Contour Tones and Contrast in Chinese Languages

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CONTOUR TONES AND CONTRAST IN CHINESE LANGUAGES

Abstract

The goal of this paper is twofold. First, it discusses the tonal systems of several Chinese languages within the framework of the Theory of the Contrastive Hierarchy (Dresher et al., 1994, Dresher, 1998, 2003a, b). In particular, this paper demonstrates that disparities between phonetic characteristics of tones and their phonological activity can be understood as a kind of underspecification that the Contrastive Hierarchy affords. The second goal of this paper is to propose an analysis in which contour tones in Chinese languages generally are represented as unitary entities rather than as a concatenation of level tones (tone clusters). This contrasts with the tonal systems found in African languages, in which contour tones are demonstrably composed of level tones. Thus, this paper argues for the existence of two types of contour tones in natural language—unitary contour tones and tone clusters.

1. **Introduction**

This paper argues for a contrastive analysis of tone in several Chinese languages within the framework of the Contrastive Hierarchy as laid out in Dresher *et al.* (1994) and Dresher (Dresher, 1998, 2003a, 2003b). In particular, we discuss Cantonese, Hakka, Lungtu, Taishan and Huojia. We propose that the tonal inventories and sandhi processes of these languages can be best understood if we assume that featural specifications of the tonemes are executed by the Successive Binary Algorithm (SBA), to be discussed below.

The premise of the theory of the Contrastive Hierarchy is that a given segment is specified with a particular feature only if it contrasts with some other segment with respect to that same feature.[1] Furthermore, specifications are made by the SBA, which operates hierarchically, rather than all at once. The exact order of the feature specifications may differ cross-linguistically. Thus, featural specifications of the same phonetic segment may differ across languages. Also, it is often the case that certain phonetic properties of a segment are phonologically inert.[2] Thus, certain phonetic/phonological mismatches can be captured by the Contrastive Hierarchy. In this paper, we discuss some phonetic/phonological mismatches in the tonal phonology of various Chinese languages and argue that the Contrastive Hierarchy provides a straightforward account of these facts.

This paper also argues for an unitary structure of contour tones in the sense of Pike (1948), Wang (1967) and Cheng (1973a). We discuss and compare the two main competing models for contour tones, tone clusters and Contour Tone Units, and show that neither is viable for the languages under discussion.[3] Building on a suggestion by Yip (2001), I argue that contour tones are marked directly by a feature [contour]. The direction of the contour (rising or falling) is determined by default phonetic implementation rules that depend on the other tonal features present (Yip, 2001). This solution eliminates many of the empirical and theory-internal problems of the tone cluster and Contour Tone Unit analyses and can account for the facts concerning tonal inventories and tone sandhi.

This paper is organized as follows. Section 2 discusses previous analyses of contour tones: Contour Tone Units and tone clusters. This section puts forth arguments for a unitary representation of contour tones in Chinese languages. Section 3 introduces the Theory of the Contrastive Hierarchy in Dresher *et al.* (1994) and Dresher (Dresher, 1998, 2003a, 2003b). In section 4, I illustrate how the Contrastive Hierarchy can account for the behaviour of tones in several Chinese languages and show how the competing analyses discussed in section 2 are problematic for the tonal systems in these languages. Section 5 is a brief conclusion.

2. The Representation of Tone

Early analyses of tones in Chinese languages assumed that contour tones were unitary units (Cheng, 1973a, Pike, 1948, Wang, 1967).[4] Based on subsequent pioneering work on African tonal languages (Goldsmith (1976), Leben (1978) among others) contour tones were argued to be composed of a sequence of two level tones (the tone cluster analysis). Later on, contour tones were analyzed as contoured segments, following Sagey (1986), and as Contour Tone Units (CTU) (see Yip (1995) for a summary). I consider each of these treatments in turn in the following sections, where I demonstrate that the latter two approaches are problematic for Chinese languages, and propose an alternative based on recent work by Yip (2001) that is strongly reminiscent of the early analyses which argue for an unitary model for contour tones.

Finally, it has been observed that tonal languages do not have more than four level, two falling and two rising tones (Bao, 1990, 1999, Maddieson, 1978, Yip, 1980). If complex contour tones are present (such as falling then rising), they supplant the simple contour tones, so that there are never more than four contour tones and eight tones altogether. Also, Zhang (2002) undertakes a large survey of tonal languages and deduces the following implicational universals.

(1) a. If a language has contour tones, then it also has level tones

b. If a language has complex contour tones, then it also has simple contour tones.

c. If a language has rising tones, then it also has falling tones.

In the proposal to be advanced below we will attempt to capture many of these universals, although we will have nothing to say about the distribution of complex versus simple contour tones here.

2.1. Against a cluster model for contour tones in Chinese languages

A cluster model assumes that contour tones are formed by the concatenation of two or more level tones. Typically, an inventory of two or three level tones is assumed from which the contour tones are formed. A contour tone is represented by two tonal nodes in succession, attached to the Tone Bearing Unit

(TBU).[5] Example (2) shows a high-rising tone and a low-falling tone, respectively.[6]

(2)

TBU		TBU	
M	*H*	*M*	*L*

There are various problems this model poses for Chinese languages. First, it predicts the possibility of more contour tones than are actually found. In a language that has three level tones, this model predicts 3 X 2 = 6 possible contour tones. In a language with four level tones, as Cantonese is argued to have here, the model predicts 4 X 3 = 12 possible contour tones. Both results exceed the observed limit of four contour tones. Furthermore, it has been shown that complex contour tones in African languages result from the concatenation of three level tones. If we allow this possibility in a language with three contrastive level tones, this would give rise to another ten complex contour tones.

A second problem with tone clusters is that the representations in (2) predict that the individual level tones forming the contour tone cluster should be able to act independently in the phonology. Yip (1989) gives several lines of evidence showing that contour tones in Chinese languages do not separate into their putative level components across polysyllabic domains.[7] For instance, Yip observes that polysyllabic monomorphemic words in Mandarin make no attempt to avoid word-internal contours, in contrast to African languages where contours obligatorily appear at the end of the tonal association domain. Duanmu (1994) argues that the tonal association domain in Mandarin is the syllable, so word-internal contour tones are not unexpected. Duanmu's argument rests on the fact that the syllable is also the domain of stress assignment in Mandarin and an analysis in which the stress assignment and tonal association domains are co-extensive is preferred. This analysis is dependent on the existence of a small number of toneless syllables in Mandarin, however. These are mostly functional morphemes such as the perfective aspect marker *le* and the marker *de* used in possessives and relative clauses. This analysis is difficult to maintain for a language such as Cantonese which behaves identically to Mandarin in terms of allowing word-internal contour tones but has no toneless syllables. Duanmu would have to argue that every syllable in Cantonese is stressed in order to maintain that the syllable serves as the domain for tonal association. The notion that every syllable is stressed is meaningless, however, since a stressed syllable by definition is more prominent that the syllables around it. Given the problem that equating the domains of stress assignment and tonal association presents for Cantonese, we opt for an explanation along the line of Yip's in which contour tones are represented as a single entity.

Following another line of inquiry, Wan and Jaeger (1998) discuss speech error data suggesting strongly that tones in Mandarin are unitary, rather than a concatenation of level tones. For example, there were no tone splittings or hybrids produced by word blending or telescoping errors. In their study, they did not find a single example in which either the initial or final “portion” of a contour tone was accidentally substituted for another level tone. Rather, all errors involving switching one tone for another involved the exchange of the entire tone. Also, there were very few cases that could potentially be explained by the spreading of either the initial or final “level tone” in the contour. Indeed, there were far fewer examples of such types of errors than would be expected if there did exist level tones that could spread as such.[8]

Another prediction of the Cluster model is that contour tones should exhibit edge-effects, in which the individual level tones should be visible to segments on either side for phonological processes. Thus, the high-rising tone in (2) should behave like a mid-level tone with the segment to its left and a high-level tone with the segment to its right. Chen (2000: 63-64) discusses the dual nature of tone, in which he argues that contour tones behave both as unitary entities, exhibiting integrity-effects, and that they also behave as composite entities, exhibiting edge-effects. As I argue that contour tones are unitary, one might assume that edge-effects should be absent. As will be clear from the proposal below, however, edge-effects are predicted to appear on the left, but not on the right of a contour tone, a prediction which is borne out; however, I delay the discussion of the relevant facts until after the proposal in presented in section 2.3.

We have discussed various problems with the cluster model. The first is that such a model over-generates the number of contour tones attested. The second problem concerns the fact that that contour tones behave as unitary units, both phonologically (Yip, 1989) and in experimental studies (Wan and Jaeger, 1998). The cluster model predicts that component level tones should behave independently, at least sometimes. The third problem is that contour segments represented by a series of two level tones are expected to display edge-effects. As the model for contour tones proposed here predicts edge-effects on the left, but not on the right. Given these problems, we reject the cluster analysis and discuss next the CTU analysis.

2.2. Against a CTU Model for Contour Tones

Contour tones have been represented as a contoured segment, as has been proposed for affricates by Sagey (1986). The following example is a representation of a rising tone.

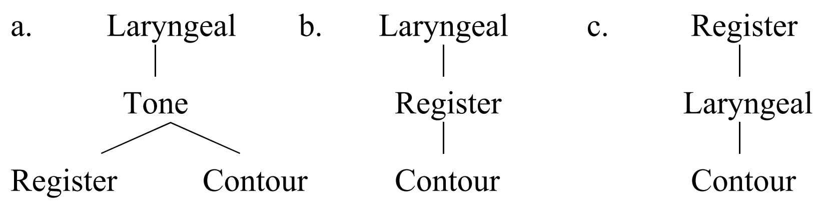
(3)

Tone		tonal root node
L	H	tonal tier

The tonal root node is typically a daughter of the Laryngeal node in an articulated feature geometry as discussed in Clements & Hume (1995). As is the case with contoured segments, the relative placement of the tonal features is crucial to the nature of the tone. Thus, if we reverse the order of the two features in (3), we obtain a falling tone. Several scholars have argued convincingly against contour segments including pre- and post-nasalized stops (Herbert, 1975, 1986, Steriade, 1993), affricates (Lombardi, 1990, Steriade, 1989) and contour tones (Duanmu, 1994). Despite these facts, many analyses of contour tone assume a representation of the kind in (3). We discuss some of these analyses next.

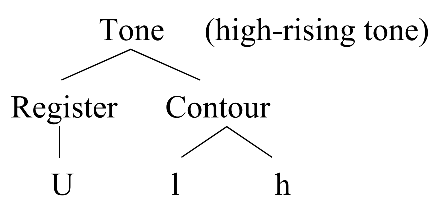
Yip (1995) discusses six proposals for the arrangement of the tonal features, Register and Contour, where three of these proposals are consistent with a CTU model. As shown in (4), these features can be organized in a sisterhood relationship (4)a, in a dominance relationship (4)b or in a independent relationship (4)c.

(4)



The Register node refers to the general pitch level of the tone and the Contour node refers to the contour of the tone (falling, rising), or to a more finely graded pitch of a level-tone (low-level versus extra-low level). Bao (1990) argues for a sisterhood relation between the two tonal nodes (examples (4)a, (5)).[9]

(5)



Yip (1989) argues for a dominance relation (examples (4)b and (6)).

(6) σ (high-rising tone)

U

l h

Despite the fact that we will reject the CTU model for contour tones below. The models in (5) and (6) will serve as a useful point of departure for the proposal below.

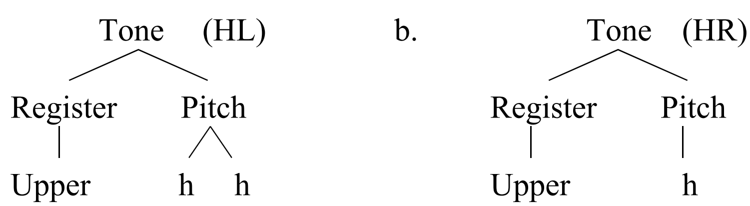
Given the growing mass of evidence against contoured segments in general and the fact that Duanmu (1994) gives several convincing arguments against a CTU model for contour tones, we will not spend too much time on this issue here. Rather, we will focus on those aspects of the CTU model that bare on the current discussion. All of these analyses have assumed a temporally-sensitive, internal branching structure. Also, as with contour segments, the ordering of the [lo] and [hi] features is crucial in (7) and (8). If these two features are reversed, a high-falling tone results. Assuming that timing is co-ordinated on the skeletal tier, it is undesirable to introduce a timing mechanism in other parts of the geometry. Finally, CTUs should display the same kind of edge effects as tone clusters as discussed above, which we shall see in the next section is not borne out.

In this section we have rejected the cluster model and followed Duanmu (1994) in rejecting the CTU models for contour tones in Chinese Languages. In the next section, we present our model for contour tones.

2.3. The Nature of Tonal Contours

Rejecting both the tone cluster and the CTU analyses forces us to seek an alternative. We begin by discussing some observations on contour tones made by Yip (2001). Yip demonstrates that contour tones tend towards the middle of their respective Registers. She proposes that a level tone is specified at both ends to keep the pitch level and stop it from rebounding to the mid-point of the register. She proposes, furthermore, that contour tones are specified for the initial pitch only. The direction of contour is determined by default rules. First, contour tones cannot cross Registers. Second, contour tones cannot go up out the top of, or down past the bottom of the available pitch spectrum. A high-level tone (7)a and a high-falling tone (7)b, then, have the following representations (structures adapted to the present discussion):

(7) a. b.



We take Yip's model as a departure for our analysis of contour tones. Note that the contour tone in (7) is less specified than the level tone. Contour tones are less common cross-linguistically than level tones and the presence of contour tones in a given language implies the presence of level tones (Maddieson, 1978). These two facts suggest that contour tones more marked than level tones, and, hence, should be more highly specified (*contra* the structures in (7)). I suggest that contour tones have a feature [contour], which level tones lack.[10] Under this view, the representations for HL and HF tones appear as follows.

(8) a. Tone (HL)

Register Pitch

Upper h

b. Tone (HF)

Register Pitch

Upper h [contour]

The use of the feature [contour] demands some explanation. One of the major achievements of phonology in the latter portion of the 20th century was the elimination of spurious features, such as [length], in favour of capturing the same effects with an enriched representation. Positing [contour] as a feature seems like a step backwards. We will see in section 4, however, that the feature [contour] is well-motivated and leads to a better understanding of tonal phonology. Furthermore, the proposed model and the CTU model make different predictions on what features may be active in the phonology. Under the CTU and cluster models, both features [lo] and [hi] (for CTUs) or both level tones (for clusters) should be available to the phonology; however, under the proposed model, only one of these features (the one that indicates the initial point of the contour) and [contour] should be available. We consider the predictions these different proposals make next.

One area in which the difference between the current proposal on the one hand and clusters and CTUs on the other can be tested is edge-effects. Under the current proposal, the initial level tone of a contour is specified, but the final tone is not. Thus, we expect to find edge effects that involve the initial level tone, on the left, but not the final level tone, on the right. Since only the left edge of the tone is visible phonologically, we expect to find far more examples of anticipatory tone sandhi than progressive tone sandhi. Chen (2000) gives only two examples of progressive tone sandhi in his discussion on tone sandhi across Chinese dialects.[11] By way of contrast, Chen gives many examples of anticipatory sandhi in several Chinese languages. Since only the initial point of the contour is available to the phonology, this argues in favour of the current model over the CTU or cluster models as discussed at the end of the previous paragraph.

Of course the idea of tone in Chinese languages as a unitary feature rather than a complex segment is not new (see Cheng, 1973a, Pike, 1948, Wang, 1967). Later studies on African tonal languages brought to light the autosegmental status of tones (Goldsmith, 1976, Leben, 1978), where contour tones were clearly shown to be composed of a sequence of level tones. The phenomena that gave rise to the analyses of contour tones as such are not found in Chinese languages; however, in the interests of theoretical parsimony, the same analysis in which contour tones are treated as a sequence of level tones was carried over to Chinese tonal systems, in the absence of evidence to the contrary. We have seen, however, enough evidence to doubt that an analysis in which a sequence of level tones is an appropriate representation for the contour tones under discussion and that, in fact, contour tones in Chinese tonal languages should be seen as unitary.[12]

Note that we have been careful to include only Chinese languages in the category of tonal languages in which contour tones are unitary segments formed with the feature [contour].[13] African tonal languages as discussed by Goldsmith (1976) among others are clearly formed by tone clusters. Thus, we follow Yip (1989) and conclude that there are two types of tonal languages with respect to contour tones. Both the current proposal and Yip's proposal argue that one type of contour tone is formed by the concatenation of two level tones on a TBU, which we call tone clusters. The difference between the current proposal and Yip's is in the second type of contour tone. Yip had argued that contour tones are contour segments in the sense of Sagey (1986), while the current proposal argues that contour tones are unitary entities.

If we assume that tone clusters do not care about the internal structure of the concatenated tones, we predict the possibility of a language with both unitary contour tones as promulgated here and tone clusters. Yip (1989) suggests that Taishan, a Yue language related to Cantonese is just such a language. We discuss Taishan in section 4.3 below in more detail, but mention here the relevant data.

(9) *Taishan Contour Tones*

a. [hoŋ-22] 'sugar' → [hoŋ-227] 'candy'[14]

b. [fuŋ-44] 'to seal (a letter)' → [ɬiŋ-44 fuŋ-447] 'envelope'

c. [ŋut-31] 'month' → [ŋut-317] 'moon'

As (9) shows, tones in Taishan can undergo a kind of raising. In all cases, the resulting tone can be analyzed as a concatenation of the underlying tone followed by an extra-high level [EHL] tone. The interesting case here is (9)c, where the underlying tone on 'ŋut' (*month*) is a unitary falling tone which can form part of a tone cluster. This is shown in (10), where SEM represents the semantic contribution of the floating [EHL] tone.

(10) hoŋ SEM

TBU

[LF] [EHL]

This section has shown that contour tones in Chinese languages are best understood as unitary entities, rather than complex entities (such as CTUs or clusters), notwithstanding the possibility of both unitary contours and tone clusters in the same language, as just described for Taishan. Specifically, I have proposed, following ideas developed by Yip (2001) and Mortensen (2002), that contour tones are represented by the feature [contour], in addition to the Register and Pitch features found in Chinese languages. In the next section, I discuss the Theory of the Contrastive Hierarchy and relate it to the model of contour tones proposed in this section.

3. The Role of Contrast

The Theory of the Contrastive Hierarchy as developed in Dresher *et al.* (1994) and Dresher (2003a, 2003b) adopts the view that only features needed to show segments as contrastive are present in the representation. For example, a back vowel such as /u/ is marked with the feature [+round] only if this feature is needed to contrast it with a [-round] vowel in the relevant domain determined by a hierarchy of features (see below). For example, back vowels in a language such as English are often assumed to be underspecified for roundness; however, the Theory of the Contrastive Hierarchy presented here provides a uniform approach to determining which features are underspecified.

3.1. The Theory of the Contrastive Hierarchy

In the approach adopted by Dresher *et al.* (1994) and Dresher (2003a, 2003b) contrast is seen as a driving force in determining the featural content of segments. They propose the Successive Binary Algorithm for deriving representations:

(11) <u>Successive Binary Algorithm</u> (SBA, Dresher *et al.* (1994))

a. In the initial state, all tokens in the inventory, I, are assumed to be variants of a single member. Set I = S, the set of all members.

b. i) If S is found to have more than one member, proceed to c.

ii) Otherwise, stop. If a member, M, has not been designated contrastive with respect to a feature, G, then G is *redundant* for M.

c. Select a new binary[15] feature, F, from the set of distinctive features. F splits members of the input set, S, into two sets, +F and –F, depending on what value of F is true of each member of S.

d. i) If either +F or –F is empty, then loop back to c.

ii) Otherwise, F is *contrastive* for all members of S.

e. For each set +F and –F, loop back to b, replacing S by +F and –F respectively.

By way of illustration, consider a language with the following three-vowel inventory /a i u/. In the initial state, these three vowels are assumed to be variants of a single member, V. If it is determined that there is some feature which determines a contrast, say [high], then the members are split into groups accordingly. This gives rise to /a/, which is specified [-high] and /i, u/, which are specified [+high]. The vowel /a/ is now uniquely specified as there are no other [-high] vowels, so it no longer participates in the algorithm. The remaining two vowels are still not uniquely specified, so another feature, say [back], is invoked. The vowel /i/ is specified [-back] and /u/ is specified [+back]. The full specifications in this hypothetical scenario are as follows:

(12) /a/ [-high]

/i/ [+high, -back]

/u/ [+high, +back]

The order of feature cuts is often presented in a tabular fashion, as will be done throughout the rest of this paper:

Table 1 Height>Backness

[-high]	[+high]	
	[+back]	[-back]
a	u	i

The feature at the top (Height) is the first feature cut. The following feature cuts proceed downward from there. The caption lists the order of the feature cuts.

Of course, the divisions in our hypothetical vowel inventory could have been made differently (or even used different features, such as [round]), giving rise to different specifications on the vowels. The decision as to which feature cuts to make and the order of the cuts is made on a case-by-case basis, depending on the phonological processes in the language, and minimal pair contrasts. For example, if [high] and [back] are active features in the phonology of a given language, then both of these cuts will be used. Furthermore, if /u/, but not /a/, acts as a back vowel, then there is justification for the order [high] before [back] as in Table 1. Next we discuss tonal features in the context of the Contrastive Hierarchy.

3.2. Tones and Contrast

We consider now how the features Register, Pitch and [contour] interact when subjected to the Contrastive Hierarchy. Recall Yip's proposal that only the starting point of a contour tone is specified. Thus, a falling tone need only be indicated with a Pitch feature [hi]. These three features give rise to eight possible contrastive specifications of tones. Table 2 illustrates the order of feature cuts Register, then Pitch, then [contour], showing eight hypothetical tones. Note that this system captures the universals on tone discussed above—namely that tonal languages have a maximum of four level and four contour tones.

Table 2 Register>Pitch>Contour

Upper				Lower			
hi		lo		hi		lo	
[contour]		[contour]		[contour]		[contour]	
high-falling	high-level	high-rising	mid-level	low-falling	low-level	low-rising	extra-low-level

We now turn to a discussion of the tonal systems of several Chinese languages and illustrate how the contrastive hierarchy and the model of contour tones proposed here can account for the observed facts.

4. **Tonal Systems of Chinese Languages**

This section gives an analysis of the tonal systems of several Chinese languages within the framework of the Contrastive Hierarchy, including Cantonese, Hakka, Lungtu, Taishan and Huojia, and contrasts these with the analyses that assume CTUs or tone clusters.

4.1. Overview of the tonal system of Cantonese

(13) lists the tonal inventory for Cantonese.[16] Note that the high-falling tone in (13)a. is found only in Guangzhou Cantonese for older speakers. The tones in (13)b-g are found in both Guangzhou and Hong Kong Cantonese.

(13)	a.	high-falling	saan-53	'to close'	53
	b.	high-level	gam-55	'gold'	55
			sap-5	'wet'	<u>5</u>
	c.	high-rising	hou-35	'good'	35
	d.	mid-level	sei-33	'four'	33
			baat-3	'eight'	<u>3</u>
	e.	extra-low-level	yau-21	'oil'	21
	f.	low-rising	ngo-23	'I, me'	23
	g.	low-level	daai-22	'big'	22
			dip-2	'dish'	<u>2</u>

The high-falling tone of Guangzhou Cantonese has merged with the high-level tone in Hong Kong Cantonese as shown in example (14):

(14)	saan-55 'hill'	saan-53 'to close'	[Guangzhou]
	saan-55 'hill'	saan-55 'to close'	[Hong Kong]

While older speakers of Guangzhou Cantonese have different pronunciations for these two lexical items, younger speakers in Guangzhou have undergone merger of the high-level and high-falling tones. Speakers of Hong Kong Cantonese pronounce both of these lexical items identically.[17]

The three *checked*[18] tones are level tones. Phonetically, the tones are identical to the level tones of the non-checked counterparts and are not contrastive, and so must be treated as allotones of their non-checked counterparts. The distinction in many current grammars between checked and non-checked tones is due to a long-standing tradition in Chinese grammar that checked tones are distinct from the other tones.[19]

Although Cantonese has a rich tonal system, it possesses relatively few instances of tone change and tone sandhi.[20] There is but a single phonologically conditioned sandhi rule in Guanzhou Cantonese shown in (15), with an example shown in (16).

(15) /53/ → [55] / ___ {53, 55, $\underline{5}$}

(16) tin-53 hak-55 → tin-55 hak-55 'dusk' (lit. 'sky dark')

These facts can be captured by the set of feature cuts in Tables 3 and 4. The relatively large toneme inventory of Cantonese matches closely the hypothetical table in section 3.2 and thus serves as a useful point of departure for our discussion.

Table 3 Register > Pitch > [contour] - Guangzhou Cantonese

<table>
<tr><td colspan="4">Upper</td><td colspan="3">Lower</td></tr>
<tr><td colspan="2">hi</td><td colspan="2">lo</td><td>hi</td><td colspan="2">lo</td></tr>
<tr><td>[contour]</td><td></td><td>[contour]</td><td></td><td rowspan="2">LL</td><td>[contour]</td><td></td></tr>
<tr><td>HF</td><td>HL</td><td>HR</td><td>ML</td><td>LR</td><td>ELL</td></tr>
</table>

Table 4 Register > Pitch > [contour] - Hong Kong Cantonese

<table>
<tr><td colspan="3">Upper</td><td colspan="3">Lower</td></tr>
<tr><td>hi</td><td colspan="2">lo</td><td>hi</td><td colspan="2">lo</td></tr>
<tr><td rowspan="2">HL</td><td>[contour]</td><td></td><td rowspan="2">LL</td><td>[contour]</td><td></td></tr>
<tr><td>HR</td><td>ML</td><td>LR</td><td>ELL</td></tr>
</table>

In both dialects, the first cut is Register, followed by Pitch, at which point the low-level (LL) tone is uniquely specified. The remaining tones are specified by a further cut with the [contour] feature. This arrangement of tones captures the neutralization between the high-falling and the high-level tone as a loss in contrast in [contour] in the [Upper, hi] tones. (17) summarizes the feature specifications for Cantonese tones:

(17) high-level [Upper, hi]

high-rising [Upper, lo, contour]

(high falling [Upper, hi, contour] – Guangzhou Cantonese only)

mid-level [Upper, lo]

low-level [Lower, hi]

low-rising [Lower, lo, contour]

extra-low-level [Lower, lo]

4.2. Lungtu[21]

Lungtu (also called Longdu) is a dialect of the Min Nan language of China and is spoken in the southern region of the province of Guangdong. Lungtu has the following tonal inventory:

(18)	high-level HL	mid-level ML
	low-level LL	mid-rising MR
	mid-falling MF	high-level – checked <u>HL</u>
	mid-level – checked <u>ML</u>	low-level – checked <u>LL</u>

Lungtu also has the obligatory sandhi rules in (19) and the optional sandhi rules in (20).

(19) *Tonal sandhi rules in Lungtu*

a. HL → ML /__ any tone

b. LL → HL / __ any tone

c. <u>LL</u> → <u>ML</u> or <u>HL</u> / __ any tone

(20) *Optional tonal sandhi rules in Lungtu*

a. ML → MF / __ {MR, LL, MF}

b. MF → ML / __ {MR, MF}

As with Cantonese and Hakka, I will assume that the checked tones are allotones of their non-checked counterparts, leaving five tonemes to account for. The sandhi rules in (20) suggest that {MR, LL, MF} and {MR, MF} are both natural classes since they serve as triggers. Thus both sets should be exhaustively identified by a single feature. The contrastive division in Table 5 achieves these results.

Table 5 Register>Contour>Pitch - Contrastive Division of Tones in Lungtu

Upper		Lower		
			[contour]	
hi	lo		hi	lo
HL	ML	LL	MF	MR

The first cut is Register, which separates HL and ML from the remaining tones. The next cut is [contour], which leaves LL uniquely specified. Finally, a cut is made for Pitch, which splits the two Upper Register tones and the two contour tones. The triggering environment in (20)a, then, is the feature [Lower], which is responsible for the first cut. In (20)b the trigger is the feature [contour], which is responsible for the second cut. It is crucial that the split for [contour] be made before the split for Pitch or one of the contour tones would not be specified [contour].[22] The results of the feature specifications for tones in Lungtu are summarized in (21).

(21)	HL	high-level	[Upper, hi]
	ML	mid-level	[Upper, lo]
	MF	mid-falling	[Lower, hi, contour]
	LL	low-level	[Lower]
	MR	mid-rising	[Lower, lo, contour]

A tone cluster analysis of these facts would assume that Lungtu has two level tones, *H* and *L*. The mid-level tone is an absence of tone and the two contour tones are tone clusters, *HL* and *LH*. The triggering environments for the sandhi rules in (20) would be {*LH*, *L*, *HL*} and {*HL*, *LH*}, respectively. The first set is simply not a natural class of any kind. The second set does appear to be a natural class, namely, the set of contour tones; however, it is unclear what exactly serves as the trigger for tone sandhi here. It appears that the sandhi rule in (20)b is sensitive to the number of tones attached to the following TBU, an undesirable state of affairs assuming we do not wish to endow the grammar with the ability to count. The Contour Tone Unit analysis runs into similar problems as the contour tones are represented by a branching Pitch node, thus requiring the grammar to count the contents of this node.

4.3. Taishan[23]

Taishan (also known as Toisan) is a dialect of Yue, closely related to, although not entirely mutually intelligible with Cantonese. Taishan has the following tonemic inventory:

(22) *Tones in Taishan*

a.	high-level	HL	66	i	‘to give’	ma	‘mother’
b.	high-falling	HF	52	haw	‘back’	ŋut	‘month’
c.	mid-level	ML	44	i	‘to know’	ŋoy	‘I’

d.	low-falling	LF	31	haw	‘thick’	sek	‘stone’
e.	low-level	LL	22	p’i	‘skin’	meŋ	‘name’

As with Cantonese and Lungtu, there are allotonemic checked tones which can be dispensed with in the same manner as above. In addition, there are two morpho-semantically-based rules of tone change, shown in (23). The first of these rules changes a mid-level tone into a low-falling tone. This process has the effect of pluralizing pronouns or deriving nouns from verbs. The other rule suffixes an extra-high level tone, [77], to the syllable. The second rule can apply to any tone except the high-level tone (Cheng, 1973b, Him, 1980). This process is also semantically unpredictable.

(23) *Tone Sandhi in Taishan*

a. ML → LF

i. [ŋoy-44] ‘I’ → [ŋoy-31] ‘we’

ii. [fun-44] ‘to share’ → [fun-31] ‘a share’

iii. [sew-44] ‘to roast’ → [c’a-44 sew-31] ‘roast pork’

b. T → T+EHL, T≠HL

i. [hoŋ-22] ‘sugar’ → [hoŋ-227] ‘candy’

ii. [fuŋ-44] ‘to seal (a letter)’ → [ɬiŋ-44 fuŋ-447] ‘envelope’

iii. [ŋut-31] ‘month’ → [ŋut-317] ‘moon’

iv. [an-52 ko-44] ‘cake’ → [an-527] ‘egg’

Now we can determine the order of feature cuts for Taishan tones. First, each of the falling tones must occupy a separate Register. Furthermore, since there are three level tones, the high-level tone must be in the Upper Register and the low-level tone must be in the Lower Register. This leaves us to determine the Register of only the mid-level tone. Since this tone alternates with the low-falling tone, we posit that the mid-level tone is a Lower Register tone. The fact that the high-level tone is impervious to the second rule suggests that the tone in question being affixed to the syllable is the same high-level tone already part of the tonal inventory. Thus, the concatentation between two HL tones can be ruled out by the OCP. These facts are captured by the contrastive division in Table 6.

Table 6 Register>Pitch>Contour - Contrastive Division for Tones in Taishan

<table>
<tr><td colspan="2">Upper</td><td colspan="3">Lower</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">[contour]</td><td colspan="2">hi</td><td rowspan="2">lo</td></tr>
<tr><td></td><td>[contour]</td></tr>
<tr><td>HL</td><td>HF</td><td>ML</td><td>LF</td><td>LL</td></tr>
</table>

Recall that the process in (23)b is captured by concatenating a floating HL tone creating a tone cluster. The tone change rule in (23)a can be captured by a floating [contour] feature that attaches to the Pitch node as follows. Again, SEM is simply the semantic contribution of the floating [contour] feature.

(24) Pitch SEM

hi [contour]

The rule in (24) will apply only to ML and not to HL, since HL is not specified for Pitch. Note the absence of a Pitch specification on HF. Under the theory of the Contrastive Hierarchy this is not problematic, despite the fact that we argued the Pitch specification was necessary to determine the direction of the contour. The Contrastive Hierarchy determines the underspecification of features necessary to account for the phonological behaviour of segments (and tones, as we are proposing here). Thus, phonetic details (such as [hi] Pitch) are added in the phonetic component.[24] Given that falling tones are less marked than rising tones cross-linguistically (Maddieson, 1978, Zhang, 2002), it is reasonable to propose that falling is the default contour and that rising is marked. Thus a contour tone that does not appear with a Pitch specification is more likely to be a falling tone (though see the discussion on Huojia below).[25] To summarize, we propose the following specifications for Taishan tones.

(25)	HL	high-level	[Upper]
	HF	high-falling	[Upper, contour]
	ML	mid-level	[Lower, hi]
	LL	low-level	[Lower, lo]
	LF	low-falling	[Lower, hi, contour]

A tone cluster analysis of Taishan would posit 3 level tones, *H*, *M*, and *L* from which the two falling tones *HM* and *ML* are formed. The tone change in (23)a would be the result of adding *L* to *M* forming the cluster *ML*. One could argue that high level tones are excluded from this process assuming that contour tones cannot be formed of clusters more than one level apart. Thus, *HL* is an ill-formed cluster. This cannot be correct, however, since *LH* must be available to account for the contour tone in (23)b.i, assuming the tone change in (23)b is simply adding an *H* tone to the cluster already formed. The Contrastive Hierarchy provides a way of accounting for the limited distribution of the tone change in (23)a that the tone cluster approach cannot easily account for.

Consider finally the boldfaced contour tones in the following data.

(26) [fuŋ-44] 'to seal (a letter)' → [ɬiŋ-44 **fuŋ-447**] 'envelope'

(27) [**an-52** ko-44] 'cake' → [an-527] 'egg'

Under a tone cluster analysis, the contour tone in (26) is *MH* and in (27) it is *HM*. Thus there is no fundamental difference between these two tones; however, the approach advocated here suggests there is a fundamental difference. Namely the contour tone in (26) is a true tone cluster, while the contour tone in (27) is unitary. One would hope that this distinction is somehow testable or perhaps has some phonetic correlate; however, this must await future research.

4.4. Huojia[26]

Huojia is a northern dialect of Mandarin, spoken in the Henan province. The tonal inventory is shown in (28) with some examples.

(28) *Tones in Huojia*

a.	high-falling	HF	53	p'u	'universal'	mi	'raw rice'
b.	mid-level	ML	33	tuɤ	'many'	saan	'three'
c.	low-falling	LF	31	fei	'fat'	ʐən	'person'
d.	low-rising	LR	13	p'əŋ	'friend'	pai	'white'
e.	mid-level checked	$\underline{\mathrm{ML}}$	3	paʔ	'eight'	taʔ	'answer'

Although $\underline{\mathrm{ML}}$ is phonetically similar to ML, their phonological behaviour differs in that ML participates in sandhi, while $\underline{\mathrm{ML}}$ does not. LR, on the other hand, also does not participate in sandhi; thus, we propose that $\underline{\mathrm{ML}}$ is an allotone of LR rather than ML. The remaining three tones have the following sandhi pattern shown in Table 7, with examples shown in (29).

Table 7 Tone Sandhi in Houjia

1st tone	2nd tone	33	31	53
33		31-13	31-13	31-13
31		31-13	31-13	31-13
53		53-13	53-13	53-13

(29) *Examples of Tone Sandhi in Huojia*

a. dong-33 ('east') + xi-33 ('west') → dong-31 xi-13 ('width')

b. huang-31 + shu-53 → huang-31 shu-13 (‘squirrel’)

There are two important observations to make from the data in Table 7. First, bisyllabic tone sandhi in Huojia always takes the form of T+T → F+R (a sequence of two tones gives rise to a sequence of a falling and a rising tone). Second, the Register of the first tone is retained. Again, we see Register playing an active role in the phonology. The contrastive division in Table 8, which gives rise to the feature specifications in (30), explains these phenomena.

Table 8 Pitch>Register>Contour - Contrastive Division for Tones in Huojia

<table>
<tr><td colspan="3">hi</td><td>lo</td></tr>
<tr><td>Upper</td><td colspan="2">Lower</td><td rowspan="3">LR (ML)</td></tr>
<tr><td rowspan="2">HF</td><td></td><td>[contour]</td></tr>
<tr><td>ML</td><td>LF</td></tr>
</table>

(30)	HF	high-falling	[Upper, hi]
	ML	mid-level	[Lower, hi]
	LF	low-falling	[Lower, hi, contour]
	LR/ML	low-rising/mid-level checked	[lo]

Although this ranking of feature cuts seems rather unexpected as the feature cut for Pitch is made before that of Register,[27] it readily captures the sandhi behaviour in Huojia. Specifically, only the tones with a [hi] feature participate in the sandhi pattern in Table 7. Furthermore, the Register harmony is easily accounted for by the feature specifications in example (30). Since the mid-level checked and low-rising tones are not specified for Register, they cannot participate in the sandhi based on Register harmony in Table 7. It may seem problematic that the high-falling and low-rising tones are not specified for contour, but this problem is only apparent. The Contrastive Hierarchy provides a way of underspecifying segments and suprasegmentals based on their phonological behaviour. In Huojia, the phonology is sensitive to the Register of tones; consequently, this feature must be appropriately specified on the various tones. Contour does not play a role in the phonology, and is used only to contrast the mid-level and low falling tones. Recall that the Successive Division Algorithm is activated during acquisition to assign features to the phonetic values of segment (or tones in this case) that the child hears. Specifically in the case of Huojia, the child hears a high falling tone, for example, and must decide what feature distinguishes this tone from the others. It just so happens that [contour] doesn't come into play early enough to get assigned *phonologically* to HF, even though phonetically it does have this value.

Notice one particularly welcome result of the Contrastive Hierarchy is that the low-rising tone, while phonetically a Lower Register tone, is not specified as such in the phonology. As a result, this tone does not participate in the Register sensitive sandhi. This fact would remain mysterious in a model of tones that assumed full specification of features or under a tone cluster analysis.

4.5. Hakka[28]

Hakka has the following tonal inventory, shown in (31) and the sandhi rules shown in (32).

(31) *Tones in Hakka*

a.	mid-level	ML 33	si	‘poem’	pi	‘to fly’
b.	low-level	LL 11	si	‘time’	k’ɛm	‘to hide’
c.	mid-falling	MF 42	si	‘to use’	k’ɛm	‘trap door’
d.	high-level	HL 55	si	‘generation’	k’ɛm	‘box’
e.	mid-falling	$\underline{\text{MF}}$ $\underline{21}$	sid̥	‘to recognize’	k’ɛb̥	‘to cover’
f.	high-rising	$\underline{\text{HR}}$ $\underline{45}$	sid̥	‘to eat’	id̥	‘idleness’

(32) *Tone sandhi rules in Hakka*

a. ML → HR / __ {MF, $\underline{\text{MF}}$}

b. LL → LR / __ {MF, $\underline{\text{MF}}$, HL}

Examples of these tone sandhi are given in (33).

(33) *Examples of tone sandhi in Hakka*

a. /ge-ML – lon-MF/ → [ge-HR – lon-MF] “egg”

b. /teu-LL – no-MF/ → [teu-LR – no-MF] “headman”

(32) shows that the high-rising (HR) and low-rising (LR) tones are allotones of the mid-level (ML) and low-level (LL) tones, respectively. Thus, they are not contrastive, and will not figure in the contrastive division. Furthermore, the mid-falling (MF) and mid-falling ($\underline{\text{MF}}$) checked tones are in complementary

distribution, which is highlighted by the fact that they both serve as a trigger in the sandhi rules above. Thus, only the mid-falling tone will figure in the contrastive hierarchy, along with the other tonemes. Note that HR only appears in obstruent-final syllables; however, it is not immediately clear which of the other tones in (31) it is an allophone of. Since it is phonetically similar to HR and HR is an allophone of ML, let us suppose that HR is an allotone of ML. Note that HR cannot be an allotone of HL since HL serves as a trigger in (32)b, but HR does not. Thus, Hakka possesses the following four contrastive tones (tonemes): mid-level (ML), mid-falling (MF), low-level (LL) and high-level (HL).

We turn now to the contrastive division of tonal features in Hakka. First, the mid-level tone could either fall into the Upper Register or the Lower Register. Since ML undergoes sandhi to HR (while LL undergoes sandhi to LR), let us assume that ML is an Upper Register tone. In rule (32)b, the mid-falling tone forms a natural class with the high-level tone, which we expect to be captured by a single feature. The following figure shows the contrastive division necessary to achieve these results.

Table 9 Pitch>Contour & Register - Contrastive Division for Hakka Tones

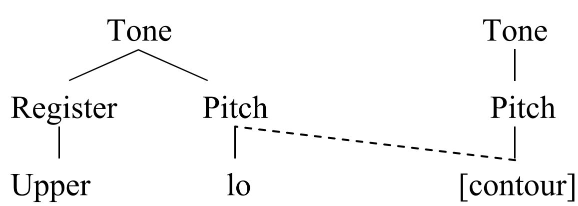
<table>
<tr><td colspan="2">hi</td><td colspan="2" rowspan="2">lo</td></tr>
<tr><td>[contour]</td><td></td></tr>
<tr><td rowspan="2">MF</td><td rowspan="2">HL</td><td>Upper</td><td>Lower</td></tr>
<tr><td>ML</td><td>LL</td></tr>
</table>

As shown in Table 9, the first cut is Pitch. This is followed by cuts for contour and Register, the order of which cannot be determined as only the [hi] tones are specified for contour and only the [lo] tones are specified for Register. The features for the Hakka tones are shown in (34).

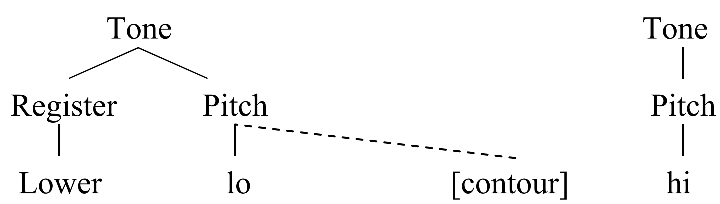
(34) LL	low-level	[Lower, lo]
ML	mid-level	[Upper, lo]
MF	mid-falling	[hi, contour]
HL	high-level	[hi]

The sandhi rules in (32)a can now be understood as the spreading of the feature [contour] to a [lo] Pitch feature. The rule in (32)b can be understood as the insertion [contour] feature, triggered by a [hi] Pitch feature. These two sandhi phenomena are both shown in (35).[29]

(35) a.



b.



Let us consider briefly how these facts would fare under a tone cluster analysis with three level tones – *H*, *M* and *L*. Recall the two sandhi rules in (32) above. These would be analyzed as follows, where *H* and *M* are inserted in (36)a and (36)b, respectively.

(36) Tone sandhi rules in Hakka assuming clusters

a. $M \rightarrow MH$ / __ $\{ML\}$

b. $L \rightarrow LM$ / __ $\{ML, H\}$

The rules in (36) seem rather ad hoc and unnatural. Although one could argue that (36)a breaks up a *MM* sequence in an effort to satisfy the OCP, no such argument can be made for (36)b. Furthermore, recall that the mid-falling and high-level tones form a natural class as they both serve as a trigger for the sandhi rule in (32)b. Under the cluster analysis, this natural class is not captured; however, under the Contrastive Hierarchy analysis, both of these tones do form a natural class which can be exhaustively identified by the feature [hi]. Thus, the current approach is preferable to a tone cluster analysis in that the current approach handles the tone sandhi facts in a more straightforward way and is able to pick out the natural classes required by the sandhi rules.

4.6. Summary

This section has proposed an analysis of the tonal systems in five Chinese languages within the framework of the Contrastive Hierarchy. It was shown that the CTU and tone cluster analyses are problematic for at least some of the languages while the Contrastive Hierarchy, coupled with the model of contour tones proposed in section 2, is capable of accounting for all the languages under consideration. For one, the Contrastive Hierarchy offers a way of underspecifying the tonal features on the tonemes in a way that captures their phonological properties. For instance, the failure of the LR tone to participate in Register harmony in Huojia is captured by the fact that this tone is not specified for any Register feature. Also, the triggering environments of many of the sandhi processes we've seen are easily captured as natural classes identified by a single feature under the approach using the Contrastive Hierarchy. Under the tone cluster or CTU approach, these natural classes are simply not formulable. Thus, we conclude that the Contrastive Hierarchy affords a more descriptively and explanatorily adequate means to account for the observed facts.

5. Conclusion

We have argued against a uniform model for contour tones cross-linguistically, following Yip (1989). Specifically, we argued that contour tones are either tone clusters (mostly in African languages as discussed by Goldsmith (1976) and Leben (1978)) or unitary units (as argued here for Chinese languages), but not Contour Tone Units. For Chinese languages we proposed that contour tones are unitary and are encoded by the feature [contour], which interacts with the value of the Pitch node to produce either a rising or falling tone. Following Yip (2001), the Pitch node specifies the starting pitch of the contour tone, which then moves toward the centre of its register. Specifically, a tone specified with [contour] is a falling tone if Pitch is specified [hi] and a rising tone is Pitch is specified [lo]. We also suggested the possibility that a language could possess both unitary contour tones and tone clusters. Again, based on a suggestion by Yip (1989), we proposed that Taishan was just such a language. Whether both types of contour tones are instantiated in other languages is a matter for future research.

Following the Successive Binary Algorithm of the Theory of the Contrastive Hierarchy, we analyzed the tonal behaviour of various Chinese dialects and were able to account for the phonological patterns by positing varying orders of feature cuts.[30] The Contrastive Hierarchy resulted in a systematic underspecification of tonal features in the languages under consideration. For example, the LR tone in Huojia is underspecified for Register and hence fails to participate in Register harmony. Neither the CTU nor the tone cluster approaches are able to provide a straightforward way to predict the underspecification of tonal features. Nor are these two approaches capable of explaining the observed facts in the languages under consideration. Only the Contrastive Hierarchy and the model of contour tones developed here offer an explanatory account of the tonal phenomena in the Chinese languages discussed here.

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[1] Thus, the Theory of Contrast presented here appeals to emergent rather than universal features. See Mielke (2004) for a detailed discussion.

[2] For instance, Dresher and Zhang (2005) discuss ATR harmony in Manchu and observe that [i], while phonetically ATR does not trigger ATR harmony. They argue that [i] fails to become specified with the feature [ATR] as a result of the SBA (again, to be described below).

[3] This is not to say that tone clusters never occur in natural language. I assume that contour tones in African languages are formed by tone clusters. Also, I show below that tone clusters do occur in Chinese languages in limited environments. Thus, I adopt the position of Yip (1989) that there are two types of contour tones, although the implementation here is considerably different than in Yip's proposal.

[4] The idea that tones, both level and contour, are unitary entities draws heavily on the description of tones in traditional Chinese grammars. See Bao (1990, 1999) for discussion.

[5] The identity of the TBU is a matter of considerable debate. The usual candidates include the mora, the syllable, the segment and the rhyme. See Duanmu (1990) for a good discussion. Since the identity of the TBU does not impinge on our discussion, I remain agnostic on this matter.

[6] For clarity, abbreviations for the names of tonemes are given in capital letters (high level = HL, low falling = LF, etc.) and the level tone components in tone clusters are italicized (high tone = *H*, falling tone = *HL*, etc.).

[7] A reviewer correctly points out that there are analyses in which one part of a contour is argued to behave independently of the whole contour. This is particularly true of various Wu dialects as Yip (1989) mentions. However, it is not clear that contour tones in Wu dialects should be analyzed the same way as in

other Chinese languages. Specifically, Yip suggests that contour tones in Wu dialects, unlike in other Chinese languages, are tone clusters.

[8] Wan and Jaeger (1998) discuss additional data in support of this conclusion, which cannot be presented here for reasons of space.

[9] In examples (5) and (6), and in the rest of the discussion, I use the values [Upper] (U) and [Lower] (L) as values for Register. Similarly, for Pitch I use [high] (h) and [low] (l). I leave aside the issue as to whether binary or privative features are more appropriate for representing tone.

[10] Mortensen (2002) independently arrives at the same conclusion in his analysis of Jingpho tones, for which he also posits the feature [contour].

[11] The following are the rules Chen gives, from Beijing Mandarin and Changting, respectively.

a. $35 \rightarrow 55$ / {35, 55} ___ T, T = any tone

b. $11 \rightarrow 42$ / 24 ___

The sandhi rule in Beijing Mandarin could be argued to be conditioned by register, rather than by the final level tone. Likewise, the Changting sandhi rule could be argued to be contour spreading. I leave this to future research.

[12] Bao (1999: 200-206) discusses the same dichotomy of tonal systems and proposes a Contour Parameter. In the current proposal, the Contour Parameter

corresponds roughly to the presence versus absence of the [contour] feature in the language.

[13] Of course, other languages have contour tones that are plausibly analyzed along the lines suggested here. Vietnamese is an obvious candidate (Pham, 2003), but this will have to wait for future research.

[14] Tone is indicated by the Chao tone letters as follows. The numbers (called tone letters) indicate the relative pitch level of the beginning and end of the tone where 1 is the lowest and 5 is the highest. The use of five levels from 1 to 5 is fairly standard in describing tonal languages, and is attributed to Chao (1930). Underlined numbers indicate a *checked* tone (see footnote 18) and double digits indicate vowel length. Cheng (1973b) augments Chao's 5-point scale, employing a scale from 1 to 7 to transcribe tones in Taishan.

[15] The SBA presented here is actually derived from the Successive Division Algorithm (SDA) which uses the term "n-ary" in place of "binary". The use of the term "n-ary" accounts for polyvalent features, which we do not use here. Of course, in step c the input set, S, would be divided into n sets, not two.

[16] Data are from Matthews & Yip (1994). See Killingly (1985); Kao (1971); Phoon (1976); Bauer & Benedict (1997) for alternative views on the inventory of Cantonese tones.

[17] Recently it has been reported that younger speakers of Hong Kong Cantonese are merging the two rising tones, but with variation in terms of the target of the merger (Bauer et al., 2003). I leave the effect of this merger on the current analysis for future research.

[18] A checked tone is a tone that appears on an obstruent-final syllable.

[19] For a good discussion on this matter, see Bao (1990, 1999). Treating checked tones and non-checked tones as allotones is not uncontroversial. See Chen (2000) and Bauer & Benedict (1997) for discussion.

[20] The most common instance of tone change occurs in reduplication. An adjective or stative verb is reduplicated and is followed by the morpheme *dei-35*. The tone of the reduplicant changes to high-rising (the same tone as the suffix). There are many other occurrences of tone change in Cantonese which follow the same pattern. High-level and high-rising tones do not change. All other tones change to a high-rising tone (Chen 2000: 33).

[21] The Lungtu data are from Egerod (1956). Egerod does not give any specific examples of tone sandhi, but only lists a few lexicalized exceptions that do not undergo obligatory sandhi.

[22] The obligatory rules in (19) can be understood as follows. (19)a is the result of changing the Pitch from [hi] to [lo] in the Upper register, and (19)b is the result of changing [Lower] to [Upper, hi]. (19)c highlights the fact the ML and

HL form a natural class. These facts raise the issue of privative features that were ignored in footnote 9. If [lo] and [Lower] are marked then (19)a can be considered adding the feature [lo] to an unmarked tone while (19)b would be deleting the feature [Lower].

[23] The Taishan data are from Cheng (1973b).

[24] A similar problem arises with the three vowel system described above. Although /u/ is assigned [hi, back], it is not assigned [round], but it still surfaces as [u] and not as [ɯ].

[25] In footnote 9 it was noted that the issue of privative versus binary features would not be worked out here. The discussion on Pitch features here suggests that [lo] might be a privative feature, the absence of which implies what we have been calling [hi] Pitch. See footnote 22 also.

[26] The Huojia data are from Chen (2000) and He (1989). The sandhi facts are a bit more complicated than as presented here, but the generalizations still hold. See He (1989) for details.

[27] It might seem necessary for the feature cut for Register to come before that of Pitch, since Register bisects the tonal space into two levels, which can further be separated by a subsequent specification of Pitch. The small number of languages surveyed here indicates that Register usually is specified earlier than Pitch; however, the opposite order is possible, if called upon. Elan Dresher (p.c.)

likens this scenario to that of vowel height and ATR. Vowels can be specified early on for height, and then be specified more precisely later for ATR. If ATR is specified early, it would seem difficult to arrange the vowels in the vocal space in the absence of height specifications. This problem is only apparent, however, since the Contrastive Hierarchy assigns features based on phonological activity. Later feature specifications will arrange the vowels in the vocal space (and the tones as we discuss here).

[28] The Hakka data are taken from Hashimoto (1973: 103-112) and are representative of the Moi-Yan dialect. Transcriptions have been modified slightly from the original source.

[29] The sandhi rule in (32)b can also be thought of as [contour] spreading as far as the MF trigger is concerned, a much tidier analysis, but one which leaves the HL trigger for this sandhi rule unexplained. One possibility is that the HL tone associates with the LL tone creating a rising tone cluster. This, then, leaves unexplained why a tone cluster cannot form with ML and HL. I leave the problem for future research.

i. TBU TBU

LL HL

[30] A reviewer points out that only three of the six logically possible orders of feature cuts are found in this discussion. Given that only five languages

were discussed, this is not surprising. Although we would expect the order Pitch < Register to be rare, I have argued that it can be found. Significantly more research on many languages would need to be done to determine if any of the three remaining possible orders are truly ruled out.