

## *Contrast and Phonological Activity in Manchu Vowel Systems*

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### 1. THE SIGNIFICANCE OF CONTRAST IN PHONOLOGICAL PATTERNING

In phonology, what is important is not just the substance of a speech sound, but also the other units it contrasts with. An early statement of this view is found in Sapir (1957), who demonstrates that, on the one hand, two languages can look similar in their surface phonetics while differing considerably in their phonological patterning, and that on the other hand, two languages can have a similar set of phonological contrasts with different phonetic realizations. Thus, while two phonetically identical sounds may have different phonological properties by virtue of the different systems of contrast they enter into, it is also possible that two phonetically distinct sounds may be similar in their phonological behaviour because they occupy parallel positions in their systems of contrasts.

Exactly how contrast enters into the picture and how it influences phonological activity have been much-debated questions. This article proposes answers to these questions by looking in detail at the role contrast plays in the patterning of vowel systems in three Manchu languages. We argue that a vowel's phonological status is only partially determined by its phonetic realizations: its patterns of activity also depend on its contrastive feature values. For example, the Written Manchu vowel /i/, while phonetically [Advanced Tongue Root] (henceforth [ATR]), fails to trigger [ATR] harmony, which is otherwise triggered by vowels

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bearing the feature [ATR]. We argue that [ATR] is not a contrastive specification for /i/ in Written Manchu, and thus predictably fails to trigger [ATR] harmony.

Two other vowels also demonstrate the importance of contrast in phonological patterning. The vowel /ə/ has different contrastive representations in different Manchu languages: in the earlier period it patterns phonologically with low vowels, but in the later languages it functions as a non-low vowel. We show that the change in its phonological status is due to a change in the system of contrasts it participates in. In turn, the change in the status of /ə/ has consequences for the high back round vowel /u/. This vowel, which exists in all Manchu languages, behaves in different ways depending on whether it is contrastively [labial] or not.

The account presented here depends on a particular way of arriving at contrastive specifications. Ever since de Saussure (1916), the notion of contrast has been central to linguistic theory. Nevertheless, exactly how one determines whether a particular feature for a particular phoneme is contrastive or redundant remains elusive. We adopt the view that contrastive specifications derive from ordering features into a *contrastive hierarchy* (Jakobson and Halle 1956; Jakobson et al. 1976; Dresher et al. 1994; Dresher 1998a, 1998b, 2003a, 2003b). We propose a particular feature hierarchy for Manchu, and show how it accounts for the synchronic and diachronic patterns of Manchu vowel systems. We show further that our results extend to other languages exhibiting similar types of vowel harmony.

The theory of phonological contrast that we require is not reducible to functional phonetic or perceptual notions. Rather, it has to do with the assignment of phonologically contrastive feature specifications, and not with whether surface contrasts between phones are easy or difficult to perceive. In Written Manchu, for example, the vowel /u/ and its non-ATR counterpart /u/ merge to [u] at the surface in many contexts, making the two vowels phonetically indistinguishable. However, they contrast at the lexical level and in the phonology, and it is important to specify what the contrast consists of.

We introduce the descriptive generalizations concerning the Manchu vowel system, and propose an analysis that makes crucial use of a contrastive feature hierarchy (section 2). We then turn to diachronic evidence (section 3), looking at developments in languages that descended from Written Manchu (or from a language closely related to it). We consider the Manchu languages in the context of a wider typology of languages exhibiting ATR and labial harmony, show how our approach relates to theories of perceptual salience, featural underspecification, and constraint ordering (section 4), and then briefly conclude (section 5).

## 2. THE ANALYSIS OF CONTRAST IN MANCHU VOWELS

We present some background information concerning Manchu languages (section 2.1), and then turn to the phonology of the Written Manchu vowel system (section 2.2). After laying out an initial analysis of the active phonological

features of the vowels of Written Manchu — as evidenced by the processes of ATR harmony, labial harmony, and palatalization (section 2.3) — we consider what sort of theory could provide the required active specifications (section 2.4). We suggest that the active features are those that are contrastive in the vowel system, and argue that a contrastive specification presupposes a particular ordering of features, which fixes the scope of the contrast established by particular features. This leads us to propose a particular feature hierarchy for Written Manchu (section 2.5).

### **2.1. The relation between Written Manchu, Spoken Manchu, and Xibe**

The Manchu languages form the southern branch of the Manchu-Tungus language family, which in turn is a part of the Altaic family (Poppe 1965; Voegelin and Voegelin 1977; Comrie 1981). Written Manchu, also known as Classical Manchu (Ard 1984; Li 1996) or Literary Manchu (Seong 1989), is the language of the documents of the Qing (Ching) dynasty (1644–1911). For linguistic purposes, Written Manchu is a dead language. Its phonetic system, and hence its phonology, can be reconstructed from the Manchu scripts, which were based on the Mongolian scripts.

Written Manchu can be regarded as an old form of Spoken Manchu, which is still a living language, though on the verge of extinction. Spoken Manchu is found in a few areas of Heilongjiang Province of China, part of the former Manchuria. Another living Manchu language is Xibe, also spelled Sibó (Voegelin and Voegelin 1977), Sibe (Norman 1974; Li and Zhong 1986), or Shibo (Matthews 1951). While the other Manchu-Tungus languages of China are distributed in the northeast, the Xibe language is now spoken in the Xinjiang (Sinkiang) Uygur (Uighur) Autonomous Region in northwest China. Historical documents indicate that the Xibe people shared a common ancestor with the Manchu in Manchuria and that they emigrated from Manchuria in the eighteenth century. Based on its phonology and its historical ethnic origins, Xibe can be regarded as a dialect of Manchu (Austin 1962; Norman 1974; Ard 1984) or a colloquial form of Written Manchu (Voegelin and Voegelin 1977). Chinese scholars, however, generally regard Xibe as an independent language that is closely related to Manchu. In this article, we consider both Spoken Manchu and Xibe to be descendants of Written Manchu, or of a language that is closely related to Written Manchu and identical to it in the relevant phonological aspects. See Zhang (1996:6–30) for more information on the Manchu-Tungus languages.

### **2.2. The vowel system of Written Manchu**

The vowel system of Written Manchu is given in (1).

(1) *Written Manchu vowel system* (Zhang 1996):

i	u
e	o
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ə	ɔ
a	

The chart in (1) represents a partial phonological analysis of the Written Manchu vowel system. It indicates that Written Manchu has six contrastive vowel phonemes. The horizontal line divides the vowels into two height classes: a set of relatively high vowels above the line, and a set of relatively low vowels below the line. This division into two contrastive heights is not obvious from the phonetics: phonetically, one might suppose that Written Manchu has four or five different heights.

The important distinction between /u/ ~ /ʊ/ and /ə/ ~ /a/ has to do with the tongue root: the first vowel in each pair is ATR, the second is not (Zhang 1996). ATR vowels tend to be higher than their non-ATR counterparts, thus accounting for the difference in height that accompanies the ATR contrast.<sup>1</sup>

The chart in (1) suggests that the horizontal division into two height groups is a fundamental contrast in the Manchu vowel system, and this suggestion is supported by the way the vowels pattern in the grammar. We therefore suppose that the vowels below the line in (1) are specified for the feature [low], while the vowels above the line are non-low. (Alternatively, we could choose the feature [high]; as there are only two height classes, [αlow] is equivalent to [-αhigh].)

To further understand the phonological patterning of the Written Manchu vowel system, we survey all the phonological processes that the vowels enter into, as far as these can be recovered from the written scripts. Zhang (1996) identifies three such processes: two different harmony processes, and palatalization of preceding consonants caused by /i/. We review these processes, and then consider how we might account for them.

<sup>1</sup>Li (1996:157) proposes a similar vowel system for Written Manchu (Classical Manchu). Many Western scholars have assumed that Manchu vowel harmony is based on a front-back distinction (Vago 1973; Odden 1978; Finer 1981) with the reconstructed vowel system in (i); or that it is a kind of height harmony (Hayata 1980; Ard 1984), with the reconstructed vowel system in (ii).

(i) *Written Manchu: Front-back harmony*    (ii) *Written Manchu: Height harmony*

i	y	u	i	u
e	a	o	ə	o
			a	ɔ

We believe these accounts are incorrect; for discussion, see Zhang (1996:69–72).

## 2.2.1. ATR harmony in Written Manchu

In Written Manchu, all vowels in a word, apart from /i/, must agree with respect to ATR. This harmony is most clearly seen in the case of /ə/ and /a/: suffixes with these vowels alternate depending on the ATR value of the stem vowels, as in (2).

(2) ATR harmony in Written Manchu /ə/ ~ /a/<sup>2</sup>

a.	xəxə	'woman'	xəxə-ŋgə	'female'
	aga	'rain'	aga-ŋga	'of rain'
	t'ɔn	'number'	t'ɔ-ŋga	'few, rare'
b.	susə	'coarse'	susə-tə-	'make coarsely'
	χuryxa	'fishing net'	χuryxa-ta-	'catch in a net'
c.	xət'u	'stocky'	xət'u-kən	'somewhat stocky'
	farχun	'dark'	farχu-qan	'somewhat dark'

Similarly, /u/ alternates with /ʊ/, as in the suffixes in (3).

## (3) ATR harmony in Written Manchu: /u/ ~ /ʊ/

a.	xərə-	'ladle out'	xərə-ku	'ladle'
	paqt'a-	'contain'	paqt'a-qu	'internal organs'
b.	səxəxun	'vertical'	səxə-xuri	'towering high'
	laqtaχun	'drooping'	laqta-χuri	'fully drooping'

However, this alternation between /u/ and /ʊ/ is apparent only after back consonants, as in the examples in (3). The back (dorsal) consonants manifest an alternation depending on the [ATR] value of the following vowel: velars [k, g, x] are found before ATR vowels, including [u], and uvulars [q, ɢ, χ] are found before non-ATR vowels, including [ʊ]. This consonantal alternation is purely allophonic. Presumably, the [ATR] distinction between /u/ and /ʊ/ is further supported by the phonetic velar ~ uvular distinction in the preceding back consonants. In other contexts, /u/ and /ʊ/ merge at the surface into [u], except for a few sporadic examples. This seems to be a late phonetic rule, since it does not affect the behaviour of /ʊ/ with respect to ATR harmony, as shown in (4).

## (4) ATR harmony with /ʊ/ not before velar/uvular consonants:

tulpa	'careless'	tulpa-ta-	'act carelessly'
tat'ʂun	'sharp'	tat'ʂu-qan	'somewhat sharp'

In each word in (4) the vowel that surfaces as [u] patterns with non-ATR vowels; compare the forms in (2b) and (2c). We suppose that [u] in (4) derives from /ʊ/, which merges with /u/ in these environments.

<sup>2</sup>Unless otherwise specified, the Written Manchu data in this article are taken from Zhang (1996). Like much of the literature on Written Manchu, Zhang employs a conventional set of graphemic correspondences to represent Manchu sounds. In this article we adopt transcriptions that more closely approximate phonetic values; thus, we write ə instead of <e>, x instead of <h>, and so on. See Zhang (1996:32) for discussion and a detailed table of correspondences.

Let us now consider the vowel /i/. Phonetically, this vowel is ATR, and we might expect it to co-occur only with ATR vowels. But we find that when /i/ is in a position of undergoing harmony, it co-occurs with all vowels. The examples in (5a) show /i/ in a suffix that co-occurs with ATR as well as with non-ATR, and the examples in (5b) show the transparency of /i/ to ATR harmony.

(5) *ATR harmony in Written Manchu: /i/ is neutral:*

a.	əmt'ə	'one each'	əmt'ə-li	'alone; sole'
	taɣa-	'follow'	taɣa-li	'the second'
b.	pəki	'firm'	pəki-lə	'make firm'
	paqtɕ'in	'opponent'	paqtɕ'i-la-	'oppose'

Surprisingly, when /i/ is in a position to trigger harmony, it occurs only with non-ATR vowels, as in (6).

(6) *Stems with only /i/: Suffixes with non-ATR vowels*<sup>3</sup>

fili	'solid'	fili-qan	'somewhat solid'
itɕ'i	'direction'	itɕ'i-ŋga	'having direction'
ili-	'stand'	ili-ɣa	'stood'
tɕili	'anger'	tɕili-ta-	'get angry'
sifi-	'stick in the hair'	sifi-qu	'hairpin'
tɕ'ipsi	'lament'	tɕ'ipsi-ta-	'to lament incessantly'
tɕ'iltɕ'i	'swelling, boil'	tɕ'iltɕ'i-na-	'to form a boil, swelling'
tɕ'ili-	'to choke'	tɕ'ili-qu	'choking'
fisin	'thick'	fisi-qan	'somewhat thick'
isi-	'to suffice'	isi-ŋga	'sufficient'
kiri-	'to endure'	kiri-qu	'endurer'
lipki-	'to be worn out'	lipki-ɣa	'(horses) worn out'
sitɕin	'line'	sitɕi-ra-	'make straight'
silxi	'envy'	silxi-ta-	'to envy'
		silxi-ŋga	'envious, jealous'
simi-	'to suck'	simi-ɣa	'sucked'
sisin	'intake, insertion'	sisi-ŋga	'having a large intake'

Historically, Manchu might have had both an ATR vowel /i/ and a non-ATR vowel /i/ phonemically. Probably because the contrast between /i/ and /i/ had been neutralized by the time the Manchu script system was invented, only one invariant Manchu script form, transliterated by the Roman letter <i>, was used to represent this merged sound.<sup>4</sup> The examples in (6) are incompatible with the idea that there are two distinct phonemes in Written Manchu that surface as [i], one ATR and the

<sup>3</sup>Data in (6) that are not found in Zhang (1996) are taken from Norman (1978).

<sup>4</sup>Binnick (1991:41) observes that the contrast between /i/ and /i/ is preserved in the Turkic sub-family of Altaic, but is lost in some Mongolian and Tungusic languages. Qingertai (1982:216) claims that /i/ and /i/ are usually the first pair of vowels in the inventory to undergo neutralization, based on evidence from dialects of Mongolian, Manchu, Finnish, and Hungarian.

other non-ATR. There appears to be only one /i/ phoneme which, contrary to its surface appearance, behaves with respect to harmony as non-ATR.<sup>5</sup>

### 2.2.2. Palatalization of consonants by /i/

The vowel /i/ is distinguished in another way, in that it provokes the palatalization of neighbouring consonants (Zhang 1996:84). There is some disagreement as to whether all or only some consonants are palatalized, but the outcome of this dispute is not crucial to our analysis.<sup>6</sup> Also relevant here is the behaviour of dorsal consonants. Recall that these consonants surface as velar when in [ATR] words and as uvular in words which lack an [ATR] specification. However, before /i/, dorsal consonants always surface as velar, even in words lacking [ATR]; see, for example, *kiri-*, *lipki-*, and *silxi-* in (6). Preceding /ə/ and /u/, the velar quality of the consonants is presumably derived by spreading [ATR] from the vowel. We

<sup>5</sup>There are a few examples in the literature that contradict our claim that /i/ in stems of Written Manchu does not trigger ATR harmony. Vago (1973:585) presents a word *ilhi-ŋge* 'next in order', which is also cited in Odden (1978), Hayata (1980), and Finer (1981). The vowel we represent as 'i' is often transcribed as <e>; we transcribe <h> as x. This example, however, cannot be found in Norman (1978) or in the Chinese literature available to us. Li (1996:162, 165) provides the following examples:

(i) *Stems with only /i/ + ATR suffix:*

- a. *bi-he* 'to exist'    b. *ji-he* 'to come'    c. *pi-le* 'to criticize' [Chinese loan word]

In Norman (1978), the Chinese loan word *pi-le* [p'i-lə] is listed as '*pile-*': the second syllable is part of the stem, not a suffix. As for the verbs *bi-he* [pi-xə] and *ji-he* [tʃi-xə], they are on the list of 'irregular' verbs in Written Manchu as discussed by Aixinjueluo (1983) and Ji et al. (1986). They are irregular not only in the suffixes they take in terms of vowel harmony, but also in that they take different suffix forms from other verbs. Compare the suffixes *bi-* and *ji-* [tʃi-] take (iib) with those of the 'regular' verbs in (iia). Note that the past tense form *bi-xə* cannot be found in Norman (1978) and other Chinese literature available to us.

(ii) *Irregular suffixes with bi- [pi-] and ji- [tʃi-]:*

Verb stem	Past	Future	Imperative	Gloss
a.	ara-	ara-χa	ara-ra	ara 'do, make'
	x'ntu-	x'ntu-x'	x'ntu-r'	x'ntu 'say, speak'
	sontʃo-	sontʃo-χo	sontʃo-rə	sontʃo 'choose'
b.	pi-		pi-sir'	pi-su 'exist'
	tʃi-	tʃi-x'	tʃi-t'r'	tʃi-o 'come'

<sup>6</sup>Odden (1978), Hayata (1980), and Ard (1984) claim that /i/ caused the palatalization of all consonants. Ji (1987) and Ji et al. (1989) claim that only three consonants, [ʃ], [tʃ'], and [tʃ], are palatalized before /i/.

have seen, however, that /i/ does not spread an [ATR] specification. Zhang (1996) proposes that velar consonants before /i/ in words lacking [ATR] are actually due to palatalization. That is, such consonants are technically palatalized uvulars, which are not distinct from velars in the Manchu scripts.

### 2.2.3. Labial harmony

Another vowel harmony process in Written Manchu is labial harmony (Zhang 1996; Zhang and Drescher 1996; Walker 2001). A suffix vowel /a/ becomes /ɔ/ if preceded by two successive /ɔ/ vowels, as in (7a).<sup>7</sup> Thus, labial harmony is not triggered by a single short or long /ɔ/, as in (7b), nor by the high round vowels, as in (7c, d).

#### (7) Labial harmony in Written Manchu:

a.	poṭṣ'᠔	'colour'	poṭṣ'᠔-ᠢᠭ᠐ᠭ	'coloured'
	fəχɔlon	'short'	fəχɔlo-qən	'somewhat short'
b.	tɔ-	'alight (birds)'	tɔ-na-	'alight in swarm'
	tɔɔ-	'cross (river)'	tɔɔ-na-	'go to cross'
c.	gulu	'plain'	gulu-kən	'somewhat plain'
	kumun	'music'	kumu-ᠢᠭᠭ᠎ᠠ	'noisy'
d.	χutun	'fast'	χutu-qan	'somewhat fast'
	tursun	'form'	tursu-ᠢᠭᠠ	'having form'

### 2.3. An analysis of the Written Manchu vowel system

Let us now consider how we might account for the phonological processes surveyed above. In particular, why does /i/ not trigger ATR harmony? And why does it nevertheless co-occur with ATR vowels, and cause palatalization of consonants? Why is labial harmony triggered only by /ɔ/ and not by /u/ or /ʊ/?

One option is simply to stipulate these restrictions: our analysis can specify that ATR harmony is triggered only by /ə/ and /u/, that palatalization is caused by /i/, and that labial harmony is triggered by /ɔ/. This is essentially the null hypothesis, and under this hypothesis we would not expect to find any correlation between these facts and the make-up of the Written Manchu vowel inventory. However, such a correlation does exist, as we show, disconfirming the null hypothesis.

By hypothesis, segments are made up of distinctive features and participate in phonological processes by virtue of their feature specifications. Of the various features that potentially characterize a segment, let us define as *active* those specifications for which we have positive evidence based on participation in phonological processes. In this section we investigate which vowel feature specifications are active in Written Manchu.

<sup>7</sup>For discussion of this condition on labial harmony see Zhang and Drescher (1996), and Walker (2001).



We have observed that the Written Manchu vowels are distributed into two height classes. Labial harmony and ATR alternations are limited to vowels in the same height class. Therefore, a height feature must be active in the phonology, which we have designated as [low]. In this case we have no direct evidence that the marked feature is [low] rather than [high], but nothing in our analysis depends crucially on this choice. What is important is that one height feature is active, and there is no evidence for any further active height distinctions.

Based on the patterns of ATR harmony, the feature [ATR] appears to be the active (or marked) feature: in the absence of harmony, suffixes with non-ATR vowels surface.<sup>8</sup> Vowels that have the feature, namely /ə/ and /u/, spread it to their right, as in (2) and (3); vowels that lack the feature may receive it from a vowel to their left, and may then pass it on, but do not initiate ATR harmony themselves.<sup>9</sup> We assume that dorsal consonants can also receive [ATR], in which case they surface as velars; dorsal consonants that are not [ATR] surface as uvulars. Evidently, /i/ has no active [ATR] feature, because it does not trigger ATR harmony, shown in (6). When /i/ follows an [ATR] vowel, it does not block spreading of [ATR] to a following vowel, shown in (5b). It is not easy to tell if /i/ receives an [ATR] specification in the context of ATR harmony. Assigning [ATR] to /i/ during ATR harmony would create no perceptible difference, because all /i/ vowels in any event become phonetically ATR.<sup>10</sup>

There is positive evidence that /i/ has a specification that provokes the palatalization of neighbouring consonants. We assume that the relevant feature is [coronal].<sup>11</sup> No other vowel is phonetically coronal or shows evidence of an active specification for this feature.

In order to trigger labial harmony, the [low] vowel /ɔ/ must have an appropriate feature, which we assume to be [labial]. However, there is no evidence from labial harmony, or from any other process, that the high back vowels /u/ and /ʊ/ have an active [labial] feature.

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<sup>8</sup>We disagree with Li (1996), who posits that [RTR] (Retracted Tongue Root) is marked in Written Manchu; see also Zhang and Drescher (2004) for further discussion.

<sup>9</sup>The assumption that [ATR] is a privative feature provides the simplest and most minimal account of ATR harmony in Manchu. An account in which [ATR] has both positive and negative values can also be constructed, as long as [+ATR] is the active value. As will become clear below, the contrastive status of the designation of /i/ with respect to the [ATR] feature is more fundamental to our account than whether it is specified or not.

<sup>10</sup>We argue below that [ATR] is not a contrastive feature of /i/. Not allowing /i/ to take on the specification [ATR] in the lexical phonology would thus be consistent with Structure Preservation (Kiparsky 1985).

<sup>11</sup>We use the term [coronal] as interchangeable with [front], and [labial] as interchangeable with [round] when applied to vowels. We take no stand here on whether vowels and consonants share a unified set of place features. For discussion, see Clements and Hume (1995); Halle et al. (2000); and Rice (2002).

Our brief survey of the phonology of Written Manchu vowels has revealed that four vowel features are required to be active in the phonology: a height feature, which we call [low], two place features, [coronal] and [labial], and a tongue root feature, [ATR]. The active values of these features are shown in (8).

(8) *Feature matrix for Written Manchu vowels: Active feature values*

Phoneme	/i/	/u/	/ʊ/	/ə/	/a/	/ɔ/
[low]				✓	✓	✓
[coronal]	✓					
[labial]						✓
[ATR]		✓		✓		

The question to be answered is whether there is anything special about the specifications in (8), compared to the specifications that are absent. That is, are the active feature values an arbitrary set, as posited by the null hypothesis, or do they follow in a principled way from something in the phonology of Written Manchu?

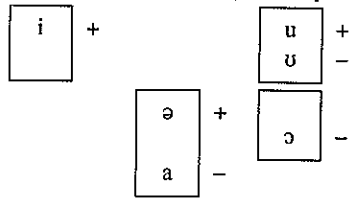
There are two distinct sources of absent feature values in (8). The first is due to the fact that only one value for each feature is specified. We can interpret this result in two ways. One is that the features are privative, having only one value available for specification. Another possibility is that the features are binary, having plus and minus values, but that only one value for each feature is phonologically active, or marked, the other value being inert. Either interpretation is consistent with the Manchu data observed above, and we do not attempt to choose between them here.

There is a second source of absent specifications in (8), because privativity, whether literal or apparent, does not account for all the missing values. In particular, /i/ is not specified [ATR], and /u/ and /ʊ/ are not specified [labial]. These specifications are not absent due to privativity, because the vowels in question potentially carry the active values. It is the inertness or absence of these values that is our particular interest in this article.

The motivation for leaving these values blank has so far been empirical: doing so gives the most economical—hence, arguably the best—account of the phonological patterning of the Written Manchu vowels. What we require now is a theory that explains why precisely these specifications are omitted, whereas other values of [ATR] and [labial] are specified. Our claim is that the distinction is bound up with the notion of contrast: the specified values in (8) are all contrastive values, whereas the missing values that are not due to privativity are redundant values. However, it is not obvious what the principled basis is for deciding which values are contrastive and which are redundant. How are contrastive values assigned? It is to this topic that we now turn.

#### 2.4. A hierarchical theory of contrastive features

Consider again the chart of Written Manchu vowels in (1). With respect to the feature [ATR], we can identify four sets of vowels, as indicated in (9).

(9) *Written Manchu: Sets of [ATR] partners*

Two of the sets have contrasting [ATR] and non-ATR vowels; the other two sets contain only one vowel each: /i/, a potentially [ATR] vowel in terms of its phonetics, and /ɔ/, which occurs with non-ATR vowels. Thus, the latter two vowels do not have a partner with respect to their value for [ATR]. Intuitively, then, we might suppose that this lack of a partner, or counterpart, has something to do with /i/'s lack of participation in ATR harmony.

In other words, the vowels that trigger and undergo ATR harmony are just the ones for which [ATR] is a contrastive feature. In the case of /i/, the specification [ATR] is redundant, as it does not serve to distinguish /i/ from other phonemes in the language. The failure of /i/ to trigger ATR harmony would follow if only contrastive features could be active in the phonology, a hypothesis we list in (10). A corollary of (10) when applied to vowel harmony is given in (11).

(10) *Contrast and phonological activity:*

Only contrastive feature values are active in the (lexical) phonology.

(11) *Contrast and vowel harmony:*

Only segments with a contrastive specification for a feature [F] can trigger harmony based on [F].

The notion that contrastive feature specifications play a special role in phonology is not new; it has appeared and reappeared in various forms throughout the last century (Jakobson and Halle 1956; Jakobson et al. 1976; Trubetzkoy 1969; Twaddell 1957). What has not been well understood is how one determines which features are contrastive in any given phoneme, or, in terms of (9), what the partners are with respect to any particular feature. Assignment of partners may appear to be obvious, especially once one draws the inventory as in (9), but such diagrams can be misleading.

In particular, one might suppose that a feature is redundant in a segment if it is predictable in that segment, given all the other feature specifications and knowledge of the inventory. We can call this *logical redundancy*, as defined in (12).

(12) *Logical redundancy:*

If  $\Phi$  is the set of feature specifications of a phoneme, P, then the feature specification [F] is logically redundant iff it is predictable from the other specifications in  $\Phi$ . (Dresher 1998b)

Logical redundancy cannot be the criterion for deciding whether a specification is *phonologically* redundant, however (Dresher 1998b, 2003a). Consider the

fully specified binary specifications for the four active features we have identified above, shown in (13).

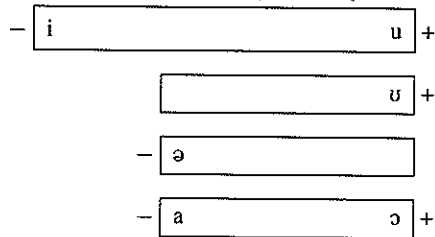
(13) *Feature matrix for Written Manchu vowels: Fully specified binary features*

Phoneme	/i/	/u/	/ʊ/	/ə/	/a/	/ɔ/
[low]	-	-	-	+	+	+
[coronal]	+	-	-	-	-	-
[labial]	-	+	+	-	-	+
[ATR]	+	+	-	+	-	-

We cannot remove all the logically redundant features at the same time. For example, /i/ is the only [+coronal] segment, so all its other features are predictable, hence logically redundant. But the specification [+coronal] can itself be predicted from the specifications [-low, -labial], which uniquely pick out /i/ in this inventory. Similarly, /u/ and /ʊ/ require only one place/timbre feature to distinguish them from /i/: [-low, +labial] implies [-coronal], and [-low, -coronal] implies [+labial]. Therefore, both [-coronal] and [+labial] are logically redundant, but not simultaneously; one of them must be retained.

Thus, there are typically more logically redundant features than can be removed while still maintaining sufficient specifications to distinguish all the phonemes from each other. For the same reason, we can often draw several incompatible diagrams along the lines of (9). For example, the diagram in (14) identifies possible labial partnerships.

(14) *Written Manchu: Sets of [labial] partners (incorrect)*



This diagram identifies two sets of labial partnerships, that is, minimal pairs differing only in their specification for [labial]. While labial harmony shows that /ɔ/ is indeed the labial counterpart of /a/, there is no such relation between /u/ and /i/: as we have seen, there is no evidence /u/ has an active [labial] specification in the phonology of Written Manchu. Moreover, we have seen that the contrast between /i/ and /u/ can equally be characterized by the feature [coronal], making [labial] redundant for this pair.

The diagrams in (9) and (14) are attempts to discover which feature values are contrastive for the vowel phonemes of Written Manchu. Contrastiveness, however, does not simply emerge from such diagrams, because inventories can be arranged in different ways. The key to resolving these apparent paradoxes is to recognize that contrast depends on an ordering of features, which determines the

contrastive scope of each feature. In the example (13), [coronal] is contrastive for the pair /i u/ and [labial] is redundant if [coronal] is ordered before [labial] (notated [coronal] > [labial]). If [labial] > [coronal], then [labial] is contrastive and [coronal] is redundant.

The idea that feature specifications are governed by a hierarchical ordering of features goes back to the work of Jakobson and his collaborators in the 1950s (Cherry et al. 1953; Jakobson and Halle 1956; Halle 1971; Jakobson et al. 1976; see Dresher 2002 for discussion). On this view, contrastive (or distinctive) feature specifications are determined by splitting the inventory by means of successive divisions, governed by an ordering of features. An algorithm corresponding to this idea, which we call the Successive Division Algorithm, is given in (15). The basic idea is that we start by assuming that all sounds form one phoneme. This primordial allophonic soup is divided into two sets by whichever distinctive feature is selected first. We assume that the ordering of the features is given partly by Universal Grammar, and partly by language-particular evidence. We keep dividing up the inventory into sets, applying successive features in turn, until every set has only one member.

(15) *Successive Division Algorithm* (Dresher 2003b):

- a. In the initial state, all tokens in 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 (i.e., not previously tried)  $n$ -ary feature, [F], from the set of distinctive features. [F] splits members of the input set, S, into  $n$  sets,  $F_1 - F_n$ , depending on what value of [F] is true of each member of S.
- d. i) If all but one of  $F_1 - F_n$  is empty, then loop back to (c).  
ii) Otherwise, [F] is *contrastive* for all members of S.
- e. For each set  $F_i$ , loop back to (b), replacing S by  $F_i$ .

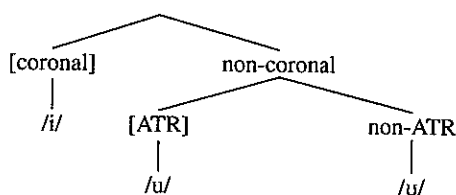
It can be shown (Dresher 1998b, 2003a, 2003b) that this approach to defining which feature values are contrastive is the only viable one that has been proposed. Unlike some other approaches based on logical redundancy, the Successive Division Algorithm gives different results depending on the ordering of features. Minimal pairs are not the starting point of the procedure, but rather emerge from the particular contrastive hierarchy that is adopted. Like Jakobson and Halle (1956), we assume that the contrastive hierarchy may vary from language to language, though no doubt within limits that need to be determined. We take the question of what the contrastive hierarchy is for each language to be an empirical one. How learners determine that there are contrasting phonemes, and how they arrive at the feature hierarchy for their language, are learnability issues that are independent of whether or not our account is descriptively adequate. In the

following section, we show how the Successive Division Algorithm derives the active specifications for Written Manchu that we arrived at in (8).

### 2.5. The contrastive hierarchy in the Written Manchu vowel system

We have observed that the vowels /ə/ ~ /a/ and /u/ ~ /ʊ/ are distinguished by [ATR], but that /i/ is not contrastively [ATR]. Since /i/ is phonetically [ATR], its lack of such a specification in the phonology must be due, on the approach taken here, to its contrastive status. We have also seen that /i/ is specified for [coronal]. Considering the relative scopes of these features, it must be the case that [coronal] takes scope over [ATR]. For then /i/, which is the only [coronal] vowel, would already be distinguished from all other vowels, and so would not be eligible to receive any further contrastive specifications, including [ATR]. On this ordering, the feature [ATR] is needed in the non-low vowels only to distinguish /u/ from /ʊ/, as shown in (16).

(16) *Written Manchu non-low vowels*: [coronal] > [ATR]



By the same token we can establish that [coronal] must take precedence over [labial]. For if [labial] > [coronal], then the back vowels in (16) would be designated as [labial], and /i/ would not require any further specification, including [coronal]. The ordering [coronal] > [labial] gives us the desired specifications.<sup>12</sup>

The fact that labial harmony is confined to the low vowels suggests that the height contrast is more fundamental than the labial contrast: labial harmony operates within a domain defined by the feature [low]. In terms of our theory of successive contrastive divisions, this suggests that the feature [low] has wider scope than [labial]. Moreover, if [labial] > [low], then the high back vowels would incorrectly receive [labial] specifications, in contrast with non-labial /a/ and /ə/. Therefore, we can establish that [low] > [labial].

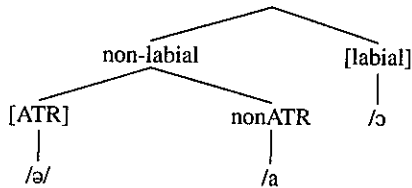
Let us now consider the [low] region. Recall that there is evidence that /ɔ/ is [labial], because it triggers labial harmony. Moreover, there is no evidence that any of the [low] vowels are [coronal]. Evidently, the feature [coronal] is not contrastive among the [low] vowels because none of these vowels meet the requirements for being [coronal]. Therefore, [coronal] applies vacuously in the

<sup>12</sup>If [labial] > [coronal], /i/ could still be specified for [coronal] if [labial] and [coronal] both took scope over [low]; for then /i/ could be [coronal] in contrast to the other low vowels that are neither [coronal] or [labial]. However, the hierarchy [labial] > [coronal] > [low] does not work for Written Manchu, because we require [low] > [labial].

[low] region, failing to make any contrasts there, and so the way is open for [labial], the next feature in the hierarchy, to be assigned to /ɔ/.

The sets of [ATR] partners in (9) suggest that [labial] > [ATR]. For then [ATR] is relevant only to /ə/ and /a/ among the [low] vowels, as shown in (17).

(17) *Written Manchu* [low] vowels: [labial] > [ATR]

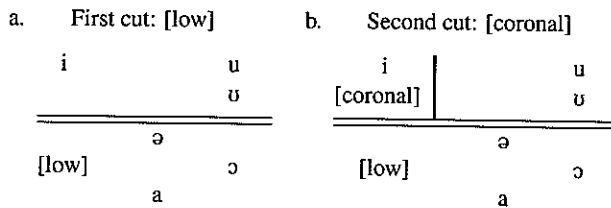


Finally, we have not seen any evidence concerning the relative scopes of [low] and [coronal]. Given that *Written Manchu* has only one potentially [coronal] vowel, /i/, we obtain the same results with either [low] or [coronal] taking precedence. Zhang has observed that a two-height system is very stable across all the Manchu-Tungus languages surveyed in Zhang (1996), suggesting that the division into two height classes is a basic property of these vowel systems. This provides support for the ordering [low] highest.<sup>13</sup> Thus, we arrive at the *Written Manchu* contrastive hierarchy shown in (18).<sup>14</sup> The successive contrasts by which the *Written Manchu* vowel space is divided are displayed in (19).

(18) *Written Manchu* contrastive hierarchy:

[low] > [coronal] > [labial] > [ATR]

(19) *Written Manchu*: Contrasts in the vowel system



<sup>13</sup>This order is in keeping with Jakobson and Halle (1956), who propose that the first split in the vowel space is between vowels of higher sonority and vowels of lower sonority. Similarly, Trubetzkoy (1969) observes that there are vowel systems that have height distinctions but no place or timbre distinctions, while there are no systems without height distinctions. Ghini (2001), however, proposes that place contrasts precede height contrasts.

<sup>14</sup>This hierarchy does not incorporate any notions of dependency between features beyond those that are given by the ordering of the features. Ghini (2001) proposes that [labial] must be a dependent of a place feature. It is an empirical question whether the theory should be modified to incorporate such dependencies.

c. Third cut: [labial]	d. Fourth cut: [ATR]																														
<table style="border-collapse: collapse; margin: auto;"> <tr> <td style="padding: 5px;">i</td> <td style="border-left: 1px solid black; width: 20px;"></td> <td style="padding: 5px;">u</td> </tr> <tr> <td style="padding: 5px;">[coronal]</td> <td style="border-left: 1px solid black;"></td> <td style="padding: 5px;">u</td> </tr> <tr> <td colspan="3" style="border-top: 1px solid black; border-bottom: 1px solid black;"></td> </tr> <tr> <td style="padding: 5px;">[low]</td> <td style="border-left: 1px solid black; padding: 5px;">ə</td> <td style="padding: 5px;">ɔ</td> </tr> <tr> <td></td> <td style="border-left: 1px solid black; padding: 5px;">a</td> <td style="padding: 5px;">[labial]</td> </tr> </table>	i		u	[coronal]		u				[low]	ə	ɔ		a	[labial]	<table style="border-collapse: collapse; margin: auto;"> <tr> <td style="padding: 5px;">i</td> <td style="border-left: 1px solid black; width: 20px;"></td> <td style="padding: 5px;">[ATR] u</td> </tr> <tr> <td style="padding: 5px;">[coronal]</td> <td style="border-left: 1px solid black;"></td> <td style="padding: 5px;">u</td> </tr> <tr> <td colspan="3" style="border-top: 1px solid black; border-bottom: 1px solid black;"></td> </tr> <tr> <td style="padding: 5px;">[low]</td> <td style="border-left: 1px solid black; padding: 5px;">[ATR] ə</td> <td style="padding: 5px;">ɔ</td> </tr> <tr> <td></td> <td style="border-left: 1px solid black; padding: 5px;">a</td> <td style="padding: 5px;">[labial]</td> </tr> </table>	i		[ATR] u	[coronal]		u				[low]	[ATR] ə	ɔ		a	[labial]
i		u																													
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	a	[labial]																													

This analysis results in the feature specifications we arrived at in (8). We are now in a position to say what is special about these specifications: they are precisely the privative contrastive specifications under the feature ordering in (18). Recall that we originally arrived at the values in (8) using the criterion of phonological activity: we specified only values for which there is direct evidence from phonological processes, in this case, from ATR harmony, labial harmony, and palatalization. Now we see that these very same values are also contrastive under the ordering in (18).

At this point a potential objection arises. Since the ordering of features can vary, one might suppose that it should be possible to find a set of contrastive values to match any set of specifications. If that were so, the relation between activity and contrast would not be empirical, but stipulative. However, this is not at all the case. Consider, for example, the Written Manchu non-low vowels /i u ʊ/. Readers can verify for themselves that there is no possible contrastive hierarchy that would make these contrastively non-low while assigning [coronal] to /i/ and [labial] to /u/ and /ʊ/. Thus, there is no logical necessity for the set of active specifications to correspond to *any* set of contrastive specifications. The fact that there is such a correspondence supports the empirical hypothesis given in (10) that phonologically active features are contrastive.

Written Manchu is not unique in this regard. The above analysis and approach to contrast and phonological activity is supported in striking fashion by diachronic developments that gave rise to the modern Manchu languages, as well as by their synchronic phonology.

### 3. DIACHRONIC DEVELOPMENTS: FURTHER EVIDENCE FOR THE ANALYSIS

Our analysis of the Written Manchu vowel system is based on a particular set of contrasts. When the system is disturbed, for example by the loss of a vowel, the system of contrasts is liable to be reanalyzed. If the hypothesis about the relation between contrast and phonological activity is correct, we expect to see concomitant changes in the phonology. We show that differences between Written Manchu and the modern languages, Spoken Manchu and Xibe, can be explained in terms of a realignment of the system of contrasts, provoked by the loss of a vowel from the inventory. Patterns of phonological activity in these languages provide dramatic further evidence for our analysis.



### 3.1. The Spoken Manchu vowel system

Spoken Manchu is a later form of Written Manchu, and it displays some interesting continuities with the older form of the language, as well as some notable differences that shed further light on the role of contrast in phonology.

The vowel system of Spoken Manchu is presented in (20).

(20) *Spoken Manchu* (based on Ji et al. 1989; Zhao 1989):

i	y	ə	u
ɛ		a	ɔ

In comparing this vowel system with that of Written Manchu in (1), we note a number of differences, which we tabulate in (21).

(21) *Differences between Written Manchu and Spoken Manchu vowel systems:*

- a. Spoken Manchu no longer has a phoneme /ʊ/ that contrasts with /u/.
- b. In Spoken Manchu /ə/ is a non-low vowel, in Written Manchu it is a low ATR counterpart to /a/.
- c. Spoken Manchu has added coronal phonemes /y/ and /ɛ/.

We argue that change (21b) follows from (21a), and (21c) follows from (21b). We begin with the first change.

We observed that in Written Manchu the contrast between /u/ and /ʊ/ is already neutralized phonetically to [u] in most contexts, with surface [u] surviving only after uvular consonants and sporadically in other contexts in a few words. Therefore, it is no surprise to see this neutralization continue to completion in Spoken Manchu, resulting in the total merger of /u/ and /ʊ/ into [u] and the complete loss of the /ʊ/ phoneme.

In a contrast-driven approach to vowel systems, the loss of a contrast in one part of the system could have wider effects. In the Written Manchu system, the contrast between /u/ and /ʊ/ involves the feature [ATR], just like the contrast between /ə/ and /a/. The unity of the [ATR] contrast is made more salient by the rule of ATR harmony, which indicates to language learners that the vowels are to be sorted into [ATR] and non-ATR sets. But with the loss of /ʊ/, the position of [ATR] in the system becomes much more tenuous. The vowel /u/ would now join /i/ as a neutral vowel, occurring with both [ATR] and non-ATR vowels.

Now, the entire burden of the [ATR] contrast falls on the contrast between /ə/ and /a/. Many languages, however, have these vowels in their inventories without the contrast being due to [ATR]. As we observed earlier, the contrast between these vowels could more straightforwardly be attributed to a difference in height. Indeed, the feature [low], which is required independently, can serve to distinguish /ə/ from /a/.

Therefore, without assuming that the phoneme /ə/ changed phonetically, the loss of /ʊ/ could have indirectly led to a change in the phonological status of /ə/.

from [low] to non-low. This reclassification, in turn, could have influenced the phonetic realizations of /ə/, because in Spoken Manchu it is definitely a non-low vowel. Zhao (1989) characterizes it as a mid-high back unrounded vowel, with an allophone [ɤ]. According to Ji et al. (1989), [ə] is in free variation with a high back unrounded vowel [u]. It is reasonable to suppose that there is a mutual influence between phonology and phonetics in such cases. The phonetics of a vowel obviously influence its phonological representation; but this influence is not simply one way, and the phonological representation can in turn affect the phonetics, by defining the space within which the vowel can range (short of neutralization).<sup>15</sup>

The change in status of /ə/ in turn has consequences for the specification of /u/. Recall that in Written Manchu we found evidence that the vowel /i/ is actively [coronal], but no evidence that the vowels /u/ and /ʊ/ are actively [labial], though they clearly are phonetically round. Recall also that this lack of an active [labial] specification is entirely expected under the theory of contrastive specification we are assuming: because only a single place contrast exists in the non-low vowels, that contrast can be either [coronal] or [labial], but not both.

The elevation of /ə/ to a non-low vowel, joining /i/ and /u/, changes the situation. Assuming, as before, that [coronal] takes precedence, /i/ is again specified [coronal], distinguishing it from /ə/ and /u/. But now we must still distinguish the latter two vowels from each other. The most straightforward distinction is again a place distinction, whereby /u/ is specified [labial], as diagrammed in (22).

(22) *Spoken Manchu after loss of /ʊ/:*

[coronal]		[labial]	
i	ə	u	
	a	ʊ	[low]

Our analysis predicts that the reclassification of /ə/ as a non-low vowel should cause /u/ to become contrastively [labial]. Is there evidence that Spoken Manchu /u/ has acquired a [labial] specification? We cannot appeal to labial harmony, because both labial and ATR harmony have been destroyed in Spoken Manchu (Zhang 1996). However, the development of the new phonemes /ɛ/ and /y/ does provide evidence bearing on this question.

According to Zhang (1996), Spoken Manchu /ɛ/ often corresponds to Written Manchu /a/ when followed by /i/; some examples are given in (23).

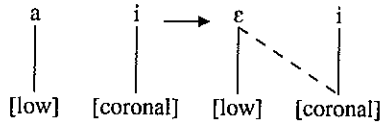
(23) *Distribution of /ɛ/ in Spoken Manchu* (Zhang 1996:112; Zhao 1989):

<i>Written Manchu</i>	<i>Spoken Manchu</i>	<i>Gloss</i>
ali-	ɛli-	'bear'
alin	ɛlin	'mountain'
t'ari-	t'ɛri-	'cultivate'

<sup>15</sup>Compare Trubetzkoy (1969), for whom the oppositions (contrasts) a phoneme enters into determine its "phonological content", which in turn influences its phonetics.

It is likely, then, that this phoneme originated from /a/ followed by /i/. Since /i/ has a [coronal] feature and /a/ has a [low] feature, it follows that the addition of the [coronal] feature from /i/ to an /a/ would result in a [low, coronal] vowel, namely /ɛ/, as shown in (24).

(24) Creation of /ɛ/ from /a/-/i/:



This development could have even begun in Written Manchu, since the features that participate in the process were all in place. Over time, however, as various other changes caused the original environment of the rule to become obscure, the vowel /ɛ/ started appearing in unpredictable contexts and became a new phoneme.

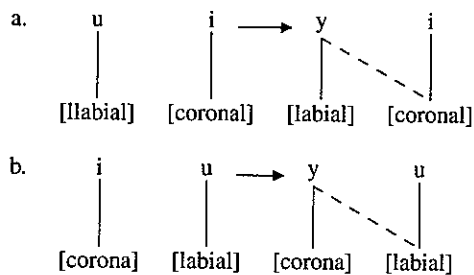
The Spoken Manchu vowel /y/ also developed from a sequence of vowels. As Zhang (1996) shows, Spoken Manchu /y/ corresponds to Written Manchu /i/ followed by /u/, as in (25a), as well as /u/ followed by /i/, as in (25b); some examples are given in (25).

(25) Distribution of /y/ in Spoken Manchu (Zhao 1989; Zhang 1996:111):

	Written Manchu	Spoken Manchu	Gloss
a.	ningun	nyngun	'six'
	iləngu	jyrugə	'tongue'
b.	t'ugi	t'ygu	'cloud'
	t'uwəri	t'yli	'winter'

Now, /y/ is a front round vowel and thus has the features [coronal] and [labial]. The feature [coronal] is clearly contributed by /i/, parallel to its role in the creation of /ɛ/. But the feature [labial] must come from /u/. In Written Manchu, we have argued that this vowel did not possess a contrastive [labial] feature, but that in Spoken Manchu, following the elevation of /ə/ to a non-low vowel, it does. The creation of /y/ thus provides independent evidence for the contrastive [labial] specification of /u/ in Spoken Manchu.

(26) Creation of /y/ from /u/ - /i/ and /i/ - /u/:



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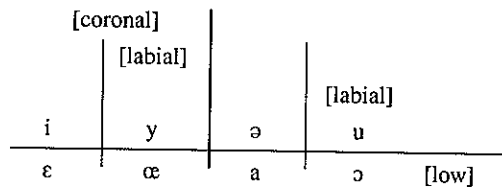
Like /ɛ/, the new vowel /y/ came to stand in environments where it could not simply be analyzed as deriving from /i/ and /u/, and thus became a separate phoneme which does not depend on receiving a [labial] specification from /u/. However, the development of [y] in the first place provides evidence for a labial feature on /u/.

We have seen, then, that the vowel systems of Written Manchu and Spoken Manchu act as expected given our theory of contrastive specification. Further evidence supporting this approach comes from Xibe, another descendent of Written Manchu.

### 3.2. The Xibe vowel system

The vowel inventory of Xibe is shown in (27).

(27) *Xibe* (based on Li and Zhong 1986):



The development of the Xibe vowel system is similar to that of Spoken Manchu: the contrast between /u/ and /ʊ/ has been lost along with the feature [ATR]; the vowel /ə/ has been reinterpreted as a non-low vowel; and new phonemes /y/ and /ɛ/ have developed from combinations of other vowels. As in Spoken Manchu, the development of these new phonemes supports the theory that /u/ has acquired a [labial] specification. In addition, a third new vowel, /œ/, has arisen, most likely from earlier /ɔ/ followed by /i/ (Zhang 1996:126).

Unlike Spoken Manchu, Xibe retains a labial harmony rule in which /ə/ alternates with /u/ in suffixes: /u/ occurs if the stem-final vowel is round (28b, d), /ə/ occurs otherwise (28a, c).<sup>16</sup>

(28) *Alternation between /ə/ and /u/ in Xibe suffixes* (Li and Zhong 1986):

	<i>Written Manchu</i>	<i>Xibe</i>	<i>Gloss</i>
a.	gət'ə-xə	gət'ə-xə	'awoke'
	uli-xə	uli-xə	'stringed'
	ana-χa	anə-χə	'pushed'
	gəŋs'i-χa	gəŋci-χə	'cherished'
b.	pu-xə	pu-xu	'gave'
	pətə-χɔ	pətə-χu	'thought'
c.	nətʃi-kən	nətçi-kən	'somewhat flat'
	ərtə-kən	ərtə-kən	'somewhat early'
	ampa-qan	am-qən	'somewhat big'
	χantʃi-qan	χantçi-qən	'somewhat near'

<sup>16</sup>This alternation is not found in Norman (1974).

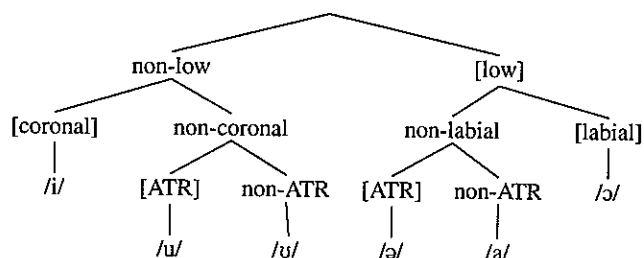
d.	dzuşuxu-kən	dzyɕxu-kun	'somewhat sour'
	xət'u-kən	xət'u-kun	'somewhat stocky'
	laptu-qan	lavtu-qun	'somewhat many'
	farɣu-qan	farɣu-qun	'somewhat dark'
	fɔɣɔɔ-qən	fɔɣulu-qun	'somewhat short'
	əsɕɔ-qən	əsɕɔ-qun	'somewhat small'

Recall that in Written Manchu labial harmony is restricted to the low vowels, and creates an alternation between /a/ and /ɔ/. In Xibe, non-initial vowels tended to be raised — almost always in suffixes, frequently in stem vowels — so an original sequence of the form /a/–/a/ would become /a/–/ə/ or /ə/–/ə/, and a sequence of the form /ɔ/–/ɔ/ would become /ɔ/–/u/ or /u/–/u/. The labial harmony observed in Xibe is not merely a holdover of Written Manchu labial harmony, however, for in Xibe, harmony is triggered not only by /u/ derived from older /ɔ/, but also by original /u/. The fact that /u/ triggers and undergoes labial harmony further supports the hypothesis that it has a [labial] specification in Xibe.

### 3.3. Summary of the Manchu vowel systems

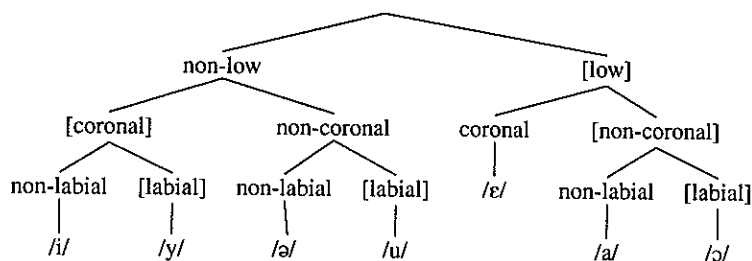
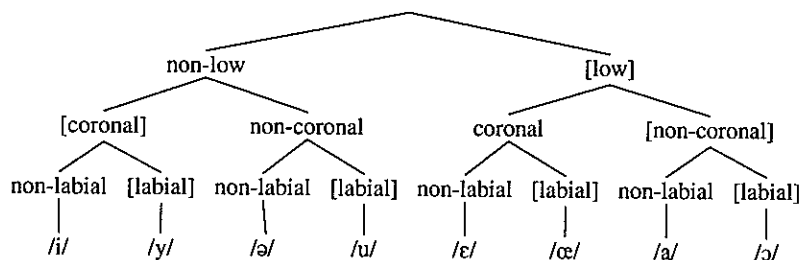
Here we summarize the contrastive features active in the vowel systems of Written Manchu and its modern relatives.<sup>17</sup> The vowel inventory of Written Manchu can be summed up in the tree diagram in (29) (compare (19)).

(29) *Written Manchu contrastive hierarchy*: [low] > [coronal] > [labial] > [ATR]



Once /ʊ/ is lost, the status of [ATR] as a contrastive feature becomes tenuous, since /ə/ can be reanalyzed as a non-low vowel. Spoken Manchu and Xibe make do with only three contrastive features. They have more vowel phonemes than Written Manchu because they exploit the possibilities of the three features more fully, as shown in (30) and (31).

<sup>17</sup>We have not discussed Hezhen, another Manchu language, whose vowel system is similar to the other modern Manchu languages discussed here. However, the vowel system of Hezhen offers no evidence bearing on our topic, because of the loss of harmony and the lack of other relevant phonological processes. For discussion and further references on Hezhen, see Zhang (1996), Zhang and Wu (1992), and Zhang et al. (1989).

(30) *Spoken Manchu contrastive hierarchy*: [low] > [coronal] > [labial](31) *Xibe contrastive hierarchy*: [low] > [coronal] > [labial]

### 3.4. Contrast in Tungusic, Mongolian, and Turkic vowel systems

The Manchu languages strikingly confirm the hypothesis that phonologically active features are contrastive, and its corollary, that harmony triggers are contrastive. The generalization holds for both ATR and labial harmony. In Written Manchu, the segments with contrastive [ATR] features, /ə/ and /u/, trigger ATR harmony, but /i/, in which [ATR] is not contrastive, does not. The contrastively [labial] vowel /ɔ/ triggers labial harmony, the non-contrastively labial /u/ and /ə/ do not. The modern Manchu languages do not employ a contrastive [ATR] feature at all, and have no ATR harmony. Labial harmony persists, and is triggered not just by /ɔ/, but also by /u/, which we know on independent grounds to have acquired a contrastive [labial] feature.

The generalization that contrastive features trigger harmony is further supported by broader surveys of Manchu-Tungus languages, as well as languages in other families. Zhang (1996:Chapter 6) surveys a number of Manchu and Tungusic languages in China and Russia. In general, where /i/ has no ATR/RTR counterpart, as in the Tungusic language Oroqen (Zhang 1996:Chapter 5), then it is neutral and does not trigger ATR or RTR harmony. This is because /i/ is typically the only [coronal] high vowel, as in the Manchu languages, and does not receive any further specifications, as shown in (32).<sup>18</sup>

<sup>18</sup>/y/ is a marginal phoneme in Oroqen, found only in a handful of words, many of which are borrowed from Chinese (Zhang 1996:160). In any case, it is distinguished from

(32) *Oroqen vowel system* (Zhang 1996):

i ii	(y)	u uu
		ʊ ʊʊ
e	ə əə	o oo
ɛ	a aa	ɔ ɔɔ

When /i/ has an ATR/RTR counterpart, /i/, as in Ewenki (Hu 1988; Zhang 1996:197–199), then [ATR] or [RTR] (depending on the language) is necessarily contrastive for these vowels, and they participate in the harmony.

(33) *Ewenki vowel system* (Hu 1988; Zhang 1996):

i ii		u uu
		ʊ ʊʊ
ee	ə əə	o oo
ɛɛ	a aa	ɔ ɔɔ

Labial harmony tends to be confined to the low vowels in all the Manchu-Tungus languages. Like Written Manchu, these languages tend to have only a single contrast in the high vowels (apart from tongue root contrasts). Since [coronal] is active, we assume it maintains its position in the feature order ahead of [labial], rendering the latter redundant in this region. In the non-high vowels, [labial] is contrastive, as it is required to distinguish between rounded and non-rounded vowels (that is, between /o/ and /ə/ and between /ɔ/ and /a/), none of which are [coronal]. In fact, Spoken Manchu and Xibe are somewhat exceptional in having a three-way contrast among the high vowels, and they are also unusual in that /u/ has an active [labial] feature. This correlation shows that the selection of harmony triggers in each language is not simply a family or areal trait unconnected to the contrasts in the inventory. Rather, it supports the hypothesis that harmony triggers must be contrastive.

Mongolian vowel inventories are similar to Manchu-Tungusic. Eastern Mongolian languages have a similar type of labial harmony triggered by and affecting low vowels. An example is Khalkha Mongolian (Svantesson 1985; Kaun 1995), shown in (34).

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<sup>1</sup>/i/ by [labial], so its presence has no consequences for the contrastive status of [ATR] in /i/ or /y/.

(34) *Khalkha Mongolian vowel system* (Svantesson 1985; Kaun 1995).<sup>19</sup>

i	u
	ʊ
ə	o
a	ɔ

Turkic languages tend to have symmetrical vowel inventories; a typical example is Turkish, shown in (35).

(35) *Turkish vowel system:*

i	ü	ɨ	u
e	ö	a	o

Assuming three features, [high], [dorsal], and [labial] (or their equivalents), the Turkish vowels exhaust the space of possible values, like Xibe. Therefore, all feature values are contrastive; in particular, [labial] is necessarily contrastive in all vowels that are rounded on the surface. In such inventories we find a variety of labial harmony patterns, where high vowels are favoured as triggers and targets (Korn 1969; Kaun 1995). Since the non-high round vowels also have a contrastive [labial] feature, their failure to trigger harmony cannot be due to their specifications, but to something else. That is, having a contrastive [labial] feature is a necessary but not sufficient condition for triggering harmony.

#### 4. THE RELATION BETWEEN CONTRAST, SALIENCE, AND UNDERSPECIFICATION

After establishing that theories of contrast that focus on contrast as a surface perceptual phenomenon are not relevant to the problems we address in this article (section 4.1), we show that our account is logically independent of theories of underspecification, though it has affinities to theories of contrastive (under)specification, and has a natural implementation in these terms (section 4.2).

##### 4.1. Contrast and perceptual salience

We now turn to the question of how the Manchu languages compare to other related languages, drawing on surveys of Manchu-Tungus languages by Zhang (1996) and of Turkic, Mongolian, and Tungusic by Kaun (1995). Kaun (1995) proposes what appears to be an alternative to the contrastive account of labial

<sup>19</sup>In Khalkha Mongolian the vowel we represent as ə is given as e by Svantesson (1985). We believe the vowel is best represented as schwa (Qingertai 1982). The formant frequencies for this vowel given by Svantesson (1985:290–293) are at least as consistent with [ə] as with [e]. Phonologically, Svantesson analyzes this vowel as the ATR ([–pharyngeal]) counterpart of /a/.



harmony systems advocated here. However, closer inspection reveals that her account presupposes a contrastive analysis such as the one presented here.

According to Kaun (1995), labial harmony is governed by the constraints in (36), among others.

(36) *Some constraints governing labial harmony* (Kaun 1995):

- a. EXTEND[RD]: The autosegment [+round] must be associated to all available vocalic positions within a word.
- b. UNIFORM[RD]: The autosegment [+round] may not be multiply linked to slots bearing distinct height feature specifications.
- c. \*ROLO: Vowels should not be simultaneously specified [+round] and [–high] (Kirchner 1993).
- d. EXTEND[RD]IF[–HI]: The autosegment [+round] must be associated to all available vocalic positions within a word when simultaneously associated with [–high].

Kaun proposes that the constraints in (36) and the other constraints governing labial harmony are rooted in perceptual and phonetic universals. Thus, \*ROLO is motivated by the antagonism between low jaw position and lip rounding. EXTEND[RD] increases the span of a feature that presents perceptual difficulties, making it easier to perceive, and EXTEND[RD]IF[–HI] increases the perceptibility of rounding in low vowels, where rounding is particularly difficult to perceive.

However, if the constraints in (36) reflect conflicting universal tendencies that may be resolved on a language-particular basis, we cannot explain why *no* Turkic language shows evidence of (36d) (that is, this constraint is never ranked highly enough to have any effect), and why *every* typical Mongolian and Manchu-Tungus language (apart from Spoken Manchu and Xibe, which have a ‘Turkic’ vowel inventory) shows the effects of (36d) and not (36a).

To address this problem, Kaun suggests that the languages in which labial harmony is confined to low vowels are characterized by greater crowding in the non-high vowels than in the high vowels. She proposes that “vowel harmony serves to extend the listener’s exposure to a vowel quality which is potentially difficult to identify accurately” (Kaun 1995:158). To implement this notion in her formal theory, she adopts the convention that EXTEND constraints may operate only on contrastive feature values. This is essentially our proposal, with the difference that Kaun proposes no theory for identifying which values are contrastive.

The lack of such a theory creates unnecessary puzzles. Yowlumne (formerly Yawelmani) Yokuts (Newman 1944; Kuroda 1967) has height-bounded labial harmony in both high and non-high vowels, though the high vowel space is not crowded; on the contrary, it has optimal separation, as shown in (37).

(37) *Yowlumne Yokuts underlying vowel inventory*:

i: i	u: u
a: a	o: o

Kaun (1995:159) cannot explain why both /u/ and /o/ trigger labial harmony, since, as she assumes, [labial] is not contrastive in the high vowels. But there is no basis for this assumption. It appears that in Yowlumne the feature hierarchy has [labial] above [coronal]. Only two features can be contrastive in this inventory, and they are [labial] and [high].<sup>20</sup> Since [labial] is a contrastive feature on both /u(:)/ and /o(:)/, it is a potential harmony trigger; crowding is not required.<sup>21</sup>

Further analysis shows that the notion of “crowding” is itself dependent on contrastive specification. That the non-high vowels of Khalkha Mongolian in (34) look crowded at all is due to the decision to portray /a/ and /ɔ/ at exactly the same height. But Kaun’s hypothesis is that the constraints reflect functional phonetic and perceptual tendencies. Phonetically, /a/ and /ɔ/ are most likely not at the same height in Khalkha Mongolian, nor are /a/ and /o/ in Yowlumne. Thus, the crowding hypothesis itself depends on hierarchical contrastive specification. That is, a labial vowel is crowded if it has a contrastive [labial] specification. This is the necessary condition for triggering labial harmony. In the absence of a hierarchical contrastive analysis, the crowding hypothesis is simply false; taken together with such an analysis, it is superfluous.<sup>22</sup>

We conclude that Kaun (1995) does not present an alternative to our theory of harmony triggers. Rather, when the details are filled in, we see that her account depends implicitly on a contrastive hierarchy along the lines presented here.

Another current approach to accounting for contrast is based on Dispersion Theory (Liljencrants and Lindblom 1972; Lindblom 1986; Flemming 1995; Ní-Chiosáin and Padgett 2001). The idea behind Dispersion Theory is that the shape of an inventory can be predicted to some extent by considerations of optimizing perceptual distinctions between contrasting segments (see also Crothers 1978; Disner 1984). Thus, /i/ ~ /u/ is a better contrast than /i/ ~ /i/. Whatever the merits of this approach to accounting for the distribution of phonetic allophones (see Hall 1999 for discussion and critique), it is not relevant to the type of phonological contrast that forms the subject of this article.

The question we address is which distinctive features are contrastive in the phonemes of an inventory, an issue which is only indirectly related to the surface

<sup>20</sup>For reasons related to phonological inactivity, Archangeli (1984) proposes that /i/ is the unspecified vowel in Yowlumne. For example, /i/ is the epenthetic vowel, and does not appear to cause palatalization or other modifications in neighbouring segments. Thus, it is quite different from Manchu /i/.

<sup>21</sup>Yowlumne vowel phonology poses another problem to any approach that posits that only contrastive feature values are active. The result of vowel lowering of /i:/ is [e:], which is not an underlying vowel. Since the only contrastive features are [high] and [labial], a further feature is required to distinguish [e] from [a]. See Hall (2002) and D’Arcy (2003) for discussion and proposals for how to account for such facts.

<sup>22</sup>This is not to say that all the constraints proposed by Kaun (1995) are superfluous. In languages like Turkic, there are limitations on labial harmony unrelated to considerations of contrast.

realizations of these phonological contrasts. Sometimes phonological contrasts are enhanced in the phonetics (Stevens et al. 1986; Rose 1993; Rice 2002), with results more or less similar to those of Dispersion Theory. For example, the [coronal] contrast between Manchu /i/ and /u/ is enhanced by rounding the non-coronal /u/. At other times, phonological contrasts are not enhanced, but are suppressed at the surface, as when Written Manchu /ʊ/ surfaces as [u], merging with /u/. Putting this issue aside, Dispersion Theory simply does not address whether [coronal] or [labial] is the contrastive feature that distinguishes Written Manchu /i/ from /u/, or whether [ATR] is a contrastive or redundant feature of /i/. Since these phonological contrasts are linked to phonological activity, the contrastive hierarchy is required, whatever the merits of Dispersion Theory.

#### 4.2. Contrast, underspecification, and constraints

Our approach does not suffer from the inadequacies that have been attributed to theories of underspecification. Similarly, this theory of contrast is orthogonal to the issue of rule-based versus constraint-based phonology. While a contrastive hierarchy can be translated into an Optimality Theoretic constraint hierarchy, not every constraint hierarchy implements a contrastive hierarchy. We show that only phonologies that incorporate a contrastive hierarchy can capture the relation between contrast and phonological activity exhibited in the Manchu languages.

The feature trees in (29)–(31) give only contrastive feature values. The trees are open to two interpretations, depending on whether the features are privative or binary. If they are privative, as assumed by Zhang (1996), then only features in square brackets contribute to the representation; on this interpretation, the terms *non-low*, *non-coronal*, *non-labial*, and *non-ATR* are simply descriptive labels, not feature values. The representation of the vowel /ʊ/ in Written Manchu, for example, would include only whatever higher-level features specify all vowels, but it would have no further vowel features. If the features in (29)–(31) are not privative, then features in square brackets are interpreted as [+F] for each feature [F], and the terms not enclosed in brackets are interpreted as [–F]. We have not found evidence from Manchu against the assumption that features are privative; however, the issue is complex, and we do not attempt to resolve it here.

Leaving aside the matter of privativity, what about the features that are entirely absent in (29)–(31), the redundant features? What is their status? If they are underspecified, which is one natural interpretation of these feature trees, then does our analysis share the weaknesses that have been attributed to theories of underspecification? This is the topic we take up in the next section. Since it has been argued that Optimality Theory (OT; Prince and Smolensky 1993) gives a superior account of underspecification and also of contrast, we also consider the relation between the theory of the contrastive hierarchy and a theory of constraint interaction such as OT. In brief, we show that a contrastive hierarchy is required whether or not representations are partially underspecified, and whether or not

one employs a derivational or an OT grammar. We argue that the most natural implementation of our analysis of Manchu is in a serial theory that allows for underspecification of redundant feature values, and in which there is a level of the phonology at which the representations implied by (29)–(31) are defined.

#### 4.2.1. *Contrast and underspecification*

At issue here is the status of features that are redundant according to the Successive Division Algorithm. This algorithm assigns contrastive features only, and stops when there are no more contrasts to draw. It does not follow from this, though, that redundant features must be absent.

One possibility is that all features are specified for all segments to which they are relevant. On this view, the role of the Successive Division Algorithm is to designate which features are contrastive. Certain phonological processes can then be limited to targeting only contrastive features (Calabrese 1995; Halle et al. 2000). In the case of Written Manchu, for example, /i/ would be specified as [ATR], but the specification would be labelled as redundant, as opposed to the [ATR] values of /a/ and /ə/, which are contrastive. Then ATR harmony would be designated as a rule that is sensitive only to contrastive values of [ATR]. Thus, the [ATR] specification of /i/ would be invisible to ATR harmony, but could play a role in processes that target all feature values, contrastive as well as redundant. Such a theory would be consistent with our analysis of the Manchu vowel systems.

A stronger theory would be one that makes redundant features unavailable to the (lexical) phonology except under special conditions. Such a restriction is captured in a natural way by supposing that only features assigned by the Successive Division Algorithm are specified. Any such proposal must overcome arguments that have been widely seen as undermining the theories that incorporate underspecification into representations. The most common arguments against underspecification, however, do not pertain to our theory.

First, it has been argued (Steriade 1995; Kirchner 1997) that underspecification is applied inconsistently. For example, in most languages there are no voiceless sonorants and no nasal obstruents. In the first case, [+voice] is typically omitted from sonorants because it is predictable. By the same token, in the second case, [+sonorant] is predictable given [+nasal]; nevertheless, this specification is rarely omitted. Numerous such cases can be adduced, and many analyses that have appealed to underspecification have indeed been inconsistent in this way.

The answer to the charge of inconsistency is that the contrastive feature hierarchy decides which features are omitted. In the above example, [sonorant] is a major class feature that is typically high in the order. Assuming [sonorant] > [voice], the inventory is divided into sonorant and non-sonorant sets before it is divided by [voice]; since there is no voicing contrast in the [sonorant] set, [voice]

is redundant in that set, hence underspecified.<sup>23</sup> Similarly, it is more common for [sonorant] to take scope over [nasal] than it is for [nasal] to take scope over [sonorant]. Therefore, [+sonorant] must be specified even where it is made logically redundant by [+nasal]. The hierarchy [nasal] > [sonorant] is less likely and could lead to an unusual set of contrasts in an inventory.

The problem of inconsistency is thus not inherent to contrastive (under)specification itself, but rather to implementations of underspecification theory (such as that of Steriade 1987) that provide no principled rationale for distinguishing between contrastive and redundant feature values. The contrastive hierarchy and the Successive Division Algorithm provide such a rationale.

Second, it has been argued that there is relatively little evidence for underspecification. This argument assumes that full specification is the null hypothesis, unless positive evidence is found to the contrary. Thus, the burden of proof has been placed on underspecification. But it is not clear why this should be; one can ask instead whether there is positive evidence for full specification. In practice, most analyses that reject underspecification do not adopt full specification: features totally irrelevant to an analysis are rarely specified. The result is not full specification but arbitrary specification.

Our theory is in keeping with some recent approaches that start from the premise that features are specified only if there is positive evidence to do so. Examples of such approaches are Modified Contrastive Specification as developed in Toronto (Avery and Rice 1989; Walker 1993; Dresher, et al. 1994; Avery 1996; Ghini 2001; Rice 2002; Hall 2003; see also footnote 2); the theory of representational economy of Clements (2001); and the system-driven specification of Hyman (2002a, 2002b). Such approaches are consistent with principles of minimalism and economy that have been fruitful in other areas of linguistic theory.

#### 4.2.2. *The contrastive hierarchy and Optimality Theory*<sup>24</sup>

OT puts many central issues of phonological theory in a new light, and one might ask whether a special theory of contrast is still required in OT. It has been claimed (Itô et al. 1995; Kirchner 1997) that contrasts emerge from OT constraint rankings, so one might think that there is no need to say anything more about it. But

<sup>23</sup>The example of [voice] being predictable given [sonorant] is perhaps the oldest and most common example of underspecification in the literature (Stanley 1967; Kiparsky 1982, 1985). Nevertheless, it may not be a good example if, as has been argued, sonorants do not have the same voicing feature as voiced obstruents (Piggott 1992; Rice 1993; Avery 1996; Boersma 1998). For purposes of this discussion, we assume for the moment that sonorants do potentially bear a feature [voice] that is also carried by voiced obstruents. What is crucial here is the logic of the argument, whether or not sonorant voicing is in fact a good exemplar of it.

<sup>24</sup>This section owes much to the work of Sara Mackenzie. See further Mackenzie (2002) and Mackenzie and Dresher (2004). We have also benefited from discussions of these issues with Kiyon Azarbar and Daniel Currie Hall.

an arbitrary constraint ranking does not express a connection between contrast and phonological activity. If there is such a connection, it should be captured in phonological theory.

A contrastive hierarchy, being essentially a set of wellformedness conditions on representations, can be stated as a set of OT constraints. Feature trees such as (29)–(31) correspond to two types of constraints: constraints that require the preservation of an underlying feature, and constraints that exclude certain combinations of features. For the sake of concreteness, we use the constraints in (38). These constraints presuppose binary features, though they can easily be adapted to privative features.

(38) *Constraints used to model a contrastive hierarchy:*

- a. IO-IDENT [F]: Correspondent segments must have the same value of the feature [F] (either + or –).
- b. \*[F, Φ]: Exclude feature [F] in the context Φ, where Φ is the set of features (with wider scope than [F]) forming the context of [F].

To illustrate, consider the Written Manchu feature hierarchy in (29).<sup>25</sup> The first feature in the hierarchy is [low]; hence, in the highest stratum we place the constraint IO-IDENT [low]. This feature has no exclusions, because there is no vowel feature with wider scope. The effect of this ordering is to require that any underlying value of [low] must be preserved.

The second feature is [coronal]. It is excluded with [+low]. Therefore, in the next stratum we place the constraint \*[coronal, +low], and ranked below that, IO-IDENT [coronal]. That is, where a segment has the feature [+low], any underlying value of [coronal] is filtered out, since a segment specified [+low] may not have a value for [coronal]. Segments bearing the feature [–low] must retain their underlying value of [coronal].

The third feature is [labial], excluded with [–low]. Hence, the next two constraints are \*[labial, –low] (no value of [labial] is permitted with [–low]) followed by IO-IDENT [labial] (otherwise, preserve the underlying value of [labial]).

The fourth feature is [ATR]. It is excluded with [+coronal] and [+labial]. We thus have the two constraints \*[ATR, +coronal] and \*[ATR, +labial], ranked equally, followed by IO-IDENT [ATR].

All other features are redundant and are excluded by the general constraint \*[F].

The constraint set corresponding to the contrastive hierarchy of Written Manchu is thus as in (39).

<sup>25</sup>In keeping with the formulation of the IO-IDENT constraint, we adopt a binary interpretation of the tree in (29). A similar demonstration can be made for a privative interpretation.

(39) *Constraint set for the Written Manchu contrastive hierarchy:*

IO-IDENT [low] >> \*[coronal, +low] >> IO-IDENT [coronal] >> \*[labial, -low]  
 >> IO-IDENT [labial] >> \*[ATR, +coronal], \*[ATR, +labial] >> IO-IDENT [ATR]  
 >> \*[F]

A sample tableau illustrating the operation of this constraint set is given in (40).<sup>26</sup>

(40) *Sample tableau: Written Manchu contrastive specifications*

Input /-low +cor	ID	*cor	ID	*lb	ID	*at	*at	ID	*F
-lb +at/	low	+low	cor	-low	lb	+cor	+lb	at	
a. -low +cor -lb +at				*!		*			
b. +low +cor	*!	*			*			*	
c. -low -cor +at			*!		*				
d. -low +cor +at					*	*!			
e. -low +cor +hi					*			*	*!
f. <sup>US</sup> -low +cor					*			*	

In this example the input is the feature combination /-low, +coronal, -labial +ATR/. This is an impossible combination, according to the contrastive system of Written Manchu, and candidate (a), which faithfully preserves this set of features, cannot surface, because it violates the constraint \*[labial, -low]. Candidate (b) is an example of a candidate that violates IO-IDENT [low]; since this is the highest-ranking constraint, all such candidates are eliminated. Candidate (c) violates IO-IDENT [coronal], and thus loses to candidates who observe this constraint. Candidate (d) maintains the underlying values of [low], [coronal], and [ATR], fatally violating \*[ATR, +coronal]. Candidate (e) includes the non-contrastive feature [high], violating \*[F].<sup>27</sup> The winning candidate is (f): though it violates the faithfulness constraints for [labial] and [ATR], maintaining them would result in worse violations. As we have seen, a Written Manchu segment that is [-low,

NOTE TO AUTHOR:  
 Because we were able to fit "low" and "cor" into the tableau (instead of "lo" and "cr"), these definitions will be removed from the footnote.

<sup>26</sup> Abbreviations used in the tableau are as follows: ID = IO-IDENT; lo = low; cr = coronal; lb = labial; at = ATR. Square brackets are omitted from feature specifications.

<sup>27</sup> Technically, every candidate violates \*[F] once for every feature it bears. Where these are contrastive features that must be preserved in the output, these violations play no role in the evaluation, because they are overridden by the higher-ranked faithfulness constraints. To simplify the tableau, we indicate violations only of (redundant) features that have no higher-ranking faithfulness constraint.

+coronal] has no other contrastive specifications, and this is the result we have obtained.

A general procedure for converting a contrastive hierarchy to an OT constraint hierarchy is given in (41).

(41) *Converting a contrastive hierarchy to an OT constraint hierarchy:*

- a. Go to the next contrastive feature in the list,  $F_i$ . If there are no more contrastive features, go to (e).
- b. In the next stratum of constraints, place any co-occurrence constraints of the form  $*[F_i, \Phi]$ , where  $\Phi$  consists of features ordered higher than  $F_i$ .
- c. In the next stratum, place the constraint IO-IDENT  $[F_{yi}]$ .
- d. Go to (a).
- e. In the next constraint stratum, place the constraint  $*[F]$ , and end.

Every contrastive hierarchy can be converted into a constraint hierarchy by the above procedure. But the converse does not hold: not every constraint hierarchy can be converted into a contrastive hierarchy. Limiting constraint hierarchies to those that conform to a well-formed contrastive hierarchy captures the relation between contrast and phonological activity and constrains the class of possible grammars.

In a grammar with serial derivations, the wellformedness conditions embodied in feature trees such as (29), or in constraint hierarchies such as (39), characterize underlying lexical representations. In a parallel OT grammar in which the constraints of (39) are intermixed with all the other constraints of the phonology, there is no level at which these contrastive representations are defined. The underlying level (the input) is not constrained in standard OT because of considerations of richness of the base (Prince and Smolensky 1993); however, the output of tableau (40) cannot be identified with phonetic representation, either. The output of (40) is a contrastive representation that corresponds to the underlying level of a serial grammar.

The most natural way to implement a contrastive hierarchy in OT is in a serial version of OT, in which constraint systems like (39) act as filters that accept as input any random set of features (richness of the base)<sup>28</sup> and output well-formed contrastive representations. These representations in turn can serve as the input to the phonology proper.

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<sup>28</sup>One might interpret richness of the base as allowing for underspecified inputs, that is, inputs lacking required contrastive specifications. It is not obvious what it means for a learner to be presented with such an input: what stimulus would a learner interpret as lacking a value of [low], for example? Leaving such questions aside, the constraint types in (39) can be supplemented to handle such inputs by adding constraints requiring the presence of certain features.



## 5. CONCLUSION

An approach to contrastive specification in terms of the contrastive hierarchy provides an illuminating account of the vowel system of Written Manchu, as well as of the evolution of the later Manchu languages. In particular, contrastive features are specified following the Successive Division Algorithm and a particular hierarchy of features. In Written Manchu, the hierarchy has the feature [low] at the top, followed by [coronal], then [labial], and finally [ATR] at the bottom. The synchronic and diachronic analyses of the Manchu vowel systems presented here support the hypothesized relation between contrastive feature values and phonological activity: contrastive values are active in the phonology, whereas redundant values are inert. [ATR] ceases to be a contrastive feature in the vowel systems of Spoken Manchu and Xibe. The realignment of vowel contrasts leads to different patterns of phonological activity in these languages, as expected given our hypothesis. We have also shown that our approach is consistent with the observed typology of ATR and labial harmony systems in general.

Our phonological approach to contrast differs from more phonetically oriented theories in that the latter do not address the relationship between contrast and phonological activity. We argued that this relationship cannot be captured in a constraint-based theory such as Optimality Theory unless it incorporates the contrastive hierarchy, and we presented one way of doing so in a version of serial OT.

We proposed that the feature hierarchy may vary cross-linguistically, though within certain limits.<sup>29</sup> Variability raises the issue of learnability: what evidence do language learners use to determine what the contrastive hierarchy is in their language? To our knowledge, no learning models so far proposed address this issue. In the meantime, as in other areas of phonology, we must infer what the contrastive hierarchy is in each language from the phonological and phonetic evidence available to us. The success of this approach to contrast in accounting for synchronic and diachronic patterns in Manchu, as well as in the related work cited in this article, suggests that further research along these lines can be fruitful.

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<sup>29</sup>Thus, we have seen that [coronal] is ordered ahead of [labial] in Manchu-Tungusic and Mongolian languages, but [labial] > [coronal] in Yowlumne. Languages such as Finnish and Hungarian, in which /u/ alternates with /y/ and /i/ is neutral, also require [labial] to be ordered before [coronal]. Avery and Rice (2004) present evidence for considerable variation in the markedness of consonantal place features, particularly in smaller inventories. In our terms, these variations in markedness correspond to different relative orderings of the place features.

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② Is “Kälöng” correct? (We had problems with the font used here, so are unsure if it displayed properly).

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