

Appeared in *Linguistic Inquiry* 25.4: 555-608, 1994.

AGAINST CONTOUR TONE UNITS*

San Duanmu

1 Introduction

A central issue in phonology is whether *contour segments* exist (see, for example, Chomsky and Halle 1968, Campbell 1974, Anderson 1976, Herbert 1975, 1986, Sagey 1986, Steriade 1989, 1993). A contour segment is one that contains a *contour feature*. In the feature geometry of Sagey (1986), a contour feature is represented as in (1).

- (1) N N = the Root node, or an articulator node
 / \
 [αF] [-αF] α = any value (i.e., + or -); F = any feature

A contour feature F is one that takes two, or more, values in succession within one X slot. Three kinds of contour segments are proposed: affricates (i.e., [-cont, +cont]), pre- or postnasalized stops (i.e., [+nas, -nas], or [-nas, +nas]), and contour tones (e.g., [-H, +H]).

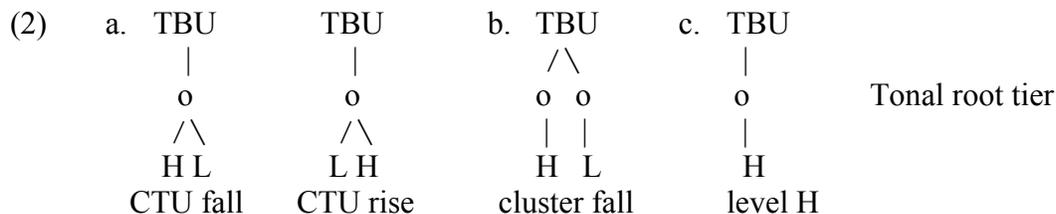
If contour features exist, one expects many more possible segments than what are actually found. To appreciate the size of the potential inventory, consider a system with 10 binary distinctive features, the values of which can be chosen freely. (Actual systems have more features, but not all of their values can combine freely, for example, *[+high, +low] and *[-son, -cons] are bad combinations.) Without contour features, the total number of possible segments is 2^{10} , or 1,024, which is not far from the total inventory found in natural languages (for example, Maddieson (1984) lists about 600 consonants and 200 vowels from 317 representative languages around the world). However, with contour segments, even if each feature may change its value just once ([+F, -F] or [-F, +F]), the number of possible segments is 4^{10} , or 1,048,576, which exceeds the observed number by far.¹

The lack of contour segments in natural languages calls for restrictions on contour features and for a reexamination of previously claimed contour segments. Thus, Herbert (1975, 1986) argues that, underlyingly, pre- and postnasalized stops can be analyzed as either a cluster, a simple nasal, or a simple stop. Following Herbert, Duanmu (1990:161-170) argues that, insofar as the data are clear, all the pre- and postnasalized stops listed in Maddieson 1984 can be analyzed in one of these ways. Moreover, Steriade (1989, 1993) and Lombardi (1990) have argued that pre- or postnasalized consonants and affricates do not contain contour features.

Less disputed, however, are contour tones. Traditionally, nasality and continuancy are considered segmental properties, but tone is considered a suprasegmental property. It is believed that segmental and suprasegmental features may behave differently. For example, although Anderson (1976) was reluctant to allow contour features in general, he was willing to accept contour *suprasegmental* features, in particular, contour tones. He suggested that although it is hard to accept a contour [continuant], it is fine to accept a contour [nasal], since [nasal] "is in some ways a suprasegmental, on a par with features of pitch" (p. 343).

Pike (1948) proposes two types of contour tones, those that derive from level tones, and those that are underlyingly units. Since the former do not involve underlying contour features, I delay their discussion until the final section. Following Yip (1989), I call the latter *contour tone units* (hereafter CTUs). CTUs occur mostly in Asian languages. To speakers of Asian tone

languages, the notion of CTU must have seemed intuitively very natural. Through hundreds of years in the history of Asian phonology, hardly anyone, to my knowledge, ever suggested decomposing contour tones into level tones. The first researcher to challenge the tradition was Woo (1969), who proposed that all contour tones are clusters of level tone. Still, although Woo's work had an impact on African tonology, it has not been widely accepted by Asian phonologists. Instead, a number of forceful arguments for CTUs, largely based on Chinese languages (or "dialects"), have recently been put forward. The proposed difference between a CTU and a contour tone cluster is shown in (2) (Yip 1989:151).



According to Yip (1989, 1992) and Bao (1990, 1992), pitch features H and L are linked to TBUs (tone-bearing units) via an intermediate node, which Yip (1989:150) calls the *Tonal Root* node, and Bao (1990:2) calls the *Contour* node.² In a CTU the Tonal root is linked to two pitch features. In a level tone the tonal root is linked to one pitch feature. In a contour cluster two level tones are linked to one TBU. Major arguments for CTUs are summarized in (3) (see, among others, Bao 1990, Chan 1991, and especially Yip 1989).

- (3)
- a. Contour tones in Chinese languages freely occur on nonfinal syllables (in contrast to African languages, where they largely occur on the final syllable).
 - b. There are dissimilation rules that apply between contour tones owing to the Obligatory Contour Principle (OCP).
 - c. A contour tones may act as a unit in initial association.
 - d. A contour tone may spread as a unit.

(3a) is true in most Chinese dialects. (3b) is found in Tianjin, among other dialects. (3c) is found in Wuxi and Old Shanghai. (3d) is found in Danyang and Changzhi.

In this article I argue against CTUs. In particular, I argue that (3a) is true only in those Chinese languages where regular rimes are heavy, but not in those where regular rimes are light. For (3b), I show that "dissimilation" between contour tones is sporadic and cannot be attributed to the OCP. Next, I show that (3c) can be accounted for without assuming CTUs. Finally, I argue that there is little evidence for CTU spreading in either Danyang or Changzhi. I conclude that there is no compelling evidence for CTUs in Chinese. Two consequences follow. First, the difference between Asian and African tones is smaller than previously thought. Second, arguments for contour segments in general are weakened.

Against (1), therefore, I propose the phonological constraint in (4), which prohibits two (or more) tokens of the same feature from docking on the same node.

- (4) $\begin{array}{c} *N \\ / \backslash \\ [\alpha F] \quad [-\alpha F] \end{array}$ N = the Root node, or an articulator node
 α = any value (i.e., + or -); F = any feature

Most evidence presented below suggests that (4) must hold at the underlying level.³ In addition, despite the popular acceptance of short contour tones, some evidence will be presented in section 4 that (4) holds at the surface level as well.

2 Arguments for CTUs

In this section I review major arguments for CTUs. I focus on Chinese languages, on which most arguments for CTUs are based. I will say little about CTUs in other languages (see, for example, Gandour and Fromkin 1978, Newman 1986).

Some background on Chinese is in order. Chinese is a monosyllabic language; nearly every native syllable is a morpheme. Except for a few weak syllables, every regular syllable has a tone, which I will call *syllable tone*. The syllable tone can be either a level tone or a contour tone. For example, Mandarin has four syllable tones, which, for exposition, I will write as H, LH, MLH, and HL. Multisyllabic words are mostly loan-words. When such a word is borrowed into Chinese, the translator chooses a set of native syllables to make up that word. The underlying tones of the native syllables then become the underlying tones of the borrowed word. For example (transcription in Pinyin):

- (5) a. H b. LH c. H LH
 kai luo kai luo
 'to open' 'to net (birds)' 'Cairo'

The word *Cairo* is translated into Mandarin with two syllables, *kai* 'to open', with the syllable tone H, and *luo* 'to net (birds)', with the syllable tone LH. The Mandarin word for *Cairo* is thus *kai luo*, with the syllable tones [H LH].

In Chinese tonology, the most widely used transcription system is that introduced by Chao (1930), where the pitch range is divided into five equal levels, represented by the digits 1 for the lowest through 5 for the highest. A tone is usually represented by two or three digits that indicate the initial, the medial, and the final pitch levels. Thus, 55 is a high level tone, 51 a high-to-low fall, 53 a high-to-mid fall, 535 a fall-rise in the upper pitch range, and so on. A graphic version of the Chao system has been adopted by the International Phonetic Association (1989).

It is important to keep in mind that the "Chao letters," as the digits are called, are inherently flexible. As Chao himself points out, a variation within one level is not to be taken seriously. In fact, Chao transcribed the Mandarin (nonfinal) third tone as 11 on one occasion and 21 on another (Chao 1931, 1968), even though the tone itself has not changed. In addition, transcribers often modify the actual values of Chao letters for "visual clarity," especially when they are using the graphic version. Two examples are given in (6) and (7).⁴

- (6) In transcribing Old Shanghai, Shen (1981a:132) says, "The real value of Yin Ping is 52; this paper marks it as 53. The real value of Yin Qu is 33 or 24; this paper marks it as 35. The real value of Yang Qu is 113 or 13; this paper marks it as 13. The real value of Yang Ru is a short tone 23, this paper marks it as 13."

- (7) In transcribing New Shanghai, Xu et al. (1981:145) say, "Yin Qu is 34; for visual clarity, this paper writes it as 24. Yang Ru is 12; for visual clarity, this paper writes it as 13."

The practice of modifying the actual values of Chao letters is extremely common, and often done silently. It is therefore no simple matter to convert Chao letters into a system of level tones. For example, 33 is clearly M; 24 could be MH, LM, or LH; and 35 could be MH or LH. Now, if a tone is 33 or 24 phonetically, and the field-worker writes it as 35, as is the case for Yin Qu in Old Shanghai, how exactly should one interpret it? For this reason, where it is not crucial for our discussion, I will cite tones in Chao letters as they are presented in the original sources.⁵ When it is necessary to convert Chao letters into level tones, justifications will be provided for the selected conversion.

2.1 Free Occurrence of Contour Tones

The first argument for CTUs comes from the observation that, although in African languages contour tones occur mostly in domain-final positions, in Chinese languages contour tones may occur anywhere. Consider the following case in Mandarin:⁶

- (8) LH LH → LH LH
 he lan he lan 'Holland'

According to Yip (1989), the TBU in Chinese is the syllable. The Mandarin word for *Holland* has two syllables, each carrying a rising tone. If we apply the standard Association Conventions (e.g., Pulleyblank 1986), which link tones to TBUs one to one, from left to right, we expect the following result:

- (9) LH LH → *L H(LH)
 he lan | |
 he lan

But (9) is incorrect. The correct pattern is [LH LH]. To reconcile the Mandarin fact with the Association Conventions, Yip suggests that LH in Mandarin is a CTU (which I notate with underlining LH). The derivation of (8) is shown in (10).

- (10) LH LH → LH LH
 he lan | |
 he lan

Underlyingly, there are two CTUs. By the Association Conventions, each CTU is linked to a syllable, giving the correct output.

It has been noted that only *simple* contour tones (i.e., LH and HL) are free to occur on nonfinal syllables; *complex* contour tones (i.e., LHL and HLH) are restricted to the final position. Bao (1990:61) stipulates that the composition of a CTU is restricted to two elements, either HL or LH but not LHL or HLH. This stipulation is also implicit in Yip 1989. It should also be

pointed out that contour tones occur freely only in some Chinese languages. I will return to these points.

2.2 Dissimilation between Contour Tones

Yip (1989) points out that successive contour tones often dissimilate. For example, Tianjin has four syllable tones, which Li and Liu (1985) transcribe as 21, 45, 213, and 53, and which Yip converts to L, H, LH, and HL respectively. When two like tones occur in succession, the first is changed in three cases, shown in (11) (transcribed in Pinyin).

- (11) a. HL HL → L HL b. LH LH → H LH
 53 53 21 53 213 213 45 213
 jian zhu 'building' guan li 'to manage'
- c. L L → LH L
 21 21 213 21
 guan xin 'to care for'
- (12) H H → no change
 45 45
 nan ren 'male person (man)'

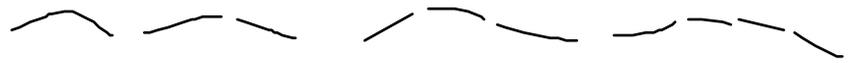
Yip attributes the change in (11a-c) to the OCP (Leben 1973, McCarthy 1986).

- (13) OCP
 *[X X], where X is any feature.
 (e.g., *[HL HL], *[LH LH], *[H H], *[L L], ...)

As Yip points out, for the OCP to apply, it is crucial that 53 in (11a) is not a cluster HL but a CTU HL. Similarly, 213 in (11b) is also a CTU. For (12), Yip assumes that 45 = H is unspecified at the time the OCP applies; a rule will assign H to it at a later stage.

2.3 Contour Tone as the Unit in Initial Association

The third argument for CTUs comes from Wuxi, where, according to Yip (1989), a contour tone may behave as a unit in initial association. Relevant phonetic data are given in (14) (adapted from Chan and Ren 1986).

- (14) Monosyllabic Bisyllabic Trisyllabic Quadrisyllabic
- a. 
- b. 
- c. 

As Yip notes, the final syllable in (14a) and the first syllable in (14b) seem always to carry a rise, and the final syllable in (14c) seems always to carry a fall. Yip offers the following analysis (\$ = syllable):

(15)	Monosyllabic	Bisyllabic	Trisyllabic	Quadrisyllabic
a.	L <u>LH</u> ✓ \$	L <u>LH</u> \$ \$	L <u>LH</u> \$ \$ \$	L <u>LH</u> \$ \$ \$ \$
b.	<u>LH</u> L ✓ \$	<u>LH</u> L \$ \$	<u>LH</u> L \$ \$ \$	<u>LH</u> L \$ \$ \$ \$
c.	L <u>HL</u> ✓ \$	L <u>HL</u> \$ \$	L <u>HL</u> \$ \$ \$	L <u>HL</u> \$ \$ \$ \$

Two assumptions are made here. First, tone-to-syllable association in Wuxi is edge-in (Yip 1988), rather than left to right. Second, the pitch of the toneless syllables depends on the interpolation between the tones at the two edges (Pierrehumbert 1980). In particular, the toneless syllables in (15a) are low, those in (15b) gradually falling, and those in (15c) gradually rising. As Yip suggests, in order for the first syllables in (15b) to have a rise, LH must be a CTU. Similarly, Yip postulates a CTU LH in (15a) and HL in (15c). However, (15c) does not quite match the contours in (14c). I return to this later.

2.4 Contour Tone Spreading

The strongest argument for CTUs comes from contour tone spreading. There are two reported cases in Chinese languages, Changzhi and Danyang. I consider them in turn.

2.4.1 Changzhi

The data for Changzhi, a Mandarin dialect, are from Hou 1983. There are five long tones (213, 24, 535, 44, and 53) and two short tones (4 and 54). The short tones occur only on syllables with a glottal coda and need not be considered separate syllable tones.

The pattern of interest is found in bisyllabic expressions that are composed of a stem syllable followed by the morpheme [təʔ], which has a diminutive meaning, or by the morpheme [ti], which has an adjectival meaning. This is shown in (16).

(16)	Stem	Stem-[təʔ] (or Stem-[ti])	
a.	213	213 213	
	kuə	kuə təʔ	'pan'
b.	24	24 24	
	səŋ	səŋ təʔ	'rope'

c.	535	535	535	
	ti	ti	təʔ	'bottom'
d.	44	44	535	
	k ^h u	k ^h u	təʔ	'pants'
e.	53	53	53	
	təu	təu	təʔ	'bean'

Except in (16d), the tone on [təʔ] is the same as that of the stem. Bao (1990:85-87) analyzes (16) as follows. First, he assumes that the syllable tones of [təʔ] and [ti] are both 535. Second, he assumes that the tone 44 is underlyingly unspecified. Third, he assumes that there is contour tone spreading from the first syllable to the second. Finally, following Yip (1989), he assumes that a doubly linked tone will split to two copies by "tier conflation"; I will return to this point later. The derivations of (16a, d) are shown in (17)-(18) respectively, where tones are linked to syllables via a *Tone node* (Bao 1990:87).

(17)

	spreading		tier conflation							
	213	535	→	213	535	→	213	213	535	
										Tone node
	o	o		o			o	o		
				\						
	\$	\$		\$ \$			\$	\$		Syllable

(18)

	default					
		535	→	44	535	
						Tone node
	o	o		o	o	
	\$	\$		\$	\$	Syllable

In (17) the spreading of 213 delinks the original 535 from the second syllable. Then 213 splits into two copies, giving the surface [213 213]. In (18) the first syllable has no underlying tone, so spreading does not take place, and the second syllable keeps its own 535. A default rule later assigns 44 to the first syllable, giving the surface [44 535].

Bao's analysis relies on CTU spreading. For example, if 213 is not a CTU, there is no way to spread it as a whole.⁷ A similar analysis of Changzhi is given in Davison (1989). In addition, Bao's analysis is essentially adopted by Yip (1991).

2.4.2 Danyang

The Danyang data come from Lü (1947, 1980). They are analyzed by Chen (1986), Yip (1989), Bao (1990), and Chan (1991) as the major evidence for the very rare phenomenon of contour tone spreading. Relevant surface patterns are given in (19).

(19) Surface tone patterns in multisyllabic domains in Danyang (Lü 1980:87-88)

	Bisyllabic	Trisyllabic	Quadrisyllabic
a.	11 11	11 11 11	11 11 11 11
b.	42 11	42 11 11	42 11 11 11
c.	42 24	42 42 24	42 42 42 24
d.	33 33	33 33 33	33 33 33 33
e.	24 55	24 55 55	24 55 55 55
f.	55 55	55 55 55	55 55 55 55

In (19) the tones on noninitial syllables are either the same as the tone on the initial syllable, as in (19a), or (allowing some flexibility for the Chao letters) are an extension of the end point of the tone on the initial syllable, as in (19b). If tones on noninitial syllables come from the initial syllable, then (19) indicates tone spreading from the initial syllable to noninitial ones. In particular, assuming that 11 = L, 42 = HL, 33 = M, 24 = LH, and 55 = H, then (19a-b) show L spreading, (19d) M spreading, and (19e-f) H spreading. Of special interest is (19c), which was thought to show CTU spreading in previous analyses.

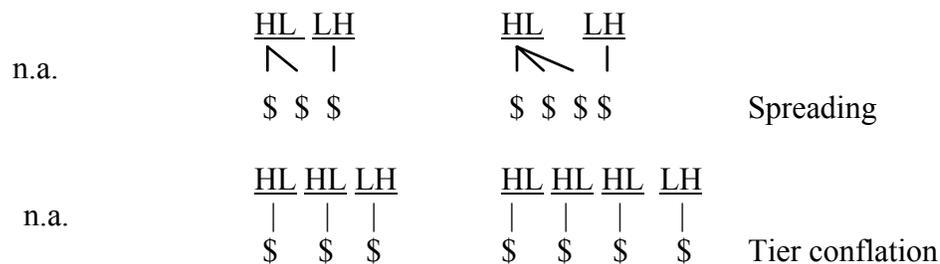
First, consider the analysis proposed by Chen (1986), which assumes that the initial syllable in (19c) has two CTUs, HL and LH. In addition, Chen assumes right-to-left association. Finally, there is leftward tone spreading. The analysis of (19c) is in (20).

(20)	a. Bisyllabic	b. Trisyllabic	c. Quadrisyllabic	
	<u>HL</u> <u>LH</u>	<u>HL</u> <u>LH</u>	<u>HL</u> <u>LH</u>	
	\$ \$	\$ \$ \$	\$ \$ \$ \$	Right-to-left linking
	n.a.	<u>HL</u> <u>LH</u>	<u>HL</u> <u>LH</u>	
		/	/	
		\$ \$ \$	\$ \$ \$ \$	Spreading

Chen does not mention why a multiply linked HL is realized as several copies of HL, rather than as a single extended falling contour.

Next, consider Yip's (1989) analysis. Like Chen, Yip assumes that the initial syllable has two CTUs, HL and LH. But unlike Chen, Yip assumes that association is "edge-in". Next, HL spreads rightward to the toneless syllables. Finally, in order for the multiply linked HL to become a separate copy on each syllable, Yip suggests the process of tier conflation, borrowed from McCarthy 1986, which splits multiple associations into individual associations. The derivations of (19c) are shown in (21).

(21)	a. Bisyllabic	b. Trisyllabic	c. Quadrisyllabic	
	<u>HL</u> <u>LH</u>	<u>HL</u> <u>LH</u>	<u>HL</u> <u>LH</u>	
	\$ \$	\$ \$ \$	\$ \$ \$ \$	Edge-in linking



Tier conflation is a crucial step, which makes sure that each syllables that is multiply linked to a CTU gets a copy of it. For example, the first three syllables in (21c) will surface as [HL HL HL], rather than as a single gradual fall that extends over the three syllables. However, the motivation for applying tier conflation in (21) differs significantly from what McCarthy (1986) proposed. I return to this in section 3.4.

The third analysis of (19c) is proposed by Chan (1991), and adopted by Bao (1990) with minor modifications. Chan (p. 248) notes a rule proposed by the original author, Lü (1980:88), which says that when two underlying rising tones occur next to each other, the first will change to a fall.

$$(22) \quad 24 \quad 24 \rightarrow 42 \quad 24 \quad \text{or} \quad LH \quad LH \rightarrow HL \quad LH$$

Chan's analysis makes crucial use of this rule.⁸ First, Chan assumes that the initial syllable in (19c) has just one CTU LH, which spreads rightward. Then tier conflation applies. Finally, applying (22), every LH except the last changes to HL. (23) illustrates Chan's analysis of the trisyllabic pattern (cf. Chan, p. 249).

$$(23) \quad \begin{array}{c} \text{spreading} \\ \underline{LH} \\ | \\ \$ \$ \$ \end{array} \rightarrow \begin{array}{c} \text{conflation} \\ \underline{LH} \\ \diagdown \\ \$ \$ \$ \end{array} \rightarrow \begin{array}{c} \underline{LH} \quad \underline{LH} \quad \underline{LH} \\ | \quad | \quad | \\ \$ \quad \$ \quad \$ \end{array} \xrightarrow{(22)} \begin{array}{c} \underline{HL} \quad \underline{HL} \quad \underline{LH} \\ | \quad | \quad | \\ \$ \quad \$ \quad \$ \end{array}$$

Although the analyses of Chen, Yip, Chan, and Bao differ in some ways, they all assume that CTU spreading is necessary in accounting for (19c).

3 Arguments against CTUs

Having reviewed arguments for CTUs, I now present arguments against CTUs.

3.1 Free Occurrence of Contour Tones and Syllabic Weight

First, let us consider free occurrence of contour tones. I will argue that there is an important correlation between syllabic weight and contour distribution, which is ignored by the CTU theory. In particular, contour tones exhibit stability only in those languages whose syllables are predominantly heavy, not in those languages whose syllables are all light. I will show that this correlation is the source for the apparently free distribution of contour tones in some languages and the lack of it in others.

As Yip (1989) notes, contour tones occur quite freely in most Chinese languages. It is also known, however, that in some Chinese languages contour tones do not occur freely. The best-known case is New Shanghai, spoken in Shanghai City.⁹

New Shanghai is studied in a number of works, notably Xu et al. 1988 and Selkirk and Shen 1990. Phonetically, New Shanghai has five syllable tones: 53, 34, 23, 55, and 12 (Xu et al, p. 72). 55 and 12 occur on glottalized vowels only and are in complementary distribution with 34 and 23, respectively. In addition, 53, 34, and 55 occur on syllables with a voiceless onset and 23 and 12 on syllables with a voiced onset. Phonemically, then, one may posit just two syllable tones: HL for 53, and LH for 34, 55, 23, and 12. This interpretation is uncontroversial among current researchers who analyze New Shanghai in multitiered phonology and will not be further justified here.

In New Shanghai a contour tone occurs only in a monosyllabic domain. In domains with two or more syllables, only level tones are found.¹⁰ Consider the following examples:

- (24) a. LH LH → L H
 du de du de 'big egg'
- b. LH HL → L H
 du tçi du tçi 'big chicken'
- c. LH HL LH → L H L
 du tçi de du tçi de 'big chicken egg'
- (25) a. HL LH → H L
 sã de sã de 'raw egg'
- b. HL HL → H L
 tçi kø tçi kø 'chicken liver'
- c. HL HL LH → H L L
 sã tçi de sã tçi de 'raw chicken egg'

In general, the tonal pattern of a domain in New Shanghai is determined entirely by the initial syllable. If the initial syllable is underlyingly LH, the domain pattern is [L H L...L]. If the initial syllable is underlyingly HL, the domain pattern is [H L...L]. The usual analysis is that first, underlying tones on noninitial syllables are deleted, then underlying tones of the initial syllable are linked to syllables one to one and left to right. Finally excess syllables are assigned L as default (or perhaps remain toneless).

The behavior of New Shanghai is reminiscent of that of African tone languages. For example, the deletion of underlying tones from noninitial syllables is found in Mende compounds (Leben 1973).¹¹ In addition, splitting a contour tone into a sequence of level tones is a well known process in African languages. On the other hand, New Shanghai contrasts sharply with Mandarin, as the cognate expressions in (26) and (27) show.

- (26) Mandarin (transcribed in phonetic symbols)
- | | | | | | | |
|-----|-------|--------------------|---|-------------------|-----|--------------------|
| HL | LH | HL | → | HL | LH | HL |
| ta | pai | ts ^h ai | | ta | pai | ts ^h ai |
| big | white | vegetable | | 'Chinese cabbage' | | |

- (27) New Shanghai (['] = glottalization of the vowel)
- | | | | | | | |
|-----|-------|-------------------|---|----------|----------|-------------------|
| LH | LH | LH | → | L | H | (L) |
| da | ba' | ts ^h e | | da | ba' | ts ^h e |
| big | white | vegetable | | 'Chinese | cabbage' | |

In Mandarin, the tonal output is a concatenation of the input syllable tones, and contour tones remain stable. In New Shanghai, however, noninitial syllables lose their syllable tones, and the contour tone of the initial syllable splits into L and H, the latter being shifted to the second syllable.

The contrast between New Shanghai and Mandarin raises two questions. First, why do noninitial syllables lose their underlying tones in New Shanghai but not in Mandarin? Second, why are contour tones stable in Mandarin but not in New Shanghai?

For the first question, the CTU theory has no answer other than stipulating a language particular rule to delete underlying tones from noninitial syllables for New Shanghai. For the second question, the CTU theory must assume that whether a language has CTUs or not is determined by a parameter in Universal Grammar; Mandarin chooses to allow CTUs, and Shanghai chooses not to. But why should New Shanghai and some of its neighbors have chosen the CTU parameter like African languages and unlike all other Chinese languages? For the CTU theory, this is just an accident.

But the CTU theory has overlooked a very important correlation between the apparent freedom of contour tones and the structure of the syllable. As argued in Duanmu 1993, in languages like Mandarin (M-languages) all regular syllables are heavy, whereas in languages like New Shanghai (S-languages) all syllables are light.¹² I will review some of the evidence shortly. From the syllabic difference, all tonal consequences follow. In particular, it is well known that in Chinese languages stressless syllables either do not carry underlying tones (such as the so called neutral-toned syllables) or will lose their underlying tones.¹³ In addition, it is often observed in metrical phonology that heavy syllables carry inherent stress; indeed, Prince (1992:358) elevates this generalization to a universal principle, which he calls the Weight-to-Stress Principle.¹⁴ In contrast, light syllables receive stress only by rule. Thus, in M-languages all regular rimes are heavy, hence stressed, hence retaining their underlying tones (which may or may not undergo additional tone sandhi). Moreover, since a heavy rime is bimoraic, it can carry two level tones, giving the impression of contour tone stability in M-languages. In contrast, in S-languages all rimes are light, hence do not carry inherent stress, hence lose their underlying tones, unless they receive stress by rule (as does the domain-initial syllable). Moreover, although underlying tones of a stressed syllable will be kept, nonetheless since the syllable is light, it will carry just one tone, shifting the rest to other syllables in the same domain. If the stressed syllable is in a monosyllabic domain, however, it will be lengthened and then carry all of its tones.

Let us now review some evidence that M-languages have heavy rimes and S-languages have light rimes. A typical Chinese syllable permits an onset consonant and a prenuclear glide, but since neither affects the syllabic weight, they will not be discussed here. For exposition, I will focus on Mandarin and New Shanghai, both because they are representative of each group and because they are the two best-studied members of the Chinese family. More discussion on other Chinese languages is given in Duanmu 1993.

Consider Mandarin first. Two kinds of syllables are distinguished in all analyses, weak syllables and full syllables. Weak syllables are shorter and carry neither stress nor underlying

tones. In what is to date the most extensive phonetic study of Mandarin weak syllables, Lin and Yan (1988) found that the average rime duration of a weak syllable is about 50% that of a full syllable; similar results are reported by Woo (1969). In addition, Lin and Yan found that when a full syllable becomes a weak syllable, it either drops its coda or shortens its vowel. This fact has been observed by other researchers as well. For example, Gao and Shi (1963:84-85) note examples like [mu t^hou] -> [mu t^ho] 'wood', and [nau tai] -> [nau tɛ] 'head', where when the second syllable becomes unstressed, its rime is shortened as well. Such evidence indicates that the weak syllable has just one X slot in the rime and is metrically monomoraic and light.¹⁵

Next consider full syllables, which are by far the majority. In traditional analyses, there are three rime types: V, VC, and VG, as in *ma* 55 'mother', *man* 51 'slow', and *mai* 51 'sell'. Phonetically, they have similar durations. Phonologically, they do not show any difference in regard to stress or tone-bearing abilities. The question is, What are their weights? Let us consider three possibilities. First, they are all light. Second, V is light and VC and VG are heavy. Third, they are all heavy.

The first possibility is supported by reports that in some languages, such as Selkup (Halle and Clements 1983:189), only long vowels are heavy, and other rimes are light. The difficulty is that if full Mandarin syllables are light, one cannot explain why they differ from the weak syllables, both phonologically and phonetically. With regard to the second possibility, it is indeed the case that in many languages VC and VG are heavy and V is light. However, one cannot explain why the full V behaves like VC and VG and unlike weak rimes. With regard to the third possibility, not only are VC and VG heavy, but V is a long vowel [V:]. This agrees with both phonological and phonetic facts and has been noted in the literature. For example, Luo and Wang (1957:135) point out that "Since there are weak syllables, it is obvious that syllables that are not weak are heavy." Similarly, Ouyang (1979:360) notes that Chinese V and VX have the same length, so the vowel is longer in V than in VX. But why is the open rime transcribed as [V] instead of [V:] all along? The only reason, as far as I can see, is phonemic economy. Since vowel length is predictable, namely, short in closed rimes and long in open rimes, there is no need to mark it. But not marking a property is not to be confused with the lack of that property. In summary, all full rimes in Mandarin are heavy.

Let us now consider New Shanghai. Two striking properties stand out. First, unlike Mandarin, New Shanghai does not show a clear distinction between full and weak syllables.¹⁶ For example, although Mandarin full syllables are considerably longer than weak syllables, such a contrast is not found in New Shanghai. Consider the following forms (V' = glottalized V, to be explained below):

(28) Mandarin
 k^wai lɿ:
 fast happy 'joyful' k^wai lə
 fast ASPECT '(have become) fast'

(29) New Shanghai
 k^wa lo'
 fast happy 'joyful' k^wa lə'
 fast ASPECT '(have become) fast'

In Mandarin the full syllable [lɤ:] 'happy' is considerably longer (indicated by [:]) than the weak syllable [lə], but in New Shanghai such durational contrast is absent.

Second, whereas Mandarin has diphthongs and coda contrasts, New Shanghai lacks both. Consider the rime inventories of New Shanghai and Mandarin (excluding prenuclear glides; some rimes are made of syllabic consonants).

(30) Mandarin (from Chao 1968:24)

- a. z r i u y A ε ɤ
 b. ai ei əu ou in an ən yn iŋ əŋ ʌŋ uŋ er

(31) New Shanghai (from Xu et al. 1988:72)¹⁷

- a. m n z i u y r ə o ɔ ε ø ã
 b. ən in yn oŋ ɤʔ oʔ iʔ

It can be seen that New Shanghai lacks all diphthongs and several [VN] rimes. The following cognate words may serve as illustrations:

(32)	Mandarin	New Shanghai		Mandarin	New Shanghai
a.	[ai]	[ε]		b. [ou]	[ɤ]
	lai	lε 'come'		lou	lɤ 'floor'
	ts ^h ai	ts ^h ε 'guess'		tsou	tsɤ 'walk'
c.	[an]	[ε]		d. [əu]	[ɔ]
	lan	lε 'blue'		ləu	lɔ 'old'
	fan	vε 'rice'		t ^h əu	tɔ 'peach'
e.	[əŋ]	[ã]		f. [ei]	[ε]
	ləŋ	lã 'wolf'		mei	mε 'coal'
	t ^h əŋ	tã 'sugar'		pei	pε 'cup'

The question now is, What are the weights of rimes in New Shanghai? We again consider three possibilities. First, all New Shanghai rimes are heavy. Second, those in (31a) are light and those in (31b) heavy. Third, all New Shanghai rimes are light (unless they are lengthened in a monosyllabic domain, to be discussed below).

The first hypothesis assumes that the rimes in (31a) must be long and that the codas in (31b) are moraic. There are, however, three difficulties. First, why is it that New Shanghai does not have weak syllables, even though all M-languages do? Second, why is it that New Shanghai has no diphthongs and few nasal codas, even though all its rimes are supposedly heavy? Third, and more serious, there is no phonological evidence that rimes in New Shanghai are all heavy. The second hypothesis agrees with the transcriptions, as they are given in (31), on the assumption that VC rimes are heavy. The difficulty is that it predicts a weight contrast between (31a) and (31b) that does not exist. The third hypothesis claims that VC rimes in (31b) are light. This in itself is not a problem, since there are languages in which VC is light. However, there is

the question of why VC is heavy in Mandarin but light in New Shanghai.

I would like to suggest that the third hypothesis is essentially correct; its apparent difficulty is due to the misleading transcription in (31b). In other words, I will argue that all rimes in (31b) are V, instead of VC.

Consider the glottal coda [ʔ] first. It will be noted that the nuclear vowel is always glottalized in such syllables. As Xu et al. (1988) point out, the glottal coda in New Shanghai is present only if the syllable is in a final position; in nonfinal positions [ʔ] is dropped, yet the vowel stays glottalized. This is generally true in other languages of the Wu family (Chao 1967). In addition, when [ʔ] is dropped, there is no lengthening of the vowel in New Shanghai, in contrast to Taiwanese, an M-language, where [ʔ] deletion does lead to compensatory lengthening (Chiu 1931, Tsay 1990). I will assume, therefore, that [Vʔ] in (31b) is underlyingly a glottal vowel, which I write as [Vʰ].

Next consider the remaining VC rimes, [ə̃n in yn oŋ], which all end in a nasal. It will be noted that the low vowel [ɑ] does not take a nasal coda. For nonlow vowels, [ŋ] occurs with the back [o], and [n] with the nonback [ə̃ i y]. Phonemically, then, [ə̃n in yn oŋ] can be analyzed as [ə̃̃ ĩ̃ ỹ̃̃ õ̃̃]. In fact, Xu et al. (1988:73) point out exactly that [ə̃n in yn oŋ] "are often pronounced as [ə̃̃ ĩ̃ ỹ̃̃ õ̃̃]."18

In summary, there is no evidence that New Shanghai has underlying heavy rimes. Instead, (31) can be analyzed as follows, where all rimes are light.

- (33) a. m n z i u y r ɑ o ɔ ε ø ã
 b. ẽ ĩ ỹ õ ɛ' o' i'

I have gone to some length to show that full rimes in Mandarin are heavy and that all rimes in New Shanghai are underlyingly light.¹⁹ I will now show that this evidence is the key to understanding contour tone stability in M-languages.²⁰

3.1.1 Mandarin

Consider Mandarin first. Since every full rime is bimoraic, everyone is able to carry two tones, assuming, as is common in African languages, that the TBU is the moraic segment instead of the syllable. This immediately explains why every full Mandarin syllable is able to carry a contour tone. But now consider (5c), repeated here as (34).

- (34) H LH H LH
 kai luo → kai luo 'Cairo'

If every Mandarin syllable has two TBUs, one would expect *kai* to carry two tones, as shown in (35).

- (35) H LH *HL H
 kai luo → kai luo 'Cairo'

But (35) is incorrect. To see why, we need to digress to two other issues, the relation between weight and stress, and the relation between stress and tonal domains. In metrical phonology, there is a general principle, which Prince (1992) calls the Weight-to-Stress Principle, that requires heavy rimes to be stressed. Now, since every full Mandarin rime is heavy, every one will be stressed. Regarding the second issue, there is evidence that a *tonal association domain*, that is, one within which tonal association and spreading take place, is the same as a stress domain (or what Yip (1980) calls a stress foot), which consists of a stressed syllable followed by one or more unstressed syllables (Duanmu 1992b, 1993). Consider the following words in New Shanghai (in fairly broad phonetic transcription), where tonal domains are indicated by parentheses:

- | | | | |
|------|--|-----------------------------------|-------------------------------------|
| (36) | (pa-li)
'Paris' | (zǎ-he)
'Shanghai' | (lu-mo)
'Rome' |
| (37) | (tsz-ka-ku)
'Chicago' | (ko-r-fu)
'golf' | (ka-na-da)
'Canada' |
| (38) | (ja-lu)(-sa-lǎ)
'Jerusalem' | (de'-ke')(-sa-sz)
'Texas' | (du-mi)(-ɲi-ka)
'Dominica' |
| (39) | (ku-r)(-pa-tʃo-fu)
'Gorbachev' | (ʔe-se')(-ɲu-pi-ja)
'Ethiopia' | (ka-li)(-fo'-ɲi-ja)
'California' |
| (40) | (dʒe'-ka')(-sz-lu)(-va'-ka')
'Czechoslovakia' | | |

All the expressions in (36)-(40) are single morphemes, yet they may form one or more domains. Duanmu (1992b, 1993) suggests that the minimal tonal domain in New Shanghai is a moraic trochee. The analyses of (36)-(40) are shown in (41)-(45).

- | | | |
|------|---|------------------|
| (41) | x
(pa-li) | 'Paris' |
| (42) | x
(tsz-ka)-(ku) | 'Chicago' |
| (43) | x x
(ja-lu)(-sa-lǎ) | 'Jerusalem' |
| (44) | x x
(ku-r)(-pa-tʃo)(-fu) | 'Gorbachev' |
| (45) | x x x
(dʒe'-ka')(-sz-lu)(-va'-ka') | 'Czechoslovakia' |

Since rimes in New Shanghai are monomoraic, a moraic trochee consists of two syllables, as in (41). In (42), after the first two syllables form a foot, there is one syllable left. Since a "degenerate" (monomoraic) foot is metrically disfavored (Prince 1992, Hayes 1992), this syllable will not form a foot, but will merge with the preceding foot. Thus, (42) forms one foot. Similarly, (43) forms two feet, (44) also forms two, and (45) forms three.

The metrical approach explains further data. Consider the following compounds:²¹

(46) (çø pa-li) 'small Paris'

(47) (nø ka-li)(-fo'-ɲi-ja) 'southern California'

In general, a monosyllabic modifier does not form a separate domain but merges with the first foot of the following noun. This phenomenon has been a puzzle, since the metrical/tonal boundaries in (47) do not match the syntactic or semantic boundaries. (47) is also unexpected if a tonal domain starts from each lexical word (Selkirk and Shen 1990), since if (47) is one lexical word, it should form just one domain, and if (47) is two lexical words, each should form a domain.

Let us now consider the metrical analysis of (47), shown in (48).

(48)

				x					x	
	x	x	x	x	x	x	x		x	x
	(nø) (ka-li)(-fo'-ɲi-ja)			→	(nø) (ka-li)(-fo'-ɲi-ja)			→	(nø ka-li)(-fo'-ɲi-ja)	
	word stress				compound stress				clash resolution	

Assume that compound stress in New Shanghai is left-headed, assigned after word stress. First, *nø* and *ka-li-fo'-ɲi-ja* will each receive word stress (moraiic trochee). Note that even though *nø* is monomoraic, it will start out as a foot, either because a lexical word cannot be left unmetrified or because word boundaries are projected as metrical boundaries. Next, compound stress adds another stress on *nø*. Now the first two syllables both have stress, resulting in the well known "stress clash," which leads to the removal of the stress from *ka*, giving the correct output. For more discussion, see Duanmu 1993.

We now return to Mandarin. The reason why tones do not move across full rimes should now be obvious. Since every full rime is bimoraic, they are either inherently stressed or assigned stress under moraic trochee (as in New Shanghai). In either case, every full syllable is a tonal domain. Consequently, the tone of a full syllable cannot shift to another full syllable. The analysis of *kai-luo* 'Cairo' is shown in (49), where vertical lines indicate tonal/metrical domains and the prenuclear glide [u] is analyzed as part of the onset.

Here, the second syllable is unstressed, and its tones are lost. There are also many bisyllabic words in which the second syllable can be either stressed or unstressed, and its tones will be either present or absent accordingly (Li 1981). For example:

- (52) a. 55 51 b. 55 ø
 tian qi tian qi 'weather'
 x x x (x = stress)

Why should an unstressed syllable lose its underlying tones? The explanation is not exactly clear, but it seems to be related to the general tendency for an unstressed segment to lose some of its features. For example, in Southern Paiute (Halle and Clements 1983, citing Sapir 1933) stressless vowels devoice, but stressed vowels do not. In any case, the answer to the question is an independent issue which I leave open.

We now consider why in a monosyllabic domain a New Shanghai syllable is able to carry two tones. One is tempted to appeal to the Association Conventions or the Well-formedness Condition (Goldsmith 1976), by which all free tones can dock on the last or the only TBU. But there is an alternative answer. I suggest that in a monosyllabic domain, a New Shanghai rime is lengthened, from monomoraic to bimoraic.²³ This follows from a metrical constraint that a light syllable does not constitute a preferred foot (McCarthy and Prince 1990, Prince 1992, Hayes 1992) but must lengthen to a bimoraic foot.²⁴ The reason why a New Shanghai syllable can carry two tones in a monosyllabic domain is that it is bimoraic and has two TBUs. For example:

- (53) LH LH
 ||
 ço → çoo 'small'

3.1.3 Summary

I have shown that CTUs cannot explain the presence of "freely occurring" contour tones in Mandarin and their absence in New Shanghai. Instead, the tonal differences between the two languages follow from their differences in syllable structure. There is therefore no need, or advantage, to postulate CTUs.

The present analysis is not limited to Mandarin and New Shanghai but applies to all Chinese languages that have been clearly documented. All M-languages, in which contour tones seem to occur freely, have complex rimes (i.e., with diphthongs and contrastive codas). All S-languages, in which contour tones do not occur freely, lack complex rimes.²⁵ The summary in (54) is an illustration (for more discussion, see Duanmu 1993).

(54)		Coda contrast	Diphthongs	Tone sandhi
	Cantonese	+	+	M
	Xiamen	+	+	M
	Mandarin	+	+	M
	Fuzhou	+	+	M

	New Shanghai	-	-	S
	Old Shanghai	-	-	S
	Suzhou	-	-	S
	Danyang	-	-	S
	Shaoxing	-	-	S
	Nantong	-	-	S

All languages above the line have complex rimes. All languages below the line lack complex rimes. The most striking aspect of (54) is that there is a systematic correlation between rime structure and tone sandhi. All languages that have complex rimes are M-languages; namely, there is neither tone deletion from full syllables nor tone shifting between full syllables, and contour tones are stable. In contrast, all languages that lack complex rimes are S-languages, namely, only the syllable tone of the initial syllable is kept and contour tones can split into level tones (see Zee and Maddieson 1979, Xu et al. 1988, Selkirk and Shen 1990 for New Shanghai; Sherard 1972, Shen 1981a, 1982, Xu et al. 1988 for Old Shanghai; Ye 1979, Xie 1982, Qian and Shi 1983 for Suzhou; Lü 1947, 1980 for Danyang; Wang 1959, Wang 1991 for Shaoxing; Ao 1993 for Nantong).

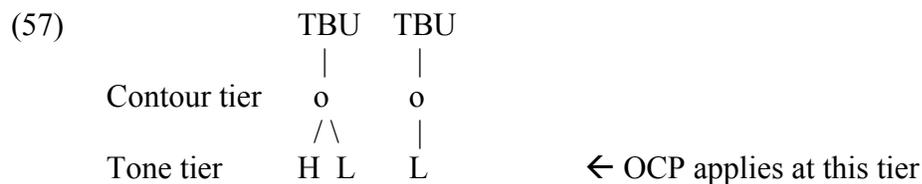
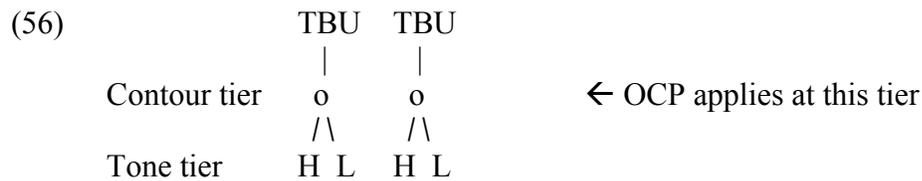
The present analysis also solves another problem. As mentioned in section 2.1, Bao (1990) observes that complex contour tones, such as LHL or HLH, rarely occur in nonfinal positions. He thus stipulates that a CTU may consist of just two elements, LH or HL. In the analysis proposed here, the rarity of complex contour tones follows from the fact that regular rimes in M-languages are bimoraic, so they can only carry two tones. In phrase-final positions a rime may be lengthened by another mora, so it can carry a complex contour tone.

3.2. Dissimilation between Contour Tones

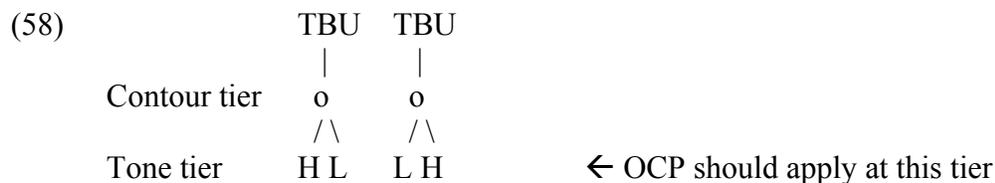
According to Yip (1989), dissimilation between contour tones is due to the OCP. If this is the case, we expect the OCP to hold for all tones in a given language, or perhaps in all languages. But neither expectation is borne out. Consider Yip's analysis of Tianjin again (cf. (11)-(12)).

(55)	a.	L	L	→	<u>LH</u>	L		d.	<u>HL</u>	L	→	H	L
	b.	<u>LH</u>	<u>LH</u>	→	H	<u>LH</u>		e.	H	H	→	(no change)	
	c.	<u>HL</u>	<u>HL</u>	→	L	<u>HL</u>		f.	<u>HL</u>	<u>LH</u>	→	(no change)	

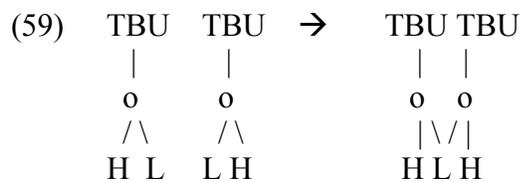
In (55a-d) there are tone changes. In (55e-f) there are not. In Yip's analysis, the OCP applies to two like tones, whether they are level tones, as in (55a), or CTUs, as in (55b-c). In (55e) the OCP does not apply; Yip suggests that H in (55e) is specified after the OCP. Now the problematic cases are (55d,f). In (55d) the OCP applies to part of a CTU (the L of HL) and a level tone L. In other words, the OCP must apply at two levels (Yip 1989:163). Consider Yip's analysis of (55c) and (55d), shown in (56) and (57), respectively.



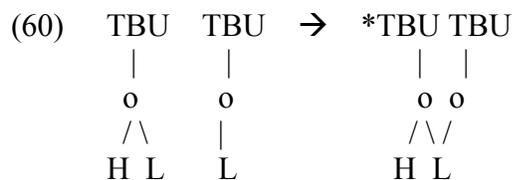
In Yip's analysis, the tonal structure has two tiers, which we will call the *Contour tier* and the *Tone tier* (not the same as Bao's *Tone node*). In (56) the OCP applies at the contour tier, but in (57) it applies at the tone tier. Now, if the OCP applies at the tone tier, as required in (57), it should apply to (55f) as well, as shown in (58).



In (58) there are two consecutive Ls on the tone tier, which should violate the OCP and trigger tone sandhi. But there is no tone sandhi. One may suggest that the two Ls can merge into one to avoid the OCP violation, as shown in (59).



But if this can happen, we expect the two Ls in (55d) = (57) to merge in the same way, as shown in (60).



But the output *[HL L] is incorrect. To get the correct output [H L], one must delink L from the first syllable in (60). But then, this delinking rule will also incorrectly delink L from the first

syllable in (59), giving the wrong *[H LH].

The OCP therefore cannot explain the tonal facts in Tianjin. Nor can it explain tonal facts in other languages. For illustration, consider Beijing Mandarin, whose tonal patterns are shown in (61).

(61)	Syllable tones	Bisyllabic expressions		
a.	55	55	55	(no change)
b.	35	35	35	(no change)
c.	214	214	214 → 35	214
d.	51	51	51	(no change)

Of the four pairs of like tones, only [214 214] undergo sandhi. There is no explanation for why the OCP, which is a *principle*, applies generously in Tianjin but sparsely in Beijing. In particular, Tianjin and Beijing are sister dialects. 53 in Tianjin and 51 in Beijing are cognate tones; their difference in transcription is probably nothing other than the transcribers' flexibility (in fact, Yip (1980) assumes that 51 in Beijing is underlyingly 53). Now if 53 is a CTU in Tianjin, 51 should also be a CTU in Beijing. Why, then, does the OCP apply to [53 53] but not to [51 51]?

Not only does the OCP not apply at the contour tier in Beijing, it does not apply at the tone tier either. For example, [35 51] and [51 35] do not undergo tone sandhi in Beijing. According to Yip (1980:283), 35 is LH and 51 is HL (ignoring tonal registers). Thus, we have the representations in (62).

(62)	a.	35	53	b.	51	35	
		TBU	TBU		TBU	TBU	
		o	o		o	o	Contour tier
		/\	/\		/\	/\	
		L H	H L		H L	L H	Tone tier

At the tone tier we find [H H] in (62a) and [L L] in (62b). Since there is no tone sandhi, the OCP cannot have applied at this tier.

A quick look through Chinese languages provides ample evidence that dissimilation between contour tones is a sporadic phenomenon. It cannot be attributed to any general principle, but reflects idiosyncrasies of particular languages. In other words, occasional contour tone dissimilations do not serve as reasonable evidence for CTUs.²⁶

This is not to suggest that the OCP is not valid. But there is a reason why it does not apply across full syllables. As discussed in section 3.1, every full syllable in an M-language is bimoraic and starts an association domain by itself. Tones on two full syllables thus belong to two separate domains, whether each syllable carries a contour tone or a level tone. If the OCP applies within an association domain, but not across association domains, the lack of the OCP effect across full syllables is just what one expects.²⁷

3.3 Contour Tones as Unit of Initial Association

Now let us examine contour tones as initial association units in Wuxi. The pitch contours and Yip's (1989) analysis in (14) and (15) are repeated in (63) and (64). Wuxi has other tonal

patterns, which do not require postulating CTUs and are not discussed here (see Chan and Ren 1986).

(63)	Monosyllabic	Bisyllabic	Trisyllabic	Quadrisyllabic
a.				
b.				
c.				

(64)	Monosyllabic	Bisyllabic	Trisyllabic	Quadrisyllabic
a.	L <u>LH</u> ✓ \$	L <u>LH</u> \$ \$	L <u>LH</u> \$ \$ \$	L <u>LH</u> \$ \$ \$ \$
b.	<u>LH</u> L ✓ \$	<u>LH</u> L \$ \$	<u>LH</u> L \$ \$ \$	<u>LH</u> L \$ \$ \$ \$
c.	L <u>HL</u> ✓ \$	L <u>HL</u> \$ \$	L <u>HL</u> \$ \$ \$	L <u>HL</u> \$ \$ \$ \$

Except for (63c), Yip's analysis fits the pitch contours fairly well. On the other hand, (64) is not the only possible interpretation of (63), especially when we consider additional evidence from neighboring dialects.

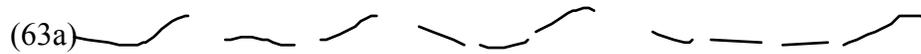
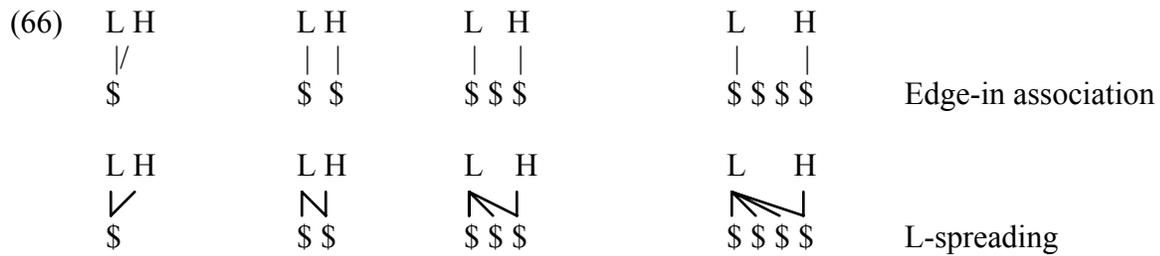
First, (63c) need not be LHL, but can be simply LH, which in a multisyllabic domain is linked to the first two syllables. In a bisyllabic (or longer) domain, the final syllable receives an additional L, perhaps owing to a domain final effect.²⁸ This analysis, shown in (65) (together with the pitch contours), agrees with the phonetic data better than Yip's (64c).

(65)	LH(L)	L H(L)	L H (L)	L H (L)
	/ \$	/ \$ \$	 \$ \$ \$	 \$ \$ \$ \$

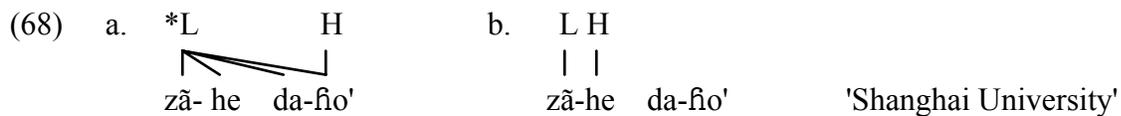
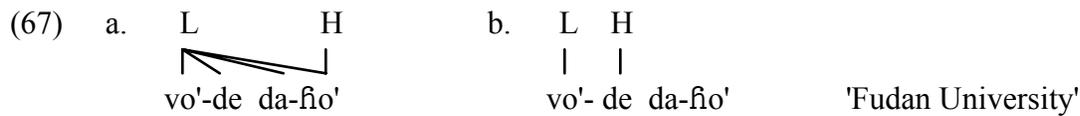
(63c)

Strictly speaking, tones are linked to mora units, instead of syllables. It can be seen from the pitch data that a contour tone is longer than a level tone. In the present analysis, a contour tone falls on a bimoraic (or trimoraic) syllable. More on this issue in section 4.

Next consider (63a). The problem here is to explain why the last syllable carries a contour tone LH. I suggest the analysis in (66) (together with the pitch contours).

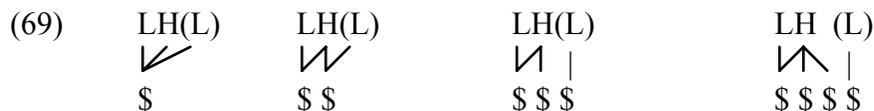


There are two tones, L and H, which are linked to syllables by edge-in association. Next L spreads rightward to all syllables. It may seem unusual for a language to have two manners of association, left-to-right in (65), and edge-in in (66). But this is not new in Wu dialects. In New Shanghai, a sister of Wuxi, exactly the same happens, as shown (67) and (68).



The syllables *vo'* and *zã* both have underlying LH. Whereas *vo'* allows both edge-in association (followed by L-spreading) and left-to-right association, shown in (67), *zã* allows left-to-right association only, shown in (68). Why does *vo'* allow two manners of association and *zã* only one? The answer is not entirely clear, but it must be related to segmental properties. (67) applies only if the initial syllable has a voiced onset and a glottal vowel (indicated by []). (68) applies if the initial syllable has a nonglottal vowel, or a glottal vowel with a voiceless onset. Exactly how segmental features affect the manner of association is beyond the scope of this article. But it is very common in Chinese for syllables with the same tones but different (historical) segmental compositions to behave differently in regard to tone sandhi. For our purposes, the independent New Shanghai facts in (67) and (68) suffice to justify the analysis in (66).

Finally, consider (63b), for which I propose the analysis in (69).



This pattern again has underlying LH. In addition, as in (65), a L is added to the final syllable. In the monosyllabic pattern all tones are linked to the same syllable. The question is why, in

and (72), so it cannot be a CTU. It is very unlikely, therefore, that Yang Shang should be a CTU in Wuxi just because the initial syllable carries a rise.³⁰

But why is it the case that an initial Yang Shang syllable takes just one tone in New Shanghai, one or two in Old Shanghai, and two in Wuxi? The answer, I suggest, is both historical and metrical. As mentioned earlier, in M-languages all full rimes are bimoraic, whereas in S-languages all rimes are simple. There is good evidence that Chinese had complex rimes historically, and simple rime inventories in S-languages are a late phenomenon. How exactly, then, is the transition made, and through what intermediate steps? Duanmu (1993) proposes the diachronic scenario shown in (73).

(73) Correlations among rime, stress, and tonal patterns

	RIME	PROPERTIES	LANGUAGES
a.	complex	Every full rime is heavy, hence stressed, hence forms an association domain (together with the following unstressed syllables, if any)	Mandarin, Cantonese, Taiwanese, Thai,...
b.	simple	No diphthongs or coda contrasts. Rimes remain bimoraic with stress, and become monomoraic without stress. Association domains become multisyllabic.	Danyang, Nantong
c.	simple	Rimes may remain bimoraic with strong stress. Some rimes begin to shorten even under stress	Suzhou, Wuxi, Old Shanghai, ...
d.	simple	Rimes remain bimoraic only in a monosyllabic domain. Otherwise all rimes are monomoraic.	New Shanghai

Stages (73a) and (73b) follow from the Weight-to-Stress Principle (Prince 1992), which requires all heavy rimes to carry inherent stress. Thus, all rimes in (73a) carry stress, whereas only some rimes in (73b) do, namely, those that are assigned stress by rule. The transition from (73b) to (73d) also has an explanation. In metrical phonology, a trochaic (left-headed) foot with a light initial rime is preferred to one with a heavy initial rime (Hayes 1985, 1992, Prince 1992). This is shown in (74).

(74) Disfavored trochee Preferred trochee

x		x	
(mm m)	→	(m m)	x = stress, m = mora, \$ = syllable, () = foot
\ /			
\$ \$		\$ \$	

As discussed earlier, the lowest level of stress is trochaic in languages like Shanghai. According to (73), therefore, it is natural that the initial rime will become light without losing its stress. Moreover, the reduction of the initial rime has apparently taken a gradual course, applying

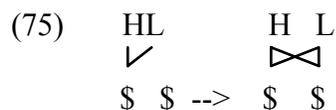
to some syllable/tone types earlier than to others. For example, in New Shanghai all initial syllables have become light. In Old Shanghai initial Yin Qu (voiceless onset and LH) remains bimoraic, Yang Shang (voiced onset and LH) optionally bimoraic, and all others obligatorily monomoraic. In Wuxi initial Yang Shang (69) = (63b) (voiced onset and LH) remains bimoraic, but Yin Shang (66) = (63a) (voiceless onset and LH) and Yang Ru (65) = (63c) (voiced onset, glottal vowel, and LH) have become monomoraic, and so on. Although the interactions among segments, tonal associations, and metrical principles are yet to be fully understood, it should be clear that the postulation of CTUs is neither necessary nor helpful in explaining the tonal facts in hand.

3.4 Contour Tone Spreading

I turn now to contour tone spreading. First, I argue that the use of tier conflation is problematic.³¹ Second, I show that evidence for contour tone spreading in Changzhi and Danyang is weak. I conclude that Changzhi and Danyang do not support the CTU theory.

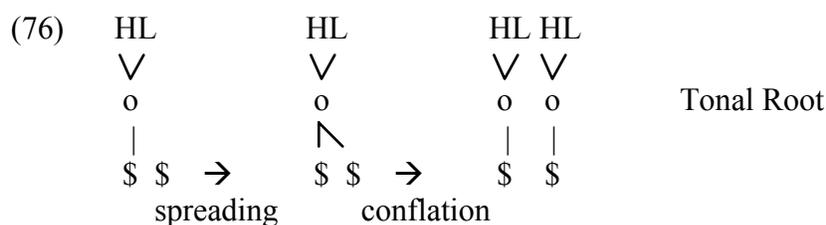
3.4.1 Tier Conflation

It has been argued that contour tone spreading, namely, a contour tone making copies of itself for other syllables, provides strong support for CTUs, since without CTUs there is no way to spread a contour tone without crossing association lines. To see why, consider a hypothetical case in which a falling tone is spread, so that both syllables surface with a fall.



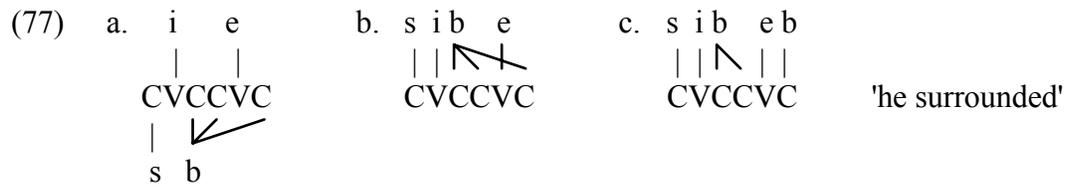
In order to spread both tones to the second syllable, there will be "line crossing," a violation of an important principle in multitiered phonology (Goldsmith 1976).

The CTU theory proposes to account for contour tone spreading as shown in (76).



First, a line from the Tonal Root node of the first syllable is extended to the second syllable. Next, tier conflation applies, which splits the doubly linked fall into two falls.

But why should tier conflation apply in (76)? The answer has never been clear. The original motivation for tier conflation as proposed in McCarthy 1986 was to put consonants and vowels on the same segmental tier without causing line crossing. Consider the following example from Tiberian Hebrew (McCarthy 1986:226).



In McCarthy's analysis, consonants and vowels in Semitic start out on separate tiers. Later they merge into a single tier. This process is called tier conflation, during which a multiply linked segment may cause line crossing, as [b] does in (77b). To avoid line crossing, it is assumed that [b] splits into two parts, as in (77c). It is important to note that the geminate [b] in the middle of (77c) does not split, since it does not cause line crossing. This analysis correctly predicts other processes such as spirantization.

But in (76) there is no line crossing after spreading, therefore there is no reason to split the doubly linked CTU. Indeed, even the term tier conflation is inappropriately used here, since tones and TBUs are already on proper tiers, and no tier is conflated with another. In other words, even if there are CTUs, and even if CTU spreading is possible, there is still no plausible way of getting several copies of a CTU by spreading it.

Yip (1989:162) seems to be aware of the problem. Nevertheless, she suggests that if a contour tone can make copies of itself for other syllables, there is no way to account for it without CTUs. With the CTU theory, however, the only assumption that needs to be made is a splitting mechanism, yet to be understood.

But if there is a splitting mechanism, would it not apply to (75) as well, so that it no longer causes line crossing? And then why should we need CTUs to account for contour tone spreading? I cannot see clear answers to these questions.

I therefore conclude that if contour tone spreading is found, it is not just a problem for a theory without CTUs but a problem for the CTU theory as well. And if contour tone spreading is not found, the CTU has even less support.

In what follows I will examine contour tone spreading for its own sake, since if it is real, it requires a phonological explanation with or without CTUs. In section 2.4 I described two reported cases of contour tone spreading, Changzhi and Danyang. As far as I am aware, they are also the only two languages in which a plausible case for contour tone spreading can be made. As I will now argue, neither case turns out to be compelling.

3.4.2 Changzhi

The Changzhi data in (16) are repeated in (78).

(78)	Stem	Stem-[təʔ] (or Stem-[ti])	
a.	213	213 213	
	kuə	kuə təʔ	'pan'
b.	24	24 24	
	səŋ	səŋ təʔ	'rope'
c.	535	535 535	
	ti	ti təʔ	'bottom'

d.	44	44	535	
	k ^h u	k ^h u	təʔ	'pants'
e.	53	53	53	
	təu	təu	təʔ	'bean'

We have already seen that in order for the CTU analysis to work, it has to assume a process to split a doubly linked CTU into two separate copies. But no justification for this process is available. In addition, even if the splitting process is available, there is no reason why it cannot apply in an analysis without CTUs. Therefore, the Changzhi data do not support CTUs.

How then can the Changzhi data be accounted for? As far as I can see, there is no principled solution. This is a problem if such data are systematic, namely, either found in a number of languages or found extensively in Changzhi. On the other hand, if such data are lexical idiosyncrasies of a few morphemes, then the problem may not be very serious; one may treat them as one treats irregular verbs in English, for example. I will argue that the Changzhi data belong to the latter type.

According to Hou (1983), apparent contour tone spreading occurs in Changzhi only with two morphemes, [təʔ] and [ti]. In all other circumstances contour tone spreading is totally lacking. Consider the bisyllabic tonal combinations in nominal compounds shown in table 1 (Hou 1983:262).

Table 1: Bisyllabic patterns in Changzhi

	213	24	535	44	53
213	213 53	213 24	35 53	213 53	213 53
24	24 53	24 24	35 53	24 53	24 53
535	535 213	535 24	35 53	535 53	535 53
44	44 213	44 24	35 53	53 44	53 53
53	53 213	53 24	35 53	53 44	53 53

The first column shows the tone of the first syllable. The top row shows the tone of the second syllable. The area in double lines shows the resulting tone patterns. In some cases there is no change, such as the column under 24. In other cases there are extensive changes, such as the column under 535. As far as I am aware, there has been no systematic account for this phenomenon. It is reasonable, therefore, not to analyze Changzhi the way one analyzes New Shanghai, namely, in terms of tone deletion and spreading. Besides, in languages that do not have tone spreading between full syllables, tone spreading can sometimes be found between a full syllable and a stressless syllable; this is true, for example, in Zhengjian (Zhang 1985). But this is not the case in Changzhi.

Now, if the data in (78) are due to the idiosyncrasies of two specific morphemes, how can they be accounted for? I suggest the following alternative. Like Bao, I assume that 44 is underlyingly unspecified and that the syllable tones of [təʔ] and [ti] are both 535. But unlike Bao, I assume that the tone of the first syllable is not *spread* to the second syllable, but *copied* to it. Consider the derivations in (79) and (80).

- (79) 53 53 53 53 53
 | | | |
 \$ ti copy \$ ti replace \$ ti
 | | | |
 535 535 535
- (80) 44
 \$ ti copy n.a. default \$ ti
 | | |
 535 535

In (79) the suffix first triggers the copying of the first syllable tone. This tone then replaces the tone of the suffix. In (80) the first syllable has no underlying tone, so copying is not applicable. The suffix retains its own tones, and the first syllable is assigned default 44.

The copying analysis has two advantages over the CTU analysis. First, the copying analysis does not regard tone copying to be a well motivated phonological process. Instead, copying is triggered by two idiosyncratic morphemes only. Therefore, we do not expect it to happen often.³² In contrast, the CTU analysis regards CTU spreading to be a common phonological process and therefore predicts similar cases to occur frequently. The rarity of contour tone spreading supports the copying analysis. Second, the CTU analysis assumes that tone spreading can happen even when the target syllable already has a tone. In most situations, however, tone spreading does not replace the tone of the target syllable, unless the latter is deleted by a prior rule. But there cannot be prior tone deletion on the Changzhi suffix; if there is, we cannot explain the 535 in [44 535] of (78d). In contrast, the copying analysis does not have this problem. Since morphologically introduced new material (here, the copied tone) usually overrides the old material (the original tone of the suffix), the replacement of the suffix tone is expected.³³

Yip (1991) raises an objection to the copying analysis. She points out that in reduplicated verbs, given in (81), the tonal patterns differ from those in (78) (Hou 1983:261).

- | | | | |
|------|---------------------|---|-----------------------|
| (82) | Verb | Reduplicated Verb | |
| a. | 213 | 213 35 | |
| | saŋ | saŋ saŋ | 'to fan (a little)' |
| b. | 24 | 24 53 | |
| | tɕ ^h iəu | tɕ ^h iəu tɕ ^h iəu | 'to beg (a little)' |
| c. | 535 | 535 35 | |
| | ts ^h ɔ | ts ^h ɔ ts ^h ɔ | 'to fry (a little)' |
| d. | 44 | 21 53 | |
| | k ^h aŋ | k ^h aŋ k ^h aŋ | 'to watch (a little)' |
| e. | 53 | 35 53 | |
| | tuŋ | tuŋ tuŋ | 'to move (a little)' |

Yip assumes that the reduplicated verbs are derived by first copying the verb syllable, including

its tones, and then applying *tonal dissimilation* between consecutive like tones (although how dissimilation applies is far from obvious; Yip leaves this issue open).³⁴ Given Yip's assumptions, if the suffixed forms come from tone copying, they should undergo dissimilation and have the same tonal output as reduplicated verbs. Since the suffixed forms do not have the same output as reduplicated verbs, Yip concludes that CTU spreading is right and tone copying wrong.

But Yip's objection to the copying analysis is also a problem for the CTU analysis. To see why, consider Bao's analysis of (78b), shown in (82).

(82)		spreading		tier conflation					
	24	535	→	24	535	→	24	24	535
	o	o		o			o	o	
				↘					
	\$	\$		\$ \$			\$	\$	

Central to the CTU analysis is tier conflation, which splits a doubly linked CTU into two copies; without it, the output in (82) will not be [24 24]. Now if tones dissimilate in Changzhi, the output of tier conflation should undergo dissimilation as well, just as reduplicated verbs do. Why, then, does dissimilation not apply after tier conflation?

Perhaps rule ordering would help. For example, if dissimilation applies after reduplication, but before tier conflation, then the suffixed forms can avoid dissimilation. But then the copying analysis can appeal to rule ordering in the same way and assume that dissimilation applies after verb reduplication but before suffixation. Thus, rule ordering cannot distinguish between the two approaches.

It should be noted that tonal dissimilation, if it applies in reduplicated verbs at all, is not a general process in Changzhi. As shown in table 1, like tone pairs, such as [24 24], [53 53], and [44 44], occur in bisyllabic nouns and compounds. Thus, whatever is going on in reduplicated verbs, it must be a process specific to that morphological environment, and not necessarily applicable in other environments. The analysis that regards tone copying and contour tone dissimilation as exceptions expects this result. The analysis that regards CTU spreading and CTU dissimilation as the norm does not.

I conclude that there is no compelling evidence for CTU spreading in Changzhi.

3.4.3 Danyang

Because of its highly complicated phonology, a complete analysis of Danyang requires a separate study. In this section I will focus on whether Danyang has CTU spreading. The multisyllabic tone patterns are repeated in (83) (= (19)).

(83)		Bisyllabic	Trisyllabic	Quadrisyllabic
	a.	11 11	11 11 11	11 11 11 11
	b.	42 11	42 11 11	42 11 11 11
	c.	42 24	42 42 24	42 42 42 24
	d.	33 33	33 33 33	33 33 33 33
	e.	24 55	24 55 55	24 55 55 55
	f.	55 55	55 55 55	55 55 55 55

A central assumption of the CTU analysis is that, as in New Shanghai, the tonal pattern of a domain in Danyang is determined *solely* by the initial syllable (Chen 1986, Yip 1989, Chan 1991, Bao 1990). In particular, underlying tones on noninitial syllables are deleted, and then the underlying tones of the initial syllable are spread over the whole domain.

As in the analysis of Wuxi, the fact that the initial syllables in (83b, e) carry a contour tone does not call for postulating CTUs; this is also the assumption made by Chan (1991). The only pattern that involves CTU spreading then is (83c). In (84) I repeat Chan's (1991) analysis of the trisyllabic domain (X, Y are tones of noninitial syllables).

(84)	Underlying	Deletion	Association	Spreading	Conflation	Dissimilation
	<u>LH</u> X Y	<u>LH</u>	<u>LH</u>	<u>LH</u>	<u>LH</u> <u>LH</u> <u>LH</u>	<u>HL</u> <u>HL</u> <u>LH</u>
	\$ \$ \$	\$ \$ \$	\$ \$ \$	\$ \$ \$	\$ \$ \$	\$ \$ \$

First, noninitial tones are deleted. Next, the CTU of the initial syllable is linked to the first syllable and then spread to the other two syllables. Next, tier conflation splits the CTU into three copies. Finally, dissimilation between [LH LH] changes the first two LH into HL (see section 2.4.2).

I have argued that tier conflation is not justified for CTUs (section 3.4.1). I will now argue that the central assumption of the CTU analyses, namely, that the domain pattern in Danyang depends solely on the initial syllable, is incorrect. I will show that although in some cases the domain pattern indeed depends on the initial syllable alone, in other cases it depends on the input tones of noninitial syllables as well. As we will see, this fact is very clear in the original data. In particular, I will show that the pattern [42...24] (i.e., [42 24], [42 42 24], or [42 42 42 24]) always depends on specific choices of both initial and noninitial syllables. Thus, it does not derive from spreading a CTU from the initial syllable.

There are two differences between my analysis and the CTU analysis. First, my analysis predicts that whenever [42...24] occurs, noninitial syllables always play a role (i.e., they are not deleted). In contrast, the CTU analysis predicts that [42...24] depends only on the choice of the initial syllable, and that it should not matter what tones noninitial syllables have, since they are all deleted.

Second, my analysis predicts that the frequency of [42...24] among all patterns should decrease as the domain gets longer. The reason is this. Suppose that 50% of Danyang syllables are of type A. In a string of syllables the chance of getting A on the first syllable is 50%, the chance of getting A on the second syllable is also 50%, and so on. Now suppose that [42...24] requires all input tones to be of type A. The probabilities of [A...A] among all possible combinations are as follows:

(85)	Probability of [A...A] among all combinations (assuming 50% of syllables are A)
	Monosyllabic [A] = 50%
	Bisyllabic [A A] = 50% x 50% = 25%
	Trisyllabic [A A A] = 50% x 50% x 50% = 12.5%
	Quadrisyllabic [A A A A] = 50% x 50% x 50% x 50% = 6.25%

In other words, the frequency of [42...24] drops geometrically with length. In contrast, in the CTU analysis, where noninitial syllables do not matter, the frequency of [42...24] should remain constant regardless of the length of the domain, since the probability of getting an initial A is always 50% no matter how long the domain is.

The two key points outlined above, namely, whether [42...24] depends on noninitial syllables and whether its frequency decreases with length, will be the focus of the following discussion.

Before we move on, it is necessary to review the syllable tones in Danyang. As Lü points out, there are three factors, listed in (86), that affect the tonal pattern of a domain.³⁵

- (86) a. The historical tone types of the syllables
 b. The historical onset categories of the syllables
 c. Whether the syllables constitute a colloquial term or a literate term.

There are four historical tone types, which I will refer to as A, B, C, and D. Relevant historical onset categories are voiceless obstruents, voiced obstruents, sonorants, and glides, denoted respectively as "p," "b," "m," and "y." Thus, there are sixteen tone classes. (87) gives the values of the tone classes on isolated syllables (Lü 1980:87, 90).

(87)	Tone classes:	Ap	Ab	Am	Ay	Bp	Bb	Bm	By
	Tone values:	33	33/24	33	33/24	55	55/24,11	55/24	55
	Tone classes:	Cp	Cb	Cm	Cy	Dp	Db	Dm	Dy
	Tone values:	24	24/11	24/11	24/11	24/33	24	24	24

When a tone class has one value, it means that this tone has the same value in both colloquial and literary words. For example, Ap is 33 in both literary and colloquial words. When a tone class has two values, the one on the left occurs in a literary word, and the one on the right occurs in a colloquial word. For example, Ab is 33 in a literary word and 24 in a colloquial word. Bb has two, equally frequent values in colloquial words, 24 and 11. (Lü lists the tonal patterns of literary and colloquial expressions together in his papers; to be completely accurate, an analysis would have to be based on separate lists of these two vocabularies.)

I now turn to (83c), the pattern that seems to show CTU spreading. I consider bisyllabic, trisyllabic, and quadrisyllabic domains separately.

3.4.3.1 Bisyllabic Domains

Table 2 below shows all the bisyllabic combinations (Lü 1980:98).³⁶

Table 2: Bisyllabic tone patterns in Danyang

	Ap,m 33	Dp 24/33	Bp,y 55	Cp 24	Ab,y 33/24	Bm 55/24	Bb 55/24,11	Cm,b 24/11	Dm,b,y 24
Ap,m 33	I								
Ab,y 33/24									
Bp,y 55	II 33 33 (42 24)		III 42 24 33 33		IV 42 24 (33 33)				
Bm 55/24									
Cp 24	V 11 11 (42 24)								
Dp 24/33									
Dm 24									
Db,y 24									
Bb 55/24,11									
Cm,b 24/11									

The first column shows the tone of the first syllable. The top row shows the tone of the second syllable. The area in double lines shows the output tones of bisyllabic combinations; it is divided into five smaller areas depending on the occurrence of [42 24]. In area I (to be discussed below), [42 24] does not occur. In area II, [33 33] is the dominant pattern and [42 24] the minor pattern (indicated by parentheses). In area III, [42 24] and [33 33] occur with equal frequency. In area IV, [42 24] is the dominant pattern, and [33 33] the minor pattern. In area V, [11 11] is the dominant pattern and [42 24] the minor pattern.

Table 2 shows that [42 24] is a very common surface pattern. Of the $15 \times 15 = 225$ bisyllabic combinations, [42 24] occurs in $11 \times 15 = 165$ of them, or 73% of the total. If for each relevant output, we consider the frequency of the minor pattern to be 20%, and that of the major pattern to be 80%, then [42 24] still occurs at an average frequency of 32%,³⁷ which is by far the highest among the six surface patterns given in (83). The question is, Does it come from CTU spreading from the initial syllable?

Let us take a closer look at table 2. Two observations can be made. First, when two given tone classes combine, they do not always give a unique output pattern. In fact, most input combinations give from two to six surface patterns, as shown in table 3.

Table 3: Number of output patterns (in double square) for each input combination

	33	55	24	11
33	4	2	5	6
55	4	3	3	3
24	5	4	5	5
11	2	2	3	2

As Lü points out, some patterns are more common, and he gives a large number of examples; other patterns are rarer, and only a few examples are given. There is no obvious way of accounting for all the variations for a given input. I will therefore follow previous analyses and focus on dominant patterns only, namely, those patterns that have a relatively large number of examples.³⁸

The second observation about table 2 is that the output pattern in area V depends on the first syllable only, in that the output pattern is predominantly [11 11] no matter what the second syllable is. In contrast, the output patterns in areas II, III, and IV depend heavily on the second syllable, in that different types of the second syllable give different output patterns. For example, when Bp is followed by Ap, the output is mostly [33 33]; when it is followed by Cp, the output is sometimes [42 24] and sometimes [33 33]; and when it is followed by Ab, the output is mostly [42 24]. This fact shows right away that the input tone of the second syllable is not always deleted; if it were, as assumed in CTU analyses, how could the second syllable have tonal effect on the output?

Now if [42 24] does not come from the initial syllable alone, we must ask what input combinations may give rise to surface [42 24]. Ignoring areas II and V, where [42 24] is a minor pattern, let us consider areas III and IV.

(88) Input combinations that give rise to surface [42 24]

Patterns	Tokens	%
[24 24]	40	55.5
[55 24]	20	28
[24 55]	8	11
[55 55]	4	5.5

Total	72	100

[24 55] and [55 55] make up just 16.5% of the input, so they will be of no special concern. In the majority of cases the input is [24 24] or [55 24].³⁹ It is not difficult to derive [42 24] from these inputs. Consider [55 24] first. The simplest analysis is as follows:⁴⁰

(89) [55 24] [42 24]
 H LH → H LH
 | ✓ ✓✓
 \$ \$ \$ \$

The initial 42 is created by spreading L from the second syllable, similar to the "contour tone formation rule" proposed by Chan (1991), probably because the initial syllable has stress (Lü 1980:89) and is bimoraic (cf. (73) for the diachronic status of Danyang rimes).

Next consider [24 24], which is the dominant input to surface [42 24]. Note the following remark made by Lü (1980:88):

(90) "(In Danyang) there cannot be two 24 tones within a tonal domain. If a 24 tone is followed by another 24 tone, the first automatically changes to a 42 tone. Thus, one may regard the [42 24] pattern in bisyllabic domains as derived from [24 24]."

What (90) describes must be idiosyncratic to Danyang, since it is not found in other Chinese languages. In Mandarin, for example, a sequence of [35 35] does not change. How (90) should be formalized, therefore, is of no special concern. I will simply restate it as follows:⁴¹

(91) 24 24 → 42 24

(91) will convert [24 24] into [42 24]. In other words, no CTU spreading is involved in bisyllabic patterns.

Let us compare the present analysis with the CTU analyses, reviewed in section 2.4. For Chen (1986) and Yip (1989), surface [42 24] is derived as follows:

(92) $\begin{array}{ccccccc} \underline{\text{HL}} & \underline{\text{LH}} & \text{X} & \rightarrow & \underline{\text{HL}} & \underline{\text{LH}} & \rightarrow & \underline{\text{HL}} & \underline{\text{LH}} \\ & \$ & & & \$ & \$ & & | & | \\ & & & & & & & \$ & \$ \end{array}$

Chen and Yip assume that in *all* inputs to surface [42 24] the initial syllable invariably has two underlying CTUs, HL and LH. After the underlying tone X is deleted from the second syllable, HL and LH are associated to the two syllables, giving [42 24].

This analysis has two problems. First, as we saw in table 2, bisyllabic outputs depend not only on the first syllable but also the second. A sweeping tone deletion rule cannot explain why the second syllable would affect the tonal output. For example, why do the combinations in area II of table 2 not surface as [42 24], as those in area IV do, given that they all have the same initial syllables? Second, this analysis predicts that when the initial syllable occurs alone, it should surface as a fall-rise 424, shown in (93).

(93) $\begin{array}{c} \underline{\text{HL}} \underline{\text{LH}} \\ \vee \\ \$ \end{array}$

But no syllable in Danyang surfaces as 424. Instead, as shown in (88), surface [42 24] has two kinds of initial syllables, 24 and 55. In the analysis of Chen and Yip, a special provision is made so that only the second CTU surfaces on a monosyllable, as in (94).

(94) $\begin{array}{c} \underline{\text{HL}} \underline{\text{LH}} \\ | \\ \$ \end{array}$

This accounts for the initial 24. But how [55 24] can possibly surface as [42 24] is not mentioned, even though it accounts for 28% of [42 24] occurrences.

Next, consider the analysis proposed by Chan (1991) and Bao (1990). Like Chen and Yip, Chan and Bao assume the tone deletion rule. But unlike Chen and Yip, Chan and Bao assume that, in all inputs to surface [42 24], the initial syllable is a single CTU LH. In addition, Chan and Bao assume the dissimilation rule (91), which applies after tier conflation. The derivation of [42 24] is as follows.

(95) $\begin{array}{ccccccc} \underline{\text{LH}} & \text{X} & & \underline{\text{LH}} & & \underline{\text{LH}} & & \underline{\text{LH}} & \underline{\text{LH}} & & \underline{\text{HL}} & \underline{\text{LH}} \\ & & & & & \searrow & & | & | & & | & | \\ & \$ & \$ & \rightarrow & \$ & \$ & \rightarrow & \$ & \$ & \rightarrow & \$ & \$ \end{array}$

First, the underlying tone of the second syllable is deleted (a). Next, the CTU of the initial syllable is associated to the two syllables (b). Next, tier conflation splits the one LH into two (c). Finally, dissimilation changes the first LH into HL (d).

This analysis predicts that when the initial syllable occurs alone, it should be 24. This is true for the input [24 24]. But what about the input [55 24]? Obviously, 55 is quite unrelated to LH. To address this problem, Chan and Bao suggest that the underlying tone of the initial syllable in a domain need not be related to the underlying tone of that syllable when it occurs alone; instead, they propose a process called "pattern substitution," by which a syllable takes an "isolation tone" when it occurs alone, but a "word tone" when it heads a domain (Chan 1991:239, Bao 1990:69-71). The isolation tone and the word tone can be totally unrelated. Thus, in their analysis, both 24 and 55 will first switch to LH when heading a domain, giving rise to [42 24] as shown in (95).

Although pattern substitution avoids the need to account for the relation between syllable tone and domain tone, it lacks independent motivation. It also goes against the fact that in languages like New Shanghai, Old Shanghai, Nantong, and Tibetan, domain tones can be related to the tone of the initial syllable. Moreover, Chan's and Bao's analysis has the same weakness as Chen's and Yip's. For example, like Chen and Yip, Chan and Bao take tone deletion to be a sweeping rule; therefore their analysis cannot explain why, for the same initial syllables, the domain output is [33 33] in area II but [42 24] in area IV.⁴² In addition, they do not note that surface [42 24] mostly comes from input [24 24], a fact that renders tone deletion, CTU spreading, and tier conflation unnecessary.

I am not suggesting that Danyang has no tone deletion, a process that is quite common in the Wu family, of which Danyang can be considered a member. For example, in area V of table 2, the surface patterns are unaffected by the second syllable; this clearly suggests the deletion of the second syllable tone. What seems to be true, however, is that tone deletion does not always apply. In particular, when the input is [24 24], dissimilation is likely to apply instead of tone deletion. Additional evidence of dissimilation overriding tone deletion can be seen in area I of table 2, expanded in table 4 (Lü 1980:98).

Table 4: Details of area I in table 2

	Ap,m 33	Dp 24/33	Bp,y 55	Cp 24	Ab,y 33/24	Bm 55/24	Bb 55/24,11	Cm,b 24/11	Dm,b,y 24
Ap 33	42 11	55 55 (42 11)							
Am 33	55 55	24 55		24 55		24 55			
Ab 33/24	42 11	(55 55)		42 11		(55 55)			
Ay 33/24	(24 55)								

Again, the second syllable sometimes has an effect, and sometimes does not. For example, when the first syllable is Ap, there are two major outputs: [42 11] when the second syllable is Ap or Am, and [55 55] otherwise. In the case of [55 55], the underlying tones of the second syllable seem to have been deleted, so they do not affect the output. But why do [Ap Ap] and [Ap Am] not surface as [55 55] as well? A reasonable answer is that the dissimilation between [33 33] has overridden tone deletion. Similarly, when the first syllable is Am, Ab, or Ay, and when the second syllable is not A, the output is [24 55], but when the second syllable is

A, other patterns surface. This again indicates dissimilation between two A syllables.

In summary, the domain pattern in Danyang does not always depend on the initial syllable alone, but often on the second syllable as well. In addition, [42 24] occurs only when both syllables contribute to the output. It is therefore not only possible but also simpler to analyze surface [42 24] without assuming CTU spreading.

3.4.3.2 Trisyllabic Domains

Next consider trisyllabic domains. I again focus on whether [42 42 24] is dependent on noninitial syllables. In addition, I also consider whether its frequency decreases from that of [42 24]. The trisyllabic tone patterns are shown in table 5 (Lü 1980:100-101).⁴³

Table 5: Trisyllabic tone patterns in Danyang

	33 33	55 55	11 11	24 55	42 24	42 11
Ap 33	55 55 55 42 11 11					
Am 33						
Ab,y 33/24	24 55 55					
Bp,y 55						
Bm 55/24	33 33 33	42 42 24	33 33 33	42 42 24	33 33 33	
Cp 24		(33 33 33)	(42 42 24)	(33 33 33)		
Dp 24/33	33 33 33					
Dm 24	(42 42 24)					
Db,y 24						
Bb 55/24,11	11 11 11					
Cm,b 24/11						

The left-hand column shows the tone of the initial syllable when it occurs alone. The top row shows the tone of the last two syllables when they occur together.⁴⁴ The double lined area shows all trisyllabic outputs.

A striking difference between bisyllabic and trisyllabic domains is that the latter are less dependent on noninitial syllables (I will return to the reason for this). In particular, domains headed by Ap, Am, Ab, Ay, Dp, and Dm are dependent on the second syllable in bisyllabic expressions (cf. tables 2 and 4), but they no longer depend on noninitial syllables in trisyllabic expressions. It is important to note that when a domain ceases to depend on noninitial syllables, [42 42 24] ceases to be a major output. For example, bisyllabic domains headed by Dp and Dm depend on the second syllable, and [42 24] often occurs as a major pattern, but trisyllabic domains headed by Dp and Dm no longer depend on noninitial syllables, and [42 42 24] is no longer a major pattern. The remaining trisyllabic domains that still depend on noninitial syllables are those headed by Bp, By, Bm, and Cp, and it is only in these cases that [42 42 24] is a major pattern. What is more, in these domains the general output is [33 33 33], and [42 42 24] occurs only when the last two syllables are [55 55] or [24 55].⁴⁵ It is reasonable to expect that had noninitial [55 55] and [24 55] not had an effect, all domains headed by Bp, By, Bm, and Cp would have surfaced as [33 33 33], and no [42 42 24] would have occurred at all. All this supports the analysis that treats [42 42 24] as a special case, and goes against the analysis that

treats [42 42 24] as a general case.

Let us now consider the frequency of surface [42 42 24] among all trisyllabic examples. The summary is given in (96) (Lü 1980:100-101)

(96)	Pattern	Tokens	%
	[42 42 24]	61	17.6
	All others	285	82.4
	<hr/>		
	Total:	346	100

Lü gives a total of 346 trisyllabic examples, of which 61, or 17.6%, surface as [42 42 24]. This represents a sharp decrease from the 32% of [42 24] in bisyllabic domains. In the present analysis, this decrease is expected; in the CTU analysis, it is not.

3.4.3.3 Quadrisyllabic Domains

Finally, let us consider quadrisyllabic domains. My analysis predicts that the frequency of [42 42 42 24] will be still lower than that of [42 42 24], but the CTU analysis predicts that [42 42 42 24] will be just as frequent as [42 42 24] and [42 24].

Quadrisyllabic domains are found in three kinds of structures: (a) reduplicated verbs [X X], where X is a bisyllabic verb, (b) nominal [X Y], where X is monosyllabic and Y trisyllabic, and (c) idiomatic expressions. Among reduplicated verbs, there are just two examples of surface [42 42 42 24], and nothing much can be said of them either way. Among nominal expressions, there is no case of [42 42 42 24] (Lü 1980:109). Regarding idiomatic expressions, Lü (1980:112) points out that the majority of them form two bisyllabic domains, and a small number of them form a quadrisyllabic domain. Those that form quadrisyllabic domains are counted in (97) (Lü 1980:111, table 13).

(97)	Quadrisyllabic idioms	Patterns	Tokens	%
a.		11 11 11 11	23	26
b.		55 55 55 55	16	18
c.		24 55 55 55	15	17
d.		42 11 11 11	15	17
e.		33 33 33 33	13	14
f.		42 42 42 24	8	9

Of all the tokens, eight are [42 42 42 24], which make up merely 9%. This is another large drop from 17.6% of [42 42 24] in trisyllabic domains, which in turn dropped from 32% of [42 24] in bisyllabic domains.

The decrease in the [42 42 42 24] pattern, or its complete absence, agrees with the present analysis and goes against the CTU spreading analysis.

3.4.3.4 Tonal Domain and Stress

I have shown that there is a geometric decrease in frequency from [42 24], to [42 42 24], to [42 42 42 24]. I suggested that this is in part because such patterns depend not just on the initial

syllable, but also on noninitial syllables. As the domain gets longer, chances for a specific input combination become smaller, so fewer [42 42 24] and [42 42 42 24] occur.

There is also a metrical reason why the longer the domain, the less important noninitial syllables are. In Duanmu (1992b, 1993), I proposed that tonal domains in languages like Shanghai and Danyang are determined by left-headed stress assignment (up to the compound level). Consider the metrical structures in bisyllabic through quadrisyllabic domains.

(98)

		x	
	x	x x	x
x	x x	x x x	x x x
x x	x x x	x x x x	x x x x
[\$ \$]	[\$ [\$ \$]]	[\$ [\$ [\$ \$]]]	[\$ [\$ [\$ \$]]]

In this analysis, the longer the domain, the greater stress the initial syllable has. In addition, the stress on the initial syllable clashes with the stresses on other syllables. If we further assume, in the spirit of Haraguchi (1991), that minor stress clash could be tolerated but serious stress clash must be resolved, then the higher the adjacent stress columns, the more likely stress clash will trigger stress deletion. Thus, stress deletion is more likely to apply to noninitial syllables in trisyllabic and quadrisyllabic domains. And once a syllable loses stress, it loses its underlying tones and no longer affects the tonal output. This may be another reason why the longer the domain, the more likely the tonal pattern will be determined by the initial syllable, and the fewer [42 42 24] and [42 42 42 24] will occur.

3.4.3.5 Summary of Danyang

I have shown that [42 24], [42 42 24], and [42 42 42 24] do not derive from CTU spreading from the initial syllable. Instead, they derive from specific combinations of initial and noninitial syllables. The present analysis accounts for not only the distribution but also the frequency of [42 24], [42 42 24], and [42 42 42 24], whereas the CTU analysis fails in both respects. Therefore, Danyang does not provide evidence for CTU spreading.

4 Concluding Remarks

I have shown that there is no clear evidence for CTUs in Chinese languages. CTUs have been claimed to exist in other languages (e.g., Fromkin 1972; Gandour and Fromkin 1978, countered in Maddieson 1979; Newman 1986), but they seem less compelling and are not discussed here. If my view is correct, a long-held typological difference between Asian and African tones is but an illusion, and the world's languages have more in common than has been previously thought. This is a welcome result for the theory of Universal Grammar.

The present study has an additional implication. Recall that contour tones are the archetype of contour features; most proponents of contour features look to contour tones for support (e.g., Anderson 1976, Sagey 1986). The present conclusion in effect removes contour tones from the underlying level, whether tone is a suprasegmental feature or a segmental feature (I return to surface contour tones below). It thus casts doubts on other contour features and provides additional support for arguments against them (Herbert 1975, 1986, Steriade 1989, 1993,⁴⁶ Lombardi 1990).

The lack of underlying contour features calls for an explanation. I suggest that, contrary to Sagey's (1), there is a phonological constraint whereby two instances of a feature cannot occur in succession within a single X slot.

- (99) *N N = any node under an X slot
 ^
 [αF] [-αF] α = any feature value; F = any feature

This constraint was first proposed in Duanmu 1990, where it was called the No Contour Principle. It was independently proposed in Steriade 1993.

(99) is a first approximation and may be subject to refinements. I will discuss two apparent problems that I see now. First, consider the following feature-geometric structure:

- (100) X
 ^
 Root Root

According to Pulleyblank (1984, 1989:389-390), segments with a secondary articulation have two Root nodes under a single X slot. If tonal features are situated under the Root, it is possible to have an underlying contour tone without violating (99).

However, the problem raised by (100) is only apparent. First, it is not obvious whether secondary articulation necessarily has a separate Root. Second, (100) is proposed for consonants. It is unclear whether it applies to vowels, which are primary tone bearers. Third, according to Pulleyblank (1989:390), the two Roots "are realized simultaneously"; if ordering between the Roots is given a distinctive role, too many segments are predicted that are not found in natural languages. In this respect, (100) does not contradict the essence of (99), which forbids two instances of a feature from occurring *in succession* within an X slot.

Let us now consider a second problem for (99).⁴⁷ I have assumed that tone is situated under the Laryngeal node in feature geometry. This is not the only view, of course. According to Hyman (1984, 1989), tones are linked to moras, as for example in (101).

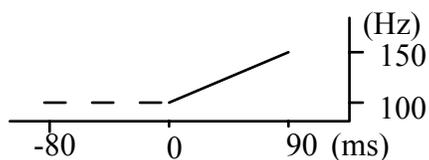
- (101) H
 |
 m m = mora
 /|
 pa

When tone is not under the Root or the X node, (99) becomes irrelevant. Representations like (101) do not in themselves present evidence for CTUs, however. Recall that my arguments against CTUs do not require tones to be inside feature geometry; they are based on independent facts and not on the formulation of (99). Thus, if tones are linked to moras, what is needed is a reformulation of (99) so that suprasegmental features are covered as well, such as (102).

In (103a) a contour tone HL falls on *ka*, while in (103b) it falls on *kaa*. Since the only contrast here is vowel length, (103a) must have a short contour tone.

As Hyman points out, the contrast between (103a) and (103b) is found only when they precede a stem, but not when they precede a pause or a prefix. Still, the contrast before a stem requires an explanation. Although I do not have a ready answer, I would like to cite a highly interesting experiment by Greenberg and Zee (1979). In their experiment, various F0 contours were synthesized on a vowel. The tones were then played to subjects, who were asked to rank how steeply the tones rose on a 6-point scale, 1 being flat and 6 being the steepest. The results show that when a tone was too short, it could not be heard as a contour tone. An example is shown in (104).

(104)



When the solid line (90 ms) was played, it was ranked below 2 (i.e., almost as a flat tone), even though the F0 increased by 50 Hz. However, when a horizontal contour (80 ms) was added, shown by the dotted line, the combined contour (170 ms) was ranked over 4 (i.e., as a fairly steep rise), even though the longer tone is physically less steep overall than the shorter one. Greenberg and Zee's findings agree with the standard phonological view that a rising tone is made of two units, LH, and the hypothesis (102) that LH must be carried by two tone bearing units (here a long vowel). Now, since in normal speech a short vowel is generally less than 90 ms long, there is some doubt whether it can possibly carry a contour tone. Since Hyman (1987) does not provide phonetic data, I leave the Kukuya case open.^{49, 50}

In order to invite better counterevidence, then, I adhere to the stronger position, namely, that (102) holds both at the underlying level and at the surface level.⁵¹

But why should (102) hold? Does it have any cognitive basis? In a classic paper, Stroud (1955) proposed that information processing in humans is based on discrete time quanta, about 100 ms each. Summarizing researches in visual masking, Kahneman (1967) arrived at a similar time quantum. In particular, within a time quantum only one visual stimulus will be perceived; if two stimuli occur in the same time quantum, the masking effect occurs. A stimulus shorter than 100 ms will be perceived as 100 ms long.

The time quantum proposed by Stroud and Kahneman is surprisingly close to the duration of a phonological segment and bears a striking relation to Greenberg and Zee's experiment. One is tempted to wonder if the so-called timing slot in phonology is in some way related to a time quantum in which a distinctive feature can be performed and/or perceived once only (assuming, following Halle (1992), that distinctive features represent articulatory activities). If so, (102) will be a trivial consequence of the human cognitive ability.⁵² It is my hope that the present work will stimulate research in this direction.

NOTES

* Part of this paper was presented at BLS 18, Special Session on the Typology of Tone Languages, University of California, Berkeley, February 1992. I would like to thank the participants for comments. I also thank Zhiming Bao, Pam Beddor, David Evans-Romaine, Morris Halle, Peter Hook, Larry Hyman, Michael Kenstowicz, Charles Kisseberth, John Lawler, James McCawley, Jindrich Toman, and Moira Yip for previously discussing some of the points presented here. Finally, I thank two anonymous LI reviewers for their criticisms.

¹ I do not suggest that the number of segments that Maddieson (1984) gives for the world's languages is correct, as pointed out by an LI reviewer. But even if the actual number is twice as many, or just half as many, it is reasonably close to the prediction of a theory without contour features, and far from the prediction of a theory with contour features.

² Like Yip and Bao, I will use H and L only. This does not imply that there is no M. In addition, I will ignore features for tonal *register*, which according to Yip are in the *Tonal Root* node, and according to Bao are in the *Register* node sister to the *Contour* node.

³ In section 4 I will argue that alternative tonal representations have no bearing on the arguments or conclusion of this article.

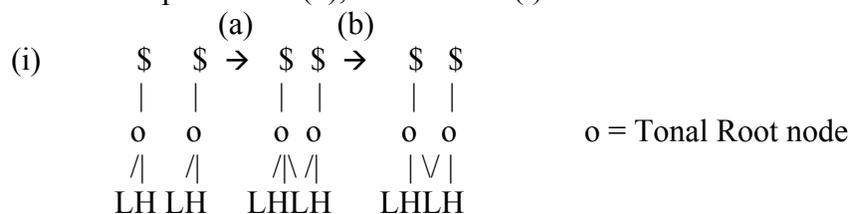
⁴ Yin Ping, Yin Qu, and so on, are traditional names for Chinese tonal categories.

⁵ For this reason, I am unable to satisfy a request by an LI reviewer that more data be presented in the familiar multi-tiered framework rather than in Chao letters.

⁶ To show that the lack of tone spreading is not due to word boundaries, multisyllabic words are used. As mentioned earlier, multisyllabic morphemes in Chinese are mostly foreign names.

⁷ I mentioned earlier that for Bao the only underlying CTUs are LH and HL. One may wonder why there is spreading of 213 and 535, which in Bao's analysis are HLH in the lower register and HLH in the upper register, respectively. Bao (1990:127-129) suggests that only simple CTUs are present underlyingly and that they later are converted to complex CTUs by a special rule.

⁸ In formal terms, Chan (1991:248) considers the rule to involve two steps, L-spreading (a) and contour simplification (b), as shown in (i)



On the other hand, Bao (1990:79) considers the rule to be the result of tonal metathesis, shown in (ii), where Bao's *Contour node* is similar to Chan's *Tonal Root node*.

$$(ii) \quad \begin{array}{ccc} c \rightarrow & c / _ & c \\ \wedge & \wedge & \wedge \\ LH & HL & LH \end{array} \quad c = \text{the "Contour node"}$$

The exactly formalization of this rule is immaterial to our discussion, however.

⁹ Xu et al. (1981) and Shen (1981a,b, 1982) distinguish two varieties of Shanghai: Old Shanghai, spoken by some elderly people in certain parts of Shanghai City, and New Shanghai, spoken by the majority in Shanghai City. The two varieties have quite different tonal patterns, although they are not always distinguished in the literature, where both are often called Shanghai. Thus, the criticism by Zee and Maddieson (1979), whose data seem to be from New Shanghai, against Sherard (1972), whose data seem to be from Old Shanghai, probably rests on a misunderstanding. Xu et al. (1988) further distinguish two varieties within New Shanghai, which they call Mainstream Shanghai and New Shanghai; I do not distinguish these two varieties here, since their tonal patterns are similar. Old Shanghai will always be distinguished, however.

¹⁰ The determination of tonal domains in New Shanghai is discussed in detail by Selkirk and Shen (1990), and from a metrical approach by Duanmu (1992b, 1993).

¹¹ An LI reviewer points out that such tone deletion in compounds is also found in Japanese.

¹² The idea that all full Mandarin rimes are bimoraic is proposed by Woo (1969) and Yip (1980:154-5). However, Yip (1989) seems to have abandoned this position.

¹³ This is not to suggest that this correlation between tone and stress is peculiar to Chinese. See Hyman 1987, Sietsema 1989, and Ao 1993 for similar proposals.

¹⁴ Like Prince, I will say nothing about the so-called weight-insensitive languages.

¹⁵ In this article, I do not choose between the X theory and the moraic theory of syllabic structure (cf. Hayes 1989). Instead, I assume that a bimoraic rime has two X slots and a monomoraic rime has one.

¹⁶ I am indebted to an anonymous reviewer for this point. On the other hand, Selkirk and Shen (1990) note that New Shanghai pronouns are more likely to lose their underlying tones than other lexical words. This suggests that even among light syllables, a difference may exist in their ability to retain stress.

¹⁷ Xu et al. writes [r] as [əɭ]. Since this rime is a single sound, I write it as [r].

¹⁸ The reason why Xu et al. use [əɳ in yn oŋ] instead of [ə̃ ĩ ỹ õ] may in part be phonetic. For example, Whalen and Beddor (1989) show that low vowels are more likely to be perceived as nasalized than high vowels. In addition, the inventory in (31) is based on syllables in isolation (Rujie You, personal communication), where the rime can be lengthened to two moras (the

"minimal word" effect; McCarthy and Prince 1990), and so a nasal closure may surface in the coda slot. The same may be said with regard to the glottal rimes.

¹⁹ Whether the proposed rime difference between Mandarin and New Shanghai leads to a difference in phonetic duration is addressed in Duanmu 1994.

²⁰ An LI reviewer wonders whether attributing the lack of CTUs in New Shanghai to its syllabic structure is as expedient as attributing it to a CTU parameter. I hope to have shown that the rime difference between Mandarin and New Shanghai is an independent fact, whether one posits CTUs or not. On the other hand, given the rime difference between the two languages, their tonal differences follow without assuming CTUs.

²¹ For arguments that Chinese [A N] nominals are compounds, see Dai 1992.

²² There are two reasons for placing tone under the Laryngeal node. First, feature geometry has alleviated the need for separating tone from the segment in order to account for its mobility and stability. Second, consonant-vowel interactions, such as tonogenesis, register genesis, tone split, and depressor consonants, suggest that voicing and tonal properties should be identified featurally in some way. See Duanmu 1991 for some discussion.

²³ This point has not been reported in the literature but is evident from my own work on New Shanghai. I intend to address it in a separate study.

²⁴ If lengthening is an option for improving a monomoraic domain, why is it not used in such compounds as *ço pa-li* 'small Paris'? Consider:

(i) x x
 x x x x
 (m) (m-m) → (m-m) (m-m) m = mora

If the first foot is lengthened, there is no longer a stress clash, and there will be two domains. But this does not happen; there can only be one domain. Apparently, lengthening is not a preferred solution for stress clash. The same is true in English, where stress clash in compounds is not resolved by lengthening but by the Rhythm Rule, which (re)moves one of the stresses (Hayes 1984, Gussenhoven 1991).

²⁵ This generalization is likely not limited to Chinese languages. To M-languages, we may add Thai, which contains complex rimes and in which tones are largely syllable-bound (Gandour 1974). To S-languages, we may perhaps add Lhasa Tibetan. The tonal behavior of Lhasa Tibetan is similar to that of New Shanghai (Duanmu 1992a). In addition, Lhasa Tibetan does not have diphthongs, although it has VC rimes. According to Qu and Tan (1983:39-40), C in a VC rime is dropped in a nonfinal position. Therefore, Lhasa Tibetan rimes should mostly be light.

²⁶ How contour tone "dissimilations" should be accounted for is a separate issue that requires a full-length study. For example, why is there "dissimilation" between [53 53] in Tianjin but not

between [51 51] in Beijing? Among other things, I suspect, there may be factors that are quite accidental.

²⁷ An LI reviewer suggests that I provide an analysis for Tianjin. At this point, I do not see any principled way of doing so, not because rules cannot be postulated, but because the rules are of no general interest. On the other hand, I hope to have shown that the CTU approach does not provide a consistent analysis of the Tianjin data.

²⁸ Final L insertion can be supported by independent data from Old Shanghai (Shen 1981a,b, 1982)

(i)	Monosyllabic	Bisyllabic	Trisyllabic
	35	35 53 or 33 53	35 55 53 or 33 55 53
	LH	LH(L) L H(L)	L H(L) L H(L)
	/	/ /	\ / \
	\$	\$ \$ \$ \$	\$ \$ \$ \$ \$ \$

With an initial syllable that is 35 (LH) in isolation, the bisyllabic pattern is [35 53] or [33 53], and the trisyllabic pattern is [35 55 53] or [33 55 53]. The final L is apparently added by a separate rule, as I am proposing for Wuxi. The question of why the initial syllable may link to either L or LH will be addressed shortly.

²⁹ There are four historical tone types in Chinese: Ping, Shang, Qu, and Ru. A tone type is called Yin when the onset is (historically) voiceless and Yang when the onset is (historically) voiced. Thus, Yang Shang is Shang with a (historically) voiced onset.

³⁰ While agreeing that the CTU analysis is weak, two LI reviewers found it hard to believe that the same tones can have different manners of association in Wuxi, and they proposed alternatives in which there is just one manner of association. Although I do not insist on my analysis as the only alternative to the CTU account (a full analysis of Wuxi needs much more evidence than the pitch contours), independent data from Old Shanghai and New Shanghai present unambiguous evidence to me that different manners of association must be possible in the same language.

³¹ I am indebted to an LI reviewer for this argument.

³² I am indebted to an LI reviewer for prompting me to clarify this point.

³³ The central point being made here is that the tonal behaviors of [təʔ] and [ti] in Changzhi do not represent a general process. How one analyzes them is thus immaterial to my argument. Instead of copying, an LI reviewer offers the following alternative:

(i)	Surface	Underlying
a.	213	L register, L tone
b.	24	L register, H tone
c.	535	H register, H tone
d.	53	H register, L tone
e.	44	unspecified

Using the tonal features proposed by Yip (1980), a level tone is represented by a "register" value and a "tone" value. Using underspecification, (ia-d) are represented as underlying level tones. In this representation one only needs to spread level tones. After the spreading some redundancy rules will change the underlying tones into relevant contour tones. This alternative has two shortcomings. First, like the CTU analysis, it requires a process to split a doubly linked tone into two copies, which lacks motivation (see section 3.4.1). Second, like the CTU analysis, it attempts to treat a special case as a general case, thus predicting other contour tone spreading cases that are not found.

³⁴ Bao (1990:130-134) does treat the reduplicated verbs, but his analysis involves a few special rules that are of no general application.

³⁵ This is another case of historical tone types affecting synchronic tone sandhi, as I suggested for Wuxi.

³⁶ For some reason, Lü does not give the entry for Cy in the table. However, all indications show that Cy should behave like Cb and Cm.

³⁷ The calculations are as follows

	Area II	Area III	Area IV	Area V	
Combinations	6 x 3 = 18	6 x 3 = 18	6 x 9 = 54	5 x 15 = 72	
Frequency	0.2	0.5	0.2	0.2	
Occurrence	3.6	9	43.2	15	(= 71 total)

The occurrence of [42 24] in an area is its frequency multiplied by the number of combinations in that area. The overall frequency of [42 24] is its total occurrences divided by the occurrences of all patterns: $71/225 = 32\%$.

³⁸ The number of irregular patterns in Danyang is strikingly high when compared with languages like New Shanghai. Duanmu (1993) offers two possible reasons. First, Danyang is situated on the border between the Mandarin family and the Wu family. Second, Danyang is in the process of shifting from a heavy rime language to a light rime language.

³⁹ I consider a syllable 24 if it is 24 either on a literary word or on a colloquial word. As mentioned earlier, a more accurate analysis should be based on separate lists of literary and colloquial vocabularies.

⁴⁰ Strictly speaking, the present analysis would link tones to mora units. But since the focus here is on CTU spreading, the representations are simplified.

⁴¹ In footnote 8, I mentioned that Chan (1991:248) considers this rule to involve two steps, spreading and delinking, whereas Bao (1990:79) considers it to involve metathesis between the LH of the first syllable. A third possibility is that the tones of the first syllable undergo value "switching" or "flip-flop" (e.g., $L \rightarrow H$ and $H \rightarrow L$), perhaps under the influence of initial stress (see Yue-Hashimoto 1986).

⁴² It is crucial that pattern substitution not be sensitive to both syllables, otherwise one might as well substitute the entire output [42 24] for inputs [55 24] and [24 24] directly, which requires no spreading, let alone CTU spreading.

⁴³ As in the bisyllabic patterns, Lü does not give the entry for Cy in trisyllabic patterns, but it obviously should be grouped with Cb and Cm.

⁴⁴ Trisyllabic domains occur in nominal expressions [X Y], where X is monosyllabic and Y bisyllabic. When X is bisyllabic and Y monosyllabic, [X Y] forms two domains. On the formation of tonal domains, see Duanmu 1992b, 1993.

⁴⁵ Why [42 42 24] occurs in these environments will be left open.

⁴⁶ I agree with Steriade's analysis only insofar as there is no need to posit underlying contour features. I leave open whether postulating a closure phase and a release phase for all noncontinuants is the correct way of treating affricates and pre- and postnasalized stops. Compare the work of Lombardi (1990), who does not make Steriade's assumption.

⁴⁷ Thanks to an LI reviewer for raising this problem.

⁴⁸ (102) prevents a feature from occurring in succession but does not prevent a feature from occurring simultaneously in different places. Thus, (102) is compatible with the proposal made by Padgett (1991), whereby every articulator under the Place node has a separate stricture feature [continuant] and thus[continuant] may appear two or more times within an X slot.

⁴⁹ In Czech the final vowel is lengthened, but the contrast between a short and a long final vowel is maintained. An obvious suggestion is that a monosyllabic vowel becomes bimoraic and a bimoraic vowel becomes trimoraic. If this is the case in Kukuya, it is no longer a problem for (107). Thanks to Jindrich Toman (personal communication) for the Czech facts.

⁵⁰ Gerard Diffloth (personal communication, 1992) informs me that short vowels may carry two registers in some Southeast Asian languages. Again, I leave open how such cases are to be reconciled with Greenberg and Zee's experiment.

⁵¹ Arguments against short contour tones are not to be taken as arguments against multi-tiered phonology. To borrow an analogy from Wittgenstein, short contour tones are a ladder that multi-tiered phonology has climbed up on and can now throw away.

⁵² It is well known that phonetically some features are shorter than others. For example, the formant transitions on a vowel, which are crucial for perceiving voiced stops, are usually shorter than 40 ms. In addition, Doughty and Garner (1947) have shown that four F0 cycles are enough for a listener to tell a pure tone. This amounts to 32 ms for a tone at 125 Hz (male voice), or just 16 ms for a tone at 250 Hz (female voice). It may appear then that a short vowel of 80 ms ought

to be long enough to be perceived as two segments, and one ought to hear a short contour tone after all. But if within each timing slot (say, on the order of 80 ms) each feature can be heard just once, whether it is a long feature or a short feature, then on a short vowel we cannot check the pitch twice and hence cannot hear a contour tone, as shown in Greenberg and Zee's experiment.

References

- Abraham, Roy C. 1940. *The principles of Tiv*. Republished in 1968 by Gregg International Publishers Ltd., Farnborough, Hants.
- Aginsky, Ethel. 1935. *A grammar of the Mende language*. Language Dissertations No. 20. Philadelphia: Linguistic Society of America.
- Anderson, Stephen. 1976. Nasal consonants and the internal structure of segments. *Language* 52:326-344.
- Ao, Benjamin X. P. 1993. Phonetics and phonology of Nantong Chinese. Doctoral dissertation, Ohio State University, Columbus.
- Arnott, D. W. 1968. Introduction to Abraham 1940.
- Bao, Zhiming. 1990. On the nature of tone. Doctoral dissertation, MIT, Cambridge, Mass.
- Bao, Zhiming. 1992. Toward a typology of tone sandhi. Paper presented at the Eighteenth Annual Meeting of the Berkeley Linguistics Society, Special Session on the Typology of Tone Languages, University of California, Berkeley, February 1992.
- Campbell, Lyle. 1974. Phonological features: Problems and proposals. *Language* 50:52-65.
- Chan, Marjorie K. M. 1991. Contour-tone spreading and tone sandhi in Danyang Chinese. *Phonology* 8:237-259.
- Chan, Marjorie K. M., and Hongmo Ren. 1986. Wuxi tone sandhi: from last to first syllable dominance. In *UCLA working papers in phonetics* 63, 48-70. Department of Linguistics, University of California, Los Angeles.
- Chao, Yuenren. 1930. A system of tone letters. *Le maître Phonétique* 45:24-27.
- Chao, Yuenren. 1931. Fanqie yu ba zhong [Eight types of Fanqie languages]. *Bulletin of Institute of History and Philology*, Academia Sinica 2:312-354.
- Chao, Yuenren. 1967. Contrastive aspects of the Wu dialects. *Language* 43:92-101.
- Chao, Yuenren. 1968. *A grammar of spoken Chinese*. Berkeley, California: University of California Press.
- Chen, Matthew. 1986. An overview of tone sandhi phenomena across Chinese dialects. Paper presented at the Conference on Languages and Dialects of China, University of California, Berkeley.
- Chiu, Bienming. 1931. The phonetic structure and tone behaviour in Hagu. *T'oung Pao* 28:245-342.
- Chomsky, Noam, and Morris Halle. 1968. *The sound pattern of English*. New York: Harper & Row.
- Clements, G. N. 1985. The geometry of phonological features. *Phonology Yearbook* 2:225-252.
- Dai, John X. L. 1992. Chinese morphology and its interface with the syntax. Doctoral dissertation, Ohio State University, Columbus.
- Davison, Debora S. 1989. Lexical prosodies of Mandarin: Comparative evidence from northern

- Chinese dialects. Doctoral dissertation, University of California, Berkeley.
- Doughty, J. M., and W. R. Garner. 1947. Pitch characteristics of short tones. 1: Two kinds of pitch threshold. *Journal of Experimental Psychology* 37:351-365.
- Duanmu, San. 1990. A formal study of syllable, tone, stress and domain in Chinese languages. Doctoral dissertation, MIT, Cambridge, Mass.
- Duanmu, San. 1991. A featural analysis of some onset-vowel interactions. Paper presented at the First Annual Conference of the Southeast Asian Linguistics Society, Detroit, May 1991. To appear in *Proceedings of the First Annual Conference of the Southeast Asian Linguistics Society*, ed. Martha Ratliff and Eric Schiller. Arizona State University Program for Southeast Asian Studies, Tempe.
- Duanmu, San. 1992a. An autosegmental analysis of tone in four Tibetan languages. *Linguistics in the Tibeto-Burman Area* 15:65-91.
- Duanmu, San. 1992b. End-based theory, cyclic stress, and tonal domains. Paper presented at the 28th Regional Meeting of the Chicago Linguistic Society, Parasession on the Cycle, University of Chicago, April 1992.
- Duanmu, San. 1993. Rime length, stress, and association domains. *Journal of East Asian Linguistics* 2:1-44.
- Duanmu, San. 1994. Syllabic weight and syllabic durations: A correlation between phonology and phonetics. To appear in *Phonology* 11.
- Fromkin, Victoria A. 1972. Tone features and tone rules. *Studies in African Linguistics* 3:47-76.
- Gandour, Jack T. 1974. On the representation of tone in Siamese. In *UCLA working papers in phonetics* 27:118-146. Department of Linguistics, University of California, Los Angeles.
- Gandour, Jack T., and Victoria A. Fromkin. 1978. On the phonological representation of contour tones. *Linguistics of the Tibeto-Burman Area* 4:73-74.
- Gao, Minkai, and Anshi Shi. 1963. *Yuyanxue gailun*. [Introduction to linguistics]. Peking: Zhonghua Shuju.
- Goldsmith, John. 1976. Autosegmental phonology. Doctoral dissertation, MIT, Cambridge, Mass.
- Green, Margaret M., and G. E. Igwe. 1963. *A descriptive grammar of Igbo*. Berlin: Akademie-Verlag.
- Greenberg, Steven, and Eric Zee. 1979. On the perception of contour tones. In *UCLA working papers in phonetics* 45:150-64. Department of Linguistics, University of California, Los Angeles.
- Gussenhoven, Carlos. 1991. The English rhythm rule as an accent deletion rule. *Phonology* 8:1-35.
- Halle, Morris. 1992. Phonological features. In *Oxford international encyclopedia of linguistics*, ed. William Bright, 207-212. New York: Oxford University Press.
- Halle, Morris, and G. N. Clements. 1983. *Problem book in phonology*. Cambridge, Mass.: MIT Press.
- Haraguchi, Shosuke. 1991. *A theory of stress and accent*. Dordrecht: Foris.
- Hayes, Bruce. 1984. The phonology of rhythm in English. *Linguistic Inquiry* 15:33-74.
- Hayes, Bruce. 1985. Iambic and trochaic rhythm in stress rules. In *Proceedings of the Eleventh Meeting of the Berkeley Linguistics Society*, 429-446. Berkeley Linguistics Society, University of California, Berkeley.
- Hayes, Bruce. 1989. Compensatory lengthening in moraic phonology. *Linguistic Inquiry* 20:253-

- 306.
- Hayes, Bruce. 1992. *Metrical stress theory: Principles and case Studies*. Ms., UCLA, Los Angeles, California.
- Herbert, Robert K. 1975. Reanalyzing prenasalized consonants. *Studies in African Linguistics* 6:105-123.
- Herbert, Robert K. 1986. *Language universals, markedness theory, and natural phonetic processes*. Berlin: Mouton de Gruyter.
- Hou, Jingyi. 1983. Changzhi fangyan jilue [Notes on the Changzhi dialect]. *Fangyan* 1983.4:260-274.
- Hulst, Harry van der, and Norval Smith. 1982. An overview of autosegmental and metrical phonology. In *The structure of phonological representations (Part 1)*, ed. Harry van der Hulst and Norval Smith, 1-45. Dordrecht: Foris.
- Hyman, Larry. 1984. On the weightlessness of syllable onsets. In *Proceedings of the Tenth Annual Meeting of the Berkeley Linguistic sSociety*, 1-14. Berkeley Linguistics Society, University of California, Berkeley.
- Hyman, Larry. 1987. Prosodic domains in Kukuya. *Natural Language & Linguistic Theory* 5:311-334.
- Hyman, Larry. 1989. Register tone and tonal geometry. In *The representation of tonal register*, ed. Keith Snider and Harry van der Hulst, 75-100. Dordrecht: Foris.
- Innes, Gorden. 1969. *Mende-English dictionary*. London: Cambridge University Press.
- International Phonetic Assciation. 1989. Report on the 1989 Kiel Convention. *Journal of the International Phonetic Association* 19.2:67-80.
- Kahneman, Daniel. 1968. Method, findings, and theory in studies of visual masking. *Psychological Bulletin* 70:404-425.
- Katamba, Francis. 1989. *An introduction to phonology*. London: Longman.
- Kenstowicz, Michael. 1993. *Phonology in generative grammar*. Oxford: Blackwell.
- Kenstowicz, Michael, and Charles Kisseberth. 1979. *Generative phonology*. San Diego: Academic Press.
- Leben, William. 1973. Suprasegmental phonology. Doctoral dissertation, MIT, Cambridge, Mass.
- Li, Weimin. 1981. Shi lun qingsheng he zhongyin [A preliminary discussion on stressless and stressed syllables]. *Zhongguo Yuwen* 1981.1:35-40.
- Li, Xingjian, and Sixun Liu. 1985. Tianjing fangyan de liandu biandiao [Tone sandhi in Tianjing dialect]. *Zhongguo Yuwen* 1985.1:76-80.
- Lin, Maochan, and Jingzhu Yan. 1988. The characteristic features of the final reduction in the neutral-tone syllable of Beijing Mandarin. In *Phonetic Laboratory annual report of phonetic research*, 37-51. Phonetic Laboratory, Institute of Linguistics, Chinese Academy of Social Sciences, Beijing.
- Lombardi, Linda. 1990. The nonlinear organization of the affricate. *Natural Language & Linguistic Theory* 8:374-425.
- Lü, Shuxiang. 1947. Danyang hua li de lianci bian tone [Tone sandhi in the Tan-yang dialect]. *Bulletin of Chinese Studies* 7:225-238.
- Lü, Shuxiang. 1980. Danyang fangyan de shengdiao xitong [The tonal system of the Danyang dialect]. *Fangyan* 1980.2:85-122.
- Luo, Changpei, and Jun Wang. 1957. *Putong yuyinxue gangyao* [Outline of general phonetics].

- Peking: Kexue Chubanshe. Reprinted in 1981 by Shangwu Yinshuguan.
- Maddieson, Ian. 1979. More on the representation of contour tones. *Linguistics of the Tibeto-Burman Area* 5:7-10.
- Maddieson, Ian. 1984. *Patterns of sounds*. London: Cambridge University Press.
- McCarthy, John. 1986. OCP effects: Gemination and antigemination. *Linguistic Inquiry* 17:207-264.
- McCarthy, John, and Alan Prince. 1990. Foot and word in prosodic morphology: The Arabic broken plural. *Natural Language & Linguistic Theory* 8:209-284.
- Newman, Paul. 1986. Contour tones as phonemic prime in Grebo. In *Phonological representations of suprasegmentals*, ed. Koen Bogers, Harry van der Hulst, and Maarten Mous, 175-193. Dordrecht: Foris.
- Ouyang, Jueya. 1979. Shengdiao yu yinjie de xianghu zhiyue guanxi [The interrelationship between tone and the syllable]. *Zhongguo Yuwen* 1979.5:359-362.
- Padgett, Jaye. 1991. Stricture in feature geometry. Doctoral dissertation, University of Massachusetts, Amherst, Mass.
- Pauling, Christiane. 1974. *Le Kukuya: Langue teke du Congo*. Paris: S.E.L.A.F.
- Pierrehumbert, Janet. 1980. The phonetics and phonology of English intonation. Doctoral dissertation, MIT, Cambridge, Mass.
- Pike, Kenneth. 1948. *Tone languages*. Ann Arbor, Mich.: University of Michigan Press.
- Prince, Alan. 1992. Quantitative consequences of rhythmic organization. In *Papers from the 26th Regional Meeting of the Chicago Linguistic Society. Vol. 2: The Parasession on the Syllable in Phonetics and Phonology*, 355-398. Chicago Linguistic Society, University of Chicago, Chicago, Ill.
- Pulleyblank, Douglas. 1986. *Tone in lexical phonology*. Dordrecht: Reidel.
- Pulleyblank, Edwin G. 1984. Vowelless Chinese? An application of the three-tiered theory of syllable structure. In *Proceedings of the Sixteenth International Conference on Sino-Tibetan Languages and Linguistics*, vol. 2, 568-619. Seattle, Wash.: University of Washington.
- Pulleyblank, Edwin G. 1989. The role of coronal in articulator based features. In *Papers from the 25th Regional Meeting of the Chicago Linguistic Society. Part 1: Main Session*, 379-393. Chicago Linguistic Society, University of Chicago, Chicago, Ill.
- Qian, Nairong, and Rujie Shi. 1983. Remarks on the tone sandhi of Suzhou. *Fangyan* 1983.4: 275-296.
- Qu, Aitang, and Kerang Tan. 1983. *Ali Zangyu* [Ali Tibetan]. Beijing: Zhongguo Shehui Kexue Yan Chubanshe [Chinese Academy of Social Sciences Press].
- Sagey, Elizabeth. 1986. The representation of features and relations in nonlinear phonology. Doctoral dissertation, MIT, Cambridge, Mass.
- Sapir, Edward. 1933. La réalité psychologique des phonèmes. *Journal de psychologie normale et pathologique* 30:247-265.
- Selkirk, Elisabeth. 1988a. A two-root theory of length. Paper presented at NELS 19. To appear in *University of Massachusetts Occasional Papers* 14, ed. Elaine Dunlap and Jaye Padgett. GLSA, University of Massachusetts, Amherst.
- Selkirk, Elisabeth, and Tong Shen. 1990. Prosodic domains in Shanghai Chinese. In *The Phonology-Syntax Connection*, ed. Sharon Inkelas and Draga Zec, 313-337. CSLI, Stanford University, Stanford, Calif. Distributed by University of Chicago Press.
- Shen, Tong. 1981a. Lao pai Shanghai fang yan de lian du bian diao [Tone sandhi in Old

- Shanghai]. *Fangyan* 1981.2:131-144.
- Shen, Tong. 1981b. Shanghai hua laopai xinpai de chabie [Differences between Old and New Shanghai dialects]. *Fangyan* 1981.4:275-283.
- Shen, Tong. 1982. Lao pai Shanghai fang yan de lian du bian diao (2) [Tone sandhi in Old Shanghai, part 2]. *Fangyan* 1982.2:100-114.
- Sherard, Michael. 1972. Shanghai phonology. Doctoral dissertation, Cornell University, Ithaca, N.Y.
- Sietsema, Brian M. 1989. Metrical dependencies in tone assignment. Doctoral dissertation, MIT, Cambridge, Mass.
- Spears, Richard A. 1967. Tone in Mende. *Journal of African Languages* 6:231-244
- Steriade, Donca. 1989. Affricate are stops. Paper presented at Conference on Features and Underspecification Theories, MIT, October 1989.
- Steriade, Donca. 1993. Closure, release, and nasal contours. In *Phonetics and phonology vol. 5: Nasals, nasalization, and the velum*, ed. Marie K. Huffman and Rena A. Krakow, 401-470. San Diego: Academic Press.
- Stroud, John M. 1955. The fine structure of psychological time. In *Information theory in psychology*, ed. Henry Quastler, 174-205. New York: Free Press.
- Tsay, Jane S. 1990. The distribution of tone in Taiwanese. In Proceedings of the 1989 Western Conference on Linguistics, vol. 2, 336-346. Department of Linguistics, California State University, Fresno.
- Wang, Futang. 1959. Shaoxing hua ji yin [A description of Shaoxing sounds]. *Yuyanxue Luncong* 3:73-126.
- Wang, Hongjun. 1991. Tonal system of Shaoxing dialect. Ms., MIT, Cambridge, Mass.
- Ward, Ida C. 1944. A phonetic introduction to Mende. In *An introduction to the study of Mende*, K. H. Crosby, 1-7. Cambridge: Heffer and Sons.
- Whalen, D.H., and Patrice S. Beddor. 1989. Connections between nasality and vowel duration and height: Elucidation of the Eastern Algonquian intrusive nasal. *Language* 65:457-486.
- Williams, Edwin. 1976. Underlying tone in Margi and Igbo. *Linguistic Inquiry* 7:436-468.
- Woo, Nancy. 1969. Prosody and phonology. Doctoral dissertation, MIT, Cambridge, Mass.
- Xie, Zili. 1982. Suzhou fangyan liang zi zu de lian du biandiao [Tone sandhi in bisyllabic phrases in Suzhou]. *Fangyan* 1982.4:245-263.
- Xu, Baohua, Zhenzhu Tang, and Nairong Qian. 1981. Xin pai Shanghai fangyan de lian du bian diao (1) [Tone sandhi in New Shanghai (part 1)]. *Fangyan* 1981.2:145-155.
- Xu, Baohua, Zhenzhu Tang, Rujie You, Nairong Qian, Rujie Shi, and Yaming Shen. 1988. *Shanghai shiqü fangyan zhi* [Urban Shanghai dialects]. Shanghai: Shanghai Jiaoyu Chubanshe [Shanghai Education Press].
- Ye, Xiangling. 1979. Suzhou fangyan de lian du biandiao [Tone sandhi in Suzhou]. *Fangyan* 1979.1:30-46.
- Yip, Moira. 1980. Tonal phonology of Chinese. Doctoral dissertation, MIT, Cambridge, Mass.
- Yip, Moira. 1988. Template morphology and the direction of association. *Natural Language & Linguistic Theory* 6:551-557.
- Yip, Moira. 1989. Contour tones. *Phonology* 6:149-174.
- Yip, Moira. 1991. Tone in East Asian languages. To appear in *Handbook of theoretical phonology*, ed. John Goldsmith. Oxford: Blackwell.
- Yip, Moira. 1992. The spreading of tonal nodes and tonal features in Chinese dialects. Paper

presented at the Eighteenth Annual Meeting of the Berkeley Linguistics Society, Special Session on the Typology of Tone Languages, Berkeley, February 1992.

Yue-Hashimoto, Anne O. 1986. Tonal flip-flop in Chinese dialects. *Journal of Chinese Linguistics* 14:161-183.

Zee, Eric, and Ian Maddieson. 1979. Tones and tone sandhi in Shanghai: Phonetic evidence and phonological analysis. In *UCLA working papers in phonetics* 45:93-129. Department of Linguistics, University of California, Los Angeles.

Zhang, Hongnian. 1985. Zhenjiang fangyan de liandu bian diao [Phrasal tone sandhi in the Zhenjiang dialect]. *Fangyan* 1985.3:191- 204.

Program in Linguistics
University of Michigan
Ann Arbor, MI 48109-1285

san.duanmu@um.cc.umich.edu