

TORONTO WORKING PAPERS  
IN  
LINGUISTICS

Editor:

Carrie Dyck

Volume 12, no. 2  
October, 1993

Linguistics Graduate Course Union  
Department of Linguistics  
University of Toronto

# A VOWEL FEATURE HIERARCHY FOR CONTRASTIVE SPECIFICATION\*

Rachel Walker  
*University of Toronto*

## 1 Introduction

Contrastive specification has been criticized on the grounds of lacking a procedure that does not require initial specification of both redundant and distinctive features for each segment (Archangeli (1988)). In reply, in this paper I define a systematic procedure for the contrastive specification of vowel inventories which specifies only distinctive features. I assume that a procedure of contrastive specification is applied universally (see, for example, the work of Steriade (1987), Clements (1988), and Avery and Rice (1989)). I argue that this procedure is performed step-wise in vowel inventories for a single feature at a time, according to a fixed hierarchy of contrastive features. When applied to inventories of different shapes, this procedure may produce different representations for a vowel and its counterpart in other inventories, thus allowing the same phonetic segment to have more than one underlying structure, depending on the system it occurs in. Since representations affect the output of rules, the shape of the vowel inventory will have a significant impact on the patterning of vowels in the phonological processes of a language.

The organization of this paper is as follows. In section 2 I outline the theoretical assumptions that I adopt concerning segment structure and phonological rules. Then in section 3 I develop the procedure of contrastive specification with exemplification from the symmetrical vowel inventory of Turkish, an Altaic language. In section 4 I present inventory-based evidence for this method of contrastive specification. I argue that the procedure of contrastive specification proposed here produces representations with a relative complexity within the inventory consistent with a cross-linguistic comparison of the possible shapes of vowel inventories. In section 5 I then turn to process-related evidence from the patterning of segments in vowel harmony. With exemplification from Khalkha and Buriat, also Altaic languages, I show that a fixed hierarchy of contrastive features determining the step-wise sequence of contrastive specification correctly predicts the emergence of neutral segments in asymmetrical vowel inventories. Finally, in section 6 I present the conclusion that the universal procedure of contrastive specification applies systematically to inventories of all shapes and sizes.

## 2 Theoretical Assumptions

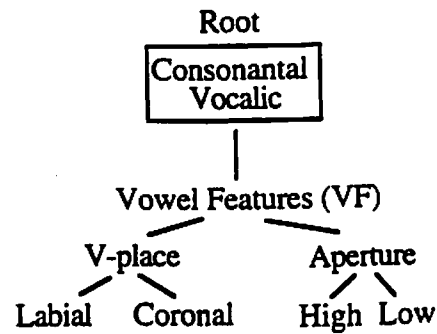
### 2.1 Segment Structure

I assume a geometrical model of segment structure following in the framework first proposed by Clements (1985) and Sagey (1986). The basic model of vowel structure that I adopt is shown in (1).

---

\*I would like to express my gratitude to Keren Rice and Greg Lamontagne for their numerous comments on this paper in its various forms. Thanks also to Elan Dresher for his comments on the procedure of contrastive specification. I am grateful to Hitay Ykseker for checking the Turkish data. This research was funded in part by SSHRC grant 410-92-0885.

(1)



(1) shows only the relevant structural detail. This model is a composite of several recent proposals in segment structure. First of all, I assume monovalent phonological features (see, for example, Anderson and Ewen (1987), Avery and Rice (1989), and van der Hulst (1989)). I also assume that the root node carries the major class features, after McCarthy (1988), Piggott (1992) and Clements and Hume (1993). These features are highlighted in a box in the model of segment structure to emphasize that they are a property of the root.

The arrangement of the Place features is of central importance to this analysis. I adopt a C-place and a V-place node (after Clements (1989), Hume (1992), and Clements and Hume (1993)), although only the V-place node is immediately relevant in this discussion. I assume that under V-place the Labial and Coronal articulator nodes are terminal, because dependent features are not required to yield the phonological contrasts in vowels. In contrast to Hume (1992) and Clements and Hume (1993), I assume that articulator nodes in C-place and V-place are on separate tiers, so that spreading between the C-place and V-place nodes is not possible (after Ní Chiosáin and Padgett (1993)). As a consequence of this assumption, vowel harmony for articulator features will only take place in V-place and will not also target C-place<sup>1</sup>. I follow Clements and Hume (1993) in adopting a node which dominates the V-place and Aperture nodes. To avoid repetition with the Vocalic root-based feature, I have changed the name of Clements and Hume's node from Vocalic to Vowel Features (VF). After Lahiri and Evers (1991), I assume that [High] and [Low] characterize vowel height, yielding maximally four contrasting levels of height.

## 2.2 Phonological Rules

The process-related evidence presented in this paper for a contrastive vowel feature hierarchy will be based on systems of vowel harmony. Accordingly, this paper will be concerned with only one type of operation: spreading. I assume that spreading rules are subject to the following universal conditions.

- (2) a. Spreading links a feature to a target node.  
b. Spreading is subject to the principle of Structure Preservation.

(2a) indicates that spreading rules spread a node or feature onto a target node. I define the target node as the node to which the spreading feature or node directly links in the structure. The target node for any spreading process is universally determined by the model of segment structure in (1). If the target node is absent in a segment, I assume that it

<sup>1</sup>I will not be concerned with establishing the representation for glides in the languages examined in the present paper and will simply assume that the representation is such that glides are neutral to vowel harmony. Note, however, that this issue is significant, because if glides have a similar representation to vowels, they might be expected to participate in vowel harmony.

cannot be interpolated through node generation, so spreading to such a segment cannot occur (see Avery and Rice (1989) and Piggott (1992) for similar assumptions).

In (2b) I assume that spreading rules are subject to the principle of Structure Preservation (as proposed by Kiparsky (1982, 1985)). As observed by Myers (1991), this principle requires that rules applying lexically may only produce phonemes and cannot yield forms with redundant features. As a consequence of this assumption, a feature may not spread onto a segment which is not contrastively specified with respect to that feature. To illustrate, if F is a redundant feature on a segment, F will be absent in the underlying representation of this segment, because only distinctive features are specified underlyingly. In such a case, F will be prevented from spreading onto this segment because doing so would realize a non-phonemic structure, violating Structure Preservation. Thus, Structure Preservation preserves the structural contrasts established through contrastive specification.

### 3 The Process of Contrastive Specification

#### 3.1 A Step-wise Process of Contrastive Specification

I adopt a model of contrastive specification in which a single monovalent feature is sufficient to contrast two segments and the absence of a feature can be as significant as the presence of a feature in the specification of a segment. For example, if the salient contrast between two vowels in an inventory was rounding, the rounded vowel would have the Labial node present, while the unrounded vowel would have the Labial node absent, yet both of these vowels would be contrastively specified with respect to Labial. Thus, I assume that features may be contrastively absent in the underlying representation (after Steriade (1987) on [Round] and Avery and Rice (1989)).

In the procedure of contrastive specification developed here, I assume that contrasts are established systematically with respect to a single feature at a time. I propose that distinctive vowel features are arranged in a hierarchy such that contrastive specification is performed with respect to a feature that is placed higher in the hierarchy before one that is placed lower. I will refer to this hierarchy of features as the *contrastive feature hierarchy*. Previous research has placed height features at the top of this hierarchy (Steriade (1987), Clements (1988), Rose (this volume)). I will assume this ranking, but I will not be concerned with the relative placement of the features High and Low and instead will focus on the ranking of vowel place features. For the contrastive specification of the vowel inventories examined in this paper I will require only two vowel place features: Labial and Coronal. I will demonstrate that these two features are the salient ones in the languages discussed in this paper because they produce vowel representations with the appropriate relative complexity in the inventory. For now I will assume that Labial is ranked above Coronal in the contrastive feature hierarchy. Thus, the contrastive feature hierarchy for vowel features is as shown in (3), where the feature at the top is the highest ranked:

- (3)           **Contrastive Vowel Feature Hierarchy**
- HEIGHT FEATURES  
LABIAL  
CORONAL

In section 5.2 I will show that the relative ranking of Labial and Coronal in (3) is motivated by evidence from phonological processes in languages with asymmetrical inventories.

#### 3.2 Contrastive Specification of Turkish: A Symmetrical Inventory

I will begin by demonstrating how contrastive specification applies to a symmetrical vowel inventory. In a symmetrical vowel inventory each vowel is opposed to another with

respect to each contrast in the system. Turkish has the following symmetrical eight vowel inventory:

	FRONT		BACK	
	unround	round	unround	round
High	i	ü	ɯ	u
Low	e	ö	a	o

In this inventory, each vowel alternates with another with respect to height, backness, and rounding. (4) outlines the articulatory descriptions of the Turkish vowels, distinct from the phonemic features required to contrast this system. The contrastive specification of this inventory is performed by making cuts or contrasts with respect to a single feature at a time, beginning at the top of the contrastive feature hierarchy and working down. Recall that height is ranked highest in the hierarchy. Since there are only two levels of height in this system, only a single height feature is required for contrast. I will simply assume that this feature is Low.

The first contrast or cut will produce the following division in the inventory:

(5)  
Non-low

i	ü	ɯ	u
e	ö	a	o

LOW

All of the vowels below the crossline will now have the feature Low in their representation. The vowels above the line will contrast with respect to the low vowels by the crucial absence of the feature Low in their representation. The annotation of non-low indicates that although these vowels do not have a height feature in their representation, they have been contrastively specified with respect to the feature Low. This annotation is simply for ease of recall of the established contrasts and does not appear in the representations resulting from the contrastive specification.

Assuming that Labial is ranked above Coronal, the second cut that must be made in the inventory will be within each height level between Labial and non-labial segments, yielding the following divisions:

(6)  
Non-low

Non-labial		LABIAL	
i	ɯ	ü	u
e	a	ö	o

LOW

As a result of this cut, all of the round vowels have the feature Labial activated in their underlying representation. The unrounded vowels on the left are annotated as non-labial, because the feature Labial will be crucially absent in their representation.

The next cut that must be made is with respect to the feature Coronal. This cut contrasts the two vowels within each box:

(7)  
Non-low

Non-labial		LABIAL	
CORONAL	Non-coronal	CORONAL	Non-coronal
i	ɯ	ü	u
e	a	ö	o

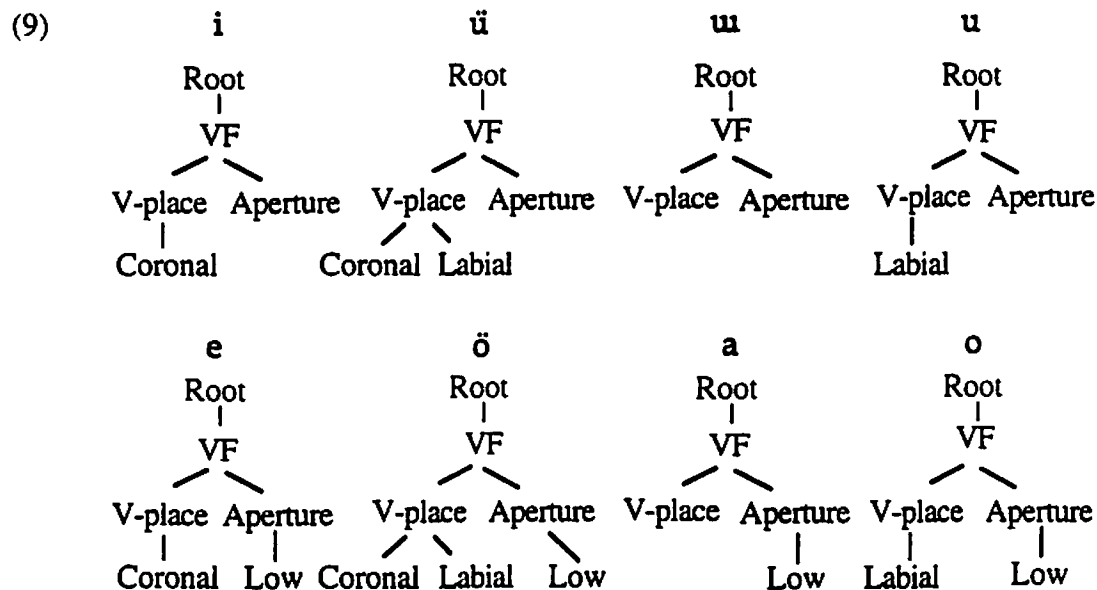
LOW

After the cut with respect to Coronal all of the vowels in the Turkish inventory are fully contrasted. The contrastive specification of the Turkish vowels activates the features shown in (8):

(8)	i	ü	ɯ	u	e	ö	a	o
Low				√	√	√	√	√
Labial		√		√		√		√
Coronal	√	√			√	√		

Note that the contrastive specification of this symmetrical inventory does not reflect on the relative ranking of Labial and Coronal in the contrastive feature hierarchy, because both of the possible rankings will ultimately produce the same output.

The table in (8) indicates which features are present in the representation of each vowel. This specification translates into the following simplified representations for the Turkish vowels:



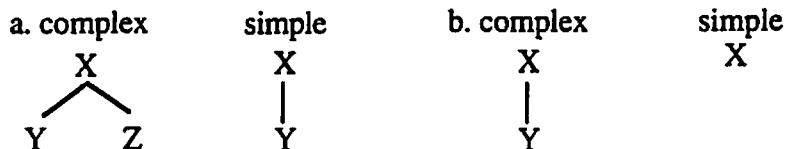
In these representations a bare V-place or Aperture node is a distinctive representation for vowel place and vowel height respectively. I assume that a principle of node activation applies to activate any node which has been contrastively specified with respect to a dependent (see Avery and Rice (1989) for discussion of node activation). Thus, in establishing vowel structure with respect to place, node activation determines that a bare V-place node will be present on a vowel for which place features are contrastively absent.

## 4 Relative Complexity in the Inventory

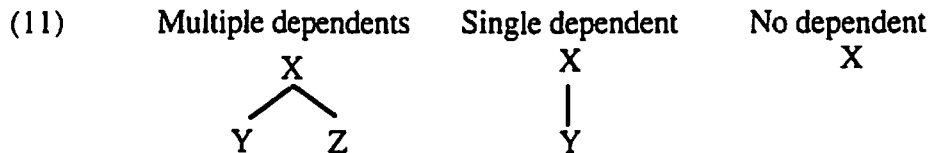
### 4.1 Evaluating the Complexity of Representations

The proposed vowel representations can be evaluated in terms of complexity. Dresher and van der Hulst (1992) claim that complexity is a relative notion and accordingly, can only be measured in relation to another constituent. They propose the following definition of local complexity:<sup>2</sup>

(10)



When all three configurations in (10) are available in the same inventory, complexity becomes a gradient measure, such that the more dependents a node has in the representation, the greater the complexity of the structure. Thus, complexity is descending in the structures from left to right in (11):



Relative complexity can be interpreted in reference to articulations. If the node X in (11) corresponds to a place node and nodes Y and Z to articulator node dependents, then the segments can be described in terms of the complexity of their articulation. I will refer to the different levels of complexity with the following terms: the structure with two articulator dependents represents a segment with a *multiple articulation*, the structure with a single articulator dependent represents a segment with a *single articulation*, and the structure with no articulator dependent represents a *default articulation*. The default articulation is realized as the opposition of the specified articulations with which it contrasts.

The notion of complexity makes predictions about possible inventories. I assume that the presence of a more complex structure implies the presence in the inventory of all less complex structure contained within it (see Rice and Avery (1991) and Dresher and van der Hulst (1992)). Thus, the implication of the relative complexity of the structures in (11) is that the structure with a single dependent will only be present in a system containing structures with no dependent. Similarly, the structure with two dependents of X will only be present in a system which also contains structures with a single dependent and no dependent. For example, a vowel that is represented as having both a Coronal and Labial dependent of V-place, such as /*ö*/ in Turkish, will only emerge in an inventory that already has vowel structures with a bare V-place node and a V-place node with a single dependent as contrastive representations (e.g. /*a*/ and /*o*/ in Turkish respectively). Furthermore, the

<sup>2</sup>In Dresher and van der Hulst's representation, both dependents of X are Y in the structure with two dependents. I have modified their representation here by showing Y and Z as dependents of X in order to emphasize that the dependents of X are not necessarily identical.

more complex vowel structures in an inventory will be the first to be eliminated through the loss of a contrast.

#### 4.2 Complexity in the Turkish Inventory

The Turkish vowel representations in (9) may now be considered in terms of their complexity and the articulation that they signify. In Turkish there are maximally two dependents of V-place, corresponding to the structures in (11). The front rounded vowels, /ü/ and /ö/ have two articulator dependents in Turkish. With a multiple articulation, these vowels constitute the most complex elements in the system. The vowels /i/, /e/, /u/, and /o/ each have a single articulator dependent. These representations make the appropriate predictions since the singly-articulated vowels occur more frequently than the more complex front rounded vowels in the inventories of the natural languages of the world (see Maddieson (1984)). A comparison of the high vowels in the inventories listed in Maddieson (1984) reveals that the 24 listed languages containing /ü/ in their inventory also contain /i/ and a high back vowel<sup>3</sup>. Thus, the prediction that the more complex structures imply the presence of all less complex structure contained within it appears to be correctly borne out<sup>4</sup>.

The vowels /u/ and /a/ have no dependents and accordingly, are characterized as segments with a default articulation. Although /u/ and /a/ occur more rarely in inventories than /i/ and /e/ (where /a/ is in the same height level as /e/, see Maddieson (1984)), this characterization is appropriate in the context of this inventory. The vowel with the default articulation will vary according to the shape of the inventory. First of all, consider how /i/ would be represented in a more common vowel inventory where /u/ is absent, such as in a triangular three vowel system /i, a, u/. In the contrastive specification of this system, height cuts are made first, and then cuts with respect to vowel place features are made within each of the height levels. In the high vowels only /i/ and /u/ need to be contrasted. Assuming that Labial is ranked above Coronal in the contrastive feature hierarchy, Labial will be the feature that contrasts the two high vowels. Since the presence or absence of Labial is sufficient to contrast /i/ and /u/, Coronal will not be required in the contrastive specification of the high vowels. The resulting representations for the high vowels will be a V-place node with a Labial dependent for /u/ and a bare V-place node for /i/. Thus, in inventories with one round vowel and one unrounded vowel in a height level, the unrounded vowel will be characterized as the segment with the default articulation.

In this analysis the bare V-place node representation for the unrounded vowel in such an inventory characterizes a front vowel rather than a back vowel. I maintain that this front articulation is a consequence of the contrast with the Labial articulation. Using Coronal and Labial as the salient features for inventories with only two degrees of backness results in a Labial articulation implying a back articulation in the default case. A Labial articulation is only interpreted as occurring with a Coronal articulation in a representation where both Labial and Coronal are dependents, producing a multiply-articulated segment. When Labial is the only place feature required to contrast two vowels in a certain height, the Labial segment again correlates with a back articulation. Consequently, the default articulation will be both unrounded and front to achieve the contrast with the back Labial segment and to fill the vowel space. Thus, in the more frequently occurring inventories which contain only two vowels in a height level, one rounded and one unrounded, a bare

<sup>3</sup>In this comparison the vowels described by Maddieson as "high front rounded" and "lowered high front rounded" qualified as /ü/ and "high front unrounded" and "lowered high front unrounded" qualified as /i/.

<sup>4</sup>The parallel cooccurrence of a mid front unrounded vowel and a mid back vowel in inventories containing /ö/ is more difficult to evaluate due to the attention given to phonetic height rather than phonemic contrasts in Maddieson (1984). In general this prediction is accurate; however, I will leave the detailed verification of this prediction for mid vowels for further research.



V-place node on a high vowel characterizes /i/ rather than /u/ and, on a non-high vowel, /e/ rather than its back counterpart /a/.

In the Turkish symmetrical eight vowel inventory, the default articulations shift. In this inventory there are two unrounded vowels in each height level. Accordingly, an additional feature, Coronal, must be added to fully contrast the system. Once Coronal is marked on one of the unrounded vowels, the vowel with the bare place node must be articulated as back in order to achieve the contrast with the unrounded Coronal vowel. Consequently, the default articulation characterized by a bare V-place node only becomes back when the Coronal contrast is added. The data in Maddieson (1984) supports this analysis. All of the 24 listed languages containing /u/ also contain /i/, while the 11 cases of languages with only one high vowel all have /i/. The presence of /u/ thus implies /i/, because a bare V-place node on an unrounded vowel is only realized as back when Coronal is a contrastive feature in the system, forcing a front counterpart to the back unrounded vowel. Similarly, when /e/ and /a/ are of the same height, the presence of /a/ implies /e/. Consequently, although /i/ and /e/ are represented as more complex within the Turkish vowel inventory, this complexity does not imply that /u/ and /a/ will be present in an inventory before /i/ and /e/ respectively.

This analysis of the relative complexity of the vowels in the Turkish inventory sheds light on the Turkish rounding process traditionally referred to as "Labial Attraction". Labial Attraction refers to the process in which a high back unrounded vowel becomes rounded when it follows a labial consonant, /p, b, m, f, v/ and a low vowel appears in the preceding syllable within the same morpheme. This may be restated as /u/ becomes /u/ in the environment /a/ /Labial C/ <sub>-5</sub>. The pattern is illustrated in the following data:<sup>6</sup>

(12)	<u>form</u>	<u>gloss</u>
	jamur	'rain'
	kabuk	'rind'
	kalbur	'sieve'
	tavuk	'hen'
	tʃapul	'raid'

However, this process does not apply to high front unrounded vowels in a parallel environment. This could be explained by a comparison of the complexity of the two high rounded vowels. I will assume that Labial Attraction involves the spreading of Labial onto the V-place node of the vowel, but I will not be concerned with the details of this process.

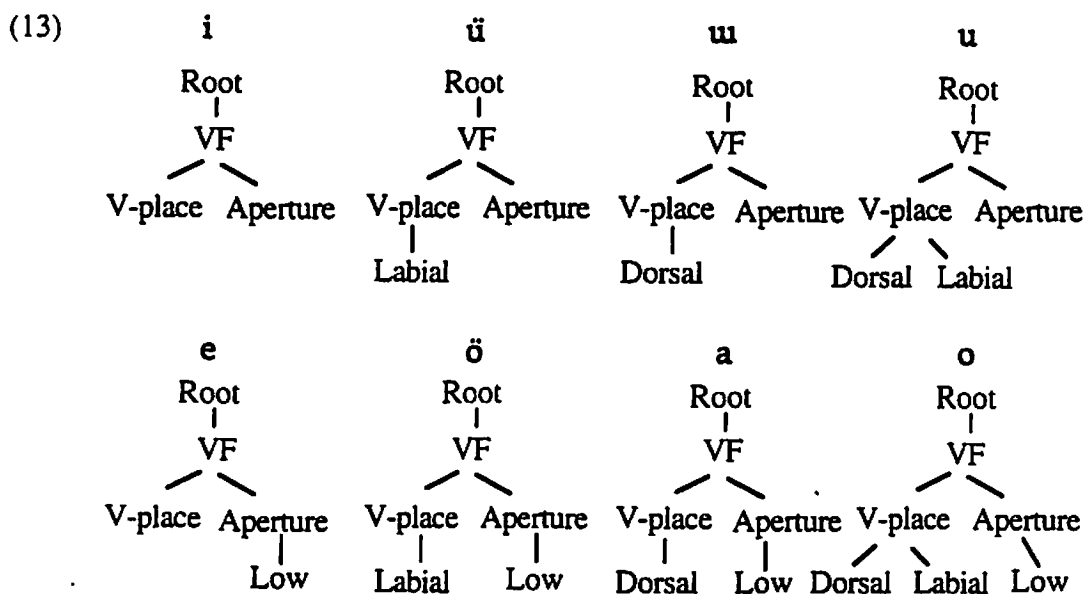
<sup>5</sup>Note that Clements and Sezer (1982) maintain that there is no rule of Labial Attraction and van der Hulst and van de Weijer (1991) adopt this analysis. However, Clements and Sezer's conclusion is based on a misinterpretation of Zimmer's study of the reality of reported morpheme structure constraints with Turkish speakers (1969). Clements and Sezer report that Zimmer found that a medial labial or non-labial consonant had no effect on preference for the /...aCu.../ pattern in nonsense words. Closer examination of Zimmer's work reveals that Zimmer actually claims that the Labial Attraction rule is active, but is neutralized for some speakers by interference from the conflicting rule of Labial harmony amongst vowels (317-9). In fact, Zimmer explicitly states that one group of speakers preferred the /...aCu.../ pattern considerably more often with a medial labial consonant than a medial non-labial consonant, providing direct evidence in favour of Labial Attraction as an active process. Accordingly, I conclude that Clements and Sezer's argument is unconvincing and I assume that Labial Attraction is an active phonological process in Turkish (following Ergin (1962), Lees (1966), Lewis (1967), Zimmer (1969), Banguoğlu (1974), Campbell (1974), Aksan (1978) and Crothers and Shibatani (1980)). Thanks to Jaye Padgett and Hitay Yüксеker for their comments on this issue.

<sup>6</sup>Turkish data and vowel harmony facts are based on the following sources: Swift (1963), Lewis (1967), Underhill (1976), Clements and Sezer (1982), Yüксеker (1983) and *Türkçe Sözlük*, Ankara: Türk Dil Kurumu Yayınları, 1983.

The effect of Labial Attraction will then be to form a vowel with a single articulation /u/ from a vowel with a default articulation /uw/. If Labial Attraction also applied to the front vowels it would form a multiply-articulated vowel /ü/ from a vowel with a single articulation /i/. However, Turkish favours less complex structures in non-initial syllables, a property it shares with many other Altaic languages<sup>7</sup>. Accordingly, I claim that Labial Attraction will only form vowels of a set maximal complexity: in this case vowels with maximally one dependent. Consequently, Labial Attraction does not create multiply-articulated vowels, explaining its failure to apply to the high front vowels. Thus, the evaluation of complexity in the Turkish vowel representations elucidates other aspects of the phonology.

### 4.3 Coronal versus Dorsal

So far, I have simply assumed that Coronal rather than Dorsal is the salient contrastive feature for backness in Turkish. This assumption is supported by the relative complexity produced in the representations in the inventory. Note that previous analyses of Turkish vowel harmony have often posited [Back] or [Dorsal] as the salient contrastive feature in Turkish which spreads in vowel harmony (see, for example, Yavas (1980) and Clements and Sezer (1982), also Clements and Hume (1993) who propose that both Coronal and Dorsal spread). If Dorsal were the feature used instead of Coronal, a very different pattern of complexity would be produced, as illustrated by the following representations for the Turkish vowels:



In these representations, /u/ and /o/ are characterized as the multiply-articulated segments. Consequently, these segments represent the most complex segments in the inventory. /ü/, /w/, /ö/, and /a/ are characterized as segments with single articulations. This representation makes inaccurate predictions, because these four vowels are the most marked or least common of the eight cross-linguistically (see Maddieson (1984) and discussion in the preceding section), yet they are represented as less complex than the frequently occurring /u/ and /o/ (see Rose (this volume) for similar objections to this type of representation). Furthermore, in this contrastive system Labial implies a front articulation in the default

<sup>7</sup>This preference for less complex structures is supported by the fact that low vowels in non-initial syllables of Turkish have reduced contrasts (see Walker (1993) for discussion).

case, rather than a back articulation, which is again not borne out cross-linguistically. Finally, /i/ and /e/ are represented here as having a bare V-place node or a default articulation. This produces an inappropriately wide gap between the complexity of these segments and /u/ and /o/, which also occur frequently. Thus, in contrast to the representations with Coronal, the vowel representations with the feature Dorsal yield a relative complexity for these vowels that is not supported by a cross-linguistic comparison of vowel inventories. Consequently, I reject the use of the feature Dorsal for vowel inventories with only a single contrast with respect to backness and instead adopt Coronal as the relevant feature for these systems<sup>8,9</sup>.

I have now established that in the symmetrical Turkish vowel inventory each vowel is contrastively specified with respect to Low, Labial and Coronal. This contrastive specification is performed with respect to one feature at a time, beginning with Low. Application of this process of contrastive specification to Turkish produces vowel representations with three degrees of complexity in the system. I have shown that these representations are consistent with the shape of vowel inventories cross-linguistically and have concluded that Labial and Coronal, rather than Labial and Dorsal, are the relevant contrastive features for this inventory.

## 5 The Contrastive Feature Hierarchy and Asymmetrical Inventories

In contrast to the symmetrical eight vowel inventory of Turkish, Khalkha and Buriat have the following asymmetrical seven vowel inventory (Poppe (1960, 1970)):

(14)	<b>FRONT</b>		<b>BACK</b>	
	<b>unround</b>	<b>round</b>	<b>unround</b>	<b>round</b>
<b>High</b>	i	ü		u
<b>Low</b>	e	ö	a	o

This inventory is identical to that of Turkish except that the high back unrounded vowel is absent from this system. As a consequence, the Coronal contrast for high unrounded vowels is absent in the inventory of Khalkha and Buriat. Since this contrast is active in the Turkish inventory but not in the Khalkha/Buriat inventory, the contrastive specification of the Khalkha/Buriat high vowels will be different from that of the Turkish high vowels. This difference in the contrastive specification will produce different representations for the high vowels in the symmetrical and asymmetrical inventories, suggesting that the high vowels will pattern differently in the vowel harmony of Turkish versus that of Khalkha and Buriat. In the following discussion I will demonstrate that this prediction proves to be correct and then show that the relative ranking of Labial and Coronal in the contrastive feature hierarchy is crucial in order to account for the neutrality effects found in the vowel harmony patterns of Khalkha and Buriat.

### 5.1 Vowel Harmony with Symmetrical versus Asymmetrical Inventories

Turkish, Khalkha, and Buriat all exhibit vowel harmony. However, the pattern of vowel harmony varies according to whether the language has a symmetrical or an asymmetrical vowel inventory. The basic vowel harmony patterns with respect to backness are outlined below<sup>10</sup>.

<sup>8</sup>See Walker (1993) for evidence that analyzing the vowel harmony in Turkish as the spreading of Coronal can account for the harmony facts in this language.

<sup>9</sup>It is not clear that Dorsal is required at all in the contrastive specification of vowel inventories. I will leave this question for further research.

<sup>10</sup>For a detailed discussion of vowel harmony in these languages see Walker (1993).

Turkish vowels exhibit back (Coronal) harmony. In this harmony, the vowels in a word must agree with respect to their front or back quality. All vowels participate in this harmony, as shown in (15).

(15)	<i>Turkish</i>	
	<u>stem + acc. pl.</u>	<u>gloss</u>
	ödül-ler-i	'award'
	güve-ler-i	'moth'
	ip-ler-i	'rope'
	odun-lar-u	'wood'
	suru-lar-u	'row'
	son-lar-u	'end'

In (15) I use the plural suffix with harmonic alternants *-ler/-lar* and the accusative suffix with alternants *-i/-ü/-u/-u* to illustrate the vowel harmony pattern in Turkish.

Khalkha and Buriat also exhibit Coronal harmony<sup>11</sup>. In this vowel harmony, all vowels participate with the exception of /i/, which patterns as neutral, as shown in (16):<sup>12</sup>

(16)	<i>Khalkha</i>		<i>Buriat</i>	
	<u>suffixed form</u>	<u>gloss</u>	<u>suffixed form</u>	<u>gloss</u>
	üz-üül-ex	'to show'	üz-üül-xe	'to show'
	or-uul-ax	'to cause to enter'	or-uul-xa	'to cause to enter'
	erbeexii-nüüd	'butterflies'	belig-eer	'by means of knowledge'
	mori-oor	'by horse'	morin-oor	'together with the horse'
	nöxör-öör	'with the help of the comrade'	düröö-göör	'by means of the stirrup'

In (16) I use various suffixes to show the Coronal harmony and transparency of /i/. These suffixes are the instrumental suffix in Khalkha and Buriat with harmonic alternants *-(g)eer/- (g)öör/- (g)aar/- (g)oor* and the causative suffix with alternants *-üül/-uul* as well as the simple future suffix *-xe/-xa/-xo* in Buriat and the plural suffix *-nüüd/-nuud* and incomplete suffix *-ex/-öx/-ax/-ox* in Khalkha.

From the above data it is clear that a pattern of neutrality emerges in the asymmetrical inventory but not in the symmetrical one. The parallel of differences in the inventory of high vowels in Turkish and Khalkha/Buriat and the differences in the patterning of high vowels in Coronal harmony in these languages raises the question of whether these facts are related. In the following section I will demonstrate that the neutrality is a consequence of contrastive specification in an asymmetrical inventory.

<sup>11</sup>I analyze the vowel contrasts and harmony in Khalkha and Buriat as a phonological front/back alternation following Poppe (1960, 1970), Bosson (1962, 1964), Street (1963), Chinchor (1979), Binnick (1980), and Hamp (1980). However, Rjalland and Djamouri (1984) claim that the vowel harmony in Khalkha instead corresponds to an ATR/RTR alternation and Svantesson (1985) maintains that this is the case in all East Mongolian languages, including Khalkha and Buriat. See Walker (1993: 73-4) for arguments that the posited ATR/RTR alternation is simply a phonetic shift and has not caused a corresponding phonological shift.

<sup>12</sup>Khalkha and Buriat vowel harmony facts are based on Poppe (1960, 1970), Bosson (1962, 1964), Street (1963), Chinchor (1979) and Binnick (1980).

### 5.2 Contrastive Specification of Khalkha and Buriat: Asymmetrical Inventories

The asymmetry in the Khalkha/Buriat inventory has an effect on the contrastive specification and the resulting representation of the vowels. The contrastive specification of the Khalkha/Buriat inventory will begin with a cut with respect to the highest ranked feature, Low, producing the following division:

(17)  
Non-low

i	ü	u	
e	ö	a	o

LOW

All of the vowels in the group below the crossline will now have the feature Low in their representation and the remaining vowels will contrast with respect to the low vowels by the absence of Low in their representation. The low vowels in this inventory are the same as in Turkish, so contrastive specification of these vowels will be as in section 3.2. However, since the high vowel inventory for Khalkha/Buriat is different from Turkish, the contrastive specification in this height level will be different.

If Labial is ranked above Coronal, the second cut that must be made will be between Labial and non-labial segments. This produces the following results in the non-low vowels:

(18)  
Non-low

Non-labial	LABIAL
i	ü u

In (18) /i/ is contrasted with both of the other non-low segments, so further contrastive specification will not apply to /i/. Accordingly, the final cut with respect to Coronal yields the following contrasts in the non-low vowels:

(19)  
Non-low

Non-labial	LABIAL
	CORONAL      Non-coronal
i	ü u

Ranking Labial above Coronal will thus produce representations for the non-low vowels where /i/ has no dependents of V-place, /u/ has a Labial dependent and /ü/ has Coronal and Labial dependents. With this contrastive specification, a non-low vowel with only a Coronal dependent of V-place is not a possible phonemic representation.

Recall that in section 3.1 I make the assumption that Labial is ranked above Coronal in the contrastive feature hierarchy. In the contrastive specification of the Turkish vowel inventory, the relative ranking of Labial and Coronal did not effect the output. However, the relative ranking of Labial and Coronal will affect the representation of the high vowels in Khalkha and Buriat.

Consider how the reverse ranking of Labial and Coronal would alter the contrastive specification of Khalkha and Buriat. Because height is always ranked above vowel place features, the first cut in the inventory will still contrast the Low and the non-low vowels as in (17). If Coronal is ranked above Labial, the second cut in the contrastive specification of the inventory will then be between Coronal and non-coronal segments, producing the following division in the non-low vowels:

(20)  
Non-low

CORONAL		Non-coronal
i	ü	u

Because /u/ is now contrasted with both of the other non-low vowels, any further contrastive specification will not apply to /u/. Accordingly, the final cut with respect to Labial yields the following contrasts:

(21)  
Non-low

Non-labial	CORONAL LABIAL	Non-coronal
i	ü	u

The ranking of Coronal above Labial will thus produce representations for the non-low vowels where /u/ has no dependents of V-place, /i/ has a Coronal dependent and /ü/ has Coronal and Labial dependents. With this ranking, a representation for a non-low vowel with just a Labial dependent of V-place is not a phonemic structure.

The different representations for the non-low vowels resulting from the different contrastive specifications make predictions concerning the role these segments will play in phonological processes, such as vowel harmony, in the language. In order to determine the correct ranking of Coronal and Labial, the accuracy of these predictions must be examined. Both rankings produce the same representation for /ü/, so only /i/ and /u/ have the potential to provide the deciding evidence.

/i/ is neutral to the Coronal harmony in Khalkha and Buriat, while /u/ participates in this harmony (see data in (16)). Since /i/ is the high vowel that patterns uniquely in the vowel harmony system, I will focus on the representation of /i/. To account for the neutrality of /i/, the failure of /i/ to trigger Coronal harmony must be explained. This patterning would be accounted for if /i/ had no Coronal feature to spread. Such a representation only occurs when /i/ has not been contrastively specified with respect to Coronal, as is the case when Labial is ranked above Coronal in the contrastive feature hierarchy.

In the structure produced by ranking Coronal above Labial, /i/ has Coronal as a dependent of V-place. This representation predicts that /i/ would trigger Coronal harmony, which does not conform to the actual patterning of /i/. Consequently, I conclude that Labial must be ranked above Coronal in the contrastive feature hierarchy, because the structures produced by this ranking make the correct predictions about the failure of /i/ to trigger Coronal harmony in Khalkha and Buriat, while the reverse ranking predicts patterns which are not found in these systems. Note that the ranking of Labial above Coronal also crucially contrasts /u/ and /ü/ only with respect to the presence or absence of Coronal in the structure. This contrastive specification correctly predicts that /u/ will alternate with /ü/ in the Coronal harmony. Thus, this ranking makes the correct predictions for all of the high vowels.

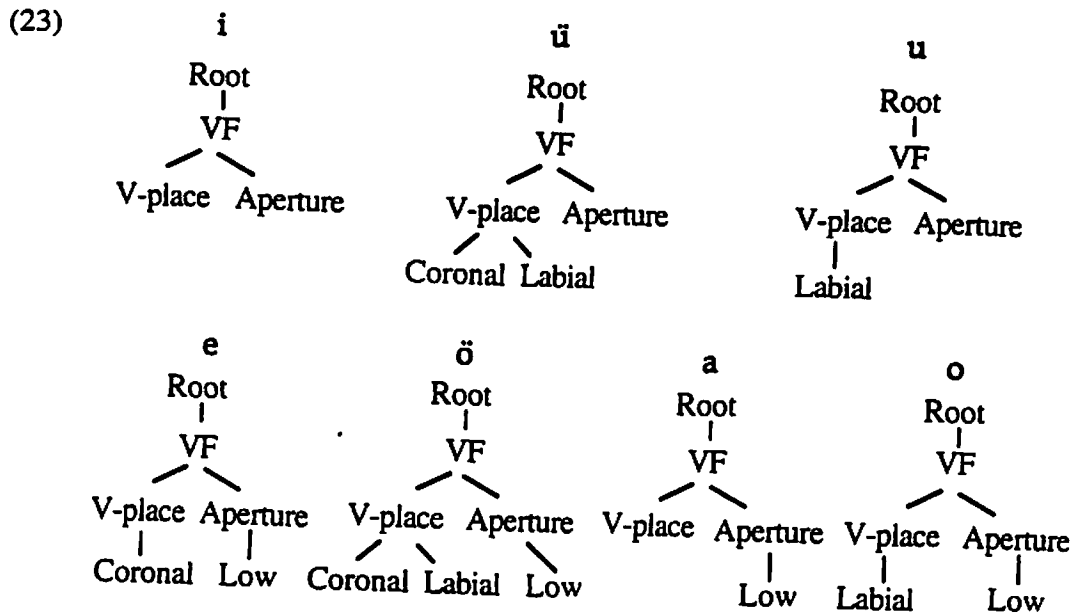
I now conclude that the correct contrastive specification of the Khalkha/Buriat vowel inventory activates the features shown in (22):

(22)	i	ü	u	e	ö	a	o
Low				√	√	√	√
Labial		√	√		√		√
Coronal		√		√	√		

This table shows that even though the inventory contains both /i/ and /ü/, /i/ does not have the Coronal articulator feature activated. Because the contrastive specification of this

inventory contrasts /i/ with both /ü/ and /u/ with respect to Labial and not with respect to Coronal, the default articulation for /i/ is realized as front and unrounded in order to oppose it to the default back articulation of a Labial segment. The Coronal contrast between /ü/ and /u/ does not affect the default articulation of /i/, because this contrast is salient only for the Labial segments and consequently, does not affect the oppositions of non-labial segments.

I conclude that contrastive specification results in the following representations for the Khalkha and Buriat vowels:



These representations are the same as for the Turkish vowels except for /i/. Unlike Turkish, /i/ is not contrastively specified with respect to Coronal in the asymmetrical inventory of Khalkha/Buriat, so /i/ does not have a Coronal dependent. How this difference produces the neutrality of /i/ in Khalkha and Buriat is the focus of the following section.

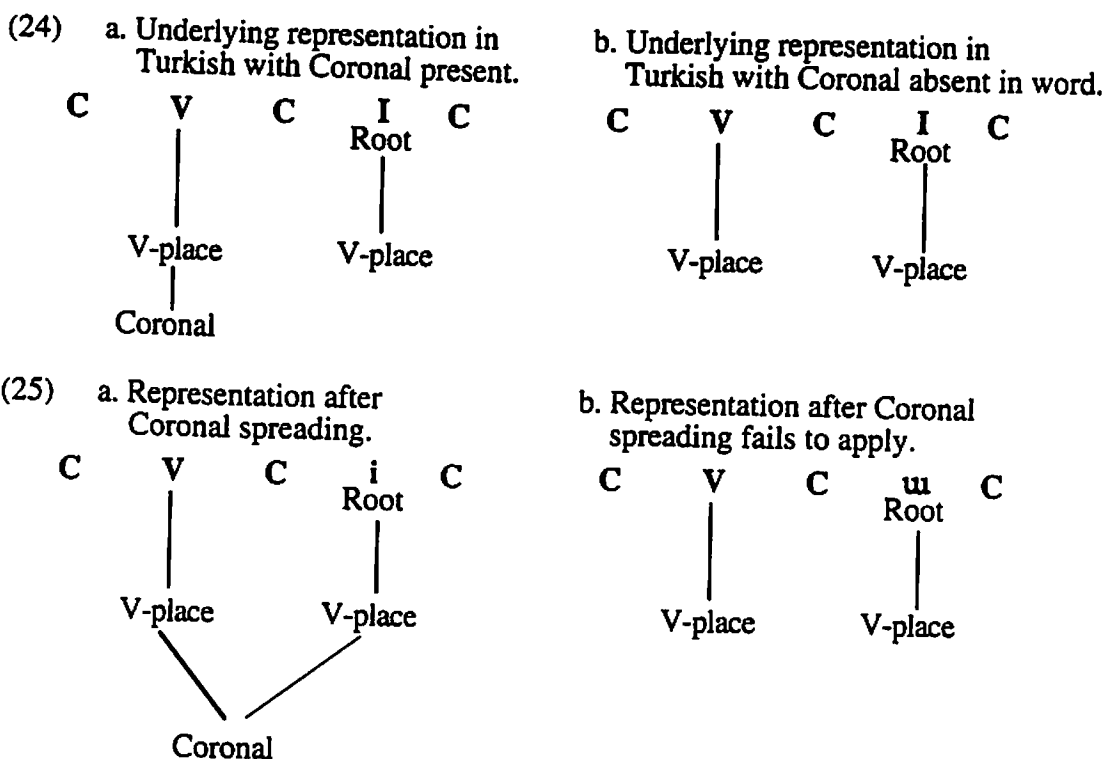
### 5.3 Neutral Vowels and Structure Preservation

I have established that the neutral vowel /i/ in Khalkha and Buriat has no Coronal dependents, as otherwise /i/ would trigger Coronal harmony. I will now examine how Structure Preservation can produce neutrality in certain segments in an asymmetrical inventory.

In Khalkha, Buriat and Turkish, the pattern of Coronal harmony is predictable on the basis of the first non-neutral vowel in the word. Accordingly, to eliminate redundant structure in the underlying representation, I will assume a traditional analysis in which there is only one specification with respect to Coronal for a word on the leftmost non-neutral vowel (see Lees (1961), Bach (1968), Binnick (1969, 1980), Hamp (1980) and others for similar assumptions). Rather than being specified in the underlying representation of each vowel, Coronal is then spread from the leftmost non-neutral vowel by a spreading rule or, in the absence of a Coronal feature in the word, all vowels are realized as their default articulation<sup>13</sup>. Thus, a representation for /i/ with a Coronal dependent predicts that Coronal could link to a non-low unrounded vowel, so that these vowels would alternate in the

<sup>13</sup>Although I have assumed the traditional analysis here, this is simply in order to focus on the issue of the representation of neutral vowels. The traditional analysis or the alternatives of autosegmental or morpheme structure condition analyses are equally compatible with this discussion. For an analysis of vowel harmony where the harmonic feature is underlyingly free over the stem and discussion of the implications of this representation for contrastive specification see Walker (1993).

Coronal harmony. Such an alternation occurs in the symmetrical inventory of Turkish. This type of alternation is illustrated in (24-25) with a schematic representation of a word with Coronal present on the initial vowel and a word with Coronal absent. In this illustration, I use <I> to signify a high unrounded vowel that has not received a specification for Coronal underlyingly. Lighter association lines signify spreading.



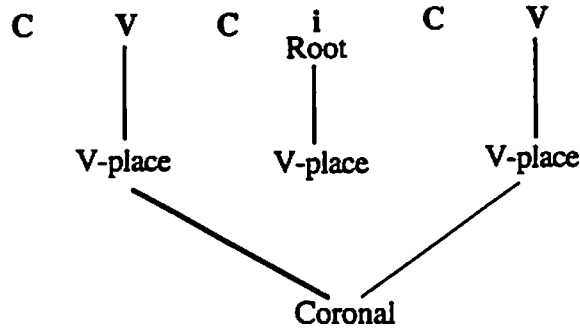
In (25a) Coronal spreads onto the high unrounded vowel, realizing [i], while in (25b), there is no Coronal feature to spread, so the high unrounded vowel with a bare V-place node is realized as [u]. Recall from section 2.2 that by the principle of Structure Preservation, I assume a feature can only spread onto a segment if the resulting structure corresponds to a possible phonemic representation. In the symmetrical inventory of Turkish, all vowels are contrastively specified with respect to Coronal. Consequently, Structure Preservation and the contrastive specification of Turkish correctly predict that Coronal can spread to any vowel in vowel harmony, because it will always produce a possible phonemic representation.

In contrast to Turkish, the phonemic representation for /i/ has no Coronal dependent in the asymmetrical inventory of Khalkha and Buriat, because it has not been contrastively specified with respect to Coronal. Consequently, in order to preserve the phonemic contrasts in the inventory, Structure Preservation will block Coronal from spreading onto a non-low unrounded vowel in Khalkha and Buriat. Structure Preservation thus prevents /i/ from alternating in Coronal harmony in these languages.

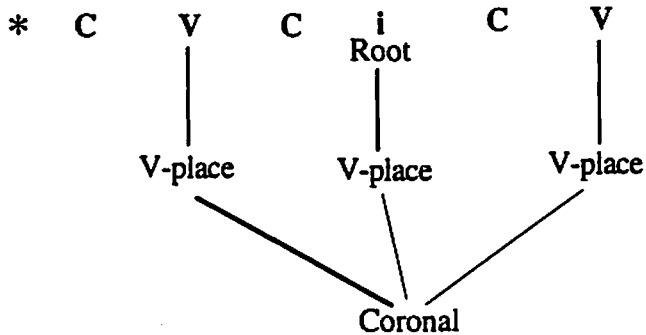
Since Structure Preservation disallows a representation in which Coronal is a dependent of a non-low unrounded vowel in Khalkha and Buriat, the non-low unrounded vowel will pattern as neutral, that is, it will not block the Coronal harmony and yet it will remain unaffected by the harmony, as illustrated in (26).



(26a) Representation of Khalkha/Buriat Coronal harmony in which /i/ is neutral.



(26b) Representation of Khalkha/Buriat Coronal harmony which violates Structure Preservation.



In (26a), Coronal does not link to /i/ because doing so would violate Structure Preservation by producing a non-phonemic representation for /i/, as shown in (26b). Instead Coronal spreads past /i/ to the next target node, producing precisely the pattern of neutrality found in Khalkha and Buriat. The spreading in (26a) has the appearance of being non-local. I assume that spreading is subject to strict adjacency between targets, where a target is a segment for which the spreading feature is contrastive (see, for example, Archangeli and Pulleyblank (1993) for similar assumptions concerning strict adjacency). In (26a) /i/ does not qualify as a target, because even though /i/ has a V-place target node in its representation, Coronal is not a contrastive feature for /i/. However, Coronal is contrastive for the vowel following /i/, so this vowel constitutes an adjacent target to the vowel in the initial syllable. The spreading configuration in (26a) thus satisfies strict adjacency for targets<sup>14</sup>.

In a word containing back vowel alternants, Coronal is absent, similar to the representation in (24b-25b). In these words, all vowels are realized as their default articulation for backness, resulting in a back articulation for all vowels except /i/, which is front. This correctly produces the pattern of neutrality for /i/ in a word with back alternants. Here the absence of a Coronal dependent in the representation of /i/ is crucial to account for its failure to trigger Coronal harmony on following vowels. I conclude that the neutrality of /i/ is explained by a representation for /i/ with a bare V-place node in combination with the principle of Structure Preservation.

This discussion has shown that the neutral patterning of /i/ in Khalkha and Buriat falls out from Structure Preservation and contrastive specification of the inventory

<sup>14</sup>Some spreading rules require strict adjacency between target nodes, rather than targets. In these cases, a vowel such as /i/ in (26a) would pattern as opaque rather than neutral, because Structure Preservation would block association to /i/ and strict adjacency would block spreading past /i/. See Labial harmony in Manchu for an example of this type of opacity (Walker (1993)).

according to the universal contrastive feature hierarchy. These principles have implications for the patterning of vowels in various inventories. They correctly predict the neutral patterning of certain vowels in a number of other Ural-Altaic languages with asymmetrical inventories, such as Manchu, Hungarian and Finnish<sup>15</sup>. See also Rose (this volume) for further evidence that the vowel representations determined by the contrastive feature hierarchy proposed here correctly predict the patterning of vowels in asymmetrical inventories of various languages.

## 6 Conclusion

In this paper I have argued for a universal procedure of contrastive specification in which contrasts are established on a step-wise basis following a fixed feature hierarchy. I have shown that this procedure produces representations for segments that have a relative complexity within the inventory consistent with a cross-linguistic comparison of vowel inventory configurations. I have also demonstrated that ranking Labial above Coronal in the contrastive feature hierarchy accounts for the phonological patterning of vowels in asymmetrical inventories. Consequently, cross-linguistic variation in processes, such as vowel harmony, is largely a result of the regular procedure of contrastive specification producing variations in the underlying representation for the same phonetic segment in different vowel inventories. Thus, this approach both yields a constrained means of establishing contrasts and explains the fact that vowels in inventories of different shapes often pattern in predictably different ways.

## References

- Aksan, D. (1978) *Türkiye Türkçesi Gelişmeli Sesbilimi*. Türk Dil Kurumu Yayınları, no. 451. Ankara: Ankara Üniversitesi Basımevi.
- Anderson, J. M. and C. J. Ewen. (1987) *Principles of Dependency Phonology*. Cambridge: Cambridge University Press.
- Archangeli, D. (1984) *Underspecification in Yawelmani Phonology and Morphology*. Doctoral dissertation, MIT. Published 1988, New York: Garland.
- Archangeli, D. (1988) "Aspects of Underspecification Theory." *Phonology*. 5: 183-207.
- Archangeli, D. and D. Pulleyblank. (1986) "The Content and Structure of Phonological Representations." Unpublished ms. University of Arizona and University of Southern California.
- Archangeli, D. and D. Pulleyblank. (1993) *Grounded Phonology*. Unpublished ms., University of Arizona and University of British Columbia.
- Avery, P. and K. Rice. (1989) "Segment Structure and Coronal Underspecification." *Phonology*. 6.2: 179-200.
- Bach, E. (1968) "Two Proposals Concerning the Simplicity Metric in Phonology." *Glossa*. 2: 128-49
- Banguoğlu, T. (1974) *Türkçenin Gremeri*. Istanbul: Baha Matbaası.
- Binnick, R. I. (1969) "Non-high Neutral Vowels in Modern Mongolian Vowel Harmony." *Chicago Linguistic Society*. 5: 295-301.

<sup>15</sup>In some of these languages, such as Manchu, consonants are palatalized before /i/. This suggests that Coronal is present in the representation of /i/ and spreads to a V-place node on a preceding consonant to produce palatalization. I assume that this type of consonant/vowel interaction takes place after vowel harmony in the derivation. If these interactions occur after redundant feature specification (see Ní Chiosáin and Padgett (1993)) then /i/ could have Coronal in its representation at this later stage due to redundant specification (see Kiparsky (1982), Archangeli (1984) and Archangeli and Pulleyblank (1986) for discussion of features being specified at different levels of the lexical phonology). I will leave this issue for further research.

- Binnick, R. I. (1980) "The Underlying Representation of Harmonizing Vowels: Evidence from Modern Mongolian." In R. M. Vago, ed., *Issues in Vowel Harmony*. Amsterdam: John Benjamins B.V.
- Bosson, J. (1962) *Buriat Reader*. Bloomington: Indiana University Publications.
- Bosson, J. (1964) *Modern Mongolian*. Bloomington: Indiana University Publications.
- Campbell, L. (1974) "Phonological Features: Problems and Proposals." *Language*. 50: 52-65.
- Chinchor, N. (1979) "On the Treatment of Mongolian Vowel Harmony." *Cunyform Papers in Linguistics*. 8: 171-87.
- Clements, G. N. (1985) "The Geometry of Phonological Features." *Phonology Yearbook*. 2: 225-252.
- Clements, G. N. (1988) "Toward a Substantive Theory of Feature Specification." *NELS*. 18: 79-93.
- Clements, G. N. (1989) "A Unified Set of Features for Consonants and Vowels." Unpublished ms., Cornell University.
- Clements, G. N. and E. Hume. (1993) "The Internal Organization of Segments." To appear in J. Goldsmith, ed., *Handbook of Phonological Theory*. Blackwell.
- Clements, G. N. and E. Sezer. (1982) "Vowel and Consonant Disharmony in Turkish." In H. van der Hulst and N. Smith eds., *The Structure of Phonological Representations 2*. Dordrecht: Foris Publications.
- Crothers, J. and M. Shibatani. (1980) "Issues in the Description of Turkish Vowel Harmony." In R. M. Vago, ed., *Issues in Vowel Harmony*. Amsterdam: John Benjamins B.V.
- Dresher, B. E. and H. van der Hulst. (1992) "Head-Dependent Asymmetries in Phonology." Paper read at the annual meeting of the CLA, Charlottetown, PEI; unpublished ms., University of Toronto and University of Leiden.
- Ergin, M. (1962) *Türk Dil Bilgisi*. Istanbul Üniversitesi Edebiyat Fakültesi Yayınları, no. 785.
- Hamp, E. P. (1980) "Mongolian Vocalic Features and the Problem of Harmony." In R. M. Vago, ed., *Issues in Vowel Harmony*. Amsterdam: John Benjamins B.V.
- Hulst, H. van der. (1989) "Atoms of Segmental Structure: Components, Gestures, and Dependency." *Phonology*. 6: 253-84.
- Hulst, H. van der and J. van de Weijer. (1991) "Topics in Turkish Phonology." In H. Boeschoten and L. Verhoeven, eds., *Turkish Linguistics Today*. Leiden: E. J. Brill.
- Hume, E. (1992) *Front Vowels, Coronal Consonants and their Interaction in Nonlinear Phonology*. Doctoral dissertation, Cornell University.
- Kiparsky, P. (1982) "Lexical Morphology and Phonology." In the Linguistic Society of Korea, ed., *Linguistics in the Morning Calm*. Seoul: Hanshin.
- Kiparsky, P. (1985) "Some Consequences of Lexical Phonology." *Phonology Yearbook*. 2: 85-138.
- Lahiri, A. and V. Evers. (1991) "Palatalization and Coronality." In C. Paradis and J.-F. Prunet, eds., *Phonetics and Phonology 2: The Special Status of Coronals, Internal and External Evidence*. Academic Press.
- Lees, R. (1961) *The Phonology of Modern Standard Turkish*. Bloomington: Indiana University Publications.
- Lees, R. (1966) "Turkish Harmony and the Phonological Description of Assimilation." *Türk Dili Araştırmaları Yıllığı*, Belleten 1966, (Türk Dil Kurumu Yayınları, no. 255), Ankara University, Ankara.
- Lewis, G. L. (1967) *Turkish Grammar*. Oxford: Clarendon Press.
- Maddieson, I. (1984) *Patterns of Sounds*. Cambridge University Press, Cambridge.
- McCarthy, J. (1988) "Feature Geometry and Dependency: A Review." *Phonetica*. 45: 84-108.

- Myers, S. (1991) "Structure Preservation and the Strong Domain Hypothesis." *Linguistic Inquiry*. 22: 379-85
- Ní Chiosáin, M. and J. Padgett. (1993) "Consonantal-Vowel Interaction and 'Cross-Tier' Effects." Paper given at the 67th Annual Meeting of the Linguistic Society of America, Los Angeles, Ca.
- Piggott, G. (1992) "Variability in Feature Dependency: The Case of Nasality." *Natural Language and Linguistic Theory*, 10: 33-77.
- Poppe, N. (1960) *Buriat Grammar*. Bloomington: Indiana University Publications.
- Poppe, N. (1970) *Mongolian Language Handbook*. Washington D.C.: Centre for Applied Linguistics.
- Rialland, A. and R. Djamouri. (1984) "Harmonie Vocalique, Consonantique et Structures de Dépendance dans le Mot en Mongol Khalkha." *Bulletin de la Société de Linguistique de Paris*. 79: 333-83.
- Rice, K. and P. Avery. (1991) "Segmental Complexity and the Structure of Inventories." Paper presented at GLOW Workshop on the Acquisition of Phonology, Leiden. To appear in *Toronto Working Papers in Linguistics*.
- Rose, S. (1993) "Coronality and Vocalic Underspecification." *Toronto Working Papers in Linguistics*. 12.2: x-x.
- Sagey, E. (1986) *The Representation of Features and Relations in Nonlinear Phonology*. Doctoral dissertation, MIT.
- Steriade, D. (1987) "Redundant Values." *Chicago Linguistic Society*. 23: 339-62.
- Street, John C. (1963) *Khalkha Structure*. Bloomington: Indiana University Publications.
- Svantesson, J.-O. (1985) "Vowel Harmony Shift in Mongolian." *Lingua*. 67: 283-327.
- Swift, L. B. (1963) *A Reference Grammar of Modern Turkish*. Bloomington: Indiana University Publications.
- Underhill, R. (1976) *Turkish Grammar*. Cambridge, Ma.: The MIT Press.
- Walker, R. (1993) "Contrastive Specification and Vowel Harmony Mechanisms in the Altaic Languages." Masters thesis. University of Toronto.
- Yavas, M. (1980) "Vowel and Consonant Harmony in Turkish." *Glossa*. 14.2: 189-211.
- Yükseker, H. (1983) "Turkish Vowel Harmony: Is It Really Very Harmonious?" Unpublished ms., University of Toronto.
- Zimmer, K. (1969) "Psychological Correlates of some Turkish Morpheme Structure Conditions." *Language*. 45: 309-21.