Perhaps, the tones are in the consonants?[1]

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0. Introduction

The Thai writing system, which distinguishes two series of voiceless aspirated stops that reflect an historical voicing contrast, may have influenced the phonology of literate Thais, especialy well-educated native speakers. As the two stop series are in partial complementary distribution with regard to the five tones in Thai at syllable onsets and the tones are not predictable in some environments in morphological processes, one plausible analysis is to differentiate these two stop series phonologically such that one is associated with a High tone and the other with a Low tone. In this case, Thai could be said to have 'tonal consonants' in the grammar.

Not only could such orthographic influence affect the phonology of the native Thai speakers, but it may also affect other Southeast Asian language speakers in Thailand who acquire standard Thai as a second language, or who learn to write their own languages with the Thai scripts.

This paper explores the possibility of 'tonal consonants' as a part of the restructured grammar of native Thai speakers.

1. Representations of Thai tones

Thai tones have been suggested to be segmentally represented by some early generativists e.g., Hiranburana 1971, Leben 1973. Gandour (1974) shows that the previous studies are based on some invalid claim concerning the behavior of contour tones, i.e., that contour tones are neutralized to Mid in fast speech. Gandour disproves the claim by showing the acoustics of fast speech. He further argues, in a generative framework, that the five contrastive tones in Thai are to be represented phonologically by three level tones; High, Mid, Low, and two sequences of level tones; High-Low for Falling, and Low-High for Rising on the basis of the co-occurrence restriction of the tones.

Gandour points out that the sequences High-Low and Low-High are restricted to syllables comprised of two or more contiguous sonorant segments in the rime,

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while level tones, on the other hand, are non-restrictive and freely co-occur with all types of syllables provided that one sonorant segment is minimally present in the rime. For example,

(1)	khaa	'a kind of grass'
	khàa	'a kind of spice'
	kháà	'to kill, n. servant'
	kháa	'to engage in trade'
	khàá	'leg'
	kháàt	'to gird'
	khàán	'to respond to a call'
	*khât	
	*khăt	

Based on the asymmetry of tonal distribution, Gandour proposes that Thai tones are segmental and the tone domain for each tone segment is a sonorant segment in syllable rime.

In the autosegmental framework (Goldsmith 1976, etc.), where features are argued to be independently yet simultaneously represented as autosegments on their own tier, tones are represented as autosegments on the tonal tier and are associated with tone bearing units on the skeletal tier. Since the tone bearing units in Thai are restricted to sonorant segments of syllable rime, Thai tones, therefore, can be represented autosegmentally, assuming one-to-one, left-to-right association convention, as schematized below:

(2) a.
```
        Tα                          TαTβ
       / | \                        |  | \
    C(C)V(V)(C)        and       C(C)V(V)(C)
              |                            |
           [+son]                       [+son]
```

b.
```
        Tα                          TαTβ
        | \                         |  |
    C(C)V(V)C          and       C(C)V  VC
             |                           |
          [-son]                      [-son]
```

For example, from (1), we have

```
(3)  a.   M           b.   L
          |\               |\
         khaa             khaa

     c.   HL          d.   H
          ||               |\
         khaa             khaa
```

e. LH
| |
khaa

2. Tonal Distribution in Thai

According to Gandour's (1974) observation, the co-occurrence restriction of the five tones in Thai are conditioned by syllable structure (rime structure) as follows:

SYLLABLE STRUCTURES	PHONEMIC TONES Mid	Low	Falling	High	Rising
(1) CVV	x	x	x	x	x
(2) CV(V)Cf Cf = m, n, ŋ, w, y	x	x	x	x	x
(3) CVVCf Cf = p,t,k		x	x	(x)	
(4) CVCf Cf = p, t, k, ʔ		x		x	

(x) = limited occurrences, restricted to non-Indic loans and onomatopoeia

Table 1: Tonal distribution in Thai according to Gandour (Gandour 1974c:138)

Gandour's observation may be summarized as shown in table 2 below :

SYLLABLE STRUCTURES	SURFACE TONES H	M	L	F	R
CV{(V)}([+son])} 'unchecked'	x	x	x	x	x
CV(V)[-son] 'checked'	x		x	x	

Table 2: Tonal distribution in Thai according to syllable types

Although Gandour has accounted for much of the previously unexplained pattern by suggesting the segmental nature of tones and the quality of the tone bearing units, he still left many gaps unsatisfactorily explained, such as those of the Mid and Rising tones on checked syllables with long vowels (CVV [-son] in table 2). Although by his account, the structual description for both Mid and Rising tones are met, these syllables never co-occur with Rising nor Mid tones. To him, the gaps are accidental, and the best explanation for the gap on Rising tone is the asymmetry of physiology of tone production which prefers Falling to Rising due to ease of production (cf. Ohala & Ewan 1973).

Moreover, scrutiny of Thai tones reveals further uneven distribution among syllables of the same type indicating other conditioning factor(s) being involved.

CONSONANT ONSETS (C_1)	SURFACE TONES Mid	Low	Falling	High	Rising
(1) $C_1(C_2)V\{(V)(C_3)\}$ where C_3 = m, n, ŋ, w, y					
ph	x	x	x	x	x
p, b	x	x	x	(x)	(x)
m	x	x	x	x	x
(2) $C_1(C_2)VC_3$ where C_3 = p, t, k, ʔ					
ph		x		x	
p, b		x		(x)	
m		(x)		x	
(2) $C_1(C_2)VVC_3$ where C_3 = p, t, k,					
ph		x	x	(x)	
p, b		x		(x)	
m		(x)	x	(x)	

where optional consonant onset (C_2) = [+son], and (x) = very limited occurrences, mainly restricted to non-Indic foreign loans and onomatopoetic words, and *ph, p, b, m* stand for aspirated voiceless stops, unaspirated voiceless stops, and unaspirated voiced stops, and sonorants respectively.

Table 3: Tonal distribution in Thai with respect to syllable rime and consonant onset.[2]

The asymmetrical distribution (cf. tables 2 & 3) leads us to ask these questions: Why are there only three tones on checked syllables? Are there five underlying tones on checked syllables? Why are the aspirated stops the only class of stops that co-occur with all five tones in unchecked syllables? Why are the unaspirated stops mainly restricted to Low tone in checked syllables? What roles do the limited non-Indic foreign loans and onomatopoeic words play in Thai phonology? And how do Indic loans differ from other foreign loans?

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[2] It is noted that voiceless fricatives form a natural class with some voiceless aspirated stops with respect to tones.

These questions suggest an investigation of an unobserved area of tonal phenomena in the language, morphological tonal alternation, in hope that it may shed some light on the synchronic tonal pattern.

3. Morphological Tonal Alternations

3.1 *Monosyllabic vs. Bisyllabic Alternation*

A subset of mono-syllabic roots have bi-syllabic alternants. These may be classified into three groups according to the type of alternation involved. Obstruents are neutralized to unaspirated voiceless stops of the same place of articulation syllable-finally, and liquids are neutralized to homorganic nasals at syllable final.[3]

3.1.1 *Short checked syllable as the monosyllabic alternant. The bisyllablic alternant takes the form as in (4)*

(4) C_1VC_2 ~ $C_1VC_2aʔ$ where C_2 = [-son]
\ | / \ | /\ | /
σ σ σ

For example,

(5) sùkh ~ sùkhàʔ 'happy'
thúkh ~ thúkhàʔ 'sad'
pháth ~ pháthá̀ʔ 'bind'

Since the first syllable (σ1) does not change structure, i.e., it is not resyllabified differently in the bisyllabic form, there is no tonal change in σ1 of the bisyllabic form.

3.1.2 *Long checked syllable as the monosyllabic alternant. The bisyllabic alternant takes the form as in (6)*

(6) C_1VVC_2 ~ $C_1VVC_2aʔ$ where C_2 = [-son]
\ | / / \ | / \ | /
σ σ σ

---

[3] Obstruent Neutralization (ON) :
[-son] > [-vce] /---] σ
[-sprd] |
[-cont] C
Liquid to Nasal Neutralization (LNN) :
[+son] > [-lat] /---] σ
[+coronal] [+nas] |
C

For example,

(7)	ráàč	~	**raačáʔ**	'of royalty'
	lóòph	~	**loopháʔ**	'greed'
	lóòk	~	**lookàʔ**	'(of the) world'
	phóòkh	~	**phookháʔ**	'eat, consume'
	čáàt	~	**čaa**tàʔ	'birth'
	ʔòoč	~	ʔoočáʔ	'delicious'
	kròoth	~	kroothá ʔ	'angry'
	sòok	~	sòókàʔ	'sad'
	thùup	~	thùúpàʔ	'a pagoda where the ashes of the deceased is kept'

Resyllabification takes place in the bisyllabic alternant, and there is a concommitant change in tone. Tone alternation takes place in the first syllable of the bisyllabic form (σ1) according to syllable type and consonant onset.

3.1.3 *The monosyllabic alternant is an unchecked syllable (σr) with either long or short vowel. There are two alternant bisyllabic forms:*

```
(8)   C1V(V)C2     ~    C1V(V)C2aʔ     ~    C1aʔ C2aʔ
       \ | / /           \ | / (/)\| /        \ | /  \ | /
          σ                  σ      σ            σ     σ
```

For example,

(9)	kɔɔr	~	**kɔɔ**ráʔ	~	**kàʔ**ráʔ	'hand'
	cɔɔr	~	**cɔɔ**ráʔ	~	**càʔ**ráʔ	'travel'
	thɔɔr			~	**tháʔ**ráʔ	'withholding'
	sɔ̌ɔr	~	**sɔ̌ɔ**ráʔ			'arrow, brave'
	nɔɔr	~	**nɔɔ**ráʔ	~	**náʔ**ráʔ	'human'
	thon			~	**tháʔ**náʔ	'property'
	thŏl			~	**thàʔ**láʔ	'highland'
	phol	~	**pho**láʔ	~	**pháʔ**láʔ	'energy'
	čol	~	**čo**láʔ	~	**čáʔ**láʔ	'water'
	čŏl			~	**čàʔ**láʔ	'cheat'
	sŏm			~	**sàʔ**máʔ	'be equal'
	thèér	~	**thèé**ráʔ			'monk'

3.1.4 *Predictability of tone in bisyllabic alternants*

In general, tonal alternations in σ1 for all three processes above seem to be governed by the resulting syllable type and the consonant onset. This may be summarized as follows:

Onset	Rime		
	unchecked	checked	
	V(V) ([+son])	VV[-son]	Vʔ
Ch, r	M	HL	H
Ch, s	LH	L	L
C, ʔ	M	L	L

where r = [+son], Ch = [+sprd GL, -son], s = [-son, +cont], C = [-sprd GL, -son, -cont], and ʔ = [+const GL]

Table 4: Summary of tonal alternation in σ1 of monosyllabic vs. bisyllabic alternation

Assuming the monosyllabic form to be the basic alternant since it is the form that occurs in isolation, the generalizations governing tonal alternation may be stated as follows:

(10) a. For all resonant onsets and some aspirated stop onsets, Mid becomes High in short checked syllables.
b. Mid becomes Low on checked syllables elsewhere.
c. For all voiceless fricative onsets and some aspirated stop onset, either Mid becomes Rising (LH) on unchecked syllables or the Rising tone is underlying.
d. Falling tone on long checked syllables becomes High when the vowel is short.

The tone realized on the second syllable of the bi-syllabic alternant, which is a CVʔ syllable formed by the coda of the monosyllabic alternant, can be summarized as follows: (from [5], [7] & [9])

Onset	Rime Vʔ
r	H
Ch	H/L
C	L

Table 5: Tones on σ2 of the bisyllabic alternant in monosyllabic vs. bisyllabic alternation

There seems to be a pattern of tonal alternation and tone assignment shared by both σ1 and σ2 of these alternants (cf. tables 4 & 5). And the pattern seem to be correlated with syllable rime and consonant onset.

3.2 *Affixation*

Monosyllabic roots become bi-syllabic via different derivations, sometimes without category or semantic change. Bi-syllabic derivations may be subgrouped into three groups according to the type of derivation involved as follows:

3.2.1 *-aa*, or *-ii* suffixation. For example,

(11)	tháàs	>	thaas**àá**	'slave, servant'
		>	*thaas**ìí***	'f. slave, servant'
	thóòs	>	thoos**àá**	'punishment'
	sùkh	>	sù**khàá**	'happy'
		>	sù**khìí**	'one who is happy'
	sòok	>	sòó**kaa**	'sad'
	sàál	>	sàá**laa**	'shelter'
	róòkh	>	rook**haa**	'disease'
		>	*rook**hii***	'disease'
	lóòk	>	look**aa**	'world'
		>	lookii	'(of the) world'
	méèkh	>	meek**haa**	'could'
	bàath	>	baat**haa**	'foot, shoes'

The tone realized on the syllable formed by consonant coda of the root and the suffix, *which takes the form Caa* or *Cii, is not influenced by the tone of the* monosyllabic root. Rather, the tone realized is determined by the consonant coda of the root which becomes the onset of the newly formed unchecked syllable (σr). The following pattern is observed:

Onset	Rime VV
r	M
Ch	M
Ch	LH
s	LH
C	M

Table 6: Tones realized on syllable formed by suffixes *-aa* or *-ii* (on σ2)

It is observable that tonal alternation in σ1 of the monosyllabic vs. bisyllabic alternation (cf. table 4) and in σ2 of monosyllabic vs. bisyllabic alternation (table 5) and in σ2 of suffixation (table 6) is more or less similar. All seem to be conditioned by syllable rime and consonant onset. The tone realized on the newly formed syllable (σ2) in both morphological processes can be summarized as follows (from tables 5 & 6):

Onset	Rime VV	V?
r	M	H
Ch	M/LH	H/L
s	LH	L
C	M	L

Table 7: Tones realized on σ2 in bi-syllabic form in both monosyllabic vs. bisyllabic alternation and suffixation

Tone assignment in newly formed syllables in bisyllabic form can be stated as follows:

(12) a. for all voiceless fricative onsets and some voiceless aspirated stop onsets, Rising tone surfaces on unchecked syllables.
b. Elsewhere, unchecked syllables surface with Mid tone.
c. For all resonant onsets and some voiceless aspirated stop onsets, short checked syllables surface with High tone.
d. Elsewhere, checked syllables surface with Low tone.
e. Either Rising tone in (a.) is derived or it is underlying.

In general, (12) repeats (10), except that there is no example of long checked syllables in σ2 of the bisyllabic forms available. The similarity of the two patterns indicate the same governing principle being involved.

3.2.2 *-am(n) infixation*

Some monosyllabic verbs become bisyllabic verbs or nouns by *-am(n)* infixation as follows:

(13) a. $C_1C_2V(V)C_3$ > $C_1am.C_2V(V)C_3$
b. $C_1V(V)C_3$ > $C_1am.nV(V)C_3$
Where C_1 = [-son], and C_1 [+vce] is optional

The derived form maintains the original tone of the root in the second syllable whereas the first syllable, which is unchecked, receives tone according to consonant onset. For example,

14.				
	dəən	>	**dam**nəən	'walk'
	khuan	>	**kham**nuan	'calculate'
	sr̥èt	>	**sǎm**rèt	'finish'
	khr̥óp	>	**kham**róp	'complete'
	pràap	>	**bam**ràap	'subdue'
	càay	>	**cam**nàay	'pay, distribute'
	sǐáŋ	>	**sǎm**niaŋ	'voice'
	sr̥ùə́n	>	**sǎm**ruən	'laugh'

pruŋ > **bamruŋ**
'improve' 'support, sustain'

trùat	>	**tam**rùat
'check'		'police'
tràt	>	**dam**ràt
'speak'		'speech'

The examples *sǐáŋ* > *sǎmniaŋ, *sǎmnǐáŋ, *samnǐáŋ* 'voice', and *sr̥ùə́n* > *sǎmruən, *sǎmrùə́n, *samrùə́n* 'laugh' seem to indicate that the underlying tone of the root is Mid which is realized on the second syllable of the derived form, rather than Rising, and that the Rising tone on *sǎm* is probably derived. Thus, the uncertainty raised in (10)c. and (12)e. is resolved.

3.2.3 *-a(n) infixation*

Some monosyllabic verbs become bisyllabic verbs or nouns by *-a(n)* infixation as follows:

15. a.	$C_1C_2V(V)C_3$	>	$C_1a.C_2V(V)C_3$	
		>	$C_1aʔC2V(V)C_3$	(by GI)[4]
b.	$C_1V(V)C_3$	>	$C_1a.nV(V)C_3$	
		>	$C_1aʔnV(V)C_3$	(by GI)

where $C_1aʔ > C_1raʔ$, with CC-cluster onset in the root.

For example,

(16)	klàt	>	**kràʔ**làt	'clip'
	phǎŋ	>	**phàʔ**nǎŋ	'wall'
	ráàp	>	**ráʔ**náàp	'flat'
	raaw	>	**ráʔ**naaw	'rail'
	rǽʔ	>	**ráʔ**nǽʔ	'foundation of a building'
	khlay	>	**khráʔ**lay	'go'
	khlɔɔŋ	>	**khráʔ**lɔɔŋ	'canal'
	čiáŋ	>	**čàʔ**ríáŋ	'oblique/corridor'
	phæ̀æk	>	**phàʔ**næ̀æk	'divide/division'
	sùk	>	**sàʔ**nùk	'be happy/fun'

The tone of the root is realized on the second syllable, and the first syllable which is short checked (σ0) in the phonetic output, receives tone according to consonant onset.

4 Glottal Insertion (GI)

$$\emptyset \quad > \quad \underset{[+\text{const}]}{\overset{}{C}} \qquad /CV\text{---}]\,\sigma$$

From *-am(n)* and *-a(n)* infixation, the following tone assignment is observed:

Onset	Rime: Root V(V)[-son]	Rime: Root V(V)[+son]	Rime: New Syllable V[+son]	Rime: New Syllable Vʔ
r	H/ HL	M		H
Ch	H	M	M	H
Ch	L	LH		L
s	L	LH	LH	L
C	L	M	M	L

Table 8: Tones on new syllables formed by *-am(n)* and *-a(n)* infixation (σ1)

Again, the pattern found in infixation is similar to those found in other morphological processes mentioned earlier (cf. tables 4 & 6). Moreover, in this case, the tone of the root arises as a third factor for determining the H or L on the new short checked syllable with voiceless aspirated stop onsets.

3.3 *Vowel-Insertion*

The default vowel *a* is inserted to break up consonant clusters incurred from morpheme concatenation according to (17) below:

(17) Ø -----> V / ...C]---[C... (optional)
| |
a [-const GL]

The inserted-vowel is resyllabified with the preceding consonant and a glottal insertion rule (cf. GI in footnote 4) inserts a glottal coda to the CV-syllable formed. The tone realized on this newly formed *Caʔ* syllable can either be Low or High, for example,

(18)	khóč	+	sàár	>	khó**čáʔ**sàán	‘elephant’
	kòč	+	kɔɔr	>	kò**čáʔ**kɔɔn	‘placing together of hands’
	sàc	+	tham	>	sà**càʔ**tham	‘truth’
	kal(p)	+	phrɨ́k	>	kaláʔ**pàʔ**phrɨ́k	‘magic tree’
	phéèth	+	phay	>	phéè**tháʔ**phay	‘danger’
	hàth	+	kam	>	hà**thàʔ**kam	‘hand crafts’
	phol	+	rɨan	>	pho**láʔ**rɨan	‘civilian’
	phŏl	+	máy	>	phŏ**láʔ**máy	‘fruit’
	čol	+	thaar	>	čo**láʔ**thaan	‘canal’
	ráàč	+	róth	>	ráà**čáʔ**rót	‘royal car’
	thós	+	kɔɔr	>	thó**sàʔ**kɔɔn	‘one with ten hands’
	rós	+	níʔyom	>	ró**sàʔ**níʔyom	‘taste’
	cĭt	+	wéèth	>	cĭ**tàʔ**wéèt	‘psychologist’
	kàak	+	bàad	>	kaa**kàʔ**bàat	‘cross’
	čák	+	tùk	>	čá**kàʔ**tùk	‘impulse’

sàph	+	sĭŋ	>	sà**phá?**sĭŋ	'all things'
lúùk	+	taa	>	lúù**kà?**taa	'eyeball'

3.4 *Fusion*

This process generally occurs with morphemes of Indic origin. When the two morphemes are juxtaposed, if the first item is bi-syllabic with a mono-syllabic alternant of the form discussed in 3.1.1 or 3.1.2 above, and the second item begins with a glottal stop or a long vowel, after Glottal & Tone Deletion rule applies,[5] the vowels are fused together and form the nucleus of a new syllable. For example,

(19)	hàthà?	+	aaphɔɔr	>	hà**thàá**phɔɔn
	'hand'		'accessories		'hand accessories'
	sùkhà?	+	?à?phí?baal	>	sùk**khàá**phí?baan
	'happy'		'take care'		'health care (for happiness)'
	phookhá?	+	?aisà?wàán	>	phoo**khai**sà?wàán
	'property'		'lordship'		'property'
	phátà?	+	aakhaar	>	phá**taa**khaan
	'food'		'building'		'restaurant'
	sàcà?	+	?à?nú?sɔ̆ɔr	>	sà**caa**nú?sɔ̆ɔn
	'truth'		'memoir'		'memoir of truth'
	raačá?	+	?à?nú?sɔ̆ɔr	>	ra**čaa**nú?sɔ̆ɔn
	'royal'		'memoir'		'memoir of the king'
	raačá?	+	?ù?pà?thăm	>	raa**čuu**pà?thăm
	'royal'		'care of'		'in royal care'
	thísà?	+	?à?nú?thís	·	thí**sàá**nú?thít
	'direction'		'little direction'		'all directions'
	pholá?		?à?naamay	>	phá?**laa**naamay
	'power'		'health'		'health'

The tones realized in the new syllables formed by either vowel insertion or fusion follow one of three patterns: those with Low and Rising on short checked and unchecked syllables respectively, those with High and Mid, and those with Low and Mid. The tones realized can be summarized as follows:

[5] Glottal and Tone Deletion (GTD) :

Tα Tβ Tα Tβ

...V ?] [(?) V (V)... > . ..(V) V ...

Onset	Rime	
	Vʔ	VV
Ch,s	L	LH
Ch,r	H	M
C	L	M

Table 9: Tones realized on new syllables formed by Vowel insertion and Fusion

Tone assignment in vowel insertion and fusion is in the same manner as in the new syllable formed in bisyllabic form (cf. table 7). And (12) may be restated as follows:

(21)
a. For all voiceless fricative onsets and some voiceless aspirated stop onsets, Rising tone surfaces on unchecked syllables.
b. Elsewhere, unchecked syllables surface with Mid tone.
c. For all resonant onsets and some voiceless aspirated stop onsets, short checked syllables surface with High tone.
d. Elsewhere, checked syllables surface with Low tone.
e. Rising tone in (a.) is derived.

3.5 *Partial Reduplication*

Partial reduplication copies the first consonant onset of a monosyllabic root and prefixes the reduplication morpheme (RED), which is a CVʔ syllable to the root ($\sqrt{\sigma}$) as follows:

(22) $C_1(C_2)V_1(V_2)(C_3)$ > $C_1\underset{a\ ʔ}{VC}\text{-}C_1(C_2)V_1(V_2)(C_3)$

i.e., $\sqrt{\sigma}$ > Caʔ- $\sqrt{\sigma}$

The tone of the root is not copied, and RED gets either High or Low tone, for example,

(23)

kráàw	>	kàʔ-kráàw,	*káʔ-kráàw	'roar'
kɔ̀ɔŋ	>	kàʔ-kɔ̀ɔŋ,	*káʔ-kɔ̀ɔŋ	'beautiful'
dan	>	dàʔ-dan,	*dáʔ-dan	'push'
čít	>	čáʔ-čít,	*čàʔ-čít	'come near'
čàán	>	čàʔ-čàán,	*čáʔ-čàán	'witty'
cæ̂æŋ	>	càʔ-cæ̂æŋ,	*cáʔ-cæ̂æŋ	'enlightened'
čɔ̂ɔŋ	>	čáʔ-čɔ̂ɔŋ,	*čàʔ-čɔ̂ɔŋ	'hole'
khæ̂æn	>	khàʔ-khæ̂æn,	*kháʔ-khæ̂æn	'strong'
khɨ́k	>	kháʔ-khɨ́k,	*khàʔ-khɨ́k	'loud noise'
phaan	>	pháʔ-phaan,	*phàʔ-phaan	'meet'
phɔ́ɔŋ	>	pháʔ-phɔ́ɔŋ,	*phàʔ-phɔ́ɔŋ	'agree'
rík	>	ráʔ-rík,	*ràʔ-rík	'laugh'
rɨ̂ɨn	>	ráʔ-rɨ̂ɨn,	*ràʔ-rɨ̂ɨn	'smooth'
laan	>	láʔ-laan,	*làʔ-laan	'exited'

léèn	>	láʔ-léèn,	*làʔ-léèn	'play'
sàáŋ	>	sàʔ-sàáŋ,	*sáʔ-sàáŋ	'untangle'
sùə́y	>	sàʔ-sùə́y,	*sáʔ-sùə́y	'pretty'

The tones on RED's can be summarized as follows:

RED Onset	RED Rime	ROOT Onset	ROOT Rime: VV[-son]	ROOT Rime: V[-son]	ROOT Rime: V(V)[+son]
	Vʔ		VV[-son]	V[-son]	V(V)[+son]
Ch, r	**H**	Ch, r	HL	H	H, M, **HL**
Ch, s	**L**	Ch, s	L	L	L, R, **HL**
C	L	C		L	L, M, HL

Table 10: Tone in partial reduplication

For all but the unchecked roots with HL and Ch onsets, the tone of RED is predictable from syllable rime, consonant onset, and when necessary, the tone of the root. Only the Ch case with HL tone needs to be specially specified for the tone realized on RED.

3.6 *Summary*

In sum, it may be said that the same restriction on tones is applicable to all the morphological processes presented. The independent variables are: consonant onset, syllable rime, and tone of the root. In all cases, consonant onset is significant, and only in a few cases is the tone of the root significant. For example, in vowel insertion, the syllable rime is fixed, and the tone of the root is insignificant; the only factor determining the tone is the consonant onset. In some other processes, such as partial reduplication or infixation, syllable rime is fixed, but the tone of the root is significant for determining the tone realized with the Ch onsets.

The systematic tone assignment in these morphological processes allows learners to make prediction of tones on REDs and on new formed syllables with infixation directly from consonant onset and tone of the root when necessary. Prediction is also possible for tones on $\sigma 1$'s or $\sigma 2$'s in monosyllabic vs. bisyllabic alternation and in suffixation, and on new syllables formed by vowel insertion and fusion from the two independent variables, consonant onset and syllable rime. The only exception when prediction is not possible is when the consonant onset is of the Ch class. For example, in partial reduplication, if the root is an unchecked syllable with Ch onset and HL, prediction is not possible. RED can either take a H or L. Another example, a short checked syllable with Ch onset formed by vowel insertion may either take a H or a L, etc. In such cases, the tone realized on the new syllables have to be morphologically marked. The question is how are these tones morphologically marked.

Do we need information such as (24) listed in the lexicon?

(24) hàth 'hand': +L (if checked)
+LH (if unchecked)

ráàč 'of royalty, of the king':
+H (if short checked)
+HL (if long checked)
+M (if unchecked)

And for all the predictable cases, learners need only to memorize the correlation of the independent variables and the dependent variable, which is tone, perhaps by something analogous to formal representation of statements in (21).

Even so, listing the lexicon as in (24) above seems redundant and would be quite costly. For the ease of language acquistion task, such information is reducible to minimum. How this is to be done and how it is (21) to be formulated is to be explored below.

4. Analysis

An alternative to listing the lexicon as in (24) is to posit some kind of unassociated or floating tones.

4.1 *Floating Tones*

Positing a floating tone, L or H, on the right edge, i.e., at morpheme final, can account for the tone realized on the new syllable formed. When the final consonant is resyllabified as an onset of a new syllable, the floating tone then, is associated with the toneless new syllable. To account for partial reduplication and infixation, L/H left edge tone is necessary for the roots with Ch onset. And RED copies both consonant onset and the floating tone. For example,

(25)
L
/khǽæn/ > khàʔ-khǽæn

H
/čɔ̂ɔŋ/ > čáʔ-čɔ̂ɔŋ, *čàʔ-čɔ̂ɔŋ

H
/kòč/ > kòčáʔ-, *kòčàʔ

L
/hàth/ > hàthàʔ-, *hàtháʔ-

Positing right-edge floating tone at the end of the morpheme is not at all ad hoc. It actually is a very plausible alternative since it is not unreasonable to postulate that such tone is developed from historical syllable loss. A comparison with Pali and Sanskrit roots does confirm such syllable loss for words with Indic origin.

And there is a systematic correlation between L/H with obstruent voicing contrast at the onset of the lost syllable in the Indic roots (Tumtavitikul 1992). For example,

(26)			Thai			Sanskrit	
	L sùkh	~	sù**kh**àʔ	'happy'	<	su**kh**a	's.n., joy'
	H khóč	~	khóčáʔ	'elephant'	<	gaja-	's.m., elephant'

For the unchecked and long checked cases, a few tone rules will derive the correct surface forms (cf. tone rules (31)-(34) below).

In the unmarked cases, i.e., those lexical items that do not need special tone marking, and the tones in morphological processes are more or less predictable given consonant onset, syllable type, and if neccessary, tone of the root. The generalizations governing the tone assignment (cf. (21)) can be formulated as follows:

Default Tone Rules

Mid Default (MD):

```
(27)   Ø      >      M / ----
                          |
                          V
```

Low Neutralization (LN):

```
(28)   M      >      L / ----
                          | (\)
                          V ....] σo
```

σo = checked syllable

```
(29)   M      >      LH / ----        if σ [C = [-son, +cont],
                           |\ (\)     or some [-son, +sprd]
                           V....] σr
```

σr = unchecked syllable

```
(30)   M      >      H / ----         if σ [C = [+son], or
                          |           some [-son, +sprd]
                          V...] σo
```

Low Neutralization (28) is a plausible rule since lowering effect of postvocalic stops on the preceding vowels is noted (Hombert 1978). And (28) can easily be reformulated to mention the obstruent segment as the environment.

```
(28)   M      >      L / ----
                          | (\)
                    [...V...[-son]] σ
```

The problem, however, is with the conditional clause 'some [-son, +sprd]' that needs to be specified as an environment for both (29) and (30). The clause indicates 'random' voiceless aspirated onsets, which entails some kind of morphological marking. Thus, it seems, morphological marking is necessary for all lexical items with aspirated obstruents at either or both ends. If the marking that would satisfy (29) and (30) were the same as that of the special cases in (25) above, it would lessen the load of language acquisition. Moreover, it has been stated in the summary section above (cf. 3.6) that all the morphological processes are governed by more or less the same principle. Therefore, there seems to be no need to differentiate the items that would satisfy rules (29) and (30) from those marked with floating tones in (25).

If we may, then, the lexical items with voiceless aspirated stops will be marked with a floating tone L for (29) and a floating tone H for (30), and rules (29) and (30) will be replaced by other rules which will interact with floating tones (cf. [32]-[34] below).

Is it justifiable to rule out (29) and (30) for the case of fricative and sonorant onsets as well? The answer lies in the naturalness of the rules themselves. How can we explain (29) being conditioned by fricative onsets and (30) by sonorant onsets? There seems to be little phonetic motivation behind the rules. Positing a uniform floating tone L for fricative onsets and uniform H for sonorant onsets that is supplied by redundancy rules, and allowing tonal interactions to take care of the phonetic output seems to be more in line with the case of voiceless aspirated onsets. If it can be shown that historically the posited tones arose from the same or parallel development as in the case of aspirated stops, our postulation will be confirmed. Historical development does in fact, confirm that such is the case (Tumtavitikul 1992).

(29) and (30) then are substituted by morphological marking for the aspirated stop onsets, and redundancy rules (31)a. and b. below:

Redundancy Rules

```
(31)  a.   Ø   >   L / ---
                        |
                     [-son]
                     [+cont]
                      x   \
                           σ

      b.   Ø   >   H / ---
                        |
                     [+son]
                      x   \
                           σ
```

Clearly, in both (31) a. and b. the consonant onset licenses the tone, which implies a one-to-one correlation between consonant onset and tone segment. And the association line linking the tone segment and the consonant onset is inevitable. Hence, 'tonal consonants', i.e., consonants with associated tones in the phonological representation are inescapable.

The analysis above shows that positing floating tones alone is insufficient, the accompanying redundancy rules require tones to be associated with at least, some consonant onsets.

Tone Rules

(32) High Spreading (HS)

```
     H    L
    ( | )`-.J (\)
  σ [C       V ...
```

(33) Low Spreading (LS)

```
     L    M
    ( | )`-.J (\)
  σ [C       V ...     ; followed by (34)
```

Contour Exaggeration (CE):
(34) L M > L H

Rule Ordering:[6]
(35) Redundancy Rules (31a & b)
Consonantal Tone Spreading (CTS)[7]
Mid Default (MD)
Low Neutralization (LN)
High / Low Spreading (HS & LS)
Contour Exaggeration (CE)
Tone Deletion (TD)[8]
Obstruent Neutralization (ON)
Liquid to Nasal Neutralization (LNN)

---

[6] With regard to level of application, TD, ON and LNN are post-lexical, and the rest of the rules in (35) are lexical rules with cyclical application.

[7] Consonantal Tone Spreading (CTS) :

```
     Tα
     |\
  σ [C C V ...]
```

[8] Tone Deletion (TD) :

```
     Tα      >      Ø
    ( | )`*.
  σ [C
```

i.e., delete the tone licensed by consonant onset that does not spread.

Example derivations:

```
(36)  a.  LL          M              LL M   M
          |           |\             |  |   |\
          hath   +   kam     >       hathaʔkam
                                     (VI, re-σ, GI, MD)

                                     LL  L   M
                                     |   |   |\
                             >       hathaʔkam
                                     (LN,TD)

                             >       hàthàʔkam

      b.  LL        M    M           L LL          M    M
          |         |\   |\\         |  |          |\   |\\
          hath  +  aaphɔɔr   >       hathaʔ    +   aaphɔɔr
                                     (MD, LN)

                                     L LM     M
                                     |  \‡\   |\\
                             >       hathaaphɔɔr
                                     (G&TD,MD,LS)

                             >       hàthàáphɔɔn
                                     (CE, LNN)

(37)  a.  LL          M              L   M     M
          |           |\             |   |     |\
          sac    +   tham    >       sa  caʔ  tham
                                     (VI, re-σ, GI, MD)

                                     L  L   M
                                     |  |   |\
                             >       sacaʔtham
                                     (LN)

                             >       sàcàʔtham
```

```
b.  L          L H   LH          L  L       L  H LH
    |          | |   ||\         |  |       |  |  ||
   sac    +  ʔaʔnuʔsɔɔr      >  sacaʔ   + ʔaʔnuʔsɔɔr
                               (MD,LN)

                                L  M   H  LH
                                |  |\  |  ||\
                       >       sacaanuʔsɔɔr
                                (G&TD,MD)

                       >        sàcaanúʔsɔ̌ɔn
                                (LNN)

(38)  a.  HLH        H          HLHM  H
          ||         |          ||  |  |
         raač   +  roth    >   raačaʔroth
                               \|//\|/ \|/
                                σ   σ   σ
                               (VI, re-σ, GI, MD)

                                 HLHL   H
                                 ||      |
                       >        raačaʔroth
                                \|//\|/ \|/
                                 σ   σ   σ
                                (LN,HS)

                       >        ràáčáʔrót
                                (ON)

      b.  HLH      L  H  LH      HLHL                   L  H  LH
          ||       |  |  ||\                             |  |  ||\
         raač  +  ʔaʔnuʔsɔɔr   > raačaʔ        +       ʔaʔnuʔsɔɔr
                               (TDS,[9] MD,LN,HS)

                                M   M   H  LH
                                |\  |\  |  ||\
                       >       raačaanuʔsɔɔr
                                (G&TD,MD)

                       >        raačaanúʔsɔ̌ɔn
                                (LNN)
```

---

[9] Tone Deletion due to re-Syllabification (TDS) :

```
       Tα  Tβ                        Tα Tβ
       |   |                         ≠  ≠
  σ[C  V  (V)  C]...        > σ [C  V  (V)]  σ [C ...
               |                                 |
            [-son]                            [-son]
```

4.2 *Tonal Consonants*

It has been shown in the previous section (4.1) that even positing floating tones to acount for tonal alternation requires some redundancy rules where consonant onset licenses tone. That is, 'tonal consonants' are inevitable even with an analysis with floating tones. Here, it will be shown that an alternative analysis with tonal consonants instead of floating tones is the correct analysis. Argument will be made on the insufficency of an anaysis with floating tones and the necessity of drawing the association line between the tone and the consonant that licenses it.

If all the morphemes in Thai end or begin with a single consonant, we would have our problem solved quite easily. Morphological marking with floating tones, at either or both left and right edges, accompanying with tone rules and redundancy rules, would have been quite a very satisfactory solution. The fact is that the Thai lexicon has a considerable number of lexical items with consonant clusters at syllable onset and/or coda. The test for morphological marking of an edge tone will be the independence of the edge tone from the aspirated consonant in the cluster. The position of the consonant in the cluster on the skeletal tier does not matter. The only important thing is that the floating tone is properly placed at either or both ends of the morpheme since they are edge tone(s) of the morpheme.

If however, it can be shown that the aspirated consonant in the cluster licenses the tone in a one-to-one fashion, that is, if the floating tone is not necessarily placed at morpheme final nor morpheme initial as edge tone, but its position on the tonal tier is segmentally fixed depending upon the position of the consonant on the skeletal tier, then we have evidence for associating the tone licensed by the aspirated consonant to the consonant itself.

4.2.1 *Cluster onset*

There are three types of cluster onsets. First, a cluster formed by an initial voiceless stop followed by a sonorant, in which case, the cluster uniformly behaves as a true cluster with respect to vowel insertion, i.e., the cluster is unbreakable. Second, a cluster formed by an obstruent followed by a sonorant in which vowel insertion is allowed and the phonetic output is a result of the cluster being broken up and resyllabified as two different syllables. And third, a cluster formed by a fricative or an affricate followed by a stop which is also breakable into two syllables.

For example,

(39)	a.	prà?paa	>	*pà?rà?paa, *pà?rá?paa	'tap water'
		praačai	>	*pà?raačai,	'defeat'
		khwan	>	*khá?wan, *khà?wan	'smoke'
		kláà	>	*kà?láà	'brave'
	b.	snǐm	>	sà?nǐm	'rust'
		syàám	>	sà?yàám	'Siam'
		phyǒŋ	>	phà?yǒŋ	'proud'

	khnàán	>	khàʔnàán	‘parallel’
	knòk	>	kàʔnòk	‘gold’
c.	stíʔ	>	sàʔtǐʔ	‘consciousness’
	sphaa	>	sàʔphaa	‘council’
	spháàp	>	sàʔpháàp	‘state of being’
	sbai	>	sàʔbai	‘shawl’
	sthǐt	>	sàʔthǐt	‘stay, remain’
	čphɔ́ʔ	>	čàʔphɔ́ʔ	‘especially’

In the first case (39a), since the sonorant in the cluster is not the first member of the onset, it is obvious that the redundancy rule (31b) does not apply and the sonorant behaves uniformly with the first consonant in the cluster with respect to tone. The uniform behavior of the cluster, at a glance, may seem to be arguing in favor of floating tone, since positing only one edge tone at morpheme initial would have accounted for the uniform behavior of the cluster with respect to tone. However, scrutinizing the structure of the cluster reveals evidence in favour of positing tonal consonants. Since the cluster is unbreakable, the consonants in the cluster may be considered a true cluster in that they both share the same C-slot on the skeletal tier. And thus, sharing the same tone attaching to that C-slot.

(40)

```
ph  r
|  /
C    V   (V) ...
|
Tα
```

In the second case, since the cluster is breakable, and thus may be considered to consist of two C-slots underlyingly instead of being a true cluster as in the case of (40) above. Since the sonorant is the second member of the onset, (31b) does not apply; instead, the tone licensed by the first consonant in the cluster spreads onto the sonorant, causing the sonorant to behave as having the same tone attaching to it. When tier conflation applies and the syllable is broken up, the tone attached to the sonorant interacts with the tone of the original syllable causing the syllable to surface differently. Thus, Rising tone is possible with sonorant onset.

(41)

```
              L M           L M          LLM
              | |\          | |\         |||\
/snim/  >     snim     >    snim    >    snim
            (31a,MD)       (CTS)       tier conflation

             LM LM                      LL LM
             ||  ||\                    || ||\
        >    saʔnim                >    saʔnim
            (VI,GI,MD)                 (LN,LS)
        >    sàʔnǐm
            (CE,TD)
```

It is the tone attached to the sonorant that blocks the application of (32b) after the syllable is broken up, otherwise, the output will be ill-formed as in (41)':

(41)'

```
                  L M
                  | |\
/snim/    >       snim
| || |            (31a,MD)
CCVC

                  LL HM
                  || ||\
          >       saʔnim
                  (VI,31b,GI,MD,LN)

          >       *sàʔnim
                  (TD)
```

Another possibility is having a Rising tone underlying. This allows (31b) to apply after the syllable is broken up. However the output would still be ill-formed.

(41)"

```
   LH            L LH
   ||            | ||
 /snim/     >    snim
  ||||           (31a)
  CCVC

                 LM HLH
                 || |||
            >    saʔnim
                 (VI,31b,GI,MD)

                 LL HLH
                  |    |
            >    saʔnim
                 (LN,HS,TD)

            >    *sàʔním
```

The well-formedness of the output lies in the blockage of (31b). And the blocking is possible only if the sonorant has a tone associated with it; hence, tonal consonant yields the correct derivation.

And finally, the last case is also a cluster of the same type as the second case where the consonants in the cluster are not true clusters and thus do not share the same underlying C-slot. Moreover, the aspirated stop in the cluster is attached to an underlying tone such that tone spreading from the first member of the onset is blocked. Thus, allowing words with *s* initial to surface with a second checked syllable with aspirated onset and Falling tone.

(42)

```
   H               LH M            LH L
   |               || |\           || |\
/sphaaph/   >      sphaaph    >    sphaaph
                   (31a,MD)        (LN)
```

```
          LM H L            LL H L
          | |  |  |\        || |  |\
>         saʔphaaph  >      saʔphaaph
          (VI,GI,MD)        (LN,HS)

>         sàʔpháàp
          (TD,ON)
```

If the aspirated stop is not specified for underling tone, tone spreading from the first member of the onset will apply resulting in ill-formed output.

```
(42)'
                          L   M             L   L
                          |   |\            |   |\
      /sphaaph/   >       sphaaph    >      sphaaph
                          (31a,MD)           (CTS,LN)

                          LL  L             LL L  L
                          | |  |\           | | |  |\
                  >       sphaaph    >      saʔphaaph
                          tier conflation    (VI,GI,MD,LN)

                  >       *sàʔphàap
                           (TD,ON)
```

It might be asked why don't we have Falling tone underlyingly for (42)? The answer lies in the behavior of the morpheme with respect to tone in mono- vs. bi-syllabic alternation.

```
(42)"      spháàph      ~     sphaawáʔ,
      or   [sàʔpháàp]   ~     [sàʔphaawáʔ]
```

Where ph > w is optional

The alternation fits into the type previously presented in (3.1.2), and the aspirated consonant in (42) falls into the same category of Ch which is later shown to be marked with [+H] tone.

In sum, cluster onsets argue for tonal consonants.

4.2.2 *Cluster coda*

The cluster coda is a case of extrasyllabicity, where all consonants in the cluster coda except the one adjacent to the vowel are treated as unsyllabified consonants or 'extrasyllabic.' When the word is pronounced in isolation, extrasyllabic consonants are deleted.

For example,

(43)	/yák(s)/	>	[yák]	'giant'
	/kal(p)/	>	[kan]	'eon'
	/sàas(tr)/	>	[sàat]	'knowledge'

In concatenation and affixation, however, the clusters are broken up and resyllabified, and the tones realized in these newly formed syllables display somewhat similar phenomena as in vowel insertion, partial reduplication and fusion, etc. mentioned earlier. For example,

(44)	a.	sàas(tr) 'knowledge'	+	aacaar 'teacher'	>	sàas**sàʔtraa**caan 'professor'
	b.	can(thn) 'a kind of flower'	+	aa 'suffix'	>	can**tháʔnaa** 'a woman's name'
	c.	can(thr) 'moon'	+	ʔùʔpraakhaa 'be caught'	>	can**tháʔrúʔ**praakhaa 'lunar eclipse'
	d.	cin(tn) 'think'	+	aakaar 'n. suffix'	>	cin**tàʔnaa**kaan 'thought'
	e.	ʔin(thr) 'a kind of bird'	+	kamhæ̀ǽŋ 'dare'	>	ʔin**tháʔráʔ**kamhæ̀ǽŋ 'a name'
	f.	pháth(n) 'progress'	+	aa 'suffix'	>	phá**tháʔnaa** 'to make progress'

If the analysis of floating tone or edge tone is correct, we would expect the underlying representations and the derivations in (44) to be something like (45) below:

(45)

a. /sàas(tr)/ + aacaar >

```
L (L)L    M    M
|\ ǂ |    |\   |\\
saas a?traacaan
```

(VI,31a,GI,MD,LN,TD)

\> sàas**sàʔtraa**caan

b. /can(thn)/ + aa >

```
M    L (H)M
|    |  ǂ |\
canth a?n aa
```

(VI,31b,GI,MD,LN,TD)

\> *can**thàʔnaa**

c. /can(thr)/ + ʔùʔpraakhaa >

```
M    L H(L)     L...
|    | |ǂ       |
canth a?r a? + ?u? ...
```

(VI,GI,31b,MD,LN,HS)

M L HL M M

> canth**aʔruʔpraakhaa** (G&TD,VI,GI,31b,MD,LN,HS)

> *canth**àʔrúʔ**praakhaa

M L HM

d. /cin(tn)/ + /aa/ > cintaʔnaa (VI,31b,GI,MD,LN,TD)

> cint**àʔnaa**

The incorrect outputs are in the case where the cluster coda consists of at least one aspirated stop (44b. & c). If a floating tone is posited for each of the aspirated stops, then it can be claimed that the consonant licenses the tone itself. Even so, the position of the floating tone in the morpheme is significant. If it is to be placed at the right edge of the morpheme, there will be a problem of association and line crossing. For example (from 44b & c),

(46) a.

H

/can(thn)/ + aa

M L H M H

> can**thaʔnaa** (VI,31b,GI,MD,LN,TD)

> *can**thàʔnaa**

H

or a.' /can(thn)/ + aa

M L H M H

> *can**tháʔnaa** (VI,31b,GI,MD,LN,HS,TD)

> can**tháʔnaa**

H

or a." /can(thn)/ + aa

M L HH M

> *can**thaʔnaa** (VI,31b,GI,MD,LN,TD)

> *can**thàʔnaa**

H

b. /can(thr)/ + ʔùʔpraakhaa

M L HLH M M

> can**thaʔruʔ**praakhaa (G&TD,VI,31b,GI,MD,LN,HS)

> *can**thàʔrúʔ**praakhaa

(cf. 45(c) for step-by-step derivation)

```
                                              M    L  HLH M    M
            H                                 |    | ..   |\   |\
or   b.' /can(thr)/ +   ʔùʔpraakhaa     >   *canthaʔruʔpraakhaa
                                        (G&TD,VI,31b,GI,MD,LN,HS,TD)

                                        >    cantháʔrúʔpraakhaa

                                              M    L  HHL  M    M
            H                                 |    |       |\   |\
or   b." /can(thr)/ +   ʔùʔpraakhaa     >    canthàʔrúʔpraakhaa
                                        (G&TD,VI,31b,GI,MD,LN,HS,TD)

                                        >   *canthàʔrúʔpraakhaa
```

It seems the only place for the floating tone on the tonal tier is directly corresponding to the position of the aspirated stop in the cluster on the skeletal tier. Only then will we get the correct phonetic output.

```
(47)  a.                                     M   HLHM
            H                                |      ||\
          /can(thn)/ +   aa             >    canthaʔnaa
                                             (VI,31b,GI,MD,LN,HS,TD)

                                        >    cantháʔnaa

                                             M  HL  HL  M    M
            H                                |          |\   |\
      b. /can(thr)/ +   ʔùʔpraakhaa     >    canthaʔruʔpraakhaa
                                        (G&TD,VI,31b,GI,MD,LN,HS,TD)

                                        >    cantháʔrúʔpraakhaa
```

Thus, it seems necessary to associate the tone and the consonant that licenses it since there is obviously a one-to-one correlation between the tone segment and the consonant such that the position of the tone on the tonal tier must be fixed. And we have the following underlying representations:

```
(48)          H
              |
          /can(thn)/          'a kind of flower'

              H
              |
          /can(thr)/          'moon'

           H  L
           |  |
          /lak(khn)/          'unique characteristic'
```

```
LH
||
/koč/          'lotus'

L HL
| ||
/khææn/        'strong'

HHL
|||
/čɔɔŋ/         'hole'
```

Cluster codas, as has been shown above, argue for segmentally associated tones rather than floating or unassociated edge tones of the morphemes, and hence, tonal consonants in morphological marking.

4.2.3 *Partial Reduplication*

Last but not least, evidence for the necessity of associating the consonant onset and the tone it licenses is found in partial reduplication. We recall the process given in (22) and (23); the consonant onset is copied for the reduplication morpheme template followed by glottal insertion, yielding the following output:

```
(49)   C   V  C  -  [C  (C)  V ....
       |   |  |      |
     [αF]  a  ʔ    [αF]
```

The floating tone in the onset of the root also needs to be copied for the correct output. (49) is more accurately represented by:

```
(50) [βT]           [βT]
       C   V  C  -  [C  (C)  V ....
       |   |  |      |
     [αF]  a  ʔ    [αF]
```

That is, the edge tone together with the consonant onset are copied onto RED morpheme. Given the common position of the tone and the consonant features which are copied, there is no reason not to link the tone and the consonant together via the C-slot on the skeletal tier. Actually, with the association lines drawn, the copy is done only once, copying all the features attached to the first C-slot of the root, simplifying the process.

```
(51) [βT]           [βT]
       |             |
       C   V  C  -  [C  (C)  V ....
       |   |  |      |
     [αF]  a  ʔ    [αF]
```

Partial reduplication also argues in favor of tonal consonants rather than floating tones.

5. Conclusion

It has been shown from morphological tonal alternations that the tone licensed by consonant onset must be segmentally associated with the consonant itself. This not only simplifies some morphological processes, but actually becomes necessary in other cases, e.g., cluster onsets and codas where otherwise ill-formedness would result. On these grounds, tonal consonants in Thai grammar are essential and inevitable.

As a consequence, we have to answer further questions: How do the lexical items which participate in morphological tonal alternation differ from others which do not participate in vowel insertion, fusion, or bi-syllabic alternation? Do these lexical items tell us anything about tonal development?

Lexical items with monosyllabic vs. bi-syllabic alternation and tonal alternation may be taken as having underlying representation with Mid tone on both unchecked and checked syllables. And the phonetic outputs or surface tones are derived. For others, we assume that lexical items which do not participate in morphological tonal alternation have the same surface tones as in the underlying representations. The underlying and surface tones for both can be summarized as follows:

UNDERLYING	SURFACE TONE		
	V[-son]	VV[-son]	V{(V)(+son])}
H	H	H	H
M	L/H	L/HL	M/LH
L	L	L	L
HL	?	HL	HL
LH	?	?	LH

Table 11: Summary of underlying and surface tones

From table 11, it is self-explanatory why there is no surface Mid on checked syllables. Tonal consonants are responsible for the surface H and HL on checked syllables for the marked lexical items, whereas Low Neutralization (LN) is responsible for all lowering of checked syllables. Tonal consonants and Low Neutralization also explain the neutralization of HL to H, and LH to L on checked syllables. Thus, the restriction to only L, H and HL on checked syllables are explained. The uncertainty lies in the case of the lexical items without tonal consonants. Do these items have underlying HL and LH on checked syllables? Do the underlying HL and LH neutralize to H and L on short checked syllables respectively in the same manner as the marked items with tonal consonants do?

If there are truly underlying LH and HL, it is obvious from the distributional fact (cf. table 2 & 3) that these must be neutralized to surface L and H respectively. Evidence which may support underlying HL is found in the rare case, which may be considered as an exception of surface HL on short checked syllables, e.g., *câ?* 'final partical'.

However, in favor of naturalness, the phonetic form which is the same as its underlying representation eases the task of language acquistion. The unmarked lexical items, without tonal consonants, are best taken to be without underlying HL for short checked syllables, and without LH for checked syllables in general. The explanation for these gaps is found in the historical development of the tones and consonants (Tumtavitikul 1992). We, at least, have the distributional gaps partially explained on the basis of tonal consonants.

One possible implication of the existence of tonal consonants and the optionality of the morphological tonal alternations is that there are co-existing grammars in the language (Fries and Pike 1949). It is plausible that the grammar with tonal consonants is re-learned, and its livelihood lies in its function as a favorable stylistic variant.

6. Postscript

What are these tones [+H] and [+L] of the consonants? We may well ask. The answer is that they are superimposed tone values analogous to the superimposed High and Low values on vowels. It is well documented that vowels with their own intrinsic fundamental frequency are modified when produced with superimposed tone values. Since the modification does not change the contrastive pattern of the vowels in the vowel space within the language system, speakers and listeners alike tolerate this inevitable consequence of the physiology of the glottal control mechanisms. In the case of Thai, however, the modification of the consonants if produced with such superimposed tone values, would have jeopardized the phonemic pattern in the language, and thus, is intolerable and undesirable. The compensation is to dock the tone on the adjacent vowel if it results in an acceptable surface pattern; otherwise the tone is deleted in avoidance of the undesirable consonant in the phonetic output.

What we have in Thai, then, is a case of unnatural phenomena. Unlike the well-studied consonant/tone interactions found in many Asian and African tone languages, whose naturalness is explicable in terms of interaction of laryngeal features,[10] such as those proposed by Halle and Stevens (1971), or in terms of interaction due to intrinsic fundamental frequency, such as the feature [+L] proposed by Goldsmith (1990) for tone depressing consonants in Digo. Such unnaturalness in the case of Thai can only find an explanation in external motivation for its development which may possibly be literacy. As the Thai writing system distinguishes two series of aspirated stops, the orthographic influence in phonology may be evidenced in 'tonal consonants'.

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[10] It is noted that Kingston and Solnit (1988) had earlier proposed tonal laryngeal features for consonants for the purpose of explaining the historical development of the Tai languages.

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