VOWEL TENSENESS AND ASSIMILATION IN YI: A FEATURE GEOMETRY STUDY

Ziwo Lama
University of Texas at Arlington

Chen et al. (1985: 26-27) mention the Nuosu Yi[1] (hereafter Yi) vowel assimilation processes whereby lax vowels become tense: *ɿ* –> *ɿ̱*, *u* –> *u̱*, *i* –> *ɛ*, *o* –> *ɔ*, and *ɯ* –> *a*. They give several examples, listed in (1):

(1)	/ndʐɿ^{33}/ 'wine'	–>	ndʐɿ̱^{44}pe^{33}	'sweet wine'
	/ʑi^{33}/ 'house'	–>	ʑɛ^{44}tshu̱^{33}	'build a house'
	/o^{33}/ 'head'	–>	ɔ^{33}ȵɛ^{33}	'head hairs'
	/ɬɯ^{21}/ 'moon'	–>	ɬa^{21}pha^{33}	'half of a month'

Unfortunately, no detailed discussion is offered regarding how this vowel assimilation process actually works.

Since the introduction of Feature Geometry Theory (Clements 1985), phonologists have applied this theory to various phonological phenomena such as tone dissimilation and vowel assimilation in languages of the world (Clements 1991, Clements et al. 1995, Halle 1995, Halle et al. 2000, Kenstowicz 1994, among others). In this paper, I will address Yi vowel quality and voice quality, and by taking advantage of the insights provided by Feature Geometry, demonstrate that vowel tenseness is directly related to vowel assimilation in Yi, and that such assimilation is mainly the process of spreading the feature [+tense]. This paper shows that feature geometry theory elegantly characterizes the dynamic movement of vowel assimilation in Yi as in Figure 1:

[1] Yi has been traditionally recognized as being composed of 6 dialects: Northern, Southern, Eastern, Western, Southeastern, and Central Yi. Nuosu Yi belongs to the Northern dialect. This dialect is mostly spoken in Sichuan Province, China.

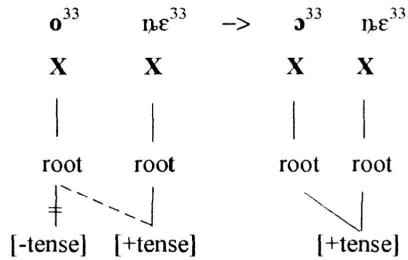


Figure 1. *Representation of an instance of feature spreading in Yi vowel assimilation.*

Such a solution is better than the representation in (1) because a geometric representation directly captures the dynamic process of vowel assimilation.

The organization of this paper is as follows: § 1 discusses Yi vowel quality and vowel tenseness; § 2 briefly reviews feature geometry theory; § 3 presents the Yi vowel feature specification, § 4 addresses Yi vowel assimilation, and § 5 draws conclusions.

1 YI VOWEL QUALITY AND VOWEL TENSENESS

Yi has 43 consonants, 10 vowels, and 4 tones, as shown in (2). All Yi syllables have a CV structure.

(2) Yi consonants, vowels, and tones (from Chen et al. 1985)

p	**ph**	**b**	**mb**	**m̥**	**m**	**f**	**v**		
t	**th**	**d**	**nd**	**n̥**	**n**	**ɬ**	**l**		
ts	**tsh**	**dz**	**ndz**			**s**	**z**		
tʂ	**tʂh**	**dʐ**	**ndʐ**			**ʂ**	**ʐ**		
tɕ	**tɕh**	**dʑ**	**ndʑ**		**ȵ**	**ɕ**	**ʑ**		
k	**kh**	**g**	**ŋg**		**ŋ**	**x**	**ɣ**	**h**	
i	**e**	**ɯ**	**a**	**o**	**ɔ**	**u**	**u̠**	**ɪ**	**ɪ̠**
˥	˧	˩	˦						
55	33	21	44						

1.1 Yi Vowel Quality

The 10 Yi vowels in (1) can be grouped into 5 pairs, with each pair having a tense-lax contrast, as in Table 1[2]:

Lax	i	ə	o	v	z
Tense	ɛ	a	ɔ	v̠	z̠

Table 1. Yi vowel system (slightly modified from Chen et al.1985: 10)

Generally speaking, the vowel tense-lax pairs *i~e, ə~a, o~ɔ,* and *v~v̠* can appear after any consonant; *z~z̠,* which are traditionally called apical vowels, occur only after a coronal affricate or coronal fricative, or after a labial that phonetically bears the fricative *z*. The vowel /z/[3] has three variations: [z], [ʐ], and [ʑ], corresponding to dental, retroflex, and palatal consonants, respectively.

The Yi vowel tense-lax pairs show a symmetric space distribution with regard to vowel height and backness. Qiu (1998) conducted a WinCECIL study on Yi vowel formants. The mean formants are shown in Table 2:

	i	ɛ	z	z̠	ə	a	v	v̠	o	ɔ
F1	309	536	335	591	380	829	370	524	368	566
F2-F1	1846	1391	915	446	1153	370	569	355	485	332

Table 2. The mean formant values of Yi vowels

---

2 Note that the Yi vowels ə, **v**, **v̠**, **z**, and **z̠** in Table 1 are written as **ɯ**, **u**, **u̠**, **ɿ**, and **ɿ̠**, respectively, in Chen et al. 1982 in (1), above. Following traditional Tibeto-Burman linguistics in China, an underline is used here as the marker of a tensed vowel. Thus, all the vowels in the tense row in Table 1 should be marked with an underline. However, considering that these tense vowels also have different vowel qualities from their lax counterparts, it is better to leave them without a marker. On the other hand, the two tense vowels **v̠** and **z̠** are underlined in Table 1 because they have the same vowel quality as their respective lax counterparts, **v** and **z**. See the detailed discussion about these special vowels in § 1.2.

3 Note that "**z**" and "**v**" are used as both consonantal and vocalic symbols in the orthography: as consonants when they occur before a vowel, but as vowels when they occur alone in a syllable or after a consonant. [Ed.]

Usually the frequency of the first formant (F1) corresponds to the height of the tongue, whereas the difference between the second and the first formant (F2-F1) reflects the degree of backness (Ladefoged 1993). Figure 2 reflects Yi vowel height and backness based on the vowel formants given in Table 2:

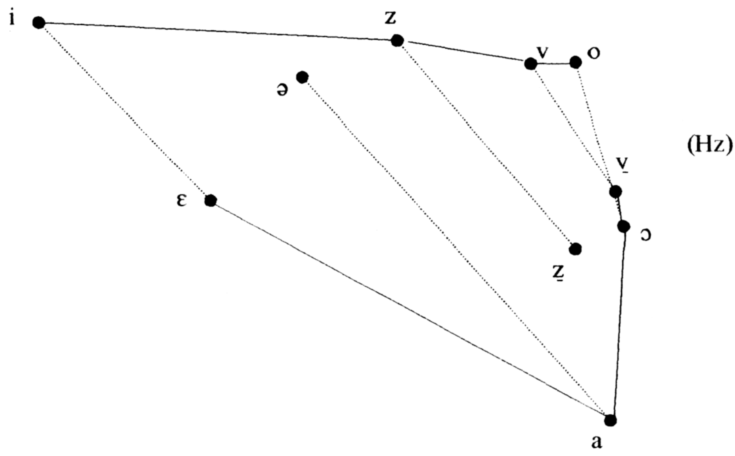


Figure 2. *The distribution of Yi vowel space in terms of vowel formants of a native speaker. Tense-lax pairs are connected with dotted lines.*

(Note that compared with the lax vowel **ɯ** in Chen et al. 1985, the vowel **ə** in Figure 2 is positioned far away from its originally assumed location. Dantsuji (1982) has a result close to Qiu (1998) in regard to this vowel.) However, Qiu 1998 did not thoroughly research Yi vowel formants. He only measured vowels after /p/, /ph/, /b/, and /s/. His formant measurements based on the Yi vowels appearing after these consonants are not sufficient for determining an exact Yi vowel space chart like the one given in Figure 2. Combining a native speaker's intuition with Qiu 1998 and Dantsuji 1982, I propose Figure 3 as the representation for Yi vowel space relative to tongue position:

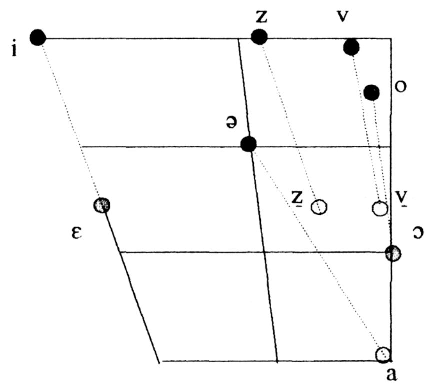


Figure 3. *A native speaker's perception of the relative tongue position of Yi vowels. Lax vowels are represented by black dots and the tense ones are indicated in gray.*

Two common characteristics of the Yi vowel distributions can be observed in Figures 2 and 3: (a) All the Yi tense vowels are relatively lower in distribution than their corresponding lax vowels, i.e. the *ɛ* is lower than the *i*, the *a* is lower than the *ə*, etc. and (b) all the tense vowels take a posterior tongue position compared with their lax counterparts; that is, the *ɛ* is posterior to the *i*, *a* is posterior to the *ə*, and so forth. For the tense-lax pairs *i~e*, *o~ɔ*, *z~z̲*, and *v~v̲*, there is a small distance between the lax vowel and its corresponding tense one; for the vowel pair *ə~a*, the spatial distance between the lax and tense vowels is almost twice that of the other pairs. As represented in Figures 2 and 3, the Yi vowels are roughly distributed in three different ranges in regard to their height. All the lax vowels, (*i*, *ə*, *z*, *v* and *o*), are positioned in the highest space; tense vowels (*e*, *ɔ*, *z̲*, and *v̲*) take the second level of distribution; and the tense vowel *a* occupies the lowest position. In addition to having the same vowel quality, the tense-lax pairs *z~z̲* [4] and *v~v̲* have the same fricative quality (for detailed discussion see § 1.2). As a whole, the Yi tense vowels are consistently lower than their lax counterparts in regard to height, and are posterior to their corresponding lax vowels with regard to backness.

[4] Chen et al. (1985) do not specify the tongue positions for the so-called apical vowels, *z* and *z̲*, in their research, so we do not know whether they have a lower, a higher, or the same level tongue position as other vowels.

1.2 The Fricativized Vowels

The *v~v̱* and *z~ẕ* pairs are vowels with fricative characteristics. Ladefoged and Maddieson (1996: 314) call them "fricative vowels". They treat these two segmental sets as syllabic fricatives, functioning like vowels. Contrasting with their definition, I propose the term *fricativized vowels* for these two pairs of vowels in Yi. Due to the constriction formed in labial (for *v~v̱*) and coronal (for *z~ẕ*) regions in their production, they have to move forward from their original positions. I assume that these two vowel pairs have originally derived from [u] and [ɯ], respectively, and that they have developed as special vowels with audible frication over the course of Yi history. This assumption is based on two facts: 1) these two pairs of fricativized vowels can extensively occur after consonants, 2) there are some examples in other dialects which have a vowel or a fricativized vowel corresponding to a fricativized vowel or vowel in this dialect. For example, Suondi Yi dialect [z] corresponds to Yi [o] in **dzz**^{44}mu^{33} 'knife' vs. **do**^{44}mu^{33}, and Suondi [ɔ] corresponds to Yi *[v̱]* in dʑz^{44}ndzɔ^{33} 'hate each other' vs. dʑz^{44}ndzv̱^{33}. If we assume that they are underlyingly inherited from labial and coronal fricatives, then the labial fricatives *v~v̱* ought to appear fronter than the coronal fricatives *z~ẕ* in accordance with their articulatory positions, since labial consonants are located fronter than coronal consonants. However, in Figures 2 and 3, *z~ẕ* are positioned in front of *v~v̱*. Hence, it is reasonable to treat these two special vowel pairs as fricativized vowels, rather than as fricative vowels (in which case these special vowels would be assumed to be fricatives first and only secondarily a vowel). The fricativized vowels must have characteristics of both vowels and fricatives, including articulatory gestures; they must have a sonorant feature, as a vowel does, and must also have audible constriction like a fricative. A fricative consonant, in contrast, does not show the significant duration or noticeable sonority that a fricativized vowel or regular vowel does. Table 3 shows the difference among fricativized vowels, oral vowels, and fricatives:

	[sonorant]	[consonantal]	[continuant]
fricativized vowel	+	+	+
fricative consonant	–	+	+
oral vowel	+	–	+

Table 3. Comparison of the features of fricativized vowels, fricative consonants, and oral vowels

Based on the feature specification in Table 3, a Yi fricativized vowel can be defined by the features [+consonant, +continuant, +sonorant]. By this definition, all fricativized vowels have the characteristics of a vowel, with audible frication during the course of pronunciation.

1.3 Vowel Tenseness

A tense vowel is much different from its lax counterpart from the perspective of voice quality. Ma (1948) was the first to mention the *sōng/jǐn* or tense/lax voice quality contrast of Luquan Yi, spoken in Yunnan Province, China. He states, "the laryngeal constriction is caused when pronouncing a *tight-throat* vowel labeled with a stroke under the target vowel": *lv*^{55} 'tiger,' *l*$\underline{v}^{55}$ 'sufficient'." (From Dai 1990a: 3) Hu and Dai (1964) were the first to systematically explore tense vs. lax voice quality in Tibeto-Burman linguistics. Based on the tense-lax contrast found in Hani, a language of the Yi group in China, they conclude that a tight-throat vowel distinguishes itself from its lax counterpart in two respects: (a) the muscles of the throat are tight and retracted during sound production and (b) the pitch is extremely strident. Chen et al. (1985) describe the difference in producing these two different phonatory types as follows: for the lax vowels, the muscles of the articulators are always tight; for the tense vowels, the muscles of the articulators are much tighter, but the tightness is not kept throughout the duration of pronunciation. According to Li and Ma (1983), the tenseness of the Yi vowels $\underline{z}$ and $\underline{v}$ actually illustrate another phonatory type, "tight throat" or "glottal tense", different from other tense vowels. In order to distinguish $\underline{z}$ and $\underline{v}$ from other tense vowels, Li and Ma (1983) and Chen et al. (1985) mark these two tight-throat vowels with an understroke, leaving other tense vowels unmarked. Dantsuji (1982) regards the "glottalized" vowels, (i.e. tense vowels) as being produced with "glottal constriction" or "glottal tension", and thus the Yi tense vowels have the same property as creaky vowels. Dantsuji (1982) has not stated whether there is a phonatory difference between a tight throat vowel type and a regular tense vowel type. Maddieson and Hess (1986:107) state that "although the difference between 'tense' and 'lax' vowel pairs is quite distinctive, with an auditorily 'harsher' quality for the tense members, the H_2 - F_0[5] measure does

[5] The relative energy of fundamental frequency (F_0) and the second harmonic (H_2) corresponds to differences in phonation type. Usually, a breathy voice vowel has comparatively more energy in the fundamental and less in the higher harmonics, whereas a vowel pronounced with a more constricted glottis has the reverse distribution. By measuring the values of amplitude between the fundamental frequency and the second harmonic of the vowels, the different voice quality of the targets can be determined in the 'spectral tilt' generated in models of the voice source by varying the rate or vocal cord closure in the glottal pulse (Maddieson and Ladefoged 1985).

not distinguish between the tense and lax members." They conclude that it is hard to determine whether there is a tense/lax contrast based on the phonatory type among the Yi vowels, though there is a significantly lower pitch in Yi lax syllables than in tense ones.

Qiu (1998) and Edmondson et al. (2000), however, take different views from those outlined above. They regard a so-called "tight-throat" vowel as having the same laryngeal behavior as a "regular tense" vowel in light of the result of a fiberscopic study of laryngeal behavior during vowel production. The difference between *tight throat* vowels and *regular tense vowels lies in* vowel quality rather than voice quality. In this sense, all the tensed vowels have the same laryngeal behavior, which is opposite to that of the lax vowels. Physiologically, a tense phonation is made by the aryepiglottal folds being tightly pulled together and down and forward toward the front laryngeal wall, covering the glottis (where the vocal folds are not observable). At the same time, the epiglottis and tongue root move toward the back laryngeal wall. All muscles are joined by sphinctering, causing a harsh energy to pass through the center of the laryngeal cavity. A lax phonation has, in essence, the opposite behavior to tense phonation or modal voice. Due to the fricatives' characteristic of frication, continuously blocking airflow through the vocal tract, the fricativized tense vowels v̠ z̠ have much more turbulence formed in the larynx, causing the muscles involved and the tongue root to have stronger tenseness, or to be "tighter" than other tense vowels. However, under fiberscopic observation, no special laryngeal behavior is captured. We would like to say that this kind of extra tenseness is caused by the fricative characteristics of these fricativized vowels rather than by extra tense phonation.

In the following sections, we will create the feature [tense] to capture this phonatory setting. As we will see, Yi vowel tense phonation is directly related to vowel assimilation; it always spreads leftward to the node of the other vowel in a word or phrase.

2 THEORETICAL REVIEW: FEATURE GEOMETRY THEORY

Given that Feature Geometry (Clements 1985) has been proven successful in accounting for vowel assimilation processes (Clements 1991, Clements et al. 1995, Halle 1995, Halle et al. 2000, among others), it is worthwhile to review it briefly.

The crucial claim of this theory is that phonological features are hierarchically organized around a structural tree. In this theory, elements on the same tier are sequentially ordered while elements on different tiers are organized and related to each other by means of association lines.

Phonological features are regarded as the basic units of phonological representation. Individual features or groups of features are assigned to separate tiers by the organization into nodes and associations between the nodes (Clements et al. 1995: 246). As a whole, feature geometry theory explains phonological processes in a dynamic way, differentiating itself from linear phonology, which takes a more static view that emphasizes classificatory features as the attributes of a sound (Kenstowicz 1994: 452).

Feature geometry theory reflects aspects of the anatomy of the vocal tract. One of the models of feature geometry theory adopted here is the Articulator Theory (Halle 1992, 1995, Halle et al. 2000). In this model, terminal features are divided into two groups. One is made up of articulator-bound features such as [round], [anterior], [high], [ATR], and [spread glottis], and the other one consists of articulator-free features such as [continuant], [strident], and [lateral]. The articulator-bound features are organized in terms of movable articulators: Lips, Tongue Blade, Tongue Body, Tongue Root, Soft Palate, and Larynx; in contrast, the articulator-free terminal features are directly linked to the root. In order to distinguish primary and secondary articulations, Halle et al. add the unary features [labial], [coronal], [dorsal], [rhinal], [radical], and [glottal] to the articulator tree diagram in their latest version of this theory, Revised Articulator Theory (RAT). Each of these articulatory features corresponds to one of the six articulators (Halle et al. 2000). This perspective rejects explanations supported by models such as Clements' Vowel Place Theory (Clements 1991, Clements et al. 1995). The rest of the terminal features in this model are treated as binary. RAT emphasizes that "only terminal feature trees are allowed to spread" (Halle et al. 2000: 393). RAT also posits that the tiers of the intervening segment cannot prevent a feature spreading from the affecting segment to the node of an affected segment in the process of vowel assimilation.

Considering that Yi vowel assimilation correlates with voice quality, we need to review the features under the larynx node in RAT. Five terminal features, including one articulator terminal feature, [glottal], are proposed by Halle et al. (2000) under the larynx: [spread glottis], [constricted glottis], [stiff vocal folds], and [slack vocal folds]. These laryngeal terminal features deal with aspiration, glottalization, and various types of voicing. Specifically, aspirated segments are represented as [spread glottis], glottalized segments are characterized by [constricted glottis], totally voiceless segments are represented by [stiff vocal folds], and totally voiced segments are referred to by [slack vocal folds]. The features [stiff vocal folds] and [slack vocal folds] are usually combined as the feature [voice] in the literature. While the features [spread glottis], [constricted glottis], and [voice] can characterize some phonations in Yi segments, for example, ***pho***^{33} 'escape' vs. *po*^{33} 'rummage', *poʔ*^{55} 'run' vs. *po*^{33} 'rummage', ***bo***^{33} 'go' vs. *po*^{33} 'rummage', they are not appropriate to capture the tenseness feature of the Yi vowels in question. Thus it is necessary to label the binary terminal feature [±tense] under the laryngeal node in order to capture the property of voice quality for Yi and other similar languages. We define the feature [±tense] as in (3):

(3) Definition of the feature [±tense]

[±tense] is a terminal feature that represents a phonatory setting in the vocal tract, in which tension is formed on the aryepiglottal folds by pulling them close to one another in a way that causes much turbulence in the larynx.

3 VOWEL FEATURE SPECIFICATION

According to RAT (Halle et al. 2000), segmental features are better fully specified in underlying articulatory representation. Before addressing Yi vowel assimilation, let us first look at the full feature specification of Yi vowels in Table 4, which is mainly based on Figure 3:

	i	ɛ	z	z̠	ə	a	v	v̠	o	ɔ
syllabic	+	+	+	+	+	+	+	+	+	+
voice	+	+	+	+	+	+	+	+	+	+
coronal	−	−	+	+	−	−	−	−	−	−
labial	−	−	−	−	−	−	+	+	−	−
high	+	−	+	−	−	−	+	−	−	−
low	−	−	−	−	−	+	−	−	−	−
back	−	−	−	−	−	+	+	+	+	+
round	−	−	−	−	−	−	−	−	+	+
RTR	−	+	−	+	−	+	−	+	−	+
tense	−	+	−	+	−	+	−	+	−	+

Table 4. A full feature specification for the ten Yi vowels

In Table 4, the features [syllabic] and [voice] can be omitted in feature representation since all the Yi vowels are voiced and syllabic by default (see 4a). The features [tense] and [RTR] have a redundant positive relationship (see 4b), where if we know a vowel has a feature [+ tense], then we can predict this vowel also has a feature [+ RTR]. Anatomically, the feature [RTR] has to do with tongue root movement, and the feature [tense] correlates with the sphinctering movement of aryepiglottal folds and glottis (cf. § 1). In vowel feature specification, we only need one of them. Here we choose the feature [tense] since, as we will see, it captures the nature of Yi vowel feature assimilation. These rules are listed in (4):

(4) Yi vowel unmarked feature rules and redundant feature rules

a. [ ] –> [syllabic] / __ [ ] –> [voice] / __

b. [α tense] <–> [α RTR] / __

With the feature rules in (4a) and (4b), Table 4 can be simplified to Table 5 in terms of underspecification theory, in which redundant and unmarked features must be unspecified (Archangeli 1988, Kiparsky 1985, Mester and Itô 1989, Pulleybank 1988, among others):

	i	ɛ	z	z̠	ə	a	v	v̠	o	ɔ
coronal	–	–	+	+	–	–	–	–	–	–
labial	–	–	–	–	–	–	+	+	–	–
high	+	–	+	–	–	–	+	–	–	–
low	–	–	–	–	–	+	–	–	–	–
back	–	–	–	–	–	+	+	+	+	+
round	–	–	–	–	–	–	–	–	+	+
tense	–	+	–	+	–	+	–	+	–	+

Table 5. A simplified full specification for the ten Yi vowels.

With this simplified feature inventory in Table 5, all the Yi vowels can be distinguished from one another.

We use the features [labial] and [coronal] to distinguish not only fricativized vowels from other vowels but also fricativized vowels from each other in both Table 4 and Table 5. Features [high], [low], [back], and [round] are related to other features in a predictable way, as stated in (5):

(5) Predictable feature rules for Yi vowels

a. [+high] -> [−low] / __ [+high] -> [−round] / __
[+high] -> [−tense] / __

b. [+low] -> [−high] /__ [+low] -> [+back] / __
[+low] -> [−round] / __ [+low] -> [+tense] / __

c. [−back] -> [−round] / __ [−back] -> [−low] / __

d. [+round] -> [−high] / __ [+round] -> [−low] / __
[+round] -> [+back] / __

The rules in (5) are predictable. Rule (5a) states that if a vowel has the feature plus [high], then we can predict that this vowel has the features minus [low], minus [round], and minus [tense]; rule (5b) represents the fact that a vowel with the feature plus [low] has the features minus [high] and minus [round] and the features plus [back] and plus [tense]. By the same reasoning, a minus [back] vowel has the features minus [round] and minus [low] (5c); a plus [round] vowel must have the features minus [high] and minus [low] as well as plus [back] (5d). All the rules in (5) are subject to left-to-right feature change; thus a reverse right-to-left feature change is not permissible in assessing the relationship of the features in question.

For the sake of economy, only the relevant features are specified in the representation of Yi vowel assimilation. We assume that all Yi vowels are by default non-consonantal. Thus, only *z* and *z̲* are specified with respect to the feature [coronal] and only *v* and *v̲* are specified for the feature [labial]. Following Halle et al. 2000, we reject the notions of C-place and V-place in this paper. In addition, we assume that all Yi vowels are by default [-round]; thus only the vowels *o* and *ɔ* are specified for this feature. Based on these observations, the Yi vowel system can be specified as in Table 6:

	i	ɛ	z	z̲	ə	a	v	v̲	o	ɔ
coronal		+	+							
labial							+	+		
high	+	−	+	−	−	−	+	−	−	−
low	−	−	−	−	−	+	−	−	−	−
back	−	−	−	−	−	+	+	+	+	+
round									+	+
tense	−	+	−	+	−	+	−	+	−	+

Table 6. A relevant specification for the ten Yi vowels.

In the following discussion, we use the features and their values given in Table 6 to represent Yi vowel assimilation.

4 THE ASSIMILATION OF YI VOWELS

Three common types of assimilation processes have been proposed for feature assimilation in the world's languages: total assimilation, partial assimilation, and single-feature assimilation (Mohanan 1983, Clements 1985, Clements et al.1995). There are two types of Yi vowel assimilation. First, in total assimilation, a tense vowel spreads all its features to its corresponding lax vowel. For example, *ε* spreads all its features, or its root node, to its lax counterpart vowel *i*. Second, in partial assimilation, a non-paired tense vowel spreads several of its features to a non-paired lax vowel. For example, in addition to spreading its laryngeal feature [+tense], a tense vowel such as *a, v, z,* or *ɔ* can spread a set of its features under the place node to the lax vowel *i*. Whatever vowel assimilation, the feature plus [tense] must be spread.

4.1 Vowel Assimilation Data

Yi vowel assimilation only occurs in compound words (most of which are disyllabic), in which the vowel in the first syllable is [-tense] and the vowel in the second syllable is [+tense]. Other possible combinations of the feature [tense] in forming disyllabic structures are [+tense] + [+tense], [+tense] + [−tense], and [−tense] + [−tense]; however, such kinds of syllable structures cannot initiate vowel assimilation. Only those adjacent syllables with a lax vowel occurring before a tense vowel can trigger vowel assimilation, as shown in (6):

(6) Data for Yi vowel assimilation

	Underlying Form	*Surface Form*	*Gloss*
(6.1)	**i –> [ɛ] / __ [ɛ, a, ɔ, z̠, v̠]**		
	a. /hi^{33}tɛ^{33}/	hɛ^{44}tɛ^{33}	'outside'
	b. /hi^{33}ka^{55}/	hɛ^{44}ka^{33}	'overflow'
	c. /ti^{33}nɔ^{33}/	tɛ^{44}nɔ^{33}	'black cloud'
	d. /li^{33}zz̠^{33}/	lɛ^{44}zz̠^{33}	'press'
	e. /ɳ̊i^{33}vv̠^{33}/	hɛ^{33}vv̠^{33} [6]	'like'

---

[6] The synchronic change of /ɳ̊/ to [h] reflects an actual historical sound change. The historical development /sn/ –> /ɳ̊/ –> /h/ has been attested in other TB languages.

(6.2) **o –> [ɔ] / __ [ɛ, a, ɔ, z̠, v̠]**

a.	/tɕo^{55}nɔ^{21}/	tɕɔ^{55}nɔ^{21}	‘hawk’
b.	/o^{33}ȵɛ^{33}/	ɔ^{33}ȵɛ^{33}	‘head hair’
c.	/ʑo^{33}n̥a^{55}/	ʑɔ^{21}n̥a^{55}	‘male sheep’
d.	/tɕo^{55}ɕz̠^{33}/	tɕɔ^{55}ɕz̠^{33}	‘be scratched by a hawk’
e.	/tɕo^{55}ŋgv̠^{55}/	tɕɔ^{55}ŋgv̠^{55}	‘be taken away by a hawk’

(6.3) **ə –> [a] / __ [a, ɔ, v̠]**

a.	/tʂhə^{33}dza^{33}/	tʂha^{44}dza^{33}	‘rice’
b.	/zə^{33}khɔ^{33}/	za^{33}khɔ^{33}	‘hero’
c.	/zə^{33}m̥v̠^{33}n̥i^{33}/	za^{33}m̥v̠^{33}n̥i^{33}	‘children’

(6.4) **ə –> [ə̠] / __ [ɛ, z̠]**

a.	/lə^{33}ȵɛ^{33}/	lə̠^{33}ȵɛ^{33}	‘cow hair’
b.	/thə^{33}sz̠^{33}/	thə̠^{33}sz̠^{33}	‘pine’
c.	/tə^{33}ndzz̠^{21}/	ta^{21}ndzz̠^{21}	‘tip of a pine tree’

(6.5) **z –> [z̠] / __ [ɛ, a, ɔ, z̠, v̠]**

a.	/dʑz^{33}ndzz̠^{55}/	dʑz̠^{33}ndzz̠^{55}	‘bite each other’
b.	/dʑz^{33}ɬɛ^{33}/	dʑz̠^{44}ɬɛ^{33}	‘fight each other’
c.	/dʐz^{33}ma^{33}/	dʐz̠^{33}ma^{33}	‘tooth’
d.	/dʑz^{33}dʑɔ^{33}/	dʑz̠^{44}dʑɔ^{33}	‘[illegible]ach other’
e.	/dʑz^{33}ndzv^{33}/	dʑz̠^{33}ndzv̠^{33}	‘hate each other’

(6.6) **v –> [v̠] / __ [ɛ, a, ɔ, z̠, v̠]**

a.	/bv^{33}dv̠^{33}/	bv̠^{44}dv̠^{33}	‘east’
b.	/phv^{33}lɛ^{33}/	phv̠^{33}lɛ^{33}	‘expensive’
c.	/sv^{33}ʂa^{33}/	sv̠^{44}ʂa^{33}	‘poor’
d.	/vv^{33}nɔ^{33}/	vv^{33}nɔ^{33}	‘intestine’
e.	/bv^{33}dʐz̠^{55}/	bv̠^{33}dʐz̠^{55}	‘speak’

Examples 6.1a, 6.2a, 6.5a, 6.6a show total feature assimilation. Other examples illustrate partial feature assimilation.

The lax vowel **ə** is assimilated either to [ə̠] or [a], depending on the features spreading from the affecting tense vowel. The examples in (6.4a, b) are very special cases, where the affected vowel /ə/ changes to [ə̠], instead of [a]. We assume that these two tense vowels **ɛ̠** and **z̠** cannot pull the high lax vowel **ə** down far enough to the position of the tense vowel **a** due to their lack of the feature [+low]. However, the tense vowel **ɔ̠**, which has the same level of tongue position as the tense vowels **ɛ̠** and **z̠** (cf. Figures 2, 3), can cause the lax vowel **ə** to lower to the position of the tense vowel **a**. Hence, our alternative assumption is that the feature [-back] of **ɛ̠** and **z̠** contribute to this unexpected vowel shift **ə** –> [ə̠] and the plus feature [back] is responsible for the vowel feature assimilation **ə** –> [a]. From the perspective of the spatial distance reflected in Figures 2 and 3, the vowel change **ə** –> [ə̠] is natural since the distribution of these two vowels is consistent with the distance between other tense-lax vowel pairs; the vowel assimilation **ə** –> [a] is somewhat unnatural because of the large gap between the two vowels. We present two rules in (7) to capture these two different methods of feature spreading:

(7) Varieties of *ə* assimilation

a. $\text{ə} \rightarrow [\text{a}] \; / \; \_\_ \; \begin{bmatrix} \text{V} \\ \text{+back} \\ \text{+tense} \end{bmatrix}$ b. $\text{ə} \rightarrow [\text{ə̠}] \; / \; \_\_ \; \begin{bmatrix} \text{V} \\ \text{−back} \\ \text{+tense} \end{bmatrix}$

Thanks to the mid tone 33 lowering to tone 21, the tense vowel [ə̠] also lowers to [a] in 6.4c (cf. Qiu 1998). In this sense, tonal level can affect the vowel height.

4.2 The Feature Templates Representing Vowel Assimilation in Yi

In this section, we will present two feature geometry templates for the two different types of Yi vowel assimilation mentioned above. For the total feature leftward spreading we posit Figure 4 as the feature template:

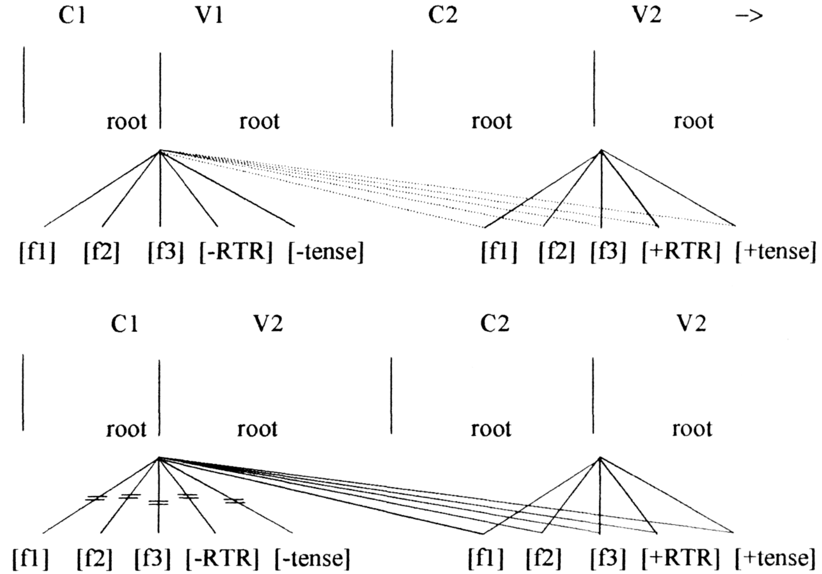


Figure 4. Yi total feature assimilation template for each tense/lax pair (where f1, f2, and f3 stand for all the terminal features and the place articulatory features dominated by the root node of a vowel)

Figure 4 demonstrates the assimilation process of a tense vowel spreading all of its features leftward to the lax vowel on the left side. That is, all the dominated features under the root node of the tense vowel on the right side, including the place articulatory terminal features such as [labial] and [coronal], directly spread to the target root node, and the feature spreading operation then deletes all the features dominated by target root node and replaces them with all the features spreading from the affecting vowel. As we will see in § 4.4, in addition to the features [tense] and [RTR], only the features [high] and [back] are relevant to the total vowel feature assimilation. Figure 4 captures the characteristics of feature assimilation of the examples in (6.1a, 6.2a, 6.3a, 6.4a, 6.6a).

For the partial feature spreading, we present Figure 5 as the assimilation template:

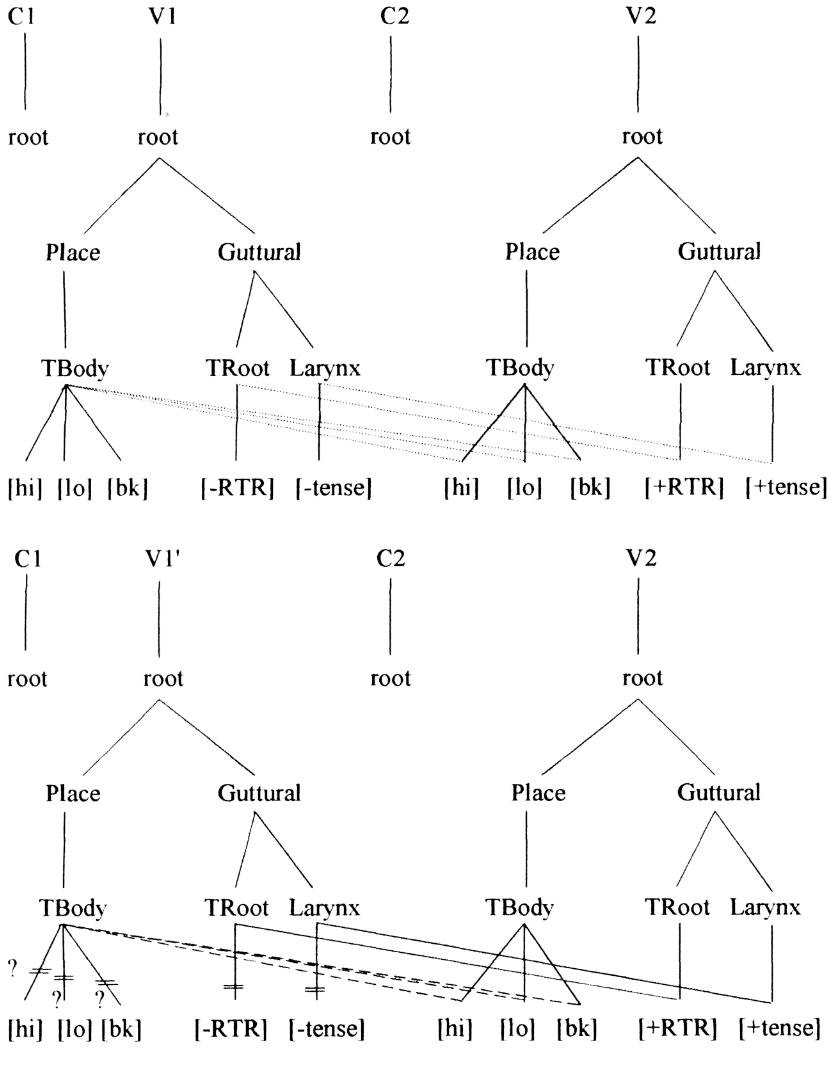


Figure 5. Yi partial vowel assimilation template representation of a non-paired tense vowel spreading its features to a non-paired lax vowel. (The question mark suggests that this feature may or may not be deleted.)

In Figure 5, the features of the tense vowel on the right side directly spread to the place and guttural nodes of the lax vowel on the left side. Figure 5 generalizes the dynamic partial feature spreading for all the examples in (6) that have not been captured by Figure 4. The features dominated by the tongue body may spread completely or partially, depending on the features of the tense vowel in question. Since it is unpredictable, we use a short-dashed line to represent such kind of feature spreading, distinguishing such a feature from that of a necessary spread feature like [tense] or [RTR], which is represented by a solid line in Figure 5. Whatever the type of feature spreading, the features [tense] and [RTR] are always correlated with vowel assimilation. Other features such as [coronal], [labial], and [round] under the articulatory places Lips and Tongue Blade are not subject to feature spreading in this type of vowel assimilation. Hence, they are omitted in the underlying representation in Figure 5. We will further discuss this issue in § 4.4.

4.3 Constraints on Yi Vowel Assimilation

Based on the examples in (6) and the feature spreading templates in Figures 4 and 5, we propose (8) as the constraints on Yi vowel assimilation:

(8) Constraints on Yi Vowel Assimilation

(a) Vowels of adjacent syllables must have a '([tense])[-tense] [+tense]' feature sequence in underlying representation. This sequence must be a syntactic category: a word or a phrase.

(b) Feature spreading must be leftward.

(c) The features [tense] and [RTR] must spread for all vowel assimilation process. Other features are context-dependent.

(d) An intervening consonant does not affect (or block) the feature spreading from right to left.

With these constraints in (8), let us now examine several examples to observe how the Yi vowel assimilation operates with respect to feature spreading:

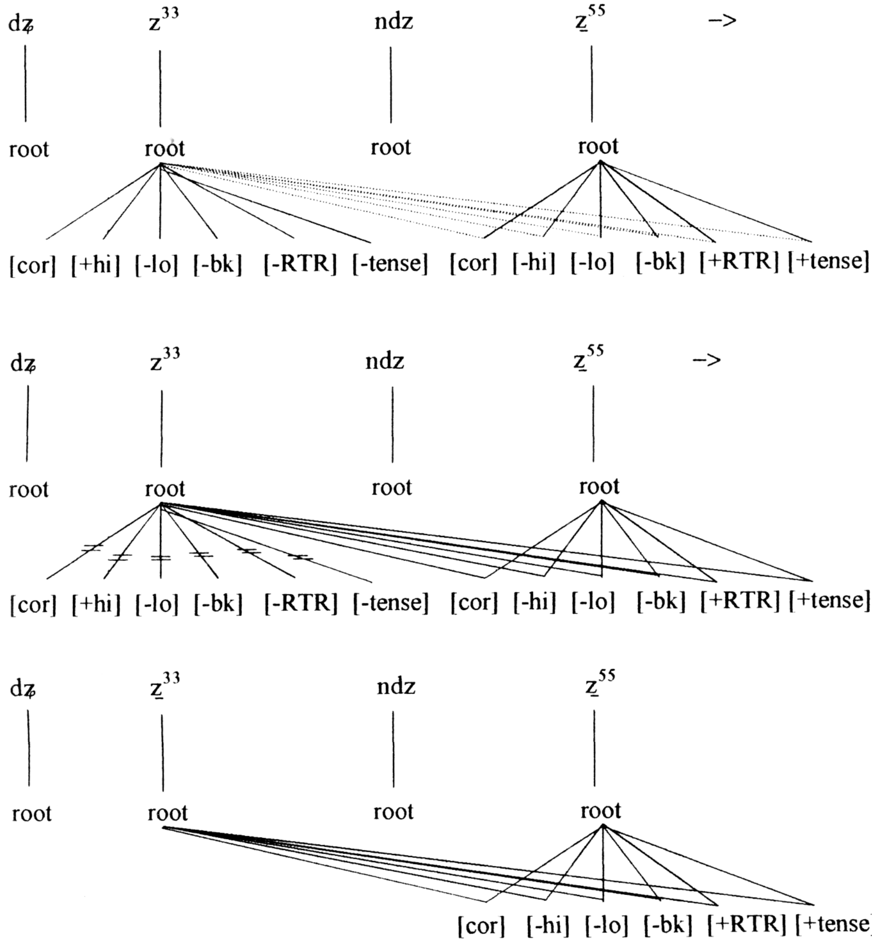


Figure 6. A full representation of vowel feature spreading: /dẓz33ndzẓ55/ -> dẓẓ33ndzẓ55 'bite each other'

Since the features [coronal], [low], [back] are the same for both of the tense-lax vowels, we omit them in representing feature spreading from the tense vowel to the lax vowel. Thus, Figure 6 can be simplified as Figure 7:

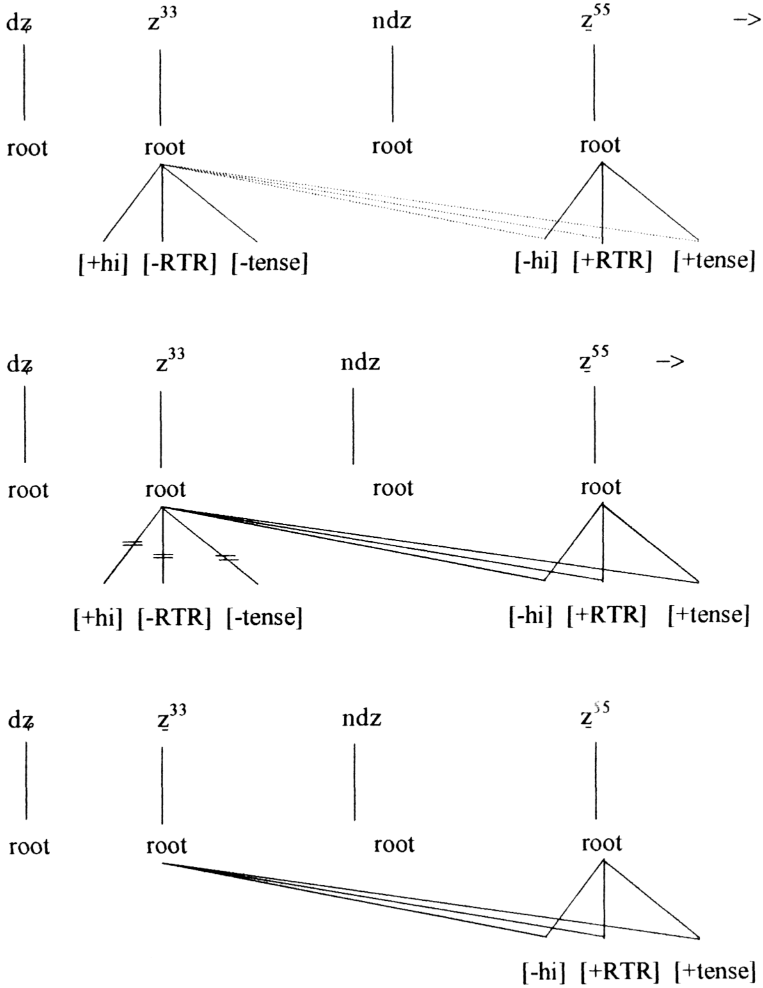
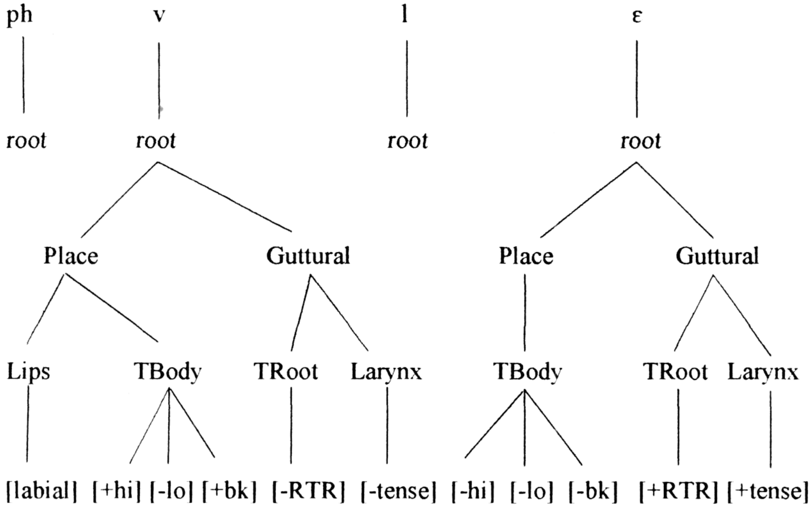


Figure 7. A simplified representation of vowel feature spreading: /dƶz̠^{33}ndƶz̠^{55}/ -> dƶz̠^{33}ndƶz̠^{55} 'to bite each other'

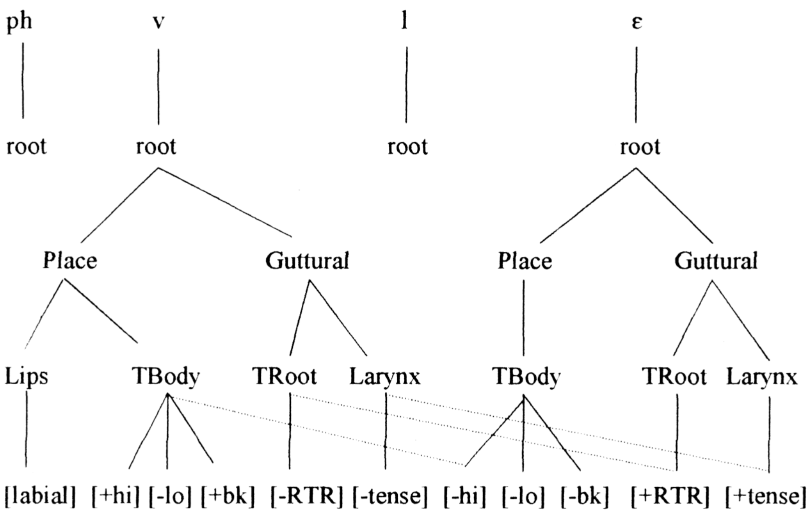
Both Figures 6 and 7 represent the total feature spreading; however, Figure 7 is more economical and elegant.

The process of vowel feature spreading consists of several steps, as shown in Figure 8:

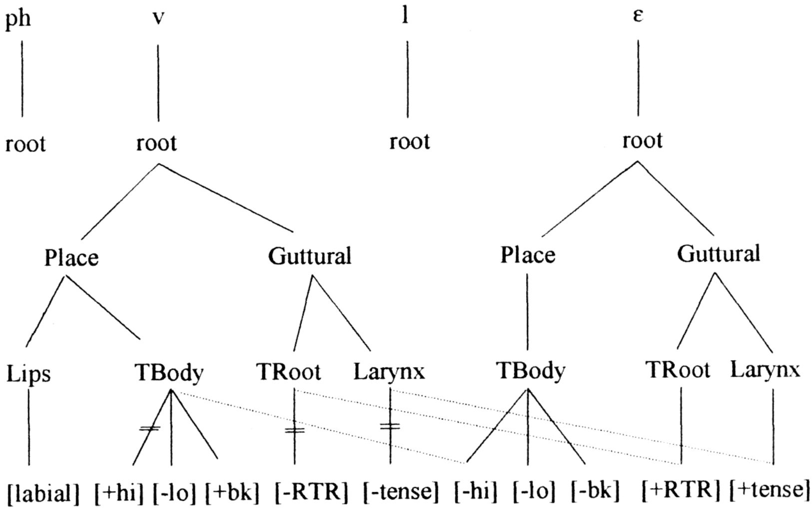
a. Underlying representation



b. Spreading the terminal features [+tense], [+RTR], and [-high] of the trigger vowel *ε*



c. Delinking the terminal features [-tense], [-RTR], and [+high] of the target vowel *v*



d. Output representation

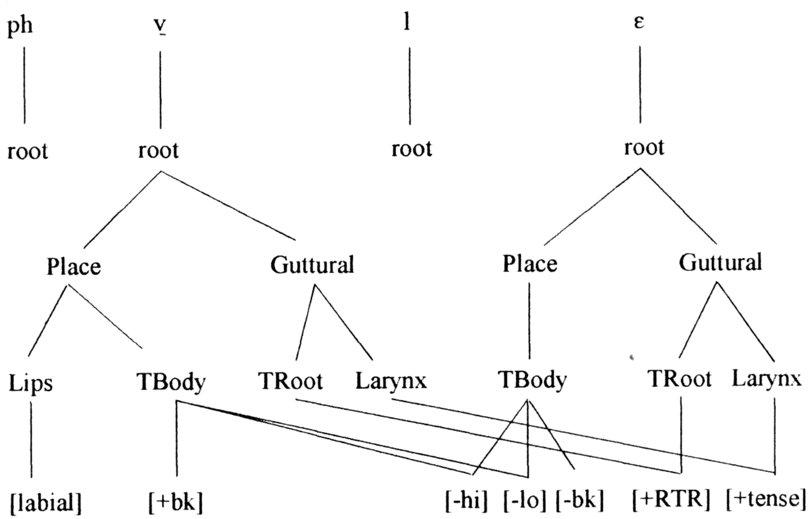


Figure 8. The representation of vowel partial feature spreading: /phv^{33}lɛ^{33}/ –> phv̱^{33}lʐ̩^{33} 'expensive'

In Figure 8, in addition to the features [tense] and [RTR], only the feature [high] among the features under the tongue body node is involved in spreading. Since both the vowels in Figure 8 have the same feature [-low], we assume that this feature is neutralized in the surface form (Figure 8d) and both vowels are associated to one feature [-low].

4.4 Analyses

This section addresses the terminal features dominated by the tongue body node and their involvement in feature assimilation.

The feature [high] dominated by the tongue body node is the most likely terminal feature to be spread to a target vowel. For the change of the vowels **i**, **z**, and **v** to their corresponding tense vowels, **ɛ**, **z̠**, and **v̠**, respectively, the minus [−high] value is directly spread from the affecting tense vowel to the tongue body node of the target. For the lax vowels **ə** and **o**, both of which have a [−high] value, the feature [−high] of the trigger may be regarded as a feature spreading leftward to the target and neutralizing with the [−high] of a target feature. In this sense, [−high] always spreads leftward regardless of whether the target feature has a plus [high] or minus [high] feature. Alternatively, considering that all the lax vowels are distributed at the highest level in the vowel space (cf. Figures 2 and 3), we can specify both of these two lax vowels **ə** and **o** with [+high] value, like the other lax vowels, and assume that all the tense vowels always spread their [−high] feature to those lax vowels with the feature [+high]. Whichever assumption is made, the result of the feature movement is that the target vowel must bear the value [-high]. Based on the feature specification in Table 6, we list the conditions of spreading the feature [high] in Table 7.

	ɛ	z̠	a	v̠	ɔ
i –> [ɛ]	+	+	+	+	+
z –> [z̠]	+	+	+	+	+
ə –> [a]	0	0	0	0	0
v –> [v̠]	+	+	+	+	+
o –> [ɔ]	0	0	0	0	0

Table 7. List of the feature [high] spreading. The leftmost column stands for a lax vowel changing to its tense counterpart and the right columns are tense vowels triggering the feature [high] spreading. The plus sign means that [−high] spreads to the target vowel and zero represents a neutralized case.

The feature [back] dominated by the tongue body node has a complicated pattern of assignment. For the change of vowels **i** and **z** to their corresponding tense vowels **ɛ** and **z̠**, the feature [-back] of the two tense vowels is neutralized with the target lax vowels' feature [-back]; the back tense vowels fail to assign their feature [+back] to any of these two target vowels. For the back lax vowels, neither of the non-back tense vowels (**ɛ** and **z̠**) can spread its [–back] to these two back vowels **v** and **o**, but we regard that the feature [+back] of the back tense vowels (**a, ɔ** and **v̠**) neutralizes with the feature [+back] of the target vowels **v** and **o**. For the middle lax vowel **ə**, the feature [–back] of both the non-back tense vowels (**ɛ** and **z̠**) neutralizes with **ə**'s feature [–back] (in the case of **ə** –> [ə̠]). In contrast, the back tense vowels (**a, ɔ** and **v̠**) can assign their feature [+back] to this lax vowel (in the case of **ə** –> [**a**]). Table 8 summarizes the conditions under which the feature [back] spreads:

	ɛ	z̠	a	v̠	ɔ
i –> [ɛ]	0	0	–	–	–
z –> [z̠]	0	0	–	–	–
ə –> [ə̠]	0	0	+	+	+
ə –> [a]	N/A	N/A	N/A	N/A	N/A
v –> [v̠]	–	–	0	0	0
o –> [ɔ]	–	–	0	0	0

Table 8. *List of the feature [back] spreading. The leftmost column stands for a lax vowel changing to its tense counterpart and the right columns are tense vowels triggering the feature [high] spreading. The plus sign means that [+back] spreads to the target vowel, the minus sign represents [+back] fails to spreading, and zero represents a neutralized case.*

The spreading of the feature [low] is contradictory. This feature assimilation is limited to the lax vowel **ə** changing to the tense vowel [a]. It is not evident where the feature [+low] of [a] comes from when the lax vowel **ə** precedes the tense vowels **v̠** or **ɔ**, which lack the feature [+low]. That is, the tense vowels **v̠**, **ɔ** cannot cause the vowel **ə** to assimilate to [a] without a feature [+low] spreading to it from a triggering vowel. Because the vowels **v̠** and **ɔ** are lacking the feature [+low] (cf. Table 6), I propose that the features [+RTR] and [+back] of these two tense vowels are responsible for this sound change. Specifically, the retraction of the tongue root causes the tongue position of the target vowel to lower and to move backward to some degree. However, a back vowel cannot move back far enough to be like a non-back lax vowel moving backward over a large distance; thus, the tongue position has to move farther down than backward.

Any tense vowel has the ability to trigger a lax vowel to move relatively lower and back; even a non-back tense vowel can cause a back lax vowel to move farther backward to some degree. For example, the front tense vowel **ɛ** technically cannot assign the value [+back] to a back lax vowel such as **v** or **o**. However, it can make each of these two lax vowels move relatively backward, contributing to the formation of the tense vowel **v̠** or **ɔ**. Since all the lax vowels are positioned in the highest range and tense vowels are located in the mid or the lowest range in the vowel space (cf. Figures 2 and 3), any tense vowel can, theoretically and practically, cause a lax vowel to lower its position.

Other features including [coronal], [labial], [round] have no effect on vowel assimilation. The feature [coronal] is an articulatory terminal feature, corresponding to the place node tongue blade, and the articulatory terminal feature [labial] corresponds to the lip node. The terminal feature [round] is dominated by the place node Lips. None of these features has any relationship with feature assimilation in Yi since they are not directly dominated by the place node tongue body, which has been regarded as the only place node that has significance for the feature movement under the major place node.

5 CONCLUSION

In this paper, we have shown that the ten Yi vowels have a symmetric tense-lax contrast distribution. In contrast to its lax counterpart, a tense vowel always has a relatively lower and posterior position. We have discussed the Yi vowel quality and tenseness voice quality. Generally speaking, all the lax vowels are located in the highest range of tongue position and the tense vowels distribute in the mid range and the lowest range. Tense voice quality reflects the laryngeal behavior on which the phonological feature [tense] is based. The process of forming a tense vowel is as follows: The tension formed in the larynx causes the tongue root to retract; the tongue root retraction further lowers the tongue body and at the same time moves it backward to some degree. The nature of Yi vowel assimilation is to copy this process from a tense vowel to its preceding lax vowel. In this sense, the Yi vowel assimilation mainly concerns the feature [tense]; the tongue root feature [RTR] and the tongue body features [high], [low], and [back] can be regarded as secondary characteristics of the feature [tense], manifesting the dynamic movement of laryngeal activity. Other features, [labial], [round] and [coronal], do not affect the vowel assimilation although they contribute to distinguishing one vowel from another.

This study may be of interest in the context of comparative TB, since the tense-lax contrast is salient not only in other Yi languages, but in many other languages throughout the TB family.

REFERENCES

ARCHANGELI, Diana. 1988. "Aspects of underspecification theory." *Phonology*: 183-207.

BURLING, Robbins. 1967. *Proto-Lolo Burmese. International Journal of American Linguistics* 33. Bloomington: Indiana University.

CHEN Shilin. 1963. "Yiyu Gaikuang." *Zhongguo Yuwen* No. 4. Beijing: Chinese Academy of Social Sciences Press.

CHEN Shilin, BIAN Shiming, and LI Xiuqing. 1985. *Yiyu Jianzhi*. Beijing: Nationality Press.

CLEMENTS, George. 1985. "The geometry of phonological features." *Phonological Yearbook* 2: 225-252.

_______ . 1991. "Place of articulation in consonants and vowels: a unified theory." *Working Papers of the Cornell Phonetics Laboratory* 5: 77-123. Ithaca, New York: Cornell University.

CLEMENTS, George and Elizabeth HUME. 1995. "The internal organization of speech sounds." In John A. Goldsmith (ed.), *The Handbook of Phonological Theory*: 246-259. Cambridge, Massachusetts: Blackwell Publishers.

DAI Qingxia. 1990a. "A study of the tense/lax vowels of Tibeto-Burman languages." In Dai (ed.), *Research on Tibeto-Burman Languages*: 1–32. Kunming: Yunnan Nationality Press.

_______ . 1990b. On the genetic classification of Tibeto-Burman languages in China. In Dai (ed.), *Research on Tibeto-Burman Languages*: 418–440. Kunming: Yunnan Nationality Press.

DANTSUJI Masatake. 1982. "An acoustic study on glottalized vowels in the Yi (Lolo) language – a preliminary report." *Studia Phonologica* 16: 1-11.

EDMONDSON, Jerold A. & LI Shaoni. 1991. "Voice quality and voice change in the Bai language of Yunnan Province." Paper presented at the International Conference on Yi-Burmese Languages, Xichang, Sichuan, China.

EDMONDSON, Jerold A., John ESLING, LI Shaoni, Jimmy G. HARRIS and Lama ZIWO. 2000. "The aryepiglottic folds and voice quality in the Yi and Bai languages: laryngoscopic case studies." To appear in *Mon Khmer Studies* 31. 17 pp.

HALLE, Morris. 1992. "Phonological features." In W. Bright (ed.), *International Encyclopedia of Linguistics*, Vol. 3: 207-12. Oxford: Oxford University Press.

_______ . 1995. "Feature geometry and feature spreading." *Linguistic Inquiry*. Vol. 26, No.1.

HALLE, Morris, Bert VAUX, and Andrew WOLFE. 2000. "On feature spreading and the representation of place of articulation." *Linguistic Inquiry* 31.3.

HU Tan and DAI Qingxia. 1964. "The tense/lax vowels of Hani." *Zhongguo Yuwen* No.1. Beijing: Chinese Academy of Social Sciences Press.

KENSTOWICZ, Michael. 1994. *Phonology in Generative Grammar*. Oxford: Blackwell Press.

KIPARSKY, Paul. 1985. "Some consequences of lexical phonology." *Phonology*: 85-138.

LADEFOGED, Peter. 1993. *A Course in Phonetics* (3rd edition). Fort Worth: Harcourt Brace Jovanovich.

LADEFOGED, Peter and Ian MADDIESON. 1996. *The Sounds of the World's Languages*. Cambridge, MA: Blackwell Publishers.

LAVER, John. 1980. *The Phonetic Description of Voice Quality*. Cambridge: University Press.

_______ . 1994. *Principles of Phonetics*. Cambridge: University Press.

LI Min, and MA Ming. 1983. *Liangshan Yiyu Yuyin Gailun*. Chengdu: Sichuan Nationality Press.

MA Xueliang. 1948. *Luowen Zuoji Xianyao Gongshengjing Yizhu*. (Research Monograph No. 20). Beijing: Institute of History and Philology of the Central Academy.

_______ . 1951. *Sani Yiyu Yanjiu*. (Linguistic Monograph No. 2). Beijing: Institute of History and Philology of the Central Academy.

MADDIESON, Ian, and Peter LADEFOGED. 1985. "'Tense' and 'lax' in four minority languages of China." *Journal of Phonetics*: 433-454.

MADDIESON, Ian, and Susan HESS. 1986. "'Tense' and 'lax' revisited: more on phonation types and pitch in minority languages of China." *UCLA Working Papers in Phonetics*: 103-109. Los Angeles.

MESTER, R. Amherst and Junko ITÔ. 1989. "Feature predictability and underspecification: palatal prosody in Japanese mimetics." *Language* 65: 258-293.

McCARTHY, John. 1988. "Feature geometry and dependency: a review." *Phonetica*: 84-108.

MOHANAN, K.P. 1983. *The Structure of the Melody*. Cambridge, MA: Massachusetts Institute of Technology. MS.

PULLEYBLANK, Douglas. 1988. "Underspecification, the feature hierarchy and Tiv vowels." *Phonology*: 299-326.

QIU Fuyuan (a.k.a. Ziwo LAMA). 1998. *A Phonetic and Phonological Overview of the Yi (Lolo) Language*. Master's Thesis. Arlington: University of Texas.

SAWASHIMA, M. and H. HIROSE. 1968. "New laryngosopic technique by use of fiber optics." *Journal of the Acoustical Society of America*: 43-168.

ZEMLIN, R. Willard. 1986. *Speech and Hearing Science*. Englewood Cliffs, New Jersey: Prentice-Hall.