[v́] [-SG]	IO-Faith (Tone)	*H	*M
a. p i k | ⋀ | [-sg] TBU TBU [-sg] | | H L	*!		*		*	*	
b. p i k | ⋀ | [-sg] TBU TBU [-sg] | | L H	*!		*	*	*	*	
c.☞p i k | ⋀ | [-sg]TBU TBU [-sg] ⋁ L		*			**		
d. p i k | ⋀ | [-sg] TBU TBU [-sg] ⋁ H	*!		*	*	*	*	
e. p i k | ⋀ | [-sg] TBU TBU [-sg] ⋁ M		*			*		*!

In this tableau, the distance parameter included in the markedness constraint in the conjoined constraint helps eliminate candidate (34a) and (34b) with the HL and LH sequence. The second TBU that follows the C_2 does violate *[-SG]∞[v́] in (34b) for example. Candidates (34a), (34b) and (34d) are therefore ruled out by the conjoined constraint. This constraint ranking provides an explanation of the restricted distribution

of tones in C_2VVT and why no rising or falling tone surfaces. Candidate (34e) with a mid tone however violates *M. As predicted, candidate (34c) surfaces as the optimal output even with faithfulness constraint violations. Tableau (35), on the other hand, illustrates the case where only falling tones can surface in $C_{1/3}$VVT syllable types. In this tableau, the input is specified for a rising tone and yet results in a falling tone on the surface.

(35) p^h û:t ‘speak’

p^h u t [+sg] TBU TBU [-sg] L H	*[SG]∞[v́] & *[v́]∞[SG]	Max-H	*[v́] [SG]	IO-Faith (Tone)	*H	*M	Linearity-IO
a.☞p^h u t [+sg] TBU TBU [-sg] H L					*		*
b. p^h u t [+sg] TBU TBU [-sg] L H			*!		*		
c. p^h u t [+sg]TBU TBU [-sg] L		*!		*			
d. p^h u t [+sg] TBU TBU [-sg] H			*!	*	*		
e. p^h u t [+sg] TBU TBU [-sg] M		*!		**		*	

This tableau shows that *[v́] [-SG] must be applied locally that candidates (35b) and (35d) fatally violate it, but (35a) does not. Candidate (35c) and (35e) are ruled out because of fatal Max-H violations. We saw that the proposed ranking makes the right prediction and can account for the fact that $C_{1/3}$VVT syllables surface with only a low and a falling tone. This also is consistent with Zhang’s analysis

(2002) that falling tone is found to correlate with shorter vowel duration and that the obstruent coda has the effect of shortening the vowel. The optimal output is therefore candidate (35a) even with a single *H violation. The Linearity-IO constraint must be ranked below *[-SG] [v́] in order to eliminate the candidate with a rising tone. The next tableau shows a case where the L tone is specified in the input. With this ranking, the L tone surfaces, as expected.

(36) fà:k ‘give’

f a k | ∧ | [+sg] TBU TBU [-sg] ∨ L	*[-SG]∞[v́] & *[v́]∞[-SG]	Max-H	*[v́] [-SG]	IO-Faith (Tone)	*H	*M
a. f a k | ∧ | [+sg] TBU TBU [-sg] | | H L				*!	*	
b. f a k | ∧ | [+sg] TBU TBU [-sg] | | L H			*!	*	*	
c.☞f a k | ∧ | [+sg]TBU TBU [-sg] ∨ L						
d. f a k | ∧ | [+sg] TBU TBU [-sg] ∨ H			*!	*	*	
e. f a k | ∧ | [+sg] TBU TBU [-sg] ∨ M				*!		*

So far, we have seen that ranking the conjoined constraint *[-SG]∞[v́] & *[v́]∞[-SG] above the faithfulness constraint (Max-H), which is in turn ranked above the simple markedness constraints *[-SG]∞[v́] and *[v́] [-SG], can capture all the cases shown in table (17): *C_2v́R , *C_2v́v, *C_2v́ T, $C_{1/3}$v́*T, *$C_{1/3}$v́vT, and *C_2v́vT.

4.3 [-SG] is Lexically Distinctive in Thai

The following data show that the prediction of my analysis is borne out in that the [-SG] feature is lexically distinctive and has an effect on the tone of the following vowel. When the suffix *-aʔ* is added to monosyllabic words then the laryngeal feature of a coda is neutralized. The coda is then resyllabified as part of the onset of the following syllable. Tones are then assigned according to the [-SG] value of the onsets.

(37)	a.	lôːp	loː.pʰáʔ	'greed'
	b.	tʰûːp	tʰuː.pàʔ	'a pagoda'
	c.	kròːt	kroː.tʰáʔ	'angry'
	d.	cʰâːt	cʰaː.tàʔ	'birth'

The data in (37) show that an underlying high tone on *-áʔ* is neutralized to a low tone when it follows C_2 as expected. I would argue that this suffix is underlyingly high, but this H is neutralized to L when following a [-SG] obstruent.

When the infix (-am) is inserted after the initial consonant of a monosyllabic word, the L and H tones in surface-derived forms (38a'-f') remain faithful to their locus in the underlying-underived forms in (38a-f). We see that this infix is lexically specified as mid tone. Since there is no high tone present, the features [-SG] and [+SG] do not force the tones on the adjacent vowel to change. The underlying tonal value surfaces on the vowel of the second syllable and there are no violations of the two markedness constraints: *[-SG]8[ý] and *[ý] [-SG]. That is, since there are no violations of the high ranked markedness constraints, the underlying tonal values are allowed to surface.

	Underlying-underived form			*Surface-derived form*	
(38)	a. trùːat	'to inspect'	a'	tam.rùːat	'policemen'
	b. tràt	'to speak'	b'	dam.ràt	'speech' (royal)
	c. pràːp	'to subdue'	c'	bamràːp	'subdue'(poetic)
	d. càːy	'to pay'	d'	cam.nàːy	'to distribute'
	e. kʰróp	'to be complete'	e'	kʰam.róp	'time' (poetic)
	f. pʰák	'to stay'	f'	pʰam.nák	'to lodge' (poetic)

4.4 Marked Cases

In this section, I suggest further research on the following interesting cases which include the behavior of /h/, tones on C_2VT, intensified reduplication and tones in onset clusters.

4.4.1 The behavior of /h/

In Thai, /h/ is classified as a C_1 segment and this would predict that /h/ should behave in the same way as the [+SG] obstruents. However, /h/ behaves differently phonologically. /h/ patterns with the [-SG] obstruents in the following way: high tones do not occur in these syllable types (*hv́V, *hv́N, *hv́G and *hv́T) when /h/ is in onset position. Falling tones also do not occur in *hv̂:T syllable types. The data is shown in (39). The fact that high tones are absent in syllables with /h/ as an onset is consistent with /h/ being specified as [-SG] phonologically in Thai. /h/ thus patterns in an unexpected way with respect to its effect on following tone, given its phonetic characteristics. If it is phonetically like a C_1 (since it is voiceless) but phonologically like a C_2 (as my data suggests), then this would possibly mean that the phonological specification of /h/ does not match its phonetic spell-out. The behavior of /h/ is interesting and requires further research.

(39)

Syllable Shape	Mid	Low	Falling	High	Rising
CVV				hí: (onomatopoeia)	hǐ: 'vagina' (V)
CVV		hè: 'parade'			hě: 'a fishing net'
CVV	hɨ: (onomatopoeia)				hɨ̌: 'dare' (S)
CVV		hə̀: 'proud'			
CVV	ha: (onomatopoeia)	hà: 'cholera'	hâ: 'five'		ha: 'look for'
CVV					hû: 'ears'
CVV	ho: (onomatopoeia)	hò: 'yell'			

CVV	hɔː ‘a helicopter’	hɔ̀ː ‘wrap’			hɔ̌ː ‘ a dormitory’
CVN					hǐn ‘rock’
CVN					hen ‘see’
CVN		hàn ‘cut’			han ‘turn back’
CVN		hùn ‘mannequin’	hûn ‘share’		
CVG			hîw ‘carry’		hǐw ‘hungry’
CVG		həy ‘bad’ (S)			
CVG			hây ‘give’		hay ‘jar’
CVG		hàw ‘bark’			haw ‘a flea’
CVT		hèp ‘flea’			
CVT		hùp ‘close’		húp (onomatopoeia)	
CVT		hìt ‘scabies’		hít ‘popular’ (L)	
CVT		hèt ‘mushroom’		hét ‘do’ (L)	
CVT				hít (onomatopoeia)	
CVT		hàt ‘train’			
CVT		hòt ‘shrink’			
CVT		hàk ‘break’			
CVT				húk ‘hook (L)	
CVT		hòk ‘six’			
CVVT		hìːp ‘a box’			
CVVT		hɛ̀ːp ‘hoarse’			
CVVT		hàːp ‘carry’			
CVVT		hɔ̀ːp ‘carry’			
CVVT		hèːt ‘cause’			
CVVT		hǐːt ‘asthma’			
CVVT		hàːt ‘beaches’			
CVVT		hùːt ‘a wart’			
CVVT		hòːt ‘cruel’			
CVVT		hɛ̀ːk ‘open’			
CVVT		hàːk ‘if’			

CVVT		hɔ̀:k ‘a lance’			
CVVG					ha:y ‘missing’
CVVG			hâ:w ‘daring’		ha:w ‘yawn’
CVVG					hǒ:y ‘exhausted’

4.4.2 High tones on C_2Vʔ syllable types

Given that a glottal stop coda also has a [-SG] feature value, this would lead one to conclude that /ʔ/ patterns with the other stop codas (p, t and k). Note that there is coda neutralization in which stops lose their distinctive marked value of [voice] and [SG] in Thai. Thus, codas can only be [-SG] on the surface. As previously discussed, [-SG] correlates with low tones. In the case of a C_2Vʔ syllable types, both onset and coda are [-SG]. Therefore, we would expect that only a L tone can surface. The data in (40) shows the contrast of five examples of loanwords that high tones do occur when C_2 segments are onsets and ʔ is a coda.

(40) Syllable shape = C_2ví̞ʔ

Mid	Low	Falling	High	Rising
	pɛ̀ʔ ‘paste’		**pɛ́ʔ ‘Chinese men’ (L)**	
	pàʔ ‘mend’			
	pùʔ ‘patch’			
	pòʔ ‘put on’			
	bìʔ ‘break’			
	bèʔ ‘grin’			
	bɛ̀ʔ ‘open up’		**bɛ́ʔ** (onomatopoeia)	
			bə́ʔ (onomatopoeia)	
	bùʔ ‘line’			
	bɔ̀ʔ ‘cushion’			
	tìʔ ‘blame’			
	tèʔ ‘kick’			
	tɛ̀ʔ ‘touch’			
			tóʔ ‘table’ (L)	
	dàʔ ‘no direction’			
	dùʔ ‘scold’			
	dɔ̀ʔ ‘fracture’			
	càʔ ‘meet’			
	càʔ ‘will’		**cáʔ ‘final particle’**	
	cùʔ ‘hold’			
	cɔ̀ʔ ‘pierce’			
	kɛ̀ʔ ‘take out’			
	kàʔ ‘calculate’			
	kùʔ ‘make up’			
	kɔ̀ʔ ‘cling’			
	ʔɨ̀ʔ ‘poop’			

As mentioned, loanwords and onomatopoeia that constitute exceptions to the regular behavior with respect to tone-consonant interaction are excluded from the Thai nativized lexicon and also from the present analysis. However, there is one lexical word, (cáʔ ‘final particle’) which can be considered as a counterexample to the generalization that is part of the native Thai lexicon. The tone is not determined in the same way it usually is where it is a properly of the

lexical item. This H tone serves a syntactic function as the polite form of the question particle, and thus can be thought of as being a separate morpheme on its own.

(41) a. pay nay maː **cá**ʔ
go where come Q particle
Where did (you) go?

b. pay talàːt maa **càʔ**
go market come final particle
(I) went to the market.

4.4.3 Intensified reduplication

Intensified reduplication data provide examples where the lexical H tone surfaces in Thai. The reduplicant copies the entire root and is lexically specified as having the shape of CV́C-CVC. This H tone is part of the reduplicant, and denotes intensification. (42) shows that unexpected high tones surface after C_2 segments in all of the following syllable types with a C_2 onset: C_2VV, C_2VN, C_2VG and C_2V(V)T.
Intensive reduplication with a H tone

(42) a. bɨ́ːabɨ̌ːa 'very bored'
b. dókdòk 'very productive, fruitful'
c. cíwčiw 'very small'
d. hómhǒm 'very good smelling'

Intensive with a H tone
e. cíːt 'very sour'
f. pɛ́ːt 'very red'
g. tíːt 'very small'

The H tone must be underlyingly present in the reduplicant as it is invariably high-tone on the surface. This is an example of fixed prosody. $Max_{O\text{-}R}$H ensures that if there is a surface H tone present on the base, then there must also be a high tone present on the reduplicant and therefore, this constraint must rank highly. This is illustrated in the tableau in (43). The optimal candidate is faithful to the input, resulting in the violation of both the conjoined constraint and the simple markedness

constraints. Candidate (43b), on the other hand, is excluded because the lexical H tone is not retained in the input reduplicant.

(43)

REDσ. d o k 'very fruitful' TBU[-sg] TBU [-sg] H L	Max_{O-R} H	*[-SG]∞[v́] & *[v́]∞[-SG]	Max -H	*[v́] [-SG]	IO-Faith (Tone)	*H	*M
a. ☞ d o k. d o k [-sg] TBU [-sg][-sg] TBU [-sg] H L		**		*		*	
b. d o k. d o k [-sg] TBU [-sg][-sg] TBU [-sg] L L	*!		*		*		

4.4.4 What determines tone in onset clusters?

Thai allows certain consonant clusters in onset position. These clusters include stops followed by the liquids or [w]: as shown pl, pr, p^hl, p^hr, tr, kl, kr, kw, k^hl, k^hr, k^hw. I have observed that a high tone does not surface in any cluster containing a C_2 obstruent. Another way to say this is that the high tone does not surface in syllables with onset clusters containing C_2 followed by a sonorant. Note that L and R are defined as liquid and sonorant respectively. All five tones however occur in LVR syllable types. Examples of the data are shown below.

(44)	a.	pruŋ	'to season'	a'	luŋ	'uncle'
	b.	plàŋ	'glowing'	b'	làŋ	'flow'
	c.	plôn	'rob'	c'	lâ:m	'an interpreter'
	d.	-		d'	rúŋ	'rainbow'
	e.	klŏn 'thin hair'		e'	ɬɨ:aŋ	'yellow'

The observation here is that the sonorant seems invisible to the regular consonant tone generalization. That is, there is no restriction on tones to prohibit from surfacing following a sonorant. When C_1 and C_3 are found in initial onset clusters, all five tones can occur as is seen in (45) below.

(45)	a.	p^hran	'a hunter'	a'	wan	'day'
	b.	k^hlùy	'a flute'	b'	lòn	'to fall'
	c.	k^hwâm	'to overturn'	c'	lên	'to play'
	d.	k^hráŋ	'times'	d'	lín	'tongue'
	e.	k^hwan	'courage'	e'	la:n	'niece or nephew'

The H tone does not occur when a C_2 obstruent is initial in C_2RVT syllable types as shown in (46), while both H and L tone occur in $C_{1/3}$VT are syllable types as shown in (47).

(46)	a.	pràp	'fine'	a'	lùt	'to come off'
	b.	-		b'	rót	'a car'
(47)	a.	p^hlàk	'to push'	a'	làk	'principle
	b.	k^hróp	'complete'	b'	róp	'battle'

The same generalizations that were made for C_2VR and C_2VT syllable types, can also be made for in C_2**R**VR and C_2**R**VT. Three voiced consonant clusters (liquid and /w/) which are closer in sonority and position to the vowels than the stops and do not have an effect in triggering H tone in this environment (44d and 46b). This suggests that liquids are transparent to the laryngeal effect of C_2 that precedes them. Thai vowels have a surface tone that is predictable based on the [SG] value of the initial onset. A [-SG] feature value of the first member of an onset cluster has an effect where it assigns a tone value to a following vowel, but [+SG] onset segments do not. The fact that sonorants are always more proximal to the vowel when in an onset cluster is because of an independent phonotactic constraint (sonority sequencing). My analysis correctly predicts this by using the distance parameter in the conjoined constraint *[-SG]∞[ý] & *[ý]∞[-SG].

(48) plàŋ ‘glowing’

p l a ŋ | | | [-sg] TBU TBU \╱ H	*[-SG]∞[v́] & *[v́]∞[-SG]	Max-H	*[-SG]∞[v́]	*[v́] [-SG]	IO-Faith (Tone)	*H	*M
a. p l a ŋ | | | [-sg] TBU TBU \╱ L		*!			*		
b. p l a ŋ | | | [-sg] TBU TBU \╱ H			**!			*	
c. p l a ŋ | | | [-sg] TBU TBU \╱ M		*!			*		*!
d. ☞ p l a ŋ | | | [-sg] TBU TBU | | H L			*		*		
e. ☞ p l a ŋ | | | [-sg] TBU TBU | | L H			*		*		

Notice that there is a gap in the set of allowed consonant clusters above. [tl] is not in the list because it is not a genuine onset cluster. [a] is epenthesized between the two consonants and brakes the homorganic CC-cluster into two syllables. Mid tone is derived in the first unstressed syllable and only the L tone is found on the surface in the second

syllable. However, when the first syllable becomes stressed in citation form, the low tone does surface in [tàʔlok], for example.

(49)	a.	talòk	*talók	'funny'
	b.	talòp	*talóp	'to be blown up like a cloud'
	c.	taɓ̀:t	*taɓ́:t	'through'
	d.	talà:t	*talá:t	'market'

(49) also provides strong evidence that [-SG] is compatible with low tones and in this case the tone of the second syllable is determined by the [SG] value of the initial C. My analysis has dealt with tautosyllabic markedness co-occurrence constraints i.e. *[-SG]∞[v́] and the others only apply within the syllable.

5. THE REMAINING ISSUES

In past research on tones, two tonal autosegments are assumed in order to derive any surface tone. For Thai, there are five tones which must be derived. Four of them are trivially derived as H, L, HL, LH. However, the question remains "can we derive mid tones and if so, then how? " In this paper, I assume there is a third tone in Thai which is Mid. The markedness constraints conspire so that the low tone acts as the default tone. If we did not assume a third tonal autosegment, this would force us to posit a sequence of two autosegmental tones from which the surface mid tone is somehow derived in Thai. This is possible in future research but it is out of the scope of this paper. The analysis proposed here relies on a 3-way tonal system. The constraint *M eliminates candidates with mid tone in the contexts needed.

This paper raises another question, namely how *[-SG]8[v́] and *[v́] [-SG] are phonetically grounded and whether this is true of language in general. I leave this for further phonetic research on the interaction of tone with consonant type in Thai.

6. CONCLUSION

I have argued that in addition to previously noted interactions of tone and vowel length, there is also a consonant-tone interaction in Thai phonology. The present analysis posits that the laryngeal properties of a consonant affect the tone on a following vowel. This has an implication for Thai phonology in that the H tone is always lexically marked, and the L tone is a default tone in stressed syllables while the mid tone is only the default in unstressed short syllables.

Both voiced and voiceless unaspirated stops have an underlying [-SG] feature value and these consonants show an incompatibility with a following H tone autosegment. The constraints, *[-SG]8 [v́] and *[v́] [-SG] reflect that Thai tones are sensitive to a [-SG] feature value of both edges of the syllable (i.e., onset and coda). The faithfulness constraint Max-H must be ranked above the simple markedness constraint because high tones do surface on $C_{1/3}$VT syllable types. Moreover, the conjoined constraint is needed to account for the fact that the high tone is allowed on C_2VT syllable types and also the restricted distribution of falling and rising tones on C_2VVT syllable types. A distance parameter must be set for co-occurrence markedness constraints to either strict segmental adjacency (in the case of *[v́] [-SG]) or to a setting that allows intervening segments (in the case of *[-SG]8 [v́]). Since Max-H outranks the simple markedness constraint, it potentially allows input with a high tone to surface on C_2VV. We thus need to impose a long-distance parameter on the *[-SG]8 [v́] constraint so that the constraint can apply at a distance in order to allow the HL and LH contour tones to surface. In order to capture all the restrictions, we rank the markedness constraints above the faithfulness constraint (IO-Faith (Tone)). The summary of the constraint ranking for Thai tones are as follows: *[-SG]∞[v́] & *[v́]∞[-SG] >> Max-H >> *[-SG]∞[v́], *[v́] [-SG] >> *[v̄]-[-SG] >> IO-Faith (Tone) >> *H >> *M. Thai provides evidence that tone can be either lexically distinctive or contextually dependent on laryngeal features of both preceding and following consonants. This is consistent with the phonological claims concerning consonant-tone interactions cross-linguistically (Bradshaw 1999, Hyman 2001).

REFERENCES

Bradshaw, Mary M. 1999. *A Crosslinguistic study of consonant-tone interaction*. Ph.D Dissertation, Ohio State University.

Chotikasathian, P. 1991. *Thai linguistics for teachers (In Thai)*. Sukhothaithammathirat, Bangkok, Thailand.

Gandour, Jack. 1974. On the representation of tone in Siamese. *UCLA Working Papers in Phonetics 27, 118-146.*

Hyman, Larry M. 2001. Tone systems. In Martin Haspelmath, Ekkehard König, Wulf Oesterreicher, & Wolfgang Raible (eds.) *Language typology and language universals: an international handbook*, vol. 2. Berlin & New York: Walter de Gruyter, 1367-1380.

Intrasri, Jiraporn. 2001. *Topics in Thai tonology: an acoustic investigation and some pedagogical applications*. Ph.D. Dissertation, University of Delaware.

McCarthy, John and Alan Prince. 1993. Generalized alignment. In Geert Booij & Jaap van Marle (eds.), *Yearbook of Morphology*, 79-153. Dordrecht: Kluwer.

Morén, Bruce and Elizabeth Zsiga. 2006. The lexical and post-lexical phonology of Thai tones. *Natural language and linguistic theory 24*, 113-178. Springer.

Ladefoged, Peter and I. Maddieson. 1996. The sound of the world's languages. Oxford: Blackwell.

Prince, Alan and Paul Somlensky. 1993. Optimality theory: constraint interaction in Generative grammar. Report. New Brunswick, NJ: Rutgers University Center for Cognitive Science.

Pulleyblank, Douglas. 1997 Optimal theory and features. In Diana Archangeli and D.Terence Langendoen (eds.), *Optimal Theory: an Overview*, 59-101. Oxford: Blackwell.

Smolensky, Paul. 1997. *Constraint interaction in generative grammar II: Local conjunction*, or random rules in universal grammar. Proceedings of the Hopkins Optimality Theory Workshop/ University of Maryland, Mayfest. Baltimore MD.

Tumtavitikul, Apiluck. 1993. Perhaps, the tones are in the consonants? *Mon-Khmer-Studies* 23:11-41.

Zhang, Jie. 2002. *The effects of duration and sonority on contour tone distribution: Typological surveyand formal analysis*. New York: Routledge.

Sugunya Ruangjaroon
Department of Linguistics
Srinakharinwirot University
Bangkok, 10110 Thailand

APPENDIX A

All five tones can occur on CVV when C_1 and C_3 are onsets.

C_1 and C_3

Syllable Shape	Mid	Low	Falling	High	Rising
CVV			pʰîː ‘older sister’		pʰiː ‘a ghost’
CVV	pʰɛː ‘a satin’	pʰɛ̀ː ‘spread’	pʰɛ̂ː ‘broadcast’	pʰɛ́ː ‘lose’	pʰɛ̌ː ‘a wound’
CVV				pʰə́ː ‘drivel’	pʰə̌ː ‘forget’
CVV	pʰaː ‘take’	pʰà ‘cut’	pʰâː ‘clothes’	pʰáː ‘a knife’	pʰaː ‘a cliff’
CVV	pʰuː ‘classifier’		pʰûː ‘a tuft’		
CVV	pʰoː ‘Bo tree’	pʰòː ‘emerge’			pʰoː ‘fly’
CVV	pʰɔː ‘enough’		pʰɔ̂ː ‘father’	pʰɔ́ː ‘complain’	
CVV	Fiː ‘free’ (L)				fiː ‘smallpox’
CVV	fɛː ‘fair’ (L)				
CVV	fəː ‘fur’ (L)				
CVV		fàː ‘go through’	fâː ‘a blemish’	Fáː ‘blue’	faː ‘lid’
CVV	Fuː ‘puffy’				
CVV		fɔ̀ː ‘wilt’		fɔ́ː ‘neat’ (S)	
CVV	tʰiː ‘time’	tʰìː ‘frequent’	tʰîː ‘place’		
CVV	tʰeː ‘throw’				
CVV				tʰɛ́ː ‘real’	
CVV			tʰɨ̂ː ‘blunt’		tʰɨ̌ː ‘hold’
CVV	tʰəː ‘3rd sg person’				
CVV	tʰaː ‘paint’		tʰâː ‘if’		
CVV			tʰûː ‘blunt’		tʰúː ‘mob’
CVV	tʰoː ‘minor’	tʰòː (exclamation)	tʰôː (exclamation)		tʰoː exclamation

CVV	tʰɔː ‘weave’	tʰɔ̀ː ‘pole’	tʰɔ̂ː ‘a pipe’	tʰɔ́ː ‘discourage’	
CVV		sìː ‘four’		síː ‘dead’ (S)	siː ‘color’
CVV		sɛ̀ː ‘snoop’	sɛ̂ː ‘a whip’		
CVV		sɨ̀ː ‘a media’	sɨ̂ː ‘honest’	sɨ̂ː ‘buy’	
CVV			sə̂ː ‘stupid’ (S)		
CVV	Saː ‘go down’		sâː ‘show off’ (S)		
CVV		sùː ‘from’	sûː ‘fight’		
CVV	sɔː ‘a fiddle’	sɔ̀ː ‘show’		sɔ́ː ‘a Chinese lady’ (L)	sɔ̌ː ‘flow copiously’
CVV	cʰiː ‘a nun’	cʰìː ‘urinate’			
CVV					cʰeː ‘deviate’
CVV	cʰɛː ‘share’ (L)		cʰɛ̂ː ‘soak’		cʰɛ̌ː ‘reveal’
CVV			cʰɨ̌ː ‘name’		
CVV	cʰaː ‘numb’			cʰáː ‘slow’	
CVV	cʰuː ‘raise’			cʰúː ‘have an affair’	
CVV	cʰoː ‘show’ (L)				
CVV			cʰɔ̂ː ‘a bunch’		
CVV	kʰiː ‘key’ (L)	kʰìː ‘ride’	kʰîː ‘poop’		
CVV					kʰeː ‘cross-eyed’
CVV	kʰɛː ‘care’ (L)		kʰɛ̂ː ‘a stretcher’		
CVV	kʰɨːˇ ‘be’	kʰɨ̌ː ‘a crossbeam’			
CVV	kʰaː ‘remain undone’	kʰàː ‘galingal’	kʰâː ‘kill’	kʰáː ‘trade’	kʰaː ‘leg’
CVV	kʰuː ‘a ditch’	kʰùː ‘threaten’	kʰûː ‘a couple’		
CVV	kʰɔː ‘neck’		kʰɔ̂ː ‘a joint’		
CVV				híː onomatopoeia	hiː ‘vagina’ (V)
CVV		hɛ̀ː ‘parade’			hɛ̌ː ‘a fishing net’
CVV	hɨː				hɨ̌ː ‘dare’ (S)

CVV		hə̀: ‘proud’			
CVV	ha: (onomatopoeia)	hà: ‘cholera’	hâ: ‘five’		ha: ‘look for’
CVV					hû: ‘ears’
CVV	ho: (onomatopoeia)	hò: ‘yell’			
CVV	hɔ: ‘a helicopter’	hɔ̀: ‘wrap’			hɔ̌: ‘ a dormitory’
CVV	mi: ‘have’	mì: ‘noodle’		mí: ‘mother’ (L)	mi: ‘a bear’
CVV			mɛ̂: ‘mother’	mɛ́: ‘if’	mɛ̌: (exclamation)
CVV	mɨ: ‘hand’				
CVV		mə̀: ‘absent minded’			
CVV	ma: ‘come’		mâ: ‘grandmother’ (L)	má: ‘mother’ (L)	ma: ‘a dog’
CVV		mù: ‘group’			mu: ‘a pig’
CVV				Mó: ‘brag’	
CVV	mɔ: ‘gray’		mɔ̂: ‘pot’		mɔ̌: ‘a doctor’
CVV					wi: ‘a comb’
CVV				wɛ́: onomatopoeia	
CVV			wə̂: ‘exaggerate’ (S)		
CVV			wâ: ‘scold’		
CVV	wɔ: ‘a litter’				wɔ̌: ‘a police car’
CVV			nî: ‘debt’	ní: ‘this’	ni: ‘escape’
CVV			nɛ̂: ‘sure’		
CVV	na: ‘field’		nâ: ‘face’	ná: ‘aunt’	na: ‘thick’
CVV					nu: ‘a rat’
CVV	nɔ: ‘a horn’	nɔ̀: ‘a sprout’			
CVV				lí: ‘distance’	li: ‘a lady’s man’ (S)

CVV		lè: ‘cross-eyed’			
CVV	lɛ: ‘see’		lɛ̀: ‘slide’		
CVV	lɨ: ‘gossip’			lɨ̌: ‘dig’	
CVV	lə: ‘burp’				
CVV	la: ‘a donkey’		lâ: ‘chase’	lá: ‘exhausted’	la: ‘yard’
CVV			lû: ‘a track’		
CVV		lò: ‘last’	lô: ‘a shield’		lo: ‘a dozen’
CVV		lɔ̀: ‘handsome’	lɔ̂: ‘trick’	lɔ́: ‘a wheel’	lɔ̌: ‘broken’
CVV	ri: ‘oval’	rì: ‘dim’			
CVV			rɛ̂: ‘mineral’		
CVV				rɨ̌: ‘or’	
CVV	ra: ‘a fungus’				
CVV	ru: ‘hole’				ru: ‘luxurious’
CVV	rɔ: ‘wait’				
CVV	yi: ‘mix’			yí: (exclamation)	yi: ‘half-closed’
CVV		yɛ̀: ‘tease’	yɛ̂: ‘terrible’	yɛ́: ‘a kind of lizard’	yɛ̌: ‘coward’ (S)
CVV				ý̃ɨ: ‘grab’	
CVV	ya: ‘medicine’	yà: ‘divorced’	yâ: ‘grass’		
CVV		yù: ‘live’	yû: ‘wrinkle		
CVV				yó: ‘sway’	
CVV	yɔ: ‘compliment’		yɔ̂: ‘bend’		
CVV	ʔa: ‘sesame’				
CVV	ʔu: ‘a snake’				
CVV			ʔô: ‘stupid’		
CVV	ʔɔ: ‘bend’			ʔɔ́: ‘make up’	ʔɔ̌: ‘afraid’ (S)

High tones do not occur when C_2 are onsets.

C_2

Syllable Shape	Mid	Low	Falling	High	Rising
CVV	pi: ‘year’	pì: ‘a flute’			pi: ‘intensifier of black’
CVV	pe: ‘a hammock’		pê: ‘a backpack’		pe: ‘limp’
CVV	Pɛ: ‘translate’				
CVV	pa: ‘throw’	pà: ‘forest’	pâ: ‘aunt’	pá: ‘father’ (L)	pa: ‘father’ (L)
CVV	pu: ‘a crab’	pù: ‘grandfather’			
CVV	Pɔ: ‘a jute’		pɔ̂: ‘strut’		
CVV			bî: ‘smash’		
CVV			bê: ‘grim’		
CVV	Bɛ: ‘show’				
CVV			bɨ̌: ‘stupid’ (S)		
CVV	Bə: ‘blur’ (L)				
CVV		bà: ‘shoulder’	bâ: ‘crazy’		
CVV			bû: ‘smash’		
CVV	bo: ‘a bow’				bo: ‘hollow’
CVV	ti: ‘hit’	tì: ‘a game’			ti: ‘a man’ (L)
CVV		tè: ‘wander’			
CVV	Tɛ: ‘a horn’	tɛ̀: ‘but’			
CVV					tɨ̌: ‘intensifier of dark’
CVV	ta: ‘eyes’				
CVV		tù: ‘lie’ (S)			
CVV	to: ‘big’				
CVV	tɔ: ‘a stump’	tɔ̀: ‘connect’			
CVV	di: ‘good’				

CVV		dè: ‘erect’			
CVV		dà: ‘scold’			
CVV	du: ‘look’				
CVV		dò: ‘erect’			
CVV			cî: ‘funny’		ci: ‘tickle’
CVV				cé: ‘a woman’ (L)	
CVV					cɛ̌: ‘intensifier of red’
CVV	cə: ‘meet’	cə̀: ‘swollen’			cə̌: ‘interfere’
CVV			câ: ‘bright’		ca: ‘yes’
CVV					cu: ‘short’
CVV	cɔ: ‘dog’		cɔ̂: ‘talk’		cɔ̌: ‘sit’ (L)
CVV		kì: ‘how much’			
CVV				ké: ‘fake’ (L)	ke: ‘chic’ (S)
CVV	kɛ: ‘3rd sg person’	kɛ̀: ‘old’	kɛ̂: ‘fix’		
CVV	kə: ‘friend’		kə̂: ‘embarrass’		
CVV	ka: ‘a crow’		kâ: ‘brave’		
CVV	ku: ‘1st sg person’	kù: ‘holler’	kû: ‘borrow’		ku: ‘uncle’ (L)
CVV	kɔ: ‘a bunch’	kɔ̀: ‘build’	kɔ̂: ‘then’		
CVV	ʔi: ‘3rd sg person’				
CVV	ʔe: ‘yes’	ʔè: ‘overflow’			
CVV	ʔa: ‘aunt’		ʔâ: ‘spread’		
CVV		ʔù: ‘a garage’	ʔû: ‘lazy’ (S)		
CVV		ʔò: ‘boast’			
CVV			ʔɔ̂: ‘a plant’		ʔɔ̌: ‘yes’

APPENDIX B

All five tones can occur on CVN when C_1 and C_3 are onsets.

C_1 and C_3 with the coda [n]

Syllable Shape	Mid	Low	Falling	High	Rising
CVN	p^{h}in ‘the vina”				
CVN		p^{h}èn ‘escape’			
CVN	p^{h}an ‘wrap’				p^{h}an ‘conjugate’
CVN	p^{h}run ‘riddled’				
CVN			p^{h}ôn ‘spray’	p^{h}ón ‘escape’	p^{h}on ‘result’
CVN		p^{h}ɔ̀n ‘pay by installment’			
CVN		fìn ‘opium’			
CVN				fén ‘choose’	
CVN	fan ‘teeth’				fan ‘dream’
CVN		fùn ‘dust’			
CVN					fon ‘rain’
CVN			fɔ̂n ‘bundle’		
CVN		t^{h}ìn ‘area’			
CVN			t^{h}ɛ̂n ‘alter’		
CVN	t^{h}an ‘in time’				
CVN	t^{h}un ‘fund’		t^{h}ûn ‘float’		
CVN			t^{h}ɔ̀n ‘piece’		
CVN			sîn ‘finish’		
CVN			sên ‘noodle’		
CVN		sàn ‘shake’	sân ‘short’		san ‘backbone’
CVN	son ‘naughty’		sôn ‘heel’	són ‘to be dislocated’	son ‘thread’
CVN	c^{h}in ‘familiar’				
CVN			c^{h}ên ‘for example’		
CVN	c^{h}an ‘steep’			c^{h}án ‘1st sg person’	c^{h}an ‘1st sg person’
CVN	c^{h}un ‘mend’			c^{h}ún ‘redup’	c^{h}un ‘angry’

CVN	c^hon ‘collide’				
CVN				k^hén ‘squeeze’	k^hen ‘push’
CVN			k^hɨn ‘go up’		
CVN	k^han ‘itch’		k^hrân ‘feel hot&cold’	k^hán ‘squeeze’	k^han ‘bowl’
CVN	k^hun ‘2nd sg person’	k^hùn ‘muddy’		k^hún ‘familiar’	k^hun ‘fatten’
CVN	k^hon ‘person’		k^hôn ‘thick’	k^hón ‘search’	k^hon ‘hair’
CVN					hin ‘rock’
CVN					hen ‘see’
CVN		hàn ‘cut’			han ‘turn back’
CVN		hùn ‘mannequin’	hûn ‘share’		
CVN		mìn ‘insult’			
CVN					men ‘smelly’
CVN	mɨn ‘dizzy’				
CVN	man ‘greasy’	màn ‘persistent’	mân ‘engage’		man ‘sterile’
CVN					mun ‘spin’
CVN	mon ‘round’	mòn ‘dull’			
CVN	wan ‘day’	wàn ‘worry’			
CVN			wûn ‘busy’	wún ‘agar’	
CVN	won ‘go round’				
CVN		nàn ‘fat’	nân ‘there’	nán ‘that’	
CVN			nûn ‘kapok’		nun ‘support’
CVN				lín ‘tongue’	
CVN	len ‘lense’ (L)		lên ‘play’		
CVN			lân ‘loud’		
CVN				lún ‘cheer’ (S)	
CVN	lon ‘in a hurry’			lón ‘overflow’	
CVN	rin ‘pour’				
CVN				rán ‘stubborn’	

CVN	yen ‘cold’				
CVN	yən ‘ugly’ (S)				
CVN	yan ‘push’	yàn ‘afraid’ (S)			
CVN		yùn ‘softy’			
CVN			yôn ‘wrinkle’		
CVN	?ən ‘money’				

High tones do not occur when C_2 are onsets.

C_2

Syllable Shape	Mid	Low	Falling	High	Rising
CVN		pìn ‘pin’			
CVN	pen ‘be’				
CVN		pə̀n ‘out of date’			
CVN		pàn ‘cycle’	pân’ ‘mold’		
CVN	pon ‘mix’	pòn ‘ground’	p(l)ôn ‘rob’		
CVN	bin ‘fly’				
CVN			bǐn (onomatopoeia)		
CVN			bə̂n ‘slang’		
CVN		bàn ‘cut down’	bân ‘a portion’		
CVN	bon ‘on’	bòn ‘complain’			
CVN					bun ‘civil’
CVN		bɔ̀n ‘casino’			
CVN			tên ‘dance’	tén ‘tent’ (L)	
CVN	tan ‘not hollow’				
CVN	tun ‘store’	tùn ‘mole’			tun ‘steam’
CVN	ton ‘body’		tôn ‘classifier for trees’		
CVN	din ‘soil’		dîn ‘move’		
CVN			də̂n ‘cool’ (S)		
CVN	dan ‘push’				
CVN	dun ‘push’		dûn ‘a piece’		
CVN			dôn ‘penetrate’		

CVN	can ‘the moon’	càn ‘a trap’			
CVN	cun ‘support’		cûn’ ‘nosy’ (S)		
CVN	con ‘poor’				
CVN	kin ‘eat’				
CVN					kǐn ‘smart’ (S)
CVN	kan ‘keep out’		kân ‘bar’		
CVN					
CVN	k(r)on ‘snore’		kôn ‘buttocks’		
CVN	ʔin ‘into’ (S)				
CVN	ʔen ‘tendon’				
CVN			ʔân ‘hold back’		
CVN		ʔùn ‘warm’			

APPENDIX C

All five tones occur on CVG when C_1 and C_3 are onsets.

C_1 and C_3

Syllable Shape	Mid	Low	Falling	High	Rising
CVG		p^{h}ày ‘bamboo’	p^{h}ây ‘cards’		
CVG		p^{h}àw ‘tribe			p^{h}aw ‘burn’
CVG				p^{h}úy ‘impel’	
CVG	fiw ‘a fuse’				
CVG	fay ‘fire’	fày ‘pay attention to’			fay ‘a mole’
CVG			fâw ‘keep an eye on’		
CVG	t^{h}iw ‘range’				
CVG	t^{h}ay ‘Thai’	t^{h}ày ‘ransom’			t^{h}ay ‘ask for’
CVG	t^{h}aw ‘grey’		t^{h}âw ‘elderly’		t^{h}aw ‘creeping’

CVG	t^huw ‘a buffalo’			t^húw (onomatopoeia)	t^huw ‘spit’
CVG	siw ‘arrest’ (S)	sìw ‘a chisel’			siw ‘pimple’
CVG	say ‘banyan tree’	sày ‘wear’	sây ‘stuffing’	sáy ‘search for food’	say ‘clear’
CVG	saw ‘tone down’ (S)		sâw ‘sad’		saw ‘pillar’
CVG					suy ‘push’
CVG					c^hiw ‘fast’
CVG			c^hây ‘yes’	c^háy ‘use’	
CVG			c^hâw ‘rent’		c^haw ‘dying’
CVG			c^hûy ‘messy’ (S)		c^huy ‘fast’
CVG	k^h(r)ay ‘who’	k^hày ‘eggs’	k^hây ‘fever’		k^hay ‘reveal’
CVG			k^hâw ‘enter’	k^háw ‘3rd sg person’	k^háw ‘3rd sg person’
CVG	k^huy ‘talk’			k^húy ‘search for’	k^huɣ ‘fluff’
CVG			hîw ‘carry’		hiw ‘hungry’
CVG		həy ‘bad’ (S)			
CVG			hây ‘give’		hay ‘jar’
CVG		hàw ‘bark’			haw ‘a flea’
CVG		mày ‘new’	mây ‘not’	máy ‘question particle’	may ‘question particle’
CVG	maw ‘drunken’				maw ‘take all of’
CVG	wiw ‘view’				wiw ‘dizzy’
CVG	way ‘fast’				way ‘move’
CVG			wâw ‘speak’ (D)	wáw ‘curve’	
CVG			nîw ‘gallstone’		
CVG	nay ‘in’				nay ‘where’
CVG	naw ‘stitch’		nâw ‘rotten’		
CVG			lây ‘chase’		lay ‘flow’
CVG			lâw ‘tell’		law ‘sharpen’
CVG	luy ‘wade through’		lûy ‘fray’		
CVG	rew ‘fast’				
CVG	ray ‘mite’		rây ‘field’		
CVG	raw ‘3rd pl person’				
CVG	yay ‘web’	yày ‘big’			

CVG	yaw ‘young’			yáw ‘tease’	
CVG			yûy ‘crumble’		
CVG	?aw ‘shadow’				?aw ‘lonely’

High tones do not occur when C_2 are onsets.

C_2

Syllable Shape	Mid	Low	Falling	High	Rising
CVG					piw ‘miss’ (S)
CVG	pay ‘go’				
CVG		pàw ‘blow’	Pâw ‘target’		
CVG	puy ‘fluffy’				puy ‘fertilizer’
CVG	bay ‘a leaf’		bây ‘dumb’		
CVG	baw ‘light’		bâw ‘a socket’		
CVG	tiw ‘teach’ (S)		tîw ‘small’ (S)		
CVG		tày ‘climb’			
CVG	taw ‘stove’	tàw ‘turtle’	Tâw ‘breast’		taw ‘dice’
CVG		tùy ‘swollen’ (S)	tûy ‘bulge’		
CVG	daw ‘guess’		dâw ‘make love’ (V)		
CVG					ciw ‘small’
CVG	cay ‘heart’				
CVG			câw ‘2n^{d} pl person’ (A)		
CVG		kìw ‘constricted’			kiw ‘shame’ (S)
CVG	kay ‘far’	kày ‘chicken’	kây ‘near’		kay ‘pretend’ (S)

CVG	kaw ‘scratch’	kàw ‘old’		káw ‘disease’(L)	kaw ‘expert’ (S)
CVG	ʔaw ‘take’				
CVG				ʔúy (onomatopoeia)	

APPENDIX D

Both high and low tones can occur when C_1 and C_3 are onsets and stops are codas. ʔ is not included in stops.

C_1 and C_3

Syllable Shape	Mid	Low	Falling	High	Rising
CVT		p^{h}àp ‘pub’ (L)		p^{h}áp ‘fold’	
CVT				p^{h}óp ‘meet’	
CVT		p^{h}ìt ‘wrong’		p^{h}ít ‘poison’	
CVT		p^{h}èt ‘spicy’		p^{h}ét ‘diamond’	
CVT		p^{h}àt ‘stir-fried’		p^{h}át ‘a fan’	
CVT		p^{h}ùt ‘bob up’		p^{h}út ‘Buddhist’	
CVT		p^{h}àk ‘vegetable’		p^{h}ák ‘relax’	
CVT				p^{h}ók ‘bring’	
CVT				fúp ‘drop’	
CVT				fít ‘tight’ (L)	
CVT				fát ‘fight’	
CVT		fàk ‘an ear’		fák ‘squash’	
CVT				f(l)úk ‘fluke’ (L)	
CVT				t^{h}íp ‘tip’ (L)	
CVT				t^{h}ɨp ‘dull’	
CVT				t^{h}áp ‘run over’	
CVT				t^{h}úp ‘smash’	
CVT				t^{h}óp ‘double’	
CVT				t^{h}ít ‘direction’	
CVT				t^{h}ét ‘lie’	
CVT		t^{h}àt ‘next’		t^{h}át ‘wear’	

CVT				t^hót ‘carry a number’	
CVT		t^hàk ‘knit’		t^hák ‘greet’	
CVT				t^húk ‘sorrow’	
CVT		t^hòk ‘discuss’			
CVT		sìp ‘ten’		síp ‘zip’ (L)	
CVT		sàp ‘chop’		sáp ‘money’	
CVT				súp ‘soup’ (L)	
CVT				sóp ‘bury one’s face	
CVT		sìt ‘students’			
CVT		sèt ‘finish’			
CVT		sàt ‘animals’		sát ‘hit’ (S)	
CVT		sùt ‘extreme’		sút ‘subside’	
CVT		sòt ‘fresh’		sót ‘sip’	
CVT		sɨ̀k ‘wear out’			
CVT		sàk ‘tattoo’		sák ‘wash’	
CVT		sùk ‘ripe’		súk ‘hide’	
CVT				c^húp ‘coat’	
CVT				c^hít ‘close’	
CVT				c^hét ‘wipe’	
CVT		c^hàt ‘umbrella’		c^hát ‘clear’	
CVT		c^hùt ‘drag’		c^hút ‘dress’	
CVT				c^hék ‘check’ (L)	
CVT				c^hák ‘seizure’	
CVT				c^húk ‘abundant’	
CVT		c^hòk ‘grab’		c^hók ‘punch’	
CVT		k^hàp ‘drive’		k^háp ‘tight’	
CVT		k^hòp ‘bite’		k^hóp ‘know’	
CVT				k^hít ‘think’	
CVT		k^hèt ‘to be afraid’			
CVT		k^hàt ‘polish’		k^hát ‘select’	
CVT		k^hùt ‘dig’			
CVT		k^hòt ‘spiral’		k^hót ‘curve’	
CVT				k^hɨ̀k ‘to be vigorous’	
CVT			k^h(l)âk‘crowded’ (S)		
CVT				k^húk ‘jail’	

CVT		hèp ‘flea’			
CVT		hùp ‘close’		húp ‘take’ (S)	
CVT		hìt ‘scabies’		hít ‘popular’ (L)	
CVT		hèt ‘mushroom’		hét ‘do’ (L)	
CVT				hît ‘fight’ (S)	
CVT		hàt ‘train’			
CVT		hòt ‘shrink’			
CVT		hàk ‘break’			
CVT				húk ‘hook (L)	
CVT		hòk ‘six’			
CVT				mít ‘to be submerged’	
CVT				mét ‘stone’	
CVT		màt ‘fist’		mát ‘tie’	
CVT				mút ‘hide’	
CVT		mòt ‘to be exhausted’		mót ‘ants’	
CVT				mík ‘mix’ (L)	
CVT		màk ‘marinate’		mák ‘often’	
CVT				múk ‘pearl’	
CVT		mòk ‘cover’			
CVT				wép ‘web’ (L)	
CVT				wáp ‘shine’	
CVT				wít ‘pump’	
CVT		wàt ‘cold’		wát ‘temple’	
CVT				wák ‘bail out’	
CVT				wók ‘circle’	
CVT		nèp ‘cramp’			
CVT				náp ‘count’	
CVT				nát ‘arrange to meet’	
CVT				nîk ‘think’	
CVT		nàk ‘heavy’			
CVT		nùk ‘fun’			
CVT				nók ‘birds’	
CVT				lép ‘nail’	

CVT		làp ‘sleep’		láp ‘secret’	
CVT		lòp ‘hide’		lóp ‘erase’	
CVT				lít ‘litre’ (L)	
CVT				lát ‘take a shortcut’	
CVT				lót ‘decrease’	
CVT		lèk ‘iron’		lék ‘small’	
CVT				lík ‘deep’	
CVT		làk ‘main’		lák ‘steal’	
CVT				lúk ‘look’ (L)	
CVT				ríp ‘confiscate’	
CVT				ráp ‘receive’	
CVT				róp ‘battle’	
CVT				rát ‘tight’	
CVT				rút ‘hurry’	
CVT				rót ‘cars’	
CVT				rák ‘love’	
CVT				rúk ‘invade’	
CVT				rók ‘messy’	
CVT				yép ‘stitch’	
CVT				yáp ‘wrinkled’	
CVT				yúp ‘reduce’	
CVT				yét ‘have sex’ (V)	
CVT				yít ‘hold’	
CVT				yát ‘stuff’	
CVT		yùt ‘stop’			
CVT		yòt ‘drop’			
CVT		yàk ‘wavy’		yák ‘a gigantic demon’	
CVT		yòk ‘jade’		yók ‘lift’	
CVT				?áp ‘bite’	
CVT				?át ‘force open’	
CVT				?ót ‘cancel’	
CVT				?ók ‘greedy’	

High tones do not occur on CVT (p, t, k) when C^2s are onsets but they do when coda is ʔ.

C_2

Syllable Shape	Mid	Low	Falling	High	Rising
CVT		pìt ‘close’			
CVT		pèt ‘duck’			
CVT		pàt ‘swipe’			
CVT		pùt (onomatopoeia)			
CVT		pòt ‘lie’			
CVT		pɨ̀k ‘a compact mass’			
CVT		pàk ‘pitch’			
CVT		bùp ‘bashed’			
CVT		bìt ‘twist’			
CVT		bèt ‘bait’			
CVT		bùt ‘children’			
CVT		bòt ‘ground’			
CVT		bɨ̀k ‘stout’			
CVT		bùk ‘invade’			
CVT		bòk ‘on land’			
CVT		tàp ‘liver’			
CVT			tûp (onomatopoeia)		
CVT		tòp ‘slap’			
CVT		tìt ‘attach’			
CVT		tàt ‘cut off’			
CVT		tòt ‘fart’			
CVT		dìp ‘raw’			
CVT		dàp ‘extinguished’			
CVT		dèt ‘’pluck’			
CVT		dàt ‘bend’			
CVT		dùt ‘as if’			
CVT		dèk ‘child’			
CVT		dɨ̀k ‘late night’			
CVT		dàk ‘trap’			
CVT		dòk ‘fruitful’			
CVT		cìp ‘sip’			
CVT		cèp ‘painful’			
CVT		càp ‘catch’			

CVT		còp ‘end’			
CVT		cìt ‘mind’			
CVT		cèt ‘seven’			
CVT		càt ‘intense’			
CVT		cùt ‘dot’			
CVT		còt ‘make notes’			
CVT				cék ‘Chinese’ (S), (L)	
CVT		cìk ‘peck’			
CVT		càk ‘a sewing machine’			
CVT		cùk ‘ a cork’			
CVT				kíp ‘clip’ (L)	
CVT		kèp ‘keep’			
CVT		kàp ‘with’			
CVT				kɨ́p ‘drink’ (S), (L)	
CVT		kòp ‘frog’			
CVT		kìt ‘business’			
CVT		kàt ‘bite’			
CVT		kùt ‘cut off’			
CVT				kék ‘arrogant’ (L), (S)	
CVT		kàk ‘confine’		kák ‘confine’ (L),(S)	
CVT				kúk ‘cook’ (L)	
CVT				ʔɨ́p (onomatopoeia)	
CVT		ʔùp ‘keep’			
CVT		ʔòp ‘bake’			
CVT		ʔìt ‘brick’			
CVT		ʔèt ‘scold’			
CVT		ʔɨ́t ‘patient’			
CVT		ʔàt ‘punch’			
CVT		ʔùt ‘fill in’			
CVT		ʔòt ‘restrain’			

APPENDIX E

CVVT only has low and falling tones when C_1 and C_3 are onsets.

C_1 and C_3

Syllable Shape	Mid	Low	Falling	High	Rising
CVVT			pʰâːp ‘painting’		
CVVT			pʰêːt ‘gender’		
CVVT			pʰɛ̂ːt ‘doctor’		
CVVT			pʰɨ̂ːt ‘plants’		
CVVT			pʰ(l)âːt ‘miss’		
CVVT			pʰûːt ‘speak’		
CVVT			pʰ (l)ɔ̂ːt ‘talk volubly’		
CVVT			pʰ (r)âːk ‘separate’		
CVVT			fîːp ‘small’		
CVVT			fɛ̂ːp ‘deflated’		
CVVT		fɨ̀ːt ‘tight money’			
CVVT		fàːt ‘acidulous’	fâːt ‘eat’ (V)		
CVVT			fɔ̂ːt ‘a kissing sound’		
CVVT				fɛ́ːk ‘fake’ (L)	
CVVT		fàːk ‘give’	fâːk ‘side’		
CVVT				f(l)úːk ‘fluke’ (L)	
CVVT			fɔ̂ːk ‘bleach’		
CVVT		hìːp ‘a box’			
CVVT		hɛ̀ːp ‘hoarse’			
CVVT		hàːp ‘carry’			
CVVT		hɔ̀ːp ‘carry’			
CVVT		hɛ̀ːt ‘cause’			
CVVT		hɨ̀ːt ‘asthma’			
CVVT		hàːt ‘beaches’			
CVVT		hùːt ‘a wart’		húːt ‘hood’ (L)	
CVVT		hòːt ‘cruel’			
CVVT		hɛ̀ːk ‘open’			
CVVT		hàːk ‘if’			

CVVT		hɔ̀:k ‘a lance’			
CVVT		mɔ̀:p ‘crouch’	mɔ̂:p ‘give’		
CVVT			mî:t ‘a knife’		
CVVT			mɨ̂:t ‘dark’		
CVVT		mà:t ‘damp’			
CVVT			mɔ̂:t ‘a weevil’		
CVVT			mê:k ‘cloud’		
CVVT		mà:k ‘an areca palm’	mâ:k ‘very’		
CVVT		mɔ̂:k ‘fog’			
CVVT			wû:p ‘pass out’		
CVVT				wí:t (onomatopoeia)	
CVVT		wà:t ‘frightened’	wâ:t ‘draw’		
CVVT		wò:t ‘vote’ (L)			
CVVT		wɔ̀:t ‘spawn’	wɔ̂:t ‘die down’		
CVVT		wɛ̀:k ‘push aside’		wɛ́:k (onomatopoeia)	
CVVT			wɔ̂:k ‘monkey’		
CVVT		nì:p ‘sandwich’			
CVVT		nɛ̀:p ‘sarcastic’			
CVVT			nə̂:p ‘slowly’		
CVVT			nɔ̂:p ‘respect’		
CVVT			nê:t ‘eyes’		
CVVT			nâ:k ‘a seal’		
CVVT		nò:k ‘a bump’			
CVVT			nɔ̂:k ‘out’		
CVVT			lî:p ‘lean’		
CVVT			lɛ̂:p ‘stick out’		
CVVT			lɨ̂:p ‘a narrow		

			hole’		
CVVT			lô:p ‘greedy’		
CVVT			lɔ̂:p ‘sneak in’		
CVVT		lè:t ‘late’ (L)			
CVVT			lâ:t ‘slope’		
CVVT		lɔ̀:t ‘straw’	lɔ̂:t ‘go through’		
CVVT		lì:k ‘avoid’			
CVVT			lê:k ‘number’		
CVVT		lɛ̀:k ‘smash’	lɛ̂:k ‘trade’		
CVVT			lə̂:k ‘break up’		
CVVT		là:k ‘assorted’	lâ:k ‘drag’		
CVVT			lû:k ‘children’		
CVVT			lô:k ‘earth’		
CVVT		lɔ̀:k ‘cheat’	lɔ̂:k ‘copy’		
CVVT			rî:p ‘hurry’		
CVVT			râ:p ‘smooth’		
CVVT			rû:p ‘pictures’		
CVVT			rɔ̂:p ‘round’		
CVVT		rì:t ‘cheer leader’	rî:t ‘iron’		
CVVT			rɛ̂:t ‘rhino’		
CVVT			rə̂:t ‘fancy’		
CVVT			râ:t ‘spill’		
CVVT			rû:t ‘pull’		
CVVT			rɔ̂:t ‘survive’		
CVVT			râ:k ‘root’		
CVVT			rɔ̂:k ‘disease’		
CVVT		yà:p ‘rough’			
CVVT		yà:t ‘drop’			
CVVT		yɔ̀:t ‘drop’	yɔ̂:t ‘tip’		
CVVT			yɛ̂:k ‘separate’		

CVVT		yà:k ‘want’	yâ:k ‘difficult’		
CVVT			yô:k ‘swing’		
CVVT		yɔ̀:k ‘tease’	yɔ̂:k ‘pain’		
CVVT			?î:p ‘take a nap’		
CVVT			?â:p ‘eat’ (s)		
CVVT			?ɔ̂:p ‘a hat’		
CVVT			?ê:k ‘exhausted’		
CVVT			?ô:k ‘nod’		
CVVT		?ɔ̀:k ‘grey hair’	?ɔ̂:k ‘grow’		

Falling tones do not occur on CVVT when C_2s are onsets.

C_2

Syllable Shape	Mid	Low	Falling	High	Rising
				pí:t ‘intensifier of sour’	
CVVT		p(r)è:t ‘a ghost’			
CVVT				pɛ́:t ‘intensifier fof red’	
CVVT		pə̀:t ‘open’			
CVVT		pà:t ‘cut’			
CVVT		pù:t ‘reveal’			
CVVT		p(r)ò:t ‘please’			
CVVT		pɔ̀:t ‘lung’			
CVVT		pì:k ‘wing’			
CVVT		p(l)ɛ̀:k ‘strange’			
CVVT		pà:k ‘a mouth’			
CVVT		p(l)ù:k ‘grow’			
CVVT		pò:k ‘uproarious’		pó:k (onomatopoeia)	
CVVT		pɔ̀:k ‘peel’			
CVVT		bì:p ‘squeeze’			

CVVT		bɛ̀:p ‘pattern’			
CVVT		bà:p ‘sin’			
CVVT		bà:t ‘feet’			
CVVT		bù:t ‘go bad’			
CVVT		bò:t ‘church’			
CVVT		bɔ̀:t ‘blind’			
CVVT		bɛ̀:k ‘carry’			
CVVT		bà:k ‘struggle’			
CVVT		bò:k ‘hitchhike’			
CVVT		bɔ̀:k ‘tell’			
CVVT		tì:p ‘constricted’			
CVVT		tù:p ‘droop’			
CVVT		tɔ̀:p ‘answer’			
CVVT		tɛ̀:t ‘clitoris’ (V)			
CVVT		tɨ̀:t ‘stingy’			
CVVT		tà:t ‘brocade’			
CVVT		tù:t ‘buttock’			
CVVT		tɔ̀:t ‘nibble’			
CVVT		tà:k ‘expose’			
CVVT		tɔ̀:k ‘hammer’			
CVVT		dà:p ‘a sword’			
CVVT				dó:p ‘dope’ (L)	
CVVT		dì:t ‘flick’			
CVVT		dɛ̀:t ‘sun’			
CVVT		dù:t ‘suck’			
CVVT		dò:t ‘jump’			
CVVT		dɔ̀:t ‘sneak out’			
CVVT		dɛ̀:k ‘eat’ (V)			
CVVT		dɔ̀:k ‘flowers’			
CVVT		cì:p ‘crimp’			
CVVT		cù:p ‘kiss’			
CVVT		cɔ̀:p ‘a digging tool’			
CVVT				cí:t ‘intensifier for sour’	

CVVT		c̈ɨ:t ‘tasteless’			
CVVT		cò:t ‘questions’			
CVVT		cɔ̀:t ‘park’			
CVVT		cɛ̀:k ‘give away’			
CVVT		cà:k ‘from’			
				có:k ‘joke’ (L)	
CVVT		cɔ̀:k ‘water lettuce’			
CVVT		kì:p ‘hoof’			
CVVT		k(l)ɛ̀:p ‘husk’			
CVVT		k(r)à:p ‘show respect’			
CVVT		k(l)ɔ̀:p ‘crispy’			
CVVT		kì:t ‘hinder’			
CVVT		kə̀:t ‘born’			
CVVT		kò:t ‘angry’			
CVVT		kɔ̀:t ‘hug’			
CVVT		kà:k ‘restrain’			
CVVT		kò:k ‘incubate’			
CVVT		kɔ̀:k ‘pour’			
CVVT		ʔɛ:p ‘hide’			
CVVT		ʔà:p ‘bathe’			
CVVT		ʔò:p ‘hug’			
CVVT		ʔè:t ‘scold’			
CVVT		ʔɨ:t ‘swollen’			
CVVT		ʔà:t ‘maybe’			
CVVT		ʔù:t ‘a camel’			
CVVT		ʔɔ̀:t ‘plead’			
CVVT		ʔè:k ‘leading’			
CVVT		ʔɔ̀:k ‘go out’			

APPENDIX F

All five tones can occur on CVV when C_1 and C_3 are onsets.

C_1 and C_3

Syllable Shape	Mid	Low	Falling	High	Rising
CVVG	pʰ(r)ɛːw ‘sparkling’				
CVVG					pʰɤ̌ːy ‘reveal’
CVVG	pʰaːy ‘pie’ (L)		pʰâːy ‘lose’		
CVVG	pʰoːy ‘note’				
CVVG	pʰ(l)ɔːy ‘a gem’		pʰ(r)ɔ̌ːy ‘indiscreetly’		
CVVG					faːy ‘a dam’
CVVG	faːw ‘fowl’ (L)				
CVVG					fɔ̌ːy ‘brag’
CVVG					tʰɛ̌ːw ‘row’
CVVG	tʰaːy ‘guess’	tʰàːy ‘transfer’		tʰáːy ‘the last’	
CVVG				tʰáːw ‘foot’	
CVVG	tʰɔːy ‘throw’	tʰɔ̀ːy ‘mean’	tʰɔ̂ːy ‘words’		tʰɔ̌ːy ‘move’
CVVG					sə̌ːy ‘turn over’
CVVG	saːy ‘sand’	sàːy ‘shake’			saːy ‘late’
CVVG	saːw ‘wash’				saːw ‘you’
CVVG	sɔːy ‘trim’		sɔ̂ːy ‘necklace’		sɔ̌ːy ‘pick’
CVVG	cʰəːy ‘out of date’				cʰə̌ːy ‘indifferent’
CVVG	cʰaːy ‘male’				cʰaːy ‘play’
CVVG	cʰaːw ‘nationality’				cʰaːw ‘scandal’
CVVG	cʰoːy ‘blow gently’				
CVVG	kʰəːy ‘use to’				kʰə̌ːy ‘son-in-law’

CVVG	k^ha:y ‘disgorge’	k^hà:y ‘net’	k^hâ:y ‘camp’	k^h(l)á:y ‘resemble’	k^ha:y ‘sell’
CVVG	k^ha:w ‘fishy’	k^hà:w ‘news’	k^hâ:w ‘rice’		k^ha:w ‘white’
CVVG					ha:y ‘missing’
CVVG			hâ:w ‘daring’		ha:w ‘yawn’
CVVG					ho:y ‘exhausted’
CVVG	mɛ:w ‘a cat’			Mɛ́:w ‘a tribesman’	
CVVG			mâ:y ‘widow’		ma:y ‘a notice’
CVVG	wɛ:w ‘sparkling’				
CVVG	Wa:y ‘die’		wâ:y ‘pay respect’	wá:y (onomatopoeia)	wa:y ‘a rattan’
CVVG	wa:w ‘sparkling’		wâ:w ‘a kite’		
CVVG	Wo:y ‘yell’				
CVVG	nɛ:w ‘range’				
CVVG	nə:y ‘butter’				
CVVG	na:y ‘a master’	nà:y ‘boring’			
CVVG					na:w ‘cold’
CVVG		nɔ̀:y ‘a little bit’		nɔ́:y ‘little’	nɔ̌:y ‘exclamation’
CVVG	le:w ‘bad’				le:w ‘liquid’
CVVG	lə:y ‘pass’				
CVVG	la:y ‘pattern’				la:y ‘diversity’
CVVG	la:w ‘Laos’				la:w ‘a spear’
CVVG	lɔ:y ‘float’				
CVVG				rá:y ‘bad’	
CVVG	ra:w ‘a rail’			rá:w ‘crack’	
CVVG	ro:y ‘wither’				
CVVG	rɔ:y ‘a trace’			rɔ́:y ‘hundred’	
CVVG				yə́:y ‘mock’	

CVVG	ya:y ‘grandmother’			yá:y ‘move out’	
CVVG	ya:w ‘long’				
CVVG				yɔ̌:y ‘weeping’	
CVVG	?ə:y ‘look up’				
CVVG			?â:y ‘easy’		?a:y ‘turn face up’
CVVG				?á:w ‘a spear’	

High tones do not occur on CVVG when C_2s are onsets.

C_2

Syllable Shape	Mid	Low	Falling	High	Rising
CVVG	p(l)e:w ‘a flame’				
CVVG	p(r)ə:y ‘hint’				
CVVG	p(l)a:y ‘tip’				
CVVG	p(r)o:y ‘sprinkle’				
CVVG		p(l)ɔ̀:y ‘let go’			
CVVG		bà:y ‘afternoon’			
CVVG		bà:w ‘a servant’			
CVVG	bo:y ‘whip’				
CVVG	tə:y ‘a plant’				
CVVG	Ta:y ‘die’		tâ:y ‘south’		
CVVG			dâ:y ‘a thread’		
CVVG	da:w ‘a star’				
CVVG	do:y ‘by’				
CVVG	dɔ:y ‘a hill’		dɔ̂:y ‘inferior’		
CVVG	cɛ:w ‘paddle’				
CVVG		cà:y ‘distribute’			

CVVG			câ:w ‘royal’		
CVVG			kɛ̂:w ‘a glass’		
CVVG	kə:y ‘overlap’				
CVVG	ka:w ‘a glue’		kâ:w ‘walk’		
CVVG	ko:y ‘shovel’				
CVVG		ʔɔ̀:y ‘speak’			
CVVG	ʔa:y ‘shy’		ʔâ:y ‘brother’ (D)		
CVVG		ʔà:w ‘a bay’	ʔâ:w ‘stuffy’		
CVVG	ʔo:y (onomatopoeia)			ʔó:y (onomatopoeia)	
CVVG			ʔɔ̂:y ‘sugar cane’		