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UNIVERSITY OF CALIFORNIA

Los Angeles

The Typology of Rounding Harmony: An Optimality Theoretic Approach

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Linguistics

by

Abigail Rhoades Kaun

1995

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1995

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ACKNOWLEDGMENTS

First, I wish to thank Bruce Hayes, my committee chair, who has been both an inspiring teacher and a tireless advisor to me. Donca Steriade has also helped me enormously during my time at UCLA; it was she who originally steered me toward the topic for this thesis. I am fortunate to have had such exceptional faculty support from both Donca and Bruce.

I am also grateful to the others who served on my committee - Pamela Munro, Donka Minkova and Ralph Sonnenschein - and thank them for their time, expertise and patience.

The people who make things work at the UCLA Department of Linguistics have always been helpful and supportive to me. Thanks to John Bulger, Yaya Hou, Anna Meyer, Russ Schuh and Tim Stowell.

There are some special friends - students, professors, colleagues and mentors from my past - who have encouraged and helped me. Thanks to Tony Bures, Dani Byrd, Rod Casali, Susie Curtiss, Bill Davies, Alice Davison, John Ellis, Edward Flemming, Mrs. Gill, Chris Golston, Robert Hagiwara, Chai-Shune Hsu, Nina Hyams, Sue Banner Inouye, Hector Javkin, C. Douglas Johnson, Jongho Jun, Pat Keating, Karn B. King, Robert Kirchner, Peggy McEachern, Catharina Marlowe, Mme. Nail, Rosemary Plapp, Anastasia Riehl, Jurek Rubach, Bonny Sands, Dan Silverman, Sandy Thompson, Daniel Valois and Karen Wood. Very special thanks are due to Anastasia Riehl for her skillful and cheerful help with the manuscript.

Finally, I would like to express my gratitude and love to Shrikanth Narayanan, and to my parents Barbara Rhoades Ellis and David Evan Kaun.

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Kaun, A. R. (August, 1995). Vowel inventories and vowel processes within optimality theory. Paper to be presented at the International Congress of Phonetic Sciences, Stockholm, Sweden.

--- (March, 1995). Harmony as alignment in Shuluun Höh. Paper presented at the West Coast Conference on Formal Linguistics, Los Angeles, California.

--- (March, 1994). An optimality-theoretic account of rounding harmony typology. Paper presented at the West Coast Conference on Formal Linguistics, San Diego, California.

--- (1993). The coronal underspecification hypothesis. In Daniel Silverman and Robert Kirchner (eds.) *Papers in Phonology:UCLA Occasional Papers in Linguistics* 13.

--- (1991). Suffixal H tone assignment in Haya verbs and the OCP. Paper presented at the 4th Arizona Phonology Conference, Tucson, Arizona.

--- (1988). Definite and indefinite noun phrases in Turkish: A discourse study. In Sandra Thompson (ed.) *Santa Barbara Papers in Linguistics* 1.

ABSTRACT OF THE DISSERTATION

The Typology of Rounding Harmony:
An Optimality Theoretic Approach

by

Abigail Rhoades Kaun
Doctor of Philosophy in Linguistics
University of California, Los Angeles, 1995
Professor Bruce Hayes, Chair

This thesis explores the typology of rounding harmony within the framework of optimality theory. A systematic survey of the range of attested rounding harmony phenomena is presented and an analysis of this typology is proposed which invokes constraints based on perceptual and articulatory principles. A central element of the theory advanced here is the claim that vowel harmony is perceptually-motivated. Harmony serves to extend the duration of phonetic information which is phonologically important (i.e. distinctive), but which is transmitted by means of relatively subtle acoustic cues. Evidence from phonetic studies of vowel articulation and vowel perception is cited in support of the comprehensive phonological analysis presented here. It is demonstrated that the substantive account of the typology of rounding harmony made possible within optimality theory provides a very close fit with the observed typological facts, whereas purely formal, representationally-based phonological theories allow for no principled or adequately restrictive account of this range of facts.

Chapter 1 Introduction

In this dissertation I present an analysis of the typology of rounding harmony systems within the framework of optimality theory (Prince & Smolensky 1993, McCarthy & Prince 1993a,b). Central to the analysis presented here is the claim that phonological systems are organized around principles of both articulation and perception. The goals of the dissertation are as follows: (i) to exemplify the range of attested rounding harmony patterns, (ii) to identify the perceptual and articulatory principles which give rise to these patterns, and (iii) to propose an explicit formal model which characterizes the role of these principles in grammar.

Vowel harmony is the phenomenon whereby the quality of a given vowel in part determines the quality of some string of vowels occurring within the same word. Various features participate in vowel harmony phenomena including features relating to vowel height, vowel backness, position of the tongue root, nasality, and roundedness. It is harmony based on roundedness, namely harmony systems which propagate the feature [±round] which are the focus of the present study.

I propose that harmony is the grammatical reflex of a perceptual principle to be called 'Bad Vowels Spread.' This conceptualization of harmony is inspired by Kari Suomi's (1983) theory of palatal (backness) harmony as a perceptually-motivated phenomenon. The ingredients of this principle are as follows. Assume that there exists a set of perceptually difficult contrasts and that vowels whose recoverability relies on the detection of such contrasts are relatively likely to be misidentified. I assume that the probability that the value for some contrast will be accurately identified by the listener increases with increased exposure to the relevant value. In the figures below, [±F] represents some phonological feature, such as [±round] or

[±back], and V representations a vocalic position to which [±F] may be associated. In the representation in (a), the feature [±F] is non-harmonic (each vowel has its own specification), whereas in the representation in (b), feature [±F] is harmonic (vowels share a single specification). Note that the temporal span of [±F] is greater in (b) than it is in (a):

The key idea is that harmony gives rise to an extension of the temporal span associated with some perceptually vulnerable quality, represented above as [±F]. By increasing the listener's exposure to the quality in question, harmony increases the probability that the listener will accurately identify that quality.

The analysis which I present invokes the framework of optimality theory. This model is well suited to the analysis of phonological typologies in that its essential claim is that phonologies are composed of constraints on representations which do not vary from language to language. That is, constraints are claimed to be a part of universal grammar, and to the extent that individual grammars differ from one another, they do so only insofar as they assign relative importance to these constraints differently.

Optimality theory also provides a means by which to relate substantive phonetic principles to grammar. In the analysis presented here, I reject the notion that grammars are arbitrary formal systems; rather, I argue that they have at their

foundation functionally based principles which, in their formal incarnation, assume the form of optimality theoretic constraints.

The typology of rounding harmony systems is interesting because rounding harmony rules nearly always impose conditions on the participating vowels which make reference to the dimensions of height and/or backness. For example, in Turkish we find the rule 'Spread the autosegment [round] rightward from vowel to vowel, but only if the target is [+high].' Despite the numerous possible forms which such conditions might take, it turns out that very clear patterns emerge, and only a small range of rounding harmony systems is attested. The attested patterns, I will argue, fall out naturally from the interaction of a quite small set of phonetically motivated constraints.

The dissertation is structured as follows. In Chapter 2, I present a range of rounding harmony data from the Turkic, Mongolian and Tungusic branches of Altaic. Chapter 3 cites rounding harmony data from other languages and presents a typology of attested rounding harmony systems. In Chapter 4, I very briefly explain why rule-based approaches are ill-suited to the data at hand, suggesting the need for a different theoretical approach. Chapter 5 sets the groundwork for an optimality theoretic analysis of rounding harmony by presenting the phonetic principles which I believe underlie the operative constraints. The optimality theoretic analysis is laid out in detail in Chapter 6, where I present a rather small set of constraints to characterize the observed typological facts. Chapter 7 deals with some of the issues which arise when the constraints which I propose to account for the typology as a whole are implemented within individual grammars. Among these issues is the analysis of transparency, which bears on the hypothesis that harmony is characterized formally by means of optimality theoretic alignment (Smolensky 1993). Finally, in Chapter 8, a

number of rule-based approaches to the typology of rounding harmony are reviewed, and I conclude that none of these is capable of providing a comprehensive and falsifiable model. I argue that an optimality theoretic account which involves phonetically-grounded constraints provides an attractive means by which to understand and model the observed typological facts.

Chapter 2 Rounding Harmony in Turkic, Mongolian and Tungusic

In this chapter, I lay out the rounding harmony patterns which are found among languages of the Altaic group. In subsequent chapters I will show that the range of variation observed in the attested systems is best conceptualized as an optimization problem (Prince & Smolensky (1993), McCarthy & Prince (1993a)) in which the observed harmony effects are driven by a small set of general principles, some of which are potentially in conflict with one another. The content of these principles will be shown to be constant across languages, while cross-linguistic variation is characterized in terms of the relative weight or importance each of these principles has in determining the overall system.

In §2.1-2.6 I lay out the patterns observed among languages of the Turkic sub-branch, focusing on the nature of the conditions which are imposed on the application of rounding harmony from language to language. Following the section on Turkic, analogous data from the other branches of Altaic, namely Mongolian (§2.7) and Tungusic (§2.8), will be presented.

2.1 Turkic

The Turkic languages are distributed from Turkey throughout regions in the former Soviet Union and into parts of China and Mongolia. In Comrie's *Languages of the Soviet Union* (1981) the classification system given in (1) is proposed for Turkic:

(1) Genetic Vlassification of Modern Turkic Languages (From Comrie 1981, p. 46)

I	Chuvash
II	Southern Turkic, South-western Turkic, Oguz
	Turkish (Osmanli)
	Azerbaydzhan (Azeri Turkic)
	Khaladzh
	Gagauz
	Balkan Gagauz (Balkan Turkic)
	Turkmen (including Trukhmen)
III	Kipchak
IIIa	Ponto-Caspian, Kipchak-Cuman
	Karaim
	Kumyk
	Karachay-Balkar
	Crimean Tatar (also assigned to II)
IIIb	Uralian, Kipchak-Bulgar
	Tatar
	Bashkir
IIIc	Central Turkic, Kipchak-Nogay
	Nogay
	Karakalpak
	Kazakh
IV	Eastern Turkic, Karluk
	Uzbek
	Uygur
	Khoton (has also some features of V)
	Yellow Uygur (Sarı Uygur) (also assigned to V)
V	Northern Turkic, Eastern Hunnic
	Tuva (Uryankhay)
	Tofa (Tofalar, Karagas)
	Yellow Uygur (Sarı Uygur) (also assigned to IV)
	Salar (also assigned to IV)
	Yakut (Sakha) (including Dolgan)
	Khakas (Abakan Tatar, Yenisey Tatar) (including Kamas)
	Shor
	Chulym (Melet) Tatar
	Kirgiz
	Altay (Oyrot)

A striking property of nearly all Turkic languages is the presence of backness harmony (sometimes referred to as palatal harmony), whereby all vowels within a word agree with respect to backness. Also typical of the Turkic languages, though

less pervasive, is the presence of some degree of rounding harmony (sometimes referred to as labial harmony or labial attraction), whereby vowels within a word agree with respect to roundness. The manifestation of rounding harmony is considerably more varied among the Turkic languages, and it is the specific nature of this variation that will be addressed in this chapter.

The dialect of Kirgiz described by Comrie (1981) may be used to demonstrate both types of vowel harmony observed in Turkic. Kirgiz possesses the canonical Turkic vowel inventory in which vowels are opposed along three dimensions: height, backness and rounding, as shown in (2). In addition to height, backness and rounding, length is also contrastive among vowels in Kirgiz:

(2) Kirgiz Vowel Inventory

	Front		Back	
	Unround	Round	Unround	Round
High	i, i:	ü, ü:	ɪ, ɪ:	u, u:
Non-high	e, e:	ö, ö:	a, a:	o, o:

In the dialect of Kirgiz described by Comrie, the quality of vowels in non-initial syllables is to a large extent predictable on the basis of the quality of the vowel occurring in the first syllable. All non-initial syllables must agree with the initial syllable in terms of both backness and rounding. The effects of backness and rounding harmony can be observed most vividly in suffixal vowel alternations, although the vowels of native polysyllabic roots display the same distributional patterns. Let us consider first the ordinative suffix which has the surface variants

{-(i)nči, -(ɪ)nčɪ, -(u)nču, -(ü)nčü}. Note that the vowels of this suffix are in all instances high. Their rounding and backness, however, is variable. When the root contains front unrounded vowels, as in (3a-b), the alternant *-(i)nči* surfaces. Following back unrounded vowels, as in (3c-d), the suffix contains back unrounded vowels and the alternant *-(ɪ)nčɪ* surfaces.:

(3) Unrounded Root Vowels (Comrie, p. 61)

a.	bir	'one'	bir-inči	'first'
b.	beš	'five'	beš-inči	'fifth'
c.	altɪ	'six'	altɪ-nčɪ	'sixth'
d.	ǯɪjɪrma	'twenty'	ǯɪjɪrma-nčɪ	'twentieth'

The vowels of this suffix are rounded following roots containing rounded vowels, as shown in (4a-d):

(4) Rounded Root Vowels (Comrie, p. 61)

a.	üč	'three'	üč-ünčü	'third'
b.	tört	'four'	tört-ünčü	'fourth'
c.	toguz	'nine'	toguz-unču	'ninth'
d.	on	'ten'	on-unču	'tenth'

To demonstrate the effects of backness and rounding harmony in non-high vowels, consider the ablative suffix which has the surface variants *{-t/den, -t/dan, -t/dön, -t/don}*. As shown in (5), the non-high suffix vowel also agrees in both backness and rounding with the vowels of the root (consonants also agree in voicing with the preceding sound, as shown):

(5) Low Vowel Suffix (Comrie, p. 61)

a.	iš	'work'	iš-ten	'work-ABL'
b.	et	'meat'	et-ten	'meat-ABL'
c.	ɜɪl	'year'	ɜɪl-dan	'year-ABL'

d.	alma	'apple'	alma-dan	'apple-ABL'
e.	üj	'house'	üj-dön	'house-ABL'
f.	köl	'lake'	köl-dön	'lake-ABL'
g.	tuz	'salt'	tuz-don	'salt-ABL'
h.	tokoj	'forest'	tokoj-don	'forest-ABL'

This effect is pervasive across sequences of suffixes, as illustrated in the polymorphemic words given in (6). These words contain the possessive suffix *{-(s)in, -(s)ın, -(s)ün, -(s)un}* followed by the locative suffix which has surface variants *{-t/da, -t/de, -t/dö, -t/do}*:

(6) <u>Harmony Effects with Multiple Suffixes</u>

a.	ata-sın-da	'at his father'
b.	ene-sin-de	'at his mother'
c.	köz-ün-dö	'in his eye'
d.	tuz-un-do	'in his salt'

The Kirgiz pattern, while simple and symmetric, is in fact very unusual. In particular, while backness harmony is nearly always pervasive and unrestricted, the great majority of Turkic languages impose restrictions on the application of rounding harmony. Korn (1969) points out the asymmetry between these two harmony phenomena within Turkic and catalogues a range of rounding harmony types. His typology is the subject of §2.2.

2.2 Korn's Typology (1969)

On the basis of a survey of over twenty Turkic languages, Korn identifies six distinct rounding harmony systems. These systems vary with respect to the range of vowels which trigger rounding harmony and the segment types which function as targets. In nearly all Turkic languages, the vowel system can be characterized in terms

of two phonologically distinctive degrees of height, contrastive backness and contrastive rounding and harmony operates from left-to-right. To illustrate the nature of Korn's typology, consider the schematic configuration in (7). The potential triggers of rounding harmony, which are listed vertically, include the non-high and high rounded vowels *o, ö, u, ü*. Potential targets are listed horizontally. The symbol I represents any high vowel, and A represents any non-high vowel:

(7) Rounding Harmony Scheme

		Potential Target	
		A	I
	o	+/-/~	+/-/~
Potential Trigger	ö	+/-/~	+/-/~
	u	+/-/~	+/-/~
	ü	+/-/~	+/-/~

A plus sign indicates that rounding harmony is observed in the relevant configuration; a minus sign indicates that rounding harmony does not take place in that context, and the symbol "~" indicates that rounding harmony is optional. The six types identified by Korn are listed in (8)-(13):

(8) Korn's Type I

Languages: Kirgiz, Altai

		Potential Target	
		A	I
	o	+	+
Potential Trigger	ö	+	+
	u	~	+
	ü	+	+

This table is to be read as follows. The vowels *o, ö,* and *ü* obligatorily trigger harmony in a following non-high vowel (A) and a following high vowel (I). The vowel *u* obligatorily triggers harmony in a following high vowel (I), but only optionally triggers harmony when the following vowel is non-high (A).

(9) Korn's Type II

Languages: Shor

		Potential Target	
		A	I
	o	+	~
Potential Trigger	ö	+	+
	u	-	+
	ü	+	+

(10) Korn's Type III

Languages: Kazakh, Chulym Tatar

		Potential Target	
		A	I
	o	-	+
Potential Trigger	ö	+	+
	u	-	+
	ü	+	+

(11) Korn's Type IV

Languages: Kyzyl

		Potential Target	
		I	A
	o	-	-
Potential Trigger	ö	+	+
	u	-	+
	ü	+	+

(12) Korn's Type V

Languages: Kachin Khakass

		Potential Target	
		A	I
	o	-	-
Potential Trigger	ö	-	-
	u	-	+
	ü	-	+

(13) Korn's Type VI[1]

Languages: Turkish, Karagass, Tuvin, Uygur, Uzbek

		Potential Target	
		A	I
	o	-	+
Potential Trigger	ö	-	+
	u	-	+
	ü	-	+

From this typology, Korn concludes that certain trigger-target combinations are more or less likely to give rise to rounding harmony. His conclusions are summarized in (14):

[1]This in fact represents Korn's type VIII. For the purposes of this discussion, Korn's Types V-VII, which distinguish sets of historically merged vowels, are equivalent.

(14) Summary of Korn's conclusions (Korn 1969, p. 105)

a. If the *target* vowel is non-high:

•Rounding harmony is more likely to be observed when the trigger is [-back] as opposed to [+back].

•Rounding harmony is less likely to be observed if the trigger is high.

b. If the *target* vowel is high:

•Rounding harmony is more likely to be observed when the trigger is [-back] as opposed to [+back].

•Rounding harmony is less likely to be observed if the trigger is non-high.

Stated differently, rounding harmony is more likely to be triggered by front vowels than by back vowels, and harmony is favored when the trigger and target agree in height.

2.3 Rounding Harmony and [+high]

In traditional Turkic grammar, particularly in the works of Menges (1947, 1968), a distinction is drawn between assimilation in rounding which targets a high vowel, referred to as *labial harmony*, and assimilation in rounding which targets a non-high vowel, referred to as *labial attraction*. Historical records indicate that labial harmony began appearing as a phonological pattern earlier than labial attraction. Here the term "labial vowel" refers to any rounded vowel:

> All the suffixes of Turkic can be divided on the basis of their vocalism into those having *a/ä* and those having *y/i* [*ı/i* -AK]. In time -- and this is as early as the earliest Turkic texts -- the suffixes with *y/i* after a preceding syllable with a labial vowel could occasionally have *u/ü*. This type of assimilation is generally called Labial Harmony... Vowel assimilation after labials is carried still further to Labial Attraction, demanding a labial vowel also in the case of the stem syllables or suffixes having a/ä. Menges (1968, p. 76)

Indeed, based upon the types discovered in Korn's survey, a distinction between rounding harmony which targets high vowels on the one hand, and rounding harmony which targets non-high vowels on the other, is clearly attested in the synchronic grammars of Turkic languages. In the languages of Korn's Types V and VI, for example, only high vowels are targeted by rounding assimilation.

Korn's Type VI (given as (13) above) is widely represented, languages of this type coming from the Western, Southern, Northern and Eastern branches of Turkic. In languages of this type, high vowels consistently undergo rounding harmony when they follow rounded vowels, whereas in non-initial syllables, non-high vowels are always unrounded. Relevant data from languages representing each of these branches are given in §2.3.1-§2.3.4.

2.3.1 Western Turkic:[2] Karačay

Karačay is a Caucasian Turkic language very closely related to Balkar. The two are so closely related, in fact, that they share a common literary language developed during the Soviet period (Grimes, 1988). My primary source for this language is an article by Herbert (1962).

Karačay has the canonical Turkic vowel inventory listed in (15):

[2]The classification "Western" is used in Grimes (1988) but for some reason is avoided in Comrie (1981).

(15) Karačay Vowel Inventory (Herbert, p. 97)

	Front		Back	
	Unround	Round	Unround	Round
High	i	ü	ı	u
Non-high	e	ö	a	o

High suffixal vowels surface as rounded following rounded root vowels, as shown below in (16e-h). These forms contain the first person possessive suffix *{-im, -ım, -üm, -um}*:

(16) High Suffixal Vowels

a.	iyt	'dog'	iyt-im	'my dog'
b.	et	'meat'	et-im	'my meat'
c.	sırt	'back'	sırt-ım	'my back'
d.	at	'horse'	at-ım	'my horse'
e.	süt	'milk'	süt-üm	'my milk'
f.	öt	'bile'	öt-üm	'my bile'
g.	but	'hind leg'	but-um	'my hind leg'
h.	ot	'grass'	ot-um	'my grass'

Low suffix vowels are consistently unrounded, as shown in (17e-f). These data contain the plural suffix *{-le, -la}*:

(17) Low Suffixal Vowels

a.	iyt	'dog'	iyt-le	'dog-PL'
b.	et	'meat'	et-le	'meat-PL'
c.	sırt	'back'	sırt-la	'back-PL'
d.	at	'horse'	at-la	'horse-PL'

e.	süt	'milk'	süt-le	'milk-PL'
f.	öt	'bile'	öt-le	'bile-PL'
g.	but	'hind leg'	but-la	'hind leg-PL'
h.	öt	'grass'	ot-la	'grass-PL'

The familiar rounding harmony pattern of Standard Turkish is also of this type.

2.3.2 Southern Turkic: Azerbaydzhan (Comrie, 1981) & Turkish

The vowel inventory of Azerbaydzhan is given in (18). Comrie states that while the language has on the surface two non-high front rounded vowels, namely *æ* and *e*, only *æ* occurs in suffixes:

(18) Azerbaydzhan Vowel Inventory

	Front		Back	
	Unround	Round	Unround	Round
High	i	ü	ɪ	u
Mid	e	ö		o
Low	æ		a	

As in Karačay, high suffixal vowels are rounded following rounded vowels, whereas non-high suffix vowels are consistently unrounded. Consider the suffixed forms in (19) and (20):

(19) <u>High Vowel Suffixes</u>

a.	jarpag	'leaf'	jarpaɣ-ɪn	'leaf-GEN'
b.	külæk	'wind'	külæj-in	'wind-GEN'
c.	ox	'arrow'	ox-un	'arrow-GEN'
d.	söz	'word'	söz-ün	'word-GEN'

(20) <u>Low Vowel Suffixes</u>

a.	jarpag	'leaf'	jarpaɣ-da	'leaf-LOC'
b.	külæk	'wind'	külæk-dæ	'wind-LOC'
c.	ox	'arrow'	ox-da (*ox-do)	'arrow-LOC'
d.	söz	'word'	söz-dæ (*söz-dö)	'word-LOC'

The pattern found in Karačay and Azerbaydzhan is also found in standard Turkish. In Turkish, however, only eight vowel qualities are contrastive:

(21) <u>Turkish Vowel Inventory</u>

	Front		Back	
	Unround	Round	Unround	Round
High	i	ü	ɪ	u
Non-high	e	ö	a	o

Words with suffixes containing high vowels are given in (22). The high vowel of the suffix undergoes rounding harmony, as indicated. The suffixes shown in (23), which contain non-high vowels, do not undergo rounding harmony:

(22) <u>High Vowel Suffixes</u>

a.	ip	'rope'	ip-im	'my rope'
b.	süt	'milk'	süt-üm	'my milk'
c.	ev	'house'	ev-im	'my house'
d.	čöp	'garbage'	čöp-üm	'my garbage'
e.	kız	'girl'	kız-ım	'my girl'
f.	buz	'ice'	buz-um	'my ice'
g.	at	'horse'	at-ım	'my horse'
h.	gol	'(football) goal'	gol-um	'my (football) goal'

(23) <u>Low Vowel Suffixes</u>

a.	ip	'rope'	ip-e	'rope-DAT'
b.	süt	'milk'	süt-e	'milk-DAT'
			*süt-ö	
c.	ev	'house'	ev-e	'house-DAT'
d.	čöp	'garbage'	čöp-e	'garbage-DAT'
			*čöp-ö	
e.	kız	'girl'	kız-a	'girl-DAT'
f.	buz	'ice'	buz-a	'ice-DAT'
			*buz-o	
g.	at	'horse'	at-a	'horse-DAT'
h.	gol	'(football) goal'	gol-a	'(football) goal-DAT'
			*gol-o	

Although high suffixal vowels undergo rounding harmony in the examples in (22) above, it is important to note that in the same forms, an intervening non-high rounded vowel would serve to block harmony. For instance, the interrogative clitic *{mi, mü, mı, mu}* is subject to rounding harmony. Thus, the words in (22) can all be made into questions by adding the interrogative clitic:[3]

[3]Although this morpoheme is written as an independent word in Turkish orthography, the fact that it is subject to both rounding harmony and backness harmony shows that it not a free root but rather an affix or a clitic. Stress patterns suggest that it should be treated as a clitic, though the stress facts themselves are not relevant to the issue under discussion here.

(24) The Interrogative Clitic

a.	ip mi?	'is it rope?'	ip-im mi?	'my rope?'
b.	süt mü?	'is it milk?'	süt-üm?	'my milk'
c.	ev mi?	'is it a house?'	ev-im mi?	'my house'
d.	čöp mü?	'is it garbage?'	čöp-üm mü?	'my garbage?'
e.	kız mı?	'is it a girl?'	kız-ım mı?	'my girl?'
f.	buz mu?	'is it ice?'	buz-um mu?	'my ice?'
g.	at mı?	'is it a horse'	at-ım mı?	'my horse?'
h.	gol mu?	'is it a goal?'	gol-um mu?	'my goal?'

However, when the suffixed words from (23) occur with the interrogative clitic, the vowel of the clitic is invariably unrounded. That is, the unrounded suffix *[-e, -a]* blocks rounding harmony from the final vowel of the root onto the clitic. This blocking effect is shown in (25):

(25) The Blocking Effect

a.	ip-e mi?	'rope-DAT?'
b.	süt-e mi?	'milk-DAT?'
	*süt-e mü?	
c.	ev-e mi?	'house-DAT?'
d.	čöp-e mi?	'garbage-DAT?'
	*čöp-d mü?	
e.	kız-a mı?	'girl-DAT?'
f.	buz-a mı?	'ice-DAT?'
	*buz-a mu?	
g.	at-a mı?	'horse-DAT?'
h.	gol-a mı?	'(football) goal-DAT?'
	*gol-a mu?	

2.3.3 Northern Turkic: Tuva (Krueger, 1977)[4]

Tuva is spoken in the former Soviet Union, in Mongolia and in China. The vowel inventory given in (26) is identical to that of Turkish The non-high vowels

[4]Krueger refers to this language as Tuvinian.

other than *a* are described as "semi-wide" or "slightly raised from a completely low position" (Krueger, p. 95). The vowel *a* is described as low and back (p. 94):

(26) Tuva Vowel Inventory[5]

	Front		Back	
	Unround	Round	Unround	Round
High	i, i:	ü, ü:	ɨ, ɨ:	u, u:
Non-high	ɛ, ɛ:	œ, œ:	a, a:	ɔ, ɔ:

Just as in Turkish, high suffix vowels are rounded when preceded by a rounded vowel, regardless of the height of the trigger. Examples are given in (27) and (28). The words in (27) contain the ordinal suffix *{-k/gi, -k/gü, -k/gɨ, -k/gu}*:

(27) High Vowel Suffixes: (Krueger, p. 122)

a.	bir-gi	'first'
b.	sɛs-ki	'eighth'
c.	üš-kü	'third'
d.	dœrt-kü	'fourth'
e.	aldɨ-gɨ	'sixth'
f.	tɔzan-gɨ	'ninetieth'
g.	muŋ-gu	'thousandth'
h.	ɔn-gu	'tenth'

The words in (28) contain the genitive suffix {-t/d/niŋ, -t/d/nüŋ, -t/d/nɨŋ, -t/d/nuŋ}:

(28) Additional High Vowel Suffixes: (Krueger, p. 112)

a.	inɛk-tiŋ	'cow-GEN'
b.	xün-nüŋ	'day/sun-GEN'

[5]According to Krueger's description, a third series of vowels, namely a glottalized series, exists in addition to the long and short pairs listed in (24).

c.	sœl-düŋ	'square-GEN'
d.	kɪm-nɪŋ	'who-GEN'
e.	xar-nɯŋ	'snow-GEN'
f.	nɔm-nuŋ	'book-GEN'
g.	xɔl-nuŋ	'arm-GEN'

And again, as in Turkish, non-high suffix vowels are not rounded following rounded vowels. The words in (29) contain the locative suffix *{-t/da, -t/dɛ}*:

(29) Non-high Vowel Suffixes: Locative (Krueger, p. 114)

a.	ɛžik-tɛ	'door-LOC'
b.	inɛk-tɛ	'cow-LOC'
c.	xün-dɛ	'sun/day-LOC'
	*xün-dœ	
d.	xœl-de	'lake-LOC'
	*xœl-dœ	
e.	kɪr-da	'ridge-LOC'
f.	dag-da	'mountain-LOC'
g.	xɔvu-da	'steppe-LOC'
	*xɔvu-dɔ	
h.	dɔš-ta	'ice-LOC'
	*dɔš-tɔ	

The words in (30) contain the ablative suffix *{-t/dan, -t/dɛn}*:

(30) Non-high Vowel Suffixes: Ablative (Krueger, p. 115)

a.	ɛžik-tɛn	'door-ABL'
b.	inɛk-tɛn	'cow-ABL'
c.	xün-dɛn	'sun/day-ABL'
	*xün-dœn	
d.	pœš-ten	'cedar-ABL'
	*pœš-tœn	

e.	kır-dan	'ridge-ABL'
f.	mal-dan	'cattle-ABL'
g.	ulus-tan	'people-ABL'
	*ulus-tan	
h.	ɔt-tan	'fire-ABL'
	*ɔt-tɔn	

And finally, just as in Turkish, when a non-high vowel intervenes between a high suffixal vowel and a preceding rounded vowel, rounding harmony is prevented from occurring. In the examples in (31e and g), the high vowel of the past tense suffix *{-d/ti, -d/tü, -d/tı ,-d/tu}* undergoes rounding harmony triggered by a rounded vowel in the root. In the examples in (31f and h) however, the low vowel suffix {-p/ba, -p/bɛ},[6] 'negative', precedes the high vowel of the past tense suffix, and rounding harmony is blocked:

(31) <u>The Blocking Effect</u>

a. kɛl-di	'He came'	b. kɛl-bɛ-di	'He didn't come'
c. al-dı	'He took'	d. al-ba-dı	'He didn't take'
e. œs-tü	'He grew'	f. œs-pɛ-di	'He didn't grow' (*ös-pɛ-dü)
g. uš-tu	'He flew'	h. uš-pa-dı	'He didn't fly' (*uš-pa-du)

2.3.4 Eastern Turkic: Uygur

Uygur (Hahn (1991), Lindblad (1990)), classified by Comrie as belonging to the Eastern Turkic branch, is spoken in the former Soviet Union, China and by small groups as far west as Turkey and Iran. This language presents an interesting case of

[6]The negative suffix in fact has the following variants (Krueger, p. 129-30):
-ba/-be: After the sonants l, r, y, γ
-pa/-pe: After voiceless consonants
-va/-ve: After vowels
-ma/-me: After nasals

Korn's Type VI because in this language, certain suffixal vowels are targeted by rounding harmony while others are not. Those suffix vowels which do undergo rounding harmony are all high. The underlying vowel inventory, as analyzed by Hahn (1991), is as shown in (32):

(32) Uygur Vowel Phonemes (Hahn's analysis, pp. 33-44)

	Front		Back	
	Unround	Round	Unround	Round
High	i	ü	ɨ[7]	u
Mid	(e)	ö		o
Non-high	ä		a	

The phoneme *e* is enclosed in parentheses because this vowel occurs only in loanwords such as *uniwersitet* (< Russ. *universitet*), *Xebey* 'Hebei' (< Chin. *Héběi*), *rentgen* 'radiography'.[8]

On the surface, Uygur has only one unrounded high vowel, *i*. Certain roots containing *i* in the final syllable take [-back] suffixes, in comformity with the typical Turkic backness harmony pattern. However, in the majority of cases, vowels following *i* are [+back]. As a further complication, certain stems in *i* are followed by the [-back] variant of one set of suffixes, while it is the [+back] variant of a second set of suffixes which surfaces following those same stems (Lindblad 1990).

[7]Under Hahn's analysis, underlying /ɨ/ and /i/ merge on the surface as [i]. The motivation for positing underlying /ɨ/ is the existence of a large class of roots containing a final-syllable [i] which take back vocalic suffixes.

[8]Hahn points out that the vowel /e/ is in certain cases followed by back vowel suffixes as in *uniwersitetta* (**uniwersitettä*), 'at a/the university' and *Xebeyda* (**Xebeyde*) 'in Hebei'.

With respect to rounding harmony in suffixal vowels, Uygur has a class of suffixes which contain alternating high vowels. The vowels of such suffixes surface with rounded vowels when a rounded vowel occurs in the preceding syllable; otherwise, they occur with unrounded vowels. This is the familiar pattern. The words in (33) contain the first person singular possessive suffix *{-im, -um, -üm}*, the rounded variants occurring when the preceding vowel is rounded:

(33) Alternating High Suffix Vowel: -Im '1.POSS' (Lindblad, p. 17)

a.	yol	'road'	yol-um	'my road'
b.	pul	'money'	pul-um	'my money'
c.	at	'horse'	et-im[9]	'my horse'
d.	qiz	'girl'	qiz-imiz	'my girl'
	(*qɪz* under Hahn's analysis)			
e.	köl	'lake'	köl-üm	'my lake'
f.	yüz	'face'	yüz-üm	'my face'
g.	xät	'letter'	xät-im	'my letter'
h.	pikir	'opinion'	pikir-im	'my opinion'

At the same time, however, Uygur has a number of suffixes which contain non-alternating high vowels. For example, another set of suffixes contains vowels which are invariably rounded, regardless of the quality of the preceding vowel. One such suffix is the gerundive, represented as /-GU/ in Lindblad's analysis. Examples containing /-GU/ are shown in (34):

[9]The a/e alternation observed here is, according to Lindblad (p. 10) the result of a raising rule. This rule raises certain low vowels in initial open syllables to mid, when the following vowel is *i*.

(34) Non-alternating Rounded Suffix Vowel: -GU 'Gerundive' (Lindblad, p. 17)

a.	bol-	'become'	bol-ğu-	'become-GER'
b.	oqut-	'teach'	oqut-qu-	'teach-GER'
c.	yaz-	'write'	yaz-ğu-	'write-GER'
d.	tiq-	'insert'	tiq-qu-	'insert-GER'
	(*tıq-* under Hahn's analysis)			
e.	kör-	'see'	kör-gü-	'see-GER'
f.	küt-	'wait'	küt-kü-	'wait-GER'
g.	käl-	'come'	käl-gü-	'come-GER'
h.	tik-	'sew'	tik-kü-	'sew-GER'

The words in (35) contain the first person plural possessive suffix /-imiz/, a suffix which contains the unrounded vowel *i* regardless of the quality of the preceding vowel:[10]

(35) Non Alternating Unrounded Suffix Vowel: -imiz ' (Lindblad, p. 17)

a.	yol	'road'	yol-imiz	'our road'
b.	pul	'money'	pul-imiz	'our money'
c.	at	'horse'	et-imiz	'our horse'
d.	qiz	'girl'	qiz-imiz	'our girl'
e.	köl	'lake'	köl-imiz	'our lake'
f.	yüz	'face'	yüz-imiz	'our face'
g.	xät	'letter'	xät-imiz	'our letter'
h.	pikir	'opinion'	pikir-imiz	'our opinion'

[10]To eliminate the hypothesis that the suffix *-imiz* resists rounding harmony due to its polysyllabicity (e.g. because harmony is a strictly local, close-range effect), consider the monosyllabic agentive suffix *-či*, which, like *-imiz*, is not subject to rounding harmony:

a.	bol-	'become'	bol-ğu-či	'become-GER-AGT'
b.	oqut-	'teach'	oqut-qu-či	'teach-GER-AGT'
c.	yaz-	'write'	yaz-ğu-či	'write-GER-AGT'
d.	tiq-	'insert'	tiq-qu-či	'insert-GER-AGT'
e.	kör-	'see'	kör-gü-či	'see-GER-AGT'
f.	küt-	'wait'	küt-kü-či	'wait-GER-AGT'
g.	käl-	'come'	käl-gü-či	'come-GER-AGT'
h.	tik-	'sow/sew'	tik-kü-či	'sow/sew-GER-AGT'

Despite the morpheme-specific nature of rounding harmony effects in Uygur, the language is arguably a Type VI language in that rounding harmony, when observed, targets only high vowels and is triggered by both high and non-high vowels. The system is clearly quite complex, however, and a phonological treatment of the alternating and non-alternating suffixes is not offered in this thesis, however it is clear that this language would also prove to be a testing ground for the theory of the content and structure of lexical representations.

2.4 Rounding Harmony and [α high]

In addition to the tendency for languages to impose a height condition on the target of rounding harmony (namely that it must be [+high]), in certain Turkic languages rounding harmony in some or all configurations is observed only when the trigger and target agree in height. As a consequence, in systems in which such a constraint is operative, sequences of distinct rounded vowels are prevented from surfacing. Some examples of this phenomenon are presented here.

2.4.1 Kachin Khakass (Korn, 1969)

Khakass is a Northern Turkic language spoken in the former Soviet Union and in China. The Kachin (or Kacha) dialect is cited by Korn as exemplifying his Type V in which the trigger and target of rounding harmony must both be [+high]. This type represents a more restrictive system than Korn's Type VI in which a height condition is placed only on the target of rounding harmony. In Type V, not only must the target be [+high], but the trigger and target must also agree with respect to height; therefore,

rounding harmony generates only the sequences *uCu* and *üCü*. The data cited in Korn's article are reproduced in (36) and (37). The only cases in which a suffixal vowel is rounded are in (37c and d), where the trigger and target are both [+high]:

(36) Kachin Khakass: Low Vowel Suffixes

a.	pol-za (*pol-zo)	'if he is'
b.	čör-gän (*čör-gön)	'who went'
c.	kuzuk-ta (*kuzuk-to)	'in the nut'
d.	kün-gä (*kün-gö)	'to the day'

(37) Kachin Khakass: High Vowel Suffixes

a.	ok-tɯŋ (*ok-tuŋ)	'of the arrow'
b.	čör-zip (*čör-züp)	'having gone'
c.	kuš-tuŋ	'of the bird'
d.	kün-nü	'day-ACC'

2.4.2 Yakut (Krueger, 1962)

Yakut is a Northern Turkic language spoken in the former Soviet Union. I rely exclusively on the descriptions, data and generalizations provided in Krueger's (1962) grammar of this language. According to Krueger, Yakut has the vowel inventory given in (38). In addition to the canonical three-dimensional Turkic system, vowel length is contrastive for all qualities other than *ö*, and the falling diphthongs listed below (each containing a single value for backness and rounding) occur:

(38) Yakut Vowel Inventory

	Front		Back	
	Unround	Round	Unround	Round
High	i, i:	ü, ü:	ɪ, ɪ:	u, u:
Non-high	e, e:	ö	a, a:	o, o:
Falling Diphthongs	ie	üö	ɪa	uo

Krueger lists the following minimal pairs, demonstrating that vowel length is contrastive:

(39) Minimal Pairs for Vowel Length

tas	'exterior'	ta:s	'stone'
at	'horse'	a:t	'name, renown'
keler	'he is coming'	kele:r	'he is going to come'
eter	'he talks'	ete:r	'he is going to talk'
bis	'to grease, oil'	bi:s	'sort, type'
is	'to drink'	i:s	'sewing'
kɪr	'to gnaw, chew'	kɪ:r	'to enter'
tolon	'degree'	tolo:n	'valley'
solo	'rank, position'	solo:	'to clean up, clear off'
tur	'to stand'	tu:r	'to handle, heft'
kur	'belt, strap'	ku:r	'to dry'
mus	'to gather'	mu:s	'ice'
üt	'to strike, hit'	ü:t	'milk'
sül	'to skin, peel'	sü:l	'to be in heat (of animals)'

In Yakut, high vowels are always subject to rounding harmony. Non-high vowels, by contrast, are only subject to rounding harmony if the potential trigger is itself a non-high vowel. Thus, we see that Yakut shares with Korn's Type VI languages the tendency to single out high vowels as targets (or, put another way, to avoid targeting non-high vowels). In addition, Yakut shares with Kachin Khakass the

tendency for rounding harmony to be observed in configurations in which the trigger and target agree with respect to height. In Kachin Khakass both trigger and target must be high, whereas in Yakut, trigger and target must either agree in height (yielding the sequences *uCu*, *üCü*, *oCo*, *öCö*), or the target must be high (thus allowing the sequences *oCu* and *öCü* as well). The patterning of diphthongs is discussed below.

Krueger's summary of the vowel harmony phenomena of Yakut (including both backness and rounding harmony) is paraphrased here in (40):

(40) Summary: Vowel Harmony in Yakut (Krueger, p. 49)

a. After a front vowel, only a front vowel may occur.

b. After a back vowel, only a back vowel may occur.

c. After an unrounded vowel, only an unrounded vowel may occur.

d. After a rounded vowel, only a rounded vowel may occur (except that unrounded *a* or *e* occur after *u* and *ü* respectively).

Examples from suffixal alternations show these patterns most vividly, though the generalizations in (40) hold for vowels within native roots as well. Let us begin with high vowel suffixes which, as stated above, exhibit rounding harmony regardless of the height of the trigger. In (41), high vowel suffixes are shown occurring following unrounded root vowels:

(41) High Vowel Suffixes, Unrounded Root Vowels

a.	aɣa-nɨ	'father-ACC'
b.	pa:rta-nɨ	'desk-ACC'
c.	ɨska:p-tɨn	'cabinet-SOC'
d.	kinige-ni	'book-PL'
e.	kihi-li:n	'man-SOC'
f.	et-im	'meat-my'

g.	iye-ɣit	'mother-1.PL.GEN'

Following rounded root vowels, the high suffixal vowels are rounded:

(42) <u>High Vowel Suffixes, Rounded Root Vowels</u>

a.	oɣo-nu	'child-ACC'
b.	oɣo-lu:n	'child-SOC'
c.	oχ-u	'arrow-ACC'
d.	murun-u	'nose-ACC'
e.	tobug-u	'knee-ACC'
f.	börö-nü	'wolf-ACC'
g.	öy-ü	'sense-ACC'
h.	kötör-dün	'bird-SOC'
i.	doɣor-uŋ	'friend-2.SG.GEN'
j.	tünnüg-ü	'window-ACC'
k.	ü:-üŋ	'milk-2.SG.GEN'

In (43), low vowel suffixes are shown following roots in which the final vowel is unrounded. As expected, in this context low suffixal vowels are themselves unrounded as well:

(43) <u>Non-high Vowel Suffixes, Unrounded Root Vowels</u>

a.	aɣa-lar	'horse-PL'
b.	balɪk-lar	'fish-PL'
c.	aɣa-ɣa	'father-DAT'
d.	et-ter	'meat-PL'
e.	kini-ler	'he-PL' ('they')

When the final vowel of the root is non-high and rounded, a non-high suffixal vowel surfaces as rounded, as shown in (44):

(44) Non-high Vowel Suffixes, Rounded Non-high Root Vowels

a.	öttöχ-tor	'farm-PL'
b.	ohoχ-tor	'stoves-PL'
c.	torbos-tor	'heifer-PL'
d.	börö-ttön	'wolf-ABL'
e.	son-ton	'jacket-ABL'

Rounding harmony fails to apply, however, when the potential trigger is [+high], as shown here in (45):

(45) Non-high Vowel Suffixes, Rounded, High Root Vowels

a.	tünnük-ter	'window-PL'
	*tünnük-tör	
b.	tobuk-ka	'knee-DAT'
	*tobuk-ko	
c.	kömüs-te:ɣer	'silver-COMP'
	*kömüs-tö:ɣör	

The rounded diphthongs *uo, üö* pattern as if they were high vowels, perhaps indicating that the first half of the diphthong occupies the syllable nucleus while the second half occupies the syllable margin. The diphthongs may occur following either high or non-high rounded vowels (although in Krueger's grammar no suffixal diphthongs are listed), and they fail to trigger rounding of a following non-high vowel. Examples of the rounded diphthongs in non-initial position are given in (46):

(46) Non-initial Rounded Diphthongs (Krueger, p. 38, 53)[11]

a.	öyüö	'provisions'
b.	söpsüö	'to approve' (< Mong. *jöbšiye*)
c.	kürüö	'fence'
d.	boppurous	'question, problem' (< Russ. *vopros*)
e.	borokuot	'steamship' (< Russ. *paraxod*)

Examples demonstrating that rounded diphthongs fail to trigger rounding of a following non-high suffixal vowel are given in (47). Given the falling nature of these diphthongs (i.e. that the first half is [+high] and the latter half is [-high]), one might expect them to pattern as low vowels with respect to vowels which follow. More specifically, the fact that the rounded diphthongs do not trigger rounding of a following non-high vowel requires an explanation, since as we saw above, non-high rounded monophthongs do trigger rounding of a following non-high vowel:[12]

(47) Diphthongs as Rounding Harmony Triggers (and *Non*-triggers)[13]

a.	üör-ü	'herd-ACC
b.	üör-ge (*üör-gö)	'herd-DAT'
c.	küöl-ü	'lake-ACC'
d.	küöl-ge (*küöl-gö)	'lake-DAT'
e.	muos-u	'horn-ACC'
f.	muos-ka (*muos-ko)	'horn-DAT'

[11]There are relatively few examples demonstrating this point. On pp. 49-50, however, Krueger states that the diphthongs (unrounded as well as rounded) are all capable of occurring in non-initial position. The rounded diphthongs occur just as long as the vowel in the preceding syllable is rounded (regardless of its height).

[12]The behavior of Yakut diphthongs in the rounding harmony system suggests that they pattern as high vowels with respect to the assessment of constraint violations. This is discussed in more detail in Chapter 6.

[13]To anticipate the analysis which will be proposed further on, the relevant constraints are *ROLO and UNIFORM[RD]. Evidently, the creation of rounded diphthongs does not violate the constraint dictating against rounded non-high vowels (*ROLO),. Furthermore, rounded diphthongs and non-high rounded vowels involve non-uniform lip-rounding. A harmonic sequence involving a rounded diphthong and a rounded non-high vowel thus will incur a violation of UNIFORM[RD]. These constraints are discussed in detail in Chapters 5 and 6.

2.5 Rounding Harmony & [back]

Just as certain rounding harmony systems discovered by Korn are subject to height conditions (requiring that the target be [+high] or that the trigger and target agree in height), certain harmony systems also refer to the backness of the trigger and target. What one finds is that rounding harmony is observed in certain configurations in which the the trigger is [-back] when, in analogous configurations in which the trigger is [+back], rounding harmony does not occur.

2.5.1 Kazakh (Korn, 1969)

In Kazakh (Korn 1969) as well as in Karakalpak (Menges 1947), rounding harmony is invariably observed when the potential trigger is [+high]. In this regard, these languages resemble Korn's Type VI languages. In addition, however, rounding harmony is also observed just in case the trigger and target are both [-back]. That is, not only are the sequences *uCu*, *üCü*, *oCu*, *öCü* observed, but the sequences *öCö* and *üCö* surface as well. The relevant data from Korn's article are shown in (48), where the suffixes contain high vowels and consistently undergo rounding harmony regardless of whether the sequence involves front vowels or back vowels. In (49), rounding harmony is shown to target non-high suffixal vowels only if the vowels in question are front:

(48) High Suffixal Vowels

a.	köl-dü	'lake-ACC'
b.	üy-dü	'house-ACC'
c.	koy-du	'sheep-ACC'
d.	kul-du	'servant-ACC'

(49) Non-high Suffixal Vowels

a.	köl-dö	'lake-LOC'
b.	üy-dö	'house-LOC'
c.	son-dan (*son-don)	'rubble-ABL'
d.	kul-da (*kul-do)	'at the servant'

2.5.2 Kirgiz (Herbert & Poppe's (1963) Dialect)

In the description of Kirgiz given in Herbert & Poppe (1963) the only configuration in which rounding harmony is *not* observed is when the trigger is high, the target disagrees with the trigger in height, and the vowels in question are back. Specifically, the sequence *u-a* surfaces in preference to the sequence *u-o*. The vowel inventory provided by Herbert and Poppe is the standard three-dimensional Turkic system, repeated in (50):

(50) Kirgiz Vowel Inventory (Herbert & Poppe, pp. 3-7)

	Front		Back	
	Unround	Round	Unround	Round
High	i	ü	ɨ	u
Non-high	e	ö	a	o

To demonstrate the pattern described above, consider the surface realizations of vowels in the ordinal suffix, which contains [+high] vowels, as compared with those of the ablative suffix, which contains low vowels. In the forms containing the ordinal *{-inči, -ünčü, -ɯnčɪ, -unču}*, shown in (51), the rounded variants surface when the final vowel of the root is rounded, regardless of the height of the potential target or the backness of the vowel sequence as a whole:

(51) <u>The Ordinal Suffix</u> (Herbert & Poppe, pp. 7-8)

a.	biri-inči	'one-ORD, *first*'
b.	beš-inči	'five-ORD, *fifth*'
c.	üč-ünčü	'three-ORD, *third*'
d.	tört-ünčü	'four-ORD, *fourth*'
e.	altɪ-ncɪ	'six-ORD, *sixth*'
f.	ǰɪyɪrma-nčɪ	'twenty-ORD, *twentieth*'
g.	toguz-unču	'nine-ORD, *ninth*'
h.	on-unču	'ten-ORD, *tenth*'

In the forms containing the ablative suffix *{-t/den, -t/dön, -t/dan, -t/don}*, the rounded variants surface just in case the vowels agree in height (i.e. the final vowel of the root is itself non-high) *or* the vowels in question are [-back]:

(52) The Ablative Suffix (Herbert & Poppe, p. 8)

a.	iš-ten	'job-ABL'
b.	et-ten	'meat-ABL'
c.	üy-dön	'house-ABL'
d.	köl-dön	'lake-ABL'
e.	jɨl-dan	'year-ABL'
f.	asan-dan	'Hasan-ABL'
g.	turmuš-tan (*turmuš-ton)	'life-ABL'
h.	tokoy-don	'forest-ABL'

Thus, from the examples above, the only instance in which a rounded root vowel fails to trigger rounding of a suffixal vowel is given in (52g). In this example, the potential trigger and target disagree in height, and the target is non-high.

2.5.3 Shor (Korn, 1969)

Shor is of particular interest because it exemplifies each restriction discussed thus far in this section. Rounding harmony in Shor is observed when the target is [+high], as long as the trigger is [+high] as well. When the potential trigger is [-high], rounding of a [+high] vowel is apparently optional. The situation is somewhat different when the potential target is [-high]. Rounding harmony is consistently observed when the vowels in question are front. If the vowels are back, then harmony is observed only when the trigger and target agree in height. This pattern is summarized in (53):

(53) Rounding Harmony in Shor (Korn 1969)

a. If trigger and target are front, rounding harmony is observed regardless of height.

b. If trigger and target are back, rounding harmony is observed when trigger and target agree in height.

c. If trigger and target are back but disagree in height, rounding harmony is *optionally* observed if the target is [+high].

d. If trigger and target are back but disagree in height, rounding harmony is never observed if the target is [-high].

Examples illustrating the statements in (53) are given in (54):

(54) Examples from Shor (Korn, 1969)

a.	mün-üp	'having mounted'
	sös-töy	'from the word'
	kör-zö	'if (he) sees'
	külük-tö	'at the brave man's'
	kök-tüŋ	'of the sky'
b.	kuš-tun	'of the bird'
	kol-doŋ	'from the hand'
	pol-zo	'if (he) is'
c.	coň-nɯŋ / coň-nuŋ	'of the people'
d.	ug-ar	'which will grasp'

2.6 Conclusions: Turkic

We have seen that the Turkic languages typically impose conditions on the application of rounding harmony and that those conditions are of two basic types: They refer either to the height of the participating vowels, or to their backness. With respect to height, we saw that rounding harmony systems frequently avoid generating non-high rounded vowels. Such is the case in the languages discussed in §2.3, where rounding harmony targets only high vowels. In addition, in some systems rounding harmony fails to occur when the output of the rule would be a sequence of distinct rounded vowels, that is a sequence of rounded vowels which disagree in height. We

saw this type of harmony in Kachin Khakass, where the trigger and target must agree in height and the vowels in question must be [+high], as well as in Yakut, where the trigger and target must agree in height *or* the target must be high. With respect to backness, we saw that in some languages rounding harmony fails to apply within certain back vocalic contexts where, in the analogous front vocalic contexts, harmony is observed. In Kazakh, Kirgiz and Shor, we saw instances in which rounding harmony is observed across-the-board when the vowels in question are front, while harmony among back vowels occurs only in restricted contexts.

In the remainder of this chapter, I present the rounding harmony patterns found in the Mongolian and Tungusic languages.

2.7 Mongolian

The Mongolian and Tungusic languages exhibit various patterns of vowel harmony. In Classical Mongolian and Modern Western Mongolian dialects, harmony based on backness is observed. Harmony based on [ATR] or tenseness, as well as rounding harmony, are found in modern Eastern Mongolian dialects, including Khalkha. And in various Tungusic languages, harmony based on relative height and on rounding is observed. In this section I will discuss these various harmony phenomena. The discussion of Mongolian is based in large part on the phonetic and phonological study published in Svantesson (1985). The rounding harmony systems found in Mongolian and Tungusic differ from those of the Turkic languages discussed above, though certain important characteristics are common to all three branches.

2.7.1 Early Mongolian

According to Svantesson, in Ancient Mongolian non-high rounded vowels occurred only in word-initial syllables, while high rounded vowels were freely distributed throughout the word. In the classical period, a phenomenon referred to as "labial attraction" began to develop, by which non-high rounded vowels appeared in post-initial syllables when the initial syllable also contained a non-high rounded vowel. For instance, words such as *monγol* 'Mongol' and *nøkør* 'friend' are attested in Classical Mongolian. Labial attraction was evidently only sporadic in its application, however, as words such as *olan* 'many' and *køke* 'blue' existed during this period as well (Svantesson, p. 318).

In the Western Mongolian languages, non-high rounded vowels continue to be limited to initial syllables, and no rounding harmony is observed. By contrast, in the Eastern branch, the process of labial attraction has become a regular feature of the phonological system, giving rise to a variety of rounding harmony unattested in the Turkic languages. Specifically, in the rounding harmony systems of Eastern Mongolian, initial non-high rounded vowels trigger rounding of non-high vowels in subsequent syllables. Two Eastern dialects are discussed in detail below.

In Svantesson's characterization of Classical Mongolian, the vowel inventory features both rounded and unrounded front vowels and the non-high back vowels, as shown in the chart in (55).

(55) Classical Mongolian Vowel Inventory (Svantesson, p. 303)

	Front		Back	
	Unround	Round	Unround	Round
High	i	ü		u
Non-high	e	ö	a	o

The historical evidence indicates that harmony in Classical Mongolian was based on backness: Within a word all vowels come either from the set *{e, ü, ö}* - the front vowels - or from the set *{a,u, o}* - the back vowels. The high front unrounded vowel *i* is neutral and may occur in words from the back harmonic set, as shown in (56):

(56) Neutral *i* in Classical Mongolian (data from Svantesson)

a.	jirga-luɣa	'live happily (Narrative Past)'
b.	ilɣaɣa-ača	'difference-ABL'
c.	ǰidan-ača	'spear-ABL'
d.	imaɣan-ača	'goat -ABL'
e.	kitad-ača	'China-ABL'
f.	ojirata-ɣul	'approach-CAU'
g.	qajilu-ɣul	'melt -CAU'
h.	morin-ača	'horse-ABL'
i.	amin-ača	'life-ABL'
j.	ɣal-i	'fire-ACC'
k.	baɣatur-i	'hero-ACC'

When a stem contains only *i*, suffix vowels are always from the front harmonic class; thus, the vowel *i*, while neutral in some contexts, does exhibit limited harmonic behavior:

(57) Stems Containing Only *i*

a.	biči-lüge	'write (Narrative Past)'
b.	bičig-eče	'letter-ABL'
c.	čikin-eče	'ear-ABL'

Suffixal vowels fall into three classes in Classical Mongolian: one class consistently contains *i*, and the quality of this vowel is not subject to harmonic alternations. The remaining classes involve backness alternations. Suffixes may contain a high rounded vowel subject to backness harmony, thus exhibiting the surface variants *u* and *ü*. The third class of suffixes contain a non-high vowel subject to backness harmony, thus surfacing as either *e* or *a*. Schematically, Svantesson represents the Classical Mongolian pattern of suffix vocalism as shown in (58). (Where Svantesson uses the feature [±open], I am using [±high]):

(58) Suffix Alternations: Classical Mongolian (Svantesson, p. 320)

[-high]	A = {a,e}	(e.g. -ača/-eče 'ablative')
[+high,+round]	U = {u, ü}	(e.g. -ɣul/-ɣül 'causative')
[+high, -round]	{i}	(e.g. -i 'accusative')

The absence of the non-high rounded vowels *o, ö* in suffixes is consistent with the pattern posited for Ancient Mongolian. In Ancient Mongolian it is believed that the occurrence of non-high rounded vowels was strictly limited to initial syllables.

Thus, while Classical Mongolian showed the beginnings of rounding harmony with roots, evident in the sporadic instances of labial attraction, affixal harmony apparently remained conservative and non-high rounded vowels were prohibited from occurring.

2.7.2 Western Mongolian: Kalmyk

Svantesson (1985) presents acoustic data from Kalmyk (a Western Mongolian language) from which he concludes that the vowels in this dialect are as shown in (59). As indicated, rounding is contrastive among the non-low front vowels. Among the back vowels, rounding is not contrastive. The high and mid back vowels are rounded, and the low back vowel is unrounded.

(59) Kalmyk Vowel Inventory (Svantesson, p. 303)

	Front		Back	
	Unround	Round	Unround	Round
High	i	ü		u
Mid	e	ö		o
Low	æ		a	

In Kalmyk, as in Classical Mongolian, two harmony classes are opposed on the basis of backness, the vowels of any given word being drawn from only one of these sets. The front harmonic vowels are *{e, ö, æ, and ü}*, the back harmonic vowels are *{u, o a}*, and the status of *i* is discussed below. As in Classical Mongolian, non-high rounded vowels are allowed to appear only in initial syllables. Apparently, Kalmyk lacks any evidence of labial attraction; that is, the contrast which obtains among the

non-high pairs *e/ö* and *a/o* is neutralized post-initially, where all non-high vowels are unrounded. This distributional restriction extends throughout the domain of the word, so, as in classical Mongolian, the non-high rounded vowels never occur in suffixes.

Kalmyk diverges from the Classical language in that there is a three-way height distinction among the front unrounded vowels *{i, e, æ}*, whereas Classical Mongolian has only two front unrounded vowels *{i,e}*. In Kalmyk suffixes, however, only two degrees of height are contrastive. Suffix vowels are either high or low. We thus find suffixes containing the high rounded vowels *u* or *ü*, and suffixes containing the low unrounded vowels *æ* or *a*. (As in Classical Mongolian, *i* may also appear in suffixes. Examples of this are provided further on.) In (60), the causative suffix *[-u:l/-ü:l]* appears with back vocalic roots in (a-b) and with front vocalic roots in (c-f).

(60) Causative Suffix [-u:/-ü:l]

a.	jov-u:l	'go-CAU'
b.	or-u:l	'enter-CAU'
c.	üz-ü:l	'see-CAU'
d.	med-ü:l	'know-CAU'
e.	ö:rd-ü:l	'approach-CAU'
f.	xæ:l-ü:l	'melt-CAU'

As shown, the variant containing *u* surfaces following back vocalic roots, while the variant containing front *ü* occurs with front vocalic roots. The non-high vowels of the ablative suffix *[-a:s/-æ:s]* display a parallel distribution, as shown in (61):

(61) Ablative Suffix [-a:s/-æ:s]

a.	uls-a:s	'nation-ABL'
b.	amn-a:s	'mouth-ABL'
c.	ükr-æ:s	'ox-ABL'

d.	mörn-æ:s	'river-ABL'
e.	mören-æ:s	'horse-ABL'
f.	bičg-æ:s	'letter-ABL'

The patterning of the high front vowel *i* is of particular interest in Mongolian because this vowel is transparent to harmony. As such, the phonology of this vowel poses an analytic challenge which is discussed in detail with in Chapter 7. As in Classical Mongolian, *i* patterns as a front vowel when it is the only vowel in a stem or when it combines with other front vowels within a stem. As shown in (62), in such cases suffixal vowels come from the front harmonic set (all of the examples available to me contain low suffixal vowels):

(62) <u>Initial *i*</u>

a.	jirh-læ:	'live happily (narrative past)'
b.	ir-læ:	'come (narrative past)'
c.	bič-læ:	'write (narrative past)'
d.	jilhæ:n-æ:s	'difference-ABL'
e.	ičr-æ:s	'shame-ABL'

As in the classical language, certain Kalmyk suffixes contain *i*, and in such suffixes no vocalic alternations are observed, regardless of the harmonic class of the stem. One such suffix is the accusative which invariably appears as *[-i:g]*, regardless of the quality of the root vowels:

(63) Suffixal *i:* (Svantesson, p. 305)

a.	hal-i:g	'fire-ACC'
b.	ba:tr-i:g	'hero-ACC'
c.	kü:kn-i:g	'girl-ACC'
d.	nüd-i:g	'eye-ACC'

In many instances in which the Classical language has *i* in the second syllable of a word, this vowel has been lost in Kalmyk. Accompanying the loss of *i* is concomitant fronting of the preceding vowel. A number of examples of this are shown in (64):

(64) Medial *i*-loss with Fronting in Kalmyk:

	Classical	*Kalmyk*	
a.	ojirata-γul	ö:rd-ü:l	'approach-CAU'
b.	qajilu-γul	xæ:l-ü:l	'melt-CAU'
c.	morin-ača	mörn-æ:s	'horse-ABL'
d.	amin-ača	æmn-æ:s	'life-ABL'
e.	bajiqu	bæ:x	'to be'
f.	qoni	xön	'sheep'
g.	ojimasu	ö:ms	'stocking'
h.	qubi	xüv	'part'

As the examples in (a-d) show, this umlaut-type sound change produced front harmonic words in Kalmyk cognate to back harmonic words in Classical Mongolian.

Another context in which original non-initial *i* was lost in Kalmyk involved words in which the classical language had the vowel sequence *ai*. All examples available to me contain the classical sequence *ai* in morpheme-final position. In this context, the Kalmyk reflexes have long *a:*. Some examples of this are shown in (65):

(65) Monophthongization (with Compensatory Lengthening)

	Classical	*Kalmyk*	
a.	γaqai	haxa:	'pig'
b.	γaqai-luγa	haxa:-ta	'pig (comitative)'
c.	noqai	noxa:	'dog'
d.	noqai-luγa	noxa:-ta:	'dog (comitative)'
e.	toluγai	tolha:	'head'
f.	toluγai-luγa	tolha:-ta:	'head (comitative)'

Thus, many instances of original medial *i* are lost in modern Kalmyk. Consequently, although the front unrounded vowel *i* is described by Svantesson as being neutral with respect to backness harmony (p. 303), actual words showing this to be so are few and far between. In fact, Svantesson provides no forms in which *i* is flanked by back vowels. Therefore, based purely on the data given in Svantesson's article, the only context in which the high front unrounded vowel *i* is neutral with respect to backness harmony in Kalmyk is when it occurs as a suffix vowel, as in (63a,b).

To summarize the facts from Kalmyk, harmony in this language is based on the back-front dimension. As in Classical Mongolian, Kalmyk limits the occurrence of non-high rounded vowels to initial syllables. The characterization of the neutral vowel *i* poses an analytical problem not raised by the facts from Classical Mongolian in the following sense. It is possible to claim that this vowel is neutral because although it is phonetically front, it lacks a back (unrounded) counterpart *ɪ and is thus exempt from participation in harmonic alternations. By similar reasoning, however, we would expect the mid vowel *e* also to exhibit neutral behavior since this vowel is phonetically front and has no back (unrounded) counterpart *ɤ. According to Svantesson's characterization, however, the vowel *e* conforms to the harmony patterns

of the language. One further complication involves suffixal alternations. While the absence of non-high rounded vowels in suffixes can be linked to the more general prohibition against their occurrence in post-initial syllables, the vowel *e* also never appears in suffixes. The facts regarding suffix vocalism in Kalmyk are summarized in (66):

(66) Suffix Alternations: Kalmyk (Svantesson, p. 321)

[+low]	A = {a,æ}	(e.g. -a:s/-æ:s 'ablative')
[+high,+round]	U = {u, ü}	(e.g. -ɣu:l/-ɣü:l 'causative')
[+high, -round]	{i}	(e.g. -i:g 'accusative')

While Kalmyk and Classical Mongolian lack rounding harmony, they exhibit the related phenomenon of positional neutralization (Steriade 1993) which will be discussed in Chapter 5.

2.7.3 Eastern Mongolian: Khalkha

Contrary to traditional assumptions, Svantesson demonstrates that in the Eastern Mongolian languages, including Khalkha and the Inner Mongolian dialects such as Shuluun Höh, contrasts among rounded vowels are not based on the backness dimension. In fact, Svantesson shows that all rounded vowels in Khalkha are phonetically back and that they are distinguished from one another on the basis of tenseness or tongue root advancement ([ATR]). Specifically, where Kalmyk has the vowels *{u, ü}*, the corresponding pair in Eastern Mongolian is best transcribed as *{ʊ, u}*, where both vowels are phonetically back. Similarly, where Kalmyk has *{o, ö}*, Eastern Mongolian has the two back vowels*{ɔ, o}*.

Svantesson's characterization of the Khalkha system is novel. Traditional studies (Binnick 1969, 1980, Hamp 1980, Steriade 1981) have assumed that the phonological oppositions relevant in Khalkha are the same as those which obtained in other familiar rounding harmony languages. However, on the basis of spectrographic data, Svantesson argues that the appropriate vowel inventory for Khalkha is that shown in (67):

(67) Khalkha Vowel Inventory

		Front	Back	
		Unround	Unround	Round
High	[+ATR]	i		u
	[-ATR]			ʊ
Non-high	[+ATR]	e		o
	[-ATR]		a	ɔ

According to Svantesson's analysis, then, the harmony classes are as follows. Vowels within a word are either all [+ATR], i.e. they come from the set *{u, e, o, i}*, or they are all [-ATR], coming from the set *{ʊ, a, ɔ, i}*. The vowel *i* may occur with vowels of either harmony class, as shown below. In (68a-c), the vowel *i* occurs in a suffix with [-ATR] stem vowels. In (68d-e), the vowel *i* occurs in a stem accompanied by [-ATR] vowels:

(68) *i* neutral to [ATR] harmony

a.	gar-i:g	'hand-ACC'
b.	ʊnta-x-i:g	'sleep-PPL. ACC'
c.	ɔrɔ-x-i:g	'enter-PPL.ACC'
d.	ǎjil-a:r	'work-INST'
e.	mɔri-ɔ:r	'horse-INST'

Apart from suffixes containing invariable *i*, suffix vowels agree with stem vowels with respect to [ATR]. Thus, Khalkha differs from Classical Mongolian and Kalmyk in the basic harmony pattern. While the Classical Mongolian and Kalmyk harmony system is based on the backness opposition, harmony in Khalkha is based on [ATR]. Furthermore, unlike Classical Mongolian and Kalmyk, the phonology of Khalkha includes a pattern of rounding harmony which gives rise to sequences of non-high rounded vowels. In Khalkha, non-high suffixal vowels are rounded when the vowel(s) of the root are non-high and rounded. Therefore, suffixes containing non-high vowels display a four-way alternation, *{e,o,a,ɔ}*, whereas high suffixal vowels are either invariably *i* or display a two-way alternation between *{u, ʊ}*. Examples of each alternating set are shown in (69) and (70):

(69) Alternating Non-high Suffixal Vowels (Svantesson, p. 302)

a.	ača:-ga:r	'burden-INST'
b.	tʊ:lai-ga:r	'hare-INST'
c.	jav-la:	'go (Narrative Past)'
d.	guze:-ge:r	'rumen-INST'
e.	de:l-e:r	'coat-INST'
f.	uz-le:	'see (Narrative Past)'
g.	bilu:d-le:	'whetted (Narrative Past)'

h.	nɔxɔi-gɔ:r	'dog-INST'
i.	ɔr-lɔ:	'enter (Narrative Past)'
j.	doro:-go:r	'stirrup-INST'
k.	og-lo:	'give (Narrative Past)'

(70) Alternating High Suffixal Vowels (Svantesson, p. 302, 319)

a.	gʊrv-ʊ:l	'three (Collective)'
b.	arv-ʊ:l	'ten (Collective)'
c.	ɔr-ʊ:l	'enter (CAU)'
d.	dorv-u:l	'four (Collective)'
e.	jos-u:l	'nine (Collective)'
f.	medegd-u:l	'know (CAU)'

Summarizing the suffixal alternations, then, we have the chart in (71), slightly modified from Svantesson:

(71) Suffix Alternations: Khalkha (Svantesson, p. 322)

[-high]	A = {a, e, ɔ, o}	(e.g. -la/-le/-lɔ/-lo 'Narrative Past')
[+high,+round]	U = {ʊ, u}	(e.g. -ʊ:l/-u:l 'causative')
[+high, -round]	{i}	(e.g. -i:g 'accusative')

Rounding harmony in Khalkha is observed across morpheme boundaries, as examples (69h-k) above demonstrate, as well as in roots. In the roots *doro:* 'stirrup' and *nɔxɔi* 'dog', shown in (69), rounding extends past the initial vowel of the root onto the following non-high vowel. Other examples of rounding harmony within a root include *dɔlɔ:* 'seven,' *tɔlgɔi* 'head' and *goro:s* 'antelope'. Note that *i*, when it is the second half of a diphthong, does not block the application of rounding harmony, as

in *nɔxɔi-gɔ:r* 'dog (INST)' (**nɔxɔi-ga:r, *nɔxɔi-ge:r*). In fact *i* is in all cases transparent to rounding harmony. Consider the examples in (72):

(72) <u>*i* Transparent to Rounding Harmony</u> (Svantesson, p. 318)

a.	očidor *očider	'yesterday'
b.	xɔt-i:xɔ: *xɔt-i:xa:	'town (REFL GEN)'
c.	nɔir-i:xɔ: *nɔir-i:xa:	'sleep (REFL GEN)'
d.	tomr-i:xo: *tomr-i:xe:	'iron (REFL GEN)'

By contrast, high *rounded* vowels are opaque to rounding harmony. Examples of this are shown here:

(73) <u>*ʊ, u* Opaque to Rounding Harmony</u> (Svantesson, p. 319)

a.	ɔr	'enter'
b.	ɔr-ɔ:d	'enter (PERF)'
c.	ɔr-ʊ:l	'enter (CAU)'
d.	ɔr-ʊ:l-a:d *ɔr-ʊ:l-ɔ:d	'enter (CAU, PERF)'
e.	tor	'be born'
f.	tor-o:d	'be born (PERF)'
g.	tor-u:l	'be born (CAU)'
h.	tor-u:l-e:d *tor-u:l-o:d	'be born (CAU, PERF)'

To summarize the facts from Khalkha as studied and analyzed by Svantesson, the basic harmony pattern involves the [ATR] dimension: Within a word, all vowels other than *i* must agree with respect to their value for the feature [ATR]. Rounding harmony is observed when the trigger and target are both non-high and a

high unrounded vowel (*i*) may intervene. By contrast, a high rounded vowel (*u*, *ʊ*) blocks the application of rounding harmony. All Khalkha vowels other than *i* enter into suffixal alternations, their distribution being a function of both [ATR] and rounding harmony.

2.7.4 Eastern Mongolian: Shuluun Höh

The Inner Mongolian dialect Shuluun Höh displays by far the richest vowel inventory of the languages discussed in Svantesson. In this dialect we find across-the-board [±ATR] pairings (cf. Khalkha, in which *i* has no [-ATR] counterpart), along with rounding contrasts among the non-high vowels. In Shuluun Höh, as in Khalkha, both [ATR] and rounding are harmonic. The Shuluun Höh vowel inventory proposed by Svantesson is given in (74):

(74) <u>Shuluun Höh Vowel Inventory</u>

		Front		Back	
		Unround	Round	Unround	Round
High	[+ATR]	i			u
	[-ATR]	ɪ			ʊ
Non-high	[+ATR]	e	ø	ə	o
	[-ATR]	æ	œ	a	ɔ

Suffix alternations in Shuluun Höh are somewhat more complex than those observed in Khalkha. As in Khalkha, high vowels in suffixes are invariant with respect to their value for rounding. Certain suffixes contain invariably unrounded

high vowels, whereas others contain invariably rounded vowels. Examples are shown in (75) and (76), where suffix vowels agree with the vowels of the root with respect to [ATR] but display invariability with respect to rounding. Note that Shuluun Höh differs from the other Mongolian systems discussed so far in that the high front unrounded vowels enter into harmonic alternations: The vowel *i* appears in [+ATR] contexts, while the vowel *ɪ* appears in [-ATR] contexts:

(75) *{i,ɪ}* Suffix Alternations

a.	gar-ɪ:g	'hand (ACC)'
b.	ɪra-x-ɪ:g	'expose (NOM, ACC)'
c.	ʊnta-x-ɪ:g	'sleep (NOM, ACC)'
d.	xærjɪ-x-ɪ:g	'return (NOM, ACC)'
e.	œ:čɪ-x-ɪ:g	'fall (NOM, ACC)'
f.	ɔrɔ-x-ɪ:g	'enter (NOM, ACC)'
g.	gər-i:g	'house (ACC)'
h.	irə-x-i:g	'come (NOM, ACC)'
i.	ŭjə-x-i:g	'see (NOM, ACC)'
j.	toro-x-i:g	'be born (NOM, ACC)'

(76) *{u,ʊ}* Suffix Alternations

a.	gʊrb-ʊ:l	'three (Collective)'
b.	arb-ʊ:l	'ten (Collective)'
c.	ɪra-x-ɪ:g-ngʊ:t	'expose (NOM, ACC, Converb)'
d.	ʊnta-x-ɪ:g-ngʊ:t	'sleep (NOM, ACC, Converb)'
e.	xærjɪ-x-ɪ:g-ngʊ:t	'return (NOM, ACC, Converb)'
f.	œ:čɪ-x-ɪ:g-ngʊ:t	'fall (NOM, ACC, Converb)'
g.	ɔrɔ-x-ɪ:g-ngʊ:t	'enter (NOM, ACC, Converb)'
h.	dorb-u:l	'four (Collective)'
i.	jis-u:l	'nine (Collective)'
j.	irə-x-i:g-ngu:t	'come (NOM, ACC, Converb)'
k.	ŭjə-x-i:g-ngu:t	'see (NOM, ACC, Converb)'
l.	toro-x-i:g-ngu:t	'be born (NOM, ACC, Converb)'

The situation with non-high suffixes in Shuluun Höh also differs from that observed in Khalkha. In Khalkha, we saw that non-high suffix vowels alternate between *{a, e, ɔ, o}*, agreeing in [ATR] with the vowels of the root and, where the root vowels are non-high and rounded, agreeing with the root vowels in rounding as well. In Shuluun Höh, there are two sets of alternating non-high suffix vowels. The first involves invariably [+back] vowels which agree with the root vowels in [ATR]. Suffix vowels of this class are also rounded when the vowels of the root are non-high and rounded. We thus see a four-way alternation among suffixes containg a non-high back vowel: *a, ə, ɔ, o*. Examples of this four-way alternation are shown in (77):

(77) <u>Four-way Alternation: Non-high Back Suffix Vowels</u>

a.	ača:-ga:r	'burden (INST)'
b.	æǰɪl-a:r	'work (INST)'
c.	tʊ:læ:-ga:r	'hare (INST)'
d.	jab-la:	'go (Narrative Past)'
e.	gǔǰ-ə:-gə:r	'rumen (INST)'
f.	də:l-ə:r	'coat (INST)'
g.	širə:-gə:r	'table (INST)'
h.	bičig-ə:r	'letter (INST)'
i.	uǰ-lə:	'see (Narrative Past)'
j.	nɔxœ:-gɔ:r	'dog (INST)'
k.	mœrj-ɔ:r	'horse (INST)'
l.	ɔr-lɔ:	'enter (Narrative Past)'
m.	doro:-go:r	'stirrup (INST)'
n.	og-lo:	'give (Narrative Past)'

The second set of non-high suffix vowels includes the vowels *{e,æ}* which are invariably non-high, front and unrounded; they agree with the vowels of the root only with respect to [ATR]. The surprising fact about vowels of this class is that they are not subject to rounding harmony, even when the stem to which they attach contains non-high rounded vowels. The non-high front rounded vowels *œ* and *ø* are found in

roots, both in initial syllables and in non-initial syllables; they are systematically excluded from suffixes, however. Examples are shown in (78), where an arrow points out those instances in which a non-high suffixal vowel fails to surface as rounded following a non-high rounded stem vowel:

(78) Two-way Alternation: *{e,æ}*

	a.	ɑl-tæ:	'mountain (Comitative)'
	b.	ǰɪd-tæ:	'spear (Comitative)'
	c.	nar-tæ:	'sun (Comitative)'
	d.	čær-tæ:	'tea (Comitative)'
→	e.	ɔd-tæ:	'star (Comitative)'
→	f.	mœrj-tæ:	'horse (Comitative)'
→	g.	nɔxœ:-tæ:	'dog (Comitative)'
	h.	xun-te:	'person (Comitative)'
	i.	bičig-te:	'letter (Comitative)'
	j.	nər-te:	'name (Comitative)'
→	k.	obs-te:	'grass (Comitative)'
→	l.	joroxø:loxč-te:	'president (Comitative)'

Thus, while rounded counterparts of *{e, æ}* exist in the Shuluun Höh inventory, namely *{ø, œ}*, these vowels never occur in suffixes, even when the stem contains non-high rounded vowels. The relevant examples are repeated in (79):

(79) *{ø, œ} in Suffixes

a.	ɔd-tæ:	'star (Comitative)'
	*ɔd-tœ:	
b.	mœrj-tæ:	'horse (Comitative)'
	*mœrj-tœ:	
c.	nɔxœ:-tæ:	'dog (Comitative)'
	*nɔxœ:-tœ:	
d.	obs-te:	'grass (Comitative)'
	*obs-tø:	
e.	joroxø:loxč-te:	'president (Comitative)'
	*joroxø:loxč-to	

The suffix alternations for Shuluun Höh can be characterized as shown in (80). All sets of suffix vowels agree with the stem with respect to [ATR]. Only the non-high back vowel set exhibits agreement for another feature. Suffix vowels from this set agree in rounding with non-high stem vowels.

(80) Suffix Alternations: Shuluun Höh (Svantesson, p. 322)

[-high, +back]	A = {a, ə, ɔ, o}	(e.g. la:/lə:/lɔ:/lo: 'Narrative Past')
[-high, -back]	E = {e,æ}	(e.g. te:/tæ: 'Comitative')
[+high, +round]	U = {ʊ, u}	(e.g. -ʊ:l/-u:l 'Causative')
[+high, -round]	I = {i, ɪ}	(e.g. -i:g/ɪ:g 'Accusative')

Finally, as in Khalkha, high unrounded vowels are transparent to rounding harmony in Shuluun Höh, whereas high rounded vowels are opaque. This is shown in (81) and (82):

(81) *{i, ɪ}* Transparent to Rounding Harmony

a.	očidor	'yesterday'
	*očidər	
b.	gɔt-ɪ:xɔ:	'town (REFL GEN)'
	*gɔt-ɪ:xa:	
c.	nœ:r-ɪ:xɔ:	'sleep (REFL GEN)'
	*nœ:r-ɪ:xa:	
d.	tomr-i:xo:	'iron (REFL GEN)'
	*tomr-i:xə:	

(82) *{u, ʊ}* Opaque to Rounding Harmony

a.	ɔr	'enter'
b.	ɔr-ɔ:d	'enter (PERF)'
c.	ɔr-ʊ:l	'enter (CAU)'
d.	ɔr-ʊ:l-a:d	'enter (CAU, PERF)'
	*ɔr-ʊ:l-ɔ:d	

e.	tor	'be born'
f.	tor-o:d	'be born (PERF)'
g.	tor-u:l	'be born (CAU)'
h.	tor-u:l-ə:d	'be born (CAU, PERF)'
	*tor-u:l-o:d	

In Chapter 7, I discuss the analysis of transparency in Mongolian in detail..

2.7.5 Eastern Mongolian: Buriat

In what follows, I will present the facts from Buriat assuming the vowel inventory and phonological analysis proposed in Svantesson (1984). Svantesson claims that what has traditionally been assumed to be a backness contrast among rounded vowels is in fact a contrast based on [ATR]. Thus, as for Khalkha, the standard assumption has been that the vowel inventory is essentially the same as that of other familiar vowel harmony languages, such as Turkish. According to Svantesson, that assumption is incorrect, however.

I assume, following both Svantesson and Poppe, that the contrastive vowel qualities of Buriat are those given in (83). According to these sources, the high [-ATR] vowels sound slightly lowered and centralized. As shown, all vowel qualities other than *o:* occur contrastively long and short:

(83) Buriat Vowel Inventory (Poppe 1960, Svantesson 1985)

		Front Unround	Back Unround	Back Round
High	[+ATR]	i, i:		u, u:
	[-ATR]	ɪ, ɪ:		ʊ, ʊ:
Non-high	[+ATR]	e, e:		o:
	[-ATR]		a, a:	ɔ, ɔ:

As in other dialects of Eastern Mongolian, the general pattern is that within a given word all vowels must agree with respect to their value for [ATR]. Examples of the basic [ATR] harmony pattern are given in (84)-(86). As the forms in (86) show, the [+ATR] vowel *i, i:* has a [-ATR] counterpart which occurs in [-ATR] words (Svantesson, 1985):

(84) [+ATR] Words (data from Poppe, pp. 22-23)

a.	ger-i:ji	'pillow (ACC)'
b.	xel-u:l	'speak (CAU)'
c.	ed-u:l	'eat (CAU)'
d.	exe-de	'mother (DAT)'
e.	xun-i:ji	'person (ACC)'
f.	xul-de	'foot (DAT)'
g.	xul-do:	'foot (REFL DAT)'
h.	xuzu:n-de	'neck (DAT)'
i.	bu-do:r	'cotton (by means of)'
j.	xi:-de	'dung dust (DAT)'
k.	to:n-de	'white spot (DAT)'

(85) [-ATR] Words (data from Poppe, pp. 22-23)

a.	al-ʊ:l	'kill (CAU)'
b.	axa-da	'elder brother (DAT)'
c.	axa-da:	'elder brother (REFL DAT)'
d.	ʊnt-ʊ:l	'sleep (CAU)'
e.	xʊng-da:	'swan (REFL DAT)'
f.	xʊng-da	'swan (DAT)'
g.	ɔr-ʊ:l	'go in (CAU)'
h.	mɔdɔn-dɔ	'tree (DAT)'

(86) [-ATR] Words Containing *ɪ, ɪ:* (data from Poppe, pp. 22-23)

a.	ɪlangaja:	'particularly'
b.	imagta	'exclusively'
c.	xɔɪšɔ	'backwards, afterwards'
d.	mɔrɪn	'horse'
e.	hʊrgʊ:lɪ	'school'
f.	mal-i:jɪ	'cattle (ACC)'
g.	mɔr-ɪ:jɪ	'horse (ACC)'
h.	bʊlag-ɪ:jɪ	'spring, well (ACC)'

In Buriat, the distribution of non-high rounded vowels is limited in essentially the same way as it is in the other Eastern Mongolian dialects: In non-initial syllables, non-high rounded vowels occur only when the initial syllable also contains a non-high rounded vowel.[14] By the same token, non-high unrounded vowels do not occur in post-initial syllables in words in which the initial syllable contains a non-high rounded vowel. Examples are shown in (87).

[14]The exception to this characterization involves non-initial o: following a high rounded vowel, as discussed above. We return to this problem below.

(87) Rounding Harmony (data from Poppe (1960) and Bosson (1960))

a.	gɔršɔ:g	'pot'
b.	gorxɔ	'brook, rivulet'
c.	ɔrɔ-	'enter'
d.	ɔrɔ-nɔb	'I enter'
e.	ɔšɔ-	'go away'
f.	ɔšɔ-žɔ	'go away (IMP GER)'
g.	to:n-do:	'white spot (REFL DAT)'
h.	ho:rgo:	'backwards, back'
i.	o:ro:	'self', 'oneself', 'himself'
j.	o:r-do:	'self (REFL DAT)'

Short *o* never occurs in Buriat. Thus, when *o:* occurs in an initial syllable, unrounded short *e* may be found in a subsequent syllable. In other words, rounding harmony is blocked when its application would give rise to an occurrence of the ill-formed short *o*. Examples are shown here (88):

(88) Surface *o:-e* Sequences (data from Poppe and Bosson)

a.	so:rem	'pond, reservoir'
	*so:rom	
b.	zo:-xe	'to transport'
	*zo:-xo	
c.	o:de	'up, upwards'
	*o:do	
d.	ho:lde-xe	'to become hoarse'
	*ho:ldo-xo	
e.	to:n-de	'white spot (DAT)'
	*to:n-do	
f.	xo:relge	'a recounting, discussion'
	*xo:rolgo	
g.	xo:rge	'bellows'
	*xo:rgo	

As in Khalkha, the high unrounded vowels *i(:)* and *ɪ(:)* are transparent to rounding harmony, as shown in (89). Similarly, short *e* is also transparent to rounding harmony. That is, although rounding harmony does not generate the ill-formed

segment *o, the process may skip over ineligible targets in order to target a long non-high vowel further on in the word. An examples of this is shown in (90).

(89) *i(:)* and *ɨ(:)* are Transparent to Rounding Harmony (data from Poppe and Bosson)

a.	mɔrɪn-hɔ:	'horse (ABL)'
b.	bɔlɪ-xɔ	'to discontinue'
c.	dɔxɪ-xɔ	'to nod, to bow'
d.	sɔxɪ-sɔ	'rhythmical beating'
e.	zo:ri-do:	'possessions (REFL DAT)'

(90) Short *e* is Transparent to Rounding Harmony (from Bosson)

a.	xo:reldo:	'conversation, discussion'

By contrast, the high rounded vowels *u:*, *ʊ*, and *ʊ:* do not trigger rounding harmony, as shown in (91), and in fact *block* harmony, as shown in (92):

(91) *u:*, *ʊ*, *ʊ:* Fail to Trigger Rounding Harmony (data from Poppe and Bosson)

a.	xuzu:n-de:	'neck (REFL DAT)'
	*xuzu:n-do:	
b.	xul-de:	'foot (REFL DAT)'
	*xul-do:	
c.	xʊng-da:	'swan (REFL DAT)'
	*xʊng-dɔ:	
d.	xʊi-da:	'tornado (REFL DAT)'
	*xʊi-dɔ:	
e.	bʊsa	'other, another, remaining'
	*bʊsɔ	
f.	bʊ:da-xa	'to shoot'
	*bʊ:dɔ-xɔ	

(92) *u:, ʊ:* Block Rounding Harmony (data from Poppe and Bosson)

a.	xo:r-u:l-e:	'he made (someone) chat'
	*xo:r-u:l-o:	
b.	zɔrjʊl-xa	'to direct toward'
	*zɔrjʊl-xɔ	
c.	dɔrjʊxana:r	'rather firmly'
	*dɔrjʊxɔnɔ:r	
d.	zɔrɪgžʊ:l-xa	'to inspire, to induce, to stimulate'
	*zɔrɪgžʊ:l-xɔ	
e.	ɔr-ʊ:l-xa	'to enter (CAU)'
	*ɔr-ʊ:l-xa	

Buriat displays an exception to the general Mongolian pattern. We saw above that in other Eastern Mongolian languages, rounding harmony is only triggered and targeted by non-high vowels. In Buriat, however, initial syllables containing the short high vowel *u* trigger rounding of a following non-high vowel, provided that the target is long. Examples of rounding harmony triggered by short *u* are given in (93):

(93) *u* Triggers Rounding Harmony

a.	xul-do:	'white spot (REFL DAT)'
b.	sub-o:	'residue (REFL DAT)'
c.	bud-o:r	'by means of cotton'
d.	uder-o:r	'by means of the day'
e.	xur-o:	'he arrived'
f.	burxo:xe	'to cover'
g.	zugo:r	'but, however, just so'
h.	muno:	'today, now, this same'
i.	sulo:	'freedom, free'
j.	turg-o:r	'quickly, swiftly, speedily'
k.	gubo:	'hill, mound, hillock'

When the potential target is short, rounding harmony does not apply and short *e* surfaces, as shown in (94). This pattern mirrors the effect shown above in (88) in

which the short non-high vowel fails to undergo rounding harmony when the trigger is also non-high:

(94) Ill-formed*_u...o_ is Avoided

a.	xul-de	'white spot (DAT)'
	*xul-do	
b.	xui-de	'umbilicus (DAT)'
	*xui-do	
c.	burged	'eagle'
	*burgod	
d.	bule	'family'
	*bulo	
e.	gulge	'puppy, whelp'
	*gulgo	
f.	durbe	'four'
	*durbo	

Thus, the Buriat system is essentially the same as that of Khalkha, with one major complication. The absence of short *o* in Buriat gives rise to an additional transparent vowel. While only *i* is transparent to rounding harmony in Khalkha, the high and mid unrounded vowels are transparent in Buriat. This transparency is discussed further in Chapter 7. Also, while in both languages the principal participants in the rounding harmony system are the non-high rounded vowels, in Buriat short *u* also participates, functioning as a trigger.[15] A summary of the suffix alternations found in Buriat is given in (95):

[15]No formal analysis of the fact that Buriat short *u* triggers harmony is proposed here.

(95) Suffix Alternations: Buriat

[-high, +back]	A = {a, e, ɔ}	(e.g. -da/-de/-dɔ 'Dative')
[-high, -back]	A: = {a:, e:, ɔ:, o:}	(e.g. -da:/-de:/-dɔ:/do: 'Reflexive Dative')
[+high, +round]	U: = {ʊ:, u:}	(e.g. -ʊ:l/-u:l 'Causative')
[+high, -round]	I(:) = {i(:), ɪ(:)}	(e.g. -i:ji/-ɪ:jɪ: 'Accusative')

2.8 Tungusic

The Tungus languages are spoken on the border between China and the former Soviet Union, in the Far East, in Eastern Siberia, and in Mongolia (Comrie 1981). Comrie proposes the genetic classification listed in (96):

(96) Genetic Classification of Tungusic (Comrie 1981, p. 58)

Northern Tungusic
- *Evenki* (sometimes called Tungus)
- *Even* (Lamut)
- *Negidal*
- *Solon*

Southern (Amur) Tungusic
- South-Western Tungusic
  - *Manchu*
  - *Juchen*
- South-Eastern Tungusic
  - Nanay Group
    - *Nanay*
    - *Ulcha*
  - Udege Group
    - *Orok*
    - *Udege*
    - *Oroch*

In general, Tungusic languages possess a vowel harmony system based on some contrast involving relative height, tenseness or position of the tongue root. Ard (1981) argues that the relevant feature in Proto-Tungus was [RTR] (retracted tongue

root), whereby the vowel inventory was divided into two sets. According to Ard, one harmonic set contained "hard" vowels, articulated with a retracted tongue root, and the other set contained "soft" vowels in which the tongue root maintained a neutral position. The system proposed by Ard for Proto-Tungus is found in modern Even, the vowels of which are listed in (97). By convention, all [+RTR] vowels other than [a] are represented with a subscript dot:

(97) <u>Even Vowel Inventory</u> (Comrie 1981)

	Front		Central		Back	
	[-RTR]	[+RTR]	[-RTR]	[+RTR]	[-RTR]	[+RTR]
High	i	i̤			u	ṳ
Mid			ə	ə̤		
Low	e			a	o	o̤

The vowels of the Even inventory are divided into two harmony classes based on tongue root position whereby the "hard" [+RTR] vowels are opposed to the "soft" [-RTR] vowels. For simplicity, I will refer to these with a binary feature [±RTR], though it may well be the case that the appropriate phonological analysis of [RTR] in Tungusic would involve a privative feature [RTR]. The vowels of a given word must all belong to the same harmony class:

(98) Even Harmonic Classes (Comrie 1981)

[+RTR]			[-RTR]		
i̤		ṵ	i		u
	ə̤			ə	
a		o̤	e		o

Some examples illustrating the Even harmony system are given in (99). These forms are provided by Comrie (1981, p. 70) and demonstrate harmonic alternations in suffixes between the pairs *[u]-[ṵ], [i]-[i̤], [e]-[a]* and *[ə]-[ə̤]*:[16]

(99) Even Suffixal Alternations

a.	berken-du	'crossbow-DAT'
b.	ʒṵṵ-dṵ	'dwelling-DAT'
c.	berken-təki	'crossbow-ALL'
d.	ʒṵṵ-tki̤	'dwelling-ALL'
e.	berken-kle	'crossbow-ALL/LOC'
f.	ʒṵṵ-kla	'dwelling-ALL/LOC'
g.	berken-klə	'crossbow-ALL/PROLATIVE'
h.	ʒṵṵ-klə̤	'dwelling-ALL/PROLATIVE'

In addition to a system of harmony based on tongue root position or relative tongue height, many of the Tungusic languages also exhibit a system of harmony based on rounding. The basic rounding harmony pattern found in Tungusic is similar to that found in Eastern Mongolian dialects: thus, harmony is triggered only by non-high vowels and is targeted only by non-high vowels. The high vowels *u, ṵ* never trigger rounding harmony, nor do they appear as the output of rounding harmony. In general, rounding contrasts among non-high vowels are distinctive in Tungus only in

[16]Comrie's examples do not contain suffixal *o/o̤*. His statements indicate that the distribution of these vowels conforms to the Even harmony pattern, however.

the initial syllable of a word. Therefore, the quality of non-initial vowels in Tungus is in many ways predictable: Vowels in non-initial syllables inherit their [RTR] value from the vowel of the initial syllable, and non-high vowels similarly inherit their value for rounding.

In what follows, I will present data from three Tungusic languages for which detailed descriptions were available, namely Oroch, Ulcha and Oxot Even.

2.8.1 Oroch

Oroch is a South-Eastern Tungusic language spoken in Eastern Siberia. Comrie (1981) places Oroch in the Udege Group. My primary source for this language is the grammar and dictionary written by Avorin & Lebedeva (1978). According to these authors, Oroch has the vowel inventory listed in (100). In addition to these contrastive vowel qualities, vowel length for all qualities except æ is also contrastive:

(100) Oroch Vowel Inventory (Avrorin & Lebedeva 1978, p. 61)

	Front	Central	Back
High	i, i:		u, u:
Lower High			ụ, ụ:
Mid		ə, ə:	o, o:
Low	æ	a, a:	

These vowels are divided into two harmonic classes apparently based on relative height. The higher vowels fall into the class labeled "soft" by Avorin &

Lebedev. These I will classify as [-RTR]. The lower vowels, referred to as "hard" by Avorin & Lebedev, will constitute the [+RTR] class:

(101) Harmonic Sets in Oroch

[+RTR]			[-RTR]	
		ụ		u
			ə	
æ	a	o		

Alternations are observed between the pairs *u/ụ* and *ə/a*, with *u* and ə appearing in [-RTR] words, and *ụ* and *a* appearing in [+RTR] words. The remaining vowels are distributed as follows: *æ* and *o* occur only in [+RTR] words, and *i* may occur in words of either harmonic class.[17]

To see the basic harmony pattern, consider first the words in (102) in which all vowels come from the [-RTR] set:

(102) [-RTR] Words

a.	gumu	'sharp sound'
b.	luku	'shaggy'
c.	gu:lə	'rocky ledge'
d.	mutə	'to be able'
e.	luki	'wooden'
f.	gusi	'eagle'
g.	dəŋsə	'scale'
h.	sə:rʤə	'red'
i.	gəbu	'honor, respect'
j.	ʤəpunə	'to go to eat'
k.	ʤə:nti	'flounder'
l.	dəkti	'toolbox'

[17]A small number of words are listed in Avrorin & Lebedeva's dictionary in which *æ* follows the vowel *u* in the initial syllable. These are *uŋæ* 'bundle of nettles', *ʤuggæ* 'chain', *ʤulæ* 'front', and *gurgulæ* 'yellow forest butterfly.' Similarly, a very small number of words contain *æ* following *o* in the initial syllable, such as *oggæ* 'pig, hog,' *oloŋkæ* 'oak.' No words are recorded in which *æ* follows ə.

In the words in (102), all vowels come from either the [-RTR] set *{ə, u}*, or the neutral set, which consists of the single vowel quality *i*. Similarly, in [+RTR] harmonic words, vowels are either the neutral vowel *i* or are members of the [+RTR] class. A further restriction is imposed on the [+RTR] harmonic words involving the distribution of the non-high rounded vowel *o*. Where the initial syllable contains the low vowel *a*, subsequent syllables may contain either the neutral vowel *i* or any of the [+RTR] vowels other than *o*. Thus, the words in (103) all conform to the Oroch harmony restrictions:

(103) <u>[+RTR] Words</u> (first syllable contains *a,a:)*

a.	daba	'Siberian salmon'
b.	kata	'strong, durable'
c.	ba:dæ	'still (adv.)'
d.	ʤavæ	'tenth (ord. num.)'
e.	da:bụ	'to obey'
f.	daksụ	'to pickle'
g.	ga:ki	'crow'
h.	kari	'to remain'

Similarly, when the initial syllable contains either of the [+RTR] vowels *ụ* or *æ:*, subsequent syllables may contain the neutral vowel or any [+RTR] vowel other than *o*. Examples are shown in (104) and (105):

(104) <u>[+RTR] Words</u> (first syllable contains *ụ, ụ:)*

a.	ʤụkụ	'otter'
b.	ŋụsụ	'fishing rod'
c.	gụgda	'high'
d.	kụta	'stomach'
e.	ụsæ	'birch box for storing cured fish'
f.	ʤụvæ	'second (ord. num.)'
g.	kụppi	'to have time'
h.	ụŋki	'having hooves'

(105) [+RTR] Words (first syllable contains *æ*)

a.	kæŋadʒa	'frog'
b.	ɲæsa	'people'
c.	ʒæŋʒæ	'left, lefthand'[18]
e.	sæntu̯	'fist'
f.	gæki	'hawk'
g.	xæsi	'sound'

The non-high rounded vowel *o* in Oroch is distributionally restricted in much the same way as the non-high rounded vowels of Eastern Mongolian. As a member of the [+RTR] harmonic class, we expect to find the vowel *o* only in [+RTR] vocalic words. This is so. A further restriction is imposed on its distribution, however. The vowel *o* occurs in post-initial syllables only when the vowel *o* occurs in the first syllable of the word. When the first syllable of a word contains the non-high rounded vowel *o*, a subsequent syllable may contain the neutral vowel *i*, the high [+RTR] vowel *u̯*, or another instance of *o*. Crucially, any non-high vowel occurring in a syllable following initial rounded *o* must itself be rounded. Thus, when the initial syllable contains *o*, the following syllable may contain neither *a* nor *æ*. Examples of words containing initial *o* are given in (106):

(106) [+RTR] Words (first syllable contains *o*)

a.	do:dip	'to be heard'
b.	dʒoɲisi	'to yawn'
c.	mo:su̯	'cover, case'
d.	xo:su̯	'scraper'
e.	doro	'law'
f.	do:lo	'lame'

[18]Words containing *æ* in the first syllable and subsequent syllables are conspicuously absent from Avrorin & Lebedeva's lexicon. This may be due to the fact that length occurs only in the first two syllables of a word, and there is usually no more than one long vowel per word. According to Avrorin & Lebedeva, *æ* is phonetically long. Thus, a word containing this vowel in both the first and second syllable would violate this pattern. Support for this explanation comes from the fact that in words containing *æ* in the second syllable, the first syllable nearly always contains a short vowel. Only a handful of exceptions to this generalization are listed in Avrorin & Lebedeva's lexicon: *ba:ʒæ* 'external, outward', *na:mčæŋga* 'comfortable', *a:læ* (translation unclear; Russian = moxovka).

g.	xoŋo	'other, another'
h.	moŋokso	'larynx'
i.	toŋoyoŋko	'to come unscrewed'

Thus, as in Eastern Mongolian, we see that rounding harmony is triggered by a non-high rounded vowel and targets non-high vowels. However, this system differs from the Mongolian pattern in that rounding harmony is blocked when any high vowel intervenes between the potential trigger and the potential target. Thus, in Oroch, all high vowels, regardless of whether or not they are rounded, are opaque to rounding harmony. Examples of this are shown in (107), where non-high *a* occurs subsequent to an initial non-high rounded *o* where some high vowel intervenes:

(107) <u>High Vowels Block Rounding Harmony</u>

a.	oggiča (*oggičo)	'dried out'
b.	do:kčina (*do:kčino)	'to hear'
c.	obbụla (*obbụlo)	'to give as a daughter's dowry'
d.	gosụla	'to quarrel'

Finally, when the initial syllable contains the neutral vowel *i*, vowels of either harmonic class may follow. The only vowel which does not occur subsequent to *i* is the non-high rounded vowel *o*:

(108) Initial Syllable Contains *i*

a.	d͡zima	'to stay with someone'
b.	inda	'dog'
c.	gičæ	'coldly'
d.	di:bæ	'fourth (ord. num.)'
e.	ikə	'to sing'
f.	si:ksə	'evening'
g.	diktụ	'thick'
h.	siŋd͡ʒụ	'to knock out'
i.	xidus	'quickly'
j.	ni:čku	'quite small'
k.	dili	'head'
l.	i:gi	'to re-enter'

To summarize, in Oroch vowels within a word may come from one of two harmonic sets divided phonologically on the basis of [RTR]. The vowel *i* may occur with vowels from either set. Furthermore, in post-initial syllables, the value for [round] of non-high vowels is predictable: If the initial syllable contains a non-high rounded vowel and no high vowels intervene, a post-initial non-high vowel will be rounded. Otherwise, non-high vowels in post-initial syllables will always be unrounded.

2.8.2 Ulcha

Ulcha is a member of the Nanay branch of South-Eastern Tungusic. It is spoken in the Russian Far East and by a small population in China (Comrie 1981). I rely on the grammar and dictionary of Sunik (1985) for the patterns reported here. According to Sunik, Ulcha has the vowel inventory shown in (109):

(109) Ulcha Vowel Inventory (Sunik 1985)

	Front		Central		Back	
	[-RTR]	[+RTR]	[-RTR]	[+RTR]	[-RTR]	[+RTR]
High	i	i̤			u	ṳ
Non-high		ẹ	ə	a		ọ

In word initial syllables, all vowel qualities may be contrastively long or short. In post-initial syllables, the length contrast is apparently neutralized. In Sunik's lexicon, all vowels in post-initial syllables are written as short.

As in Oroch, the vowels of Ulcha are divided into two harmonic classes which are mutually exclusive within the domain of the word:

(110) Harmonic Classes in Ulcha

[+RTR]			[-RTR]	
i̤		ṳ	i	u
ẹ	a	ọ	ə	

Unlike Oroch, however, the high front [-RTR] vowel *i* in Ulcha is paired with a [+RTR] counterpart, and these vowels participate in the harmonic segregation: *i* occurs in harmonically [-RTR] words, while *i̤* occurs in harmonically [+RTR] words. By contrast, the non-high vowels *ẹ* and *ọ* have no [-RTR] counterparts and occur only in [+RTR] words. Their distribution is further limited, as I will discuss shortly. Examples of [-RTR] harmonic words are shown in (111):

(111) [-RTR] Vowel Words

a.	bi:si	'to not exist'
b.	miŋgi	'my'
c.	bibu	'to live'
d.	gi:luqtu	'fly (insect)'
e.	bilə	'probably'
f.	di:rə	'small shovel'
g.	bu:li	'lamp wick'
h.	muŋti	'cooly'
i.	bu:bu	'to give'
j.	kuŋdu	'sturgeon'
k.	buksə	'cartilage'
l.	pu:msə	'filings'
m.	bəgdi	'leg'
n.	gə:ni	'steel (adj.)'
o.	bəsu	'place, site'
p.	gə:xunə	'cleanly'
q.	bəbəkə	'child's swing'
r.	kə:lə	'fast'

Within a [+RTR] harmonic word, the vowels *i̤*, *ṳ* and *a* occur in initial and non-initial syllables. Examples are shown in (112):

(112) [+RTR] Vowel Words

a.	giri̤	'river bed'
b.	ki̤ti̤	'seagull'
c.	pi̤pṳ	'reed fife'
d.	si̤lčṳ	'sack for tinder'
e.	bi̤ldʒa	'throat'
f.	si̤:ŋna	'gift, present'
g.	gṳti̤	'thirty'
h.	mṳri̤	'horse'
i.	lṳmbṳm	'file, row'
j.	gṳ:vṳ	'find one's way'
k.	pṳtsta	'dust'
l.	bṳqta	'fragment'

m.	baksi̧	'bundle'
n.	va:mi̧	'thick'
o.	garu̧	'leggings'
p.	ba:pu̧	'pack, bunch'
q.	vaqa	'good'
r.	qa:qta	'cranberries'

By contrast, the vowels ẹ and ọ are limited in their distribution. The front vowel ẹ is found only in initial syllables and may be followed by any of the vowels *i̧*, *u̧* or *a*:

(113) [+RTR] Vowel Words (first syllable contains ẹ)

a.	mẹvti̧	'gun'
b.	ɲẹ:lbi̧	'unconscious'
c.	bẹ:lbu̧bu̧	'to deny a request'
d.	ẹrku̧vu̧	'to insult'
e.	bẹlta	'moonlight'
f.	geva	'dawn, daybreak'

The back vowel ọ is also permitted in initial syllables. It is allowed in post-initial syllables as well, but only when the initial syllable also contains ọ.[19] Examples of ọ in the initial syllable are given in (114). In (a-d), the vowel in the following syllable is high, and either *i̧* or *u̧* may occur. In (e-k), by contrast, the syllable immediately following the initial syllable contains a non-high vowel. As shown, in this context a non-high, non-initial vowel must be rounded:

[19]In fact, where the initial syllable contains a non-high rounded vowel, subsequent syllables typically do not contain a non-high unrounded vowel, namely *a*. Two categories of exceptions to this generalization exist in Sunik's lexicon. A small number of words with the sequence ọC(C)a are listed, including *bọčka* 'barrel' (borrowed from Russian *bočka*), *ʒoraqta* 'temple (anat.)' and *mọ:ma* 'wooden'. In addition, a small number of words are listed which contain the sequence ọC(C)a or, as an alternate pronunciation, u̧C(C)a. These include *bọča/ bu̧ča* 'red deer', *ọlča/u̧lča* 'Family name', *dọxa/ du̧xa* 'transl. unclear '(Russian is *agnatiy*). These exceptions are very few in number, however, and the prevailing generalization holds that non-high vowels are rounded following a non-high rounded vowel in the initial syllable, unless a high vowel intervenes.

(114) [+RTR] Words (first syllable contains ọ)

a.	vọlmị	'long'
b.	gọ:lị	'wide, broad'
c.	bọ:dụ	'insufficiently'
d.	gọsụvụ	'to hate'
e.	bọ:nọ	'hail (weather)'
f.	gọrọ	'far'
g.	tọŋdọ	'straight ahead'
h.	tọtọŋgọ	'multi-colored'
i.	kọ:rọčụvụ	'to regret'
j.	ʤọgbọlọvụ	'to prick, stab'

As in Oroch, when the initial syllable contains ọ and a high vowel follows, rounding harmony of a following non-high vowel is blocked. That is, high vowels neither undergo harmony, nor are transparent to harmony:

(115) High Vowels Block Rounding Harmony

a.	ọyịlavụ *ọyịlọvu	'leggings'
b.	ọmịra *ọmịrọ	'uterus'
c.	ọrkịqtala *ọrkịqtọlọ	'uncomfortably'
d.	dọ:kịla *dọ:kịlọ	'inside'
e.	bọlọʤụvamị *bọlọʤụvọmi	'as soon as it becomes Autumn'
f.	ʤọmbụʤụvambụvụ *ʤọmbụʤụvọmbụvu	'to remind'
g.	kọ:vụ!avụ *kọ:vụlọvu	'to raise a mast (naut.)'
h.	kọrụka *kọrụkọ	'pike (fish) skin'

To summarize, within a word Ulcha vowels must come from one of two harmonic sets. The unpaired vowels ẹ and ọ occur exclusively with vowels from the [+RTR] harmonic class. Furthermore, their distribution is considerably restricted. In

fact, the identity of non-high vowels in non-initial syllables is fully predictable. The vowel ẹ occurs only in initial syllables, so the range of non-high vowels allowed in post-initial syllables consists of the set {ə, *a*, and ọ}. If the word is [-RTR] harmonic, then any non-initial non-high vowel must be ə. In [+RTR] words, a non-initial non-high vowel is ọ if the initial syllable contains ọ and no high vowel intervenes. Otherwise, a non-high vowel in a non-initial syllable will always be *a*.

2.8.3 Oxots Even

The third Tungusic language which I will discuss here is Oxots Even, described in a grammar and dictionary by Lebedev (1982). The Even dialects belong to the Northern branch of Tungusic and are spoken in Yakutia, in the Kamchatka Peninsula and across the Okhotsk Arctic Coast. Other Even dialects include Arman, Kamchatka and Indigirka. Lebedev lists the following vowel inventory for Oxots Even (116):

(116) <u>Oxots Even Vowel Inventory</u> (Lebedev 1982)[20]

	Front	Central	Back
High	i		u
Lower High	i̤		ṳ
Mid			o
Lower Mid	ɛ		ọ
Low		a	
Diphthong	i͡e		

[20]The "soft" mid vowel *o* is represented in Lebedev's transcription as *ɵ*.

All vowel qualities other than *i̯e* may be contrastively long or short in the initial syllable of a word; *i̯e* does not contrast for length. Minimal pairs demonstrating the contrastiveness of vowel length in initial syllables are shown in (117):

(117) Vowel Length Minimal Pairs

a.	boṛin	'division'	b.	bọ:ṛin	'place'
c.	gar	'bough'	d.	ga:r	'pelican'
e.	davday	'to cross'	f.	da:vday	'to infect'
g.	kɛrkɛ	'tomcat'	h.	kɛ:rkɛ	'wide'
i.	mụlkan	'bear'	j.	mụ:lgan	'thought'

Length contrasts are mostly limited to initial syllables, as in the South-Eastern languages discussed above. However, long vowels do occasionally occur post-initially in Oxots, as in the words shown in (118):

(118) Long Vowels in Post-initial Syllables (Lebedev, pp. 21-2)

a.	ọka:m	'river'
b.	ọna:ḳi	'wolverine'
c.	bumɛ:nɛl	'sick, sore'
d.	dulɛ:ski	'forward'
e.	hụ:γra:snan	'he kept silent'
f.	ɲo:nɛ:ti	'one-eyed'

As in North-Eastern Tungusic, the vowels of Oxots are divided into two harmonic classes referred to as "hard" and "soft." Again, I assume that the appropriate phonological feature is [RTR]. These sets are listed in (119):

(119) Harmonic Sets in Oxots

[+RTR]			[-RTR]	
i̤		ṳ	i	u
	a	o̤	ɛ	o

With the exception of *i͡e* which may occur with vowels from either class, all vowels are paired with a vowel from the opposing class. Examples containing *i͡e* are shown in (120) and (121):

(120) Initial Syllable Contains i͡e [-RTR] Words[21]

a.	bi͡evdɛk	'pasturage'
b.	di͡elɛ	'above'
c.	i͡etɛn	'strike, blow (n.)'

(121) Initial Syllable Contains i͡e [+RTR] Words

a.	bi͡eɣtan	'every month'
b.	gi͡ekan	'lower jaw'
c.	mi͡emsi̤	'wonder'

Aside from *i͡e*, however, within a word all vowels must come from one of the two harmonic classes. Furthermore, as in North-Eastern Tungusic, non-high rounded vowels are extremely limited in their occurrence. In (122) and (123) words are given containing the vowel pairs *{i-i̤, u-ṳ, ɛ-a}*:

(122) [-RTR] Words

a.	bɛbɛ	'cradle'
b.	dɛnɛvɛ	'comfortably'
c.	kɛli	'brother-in-law'
d.	gɛɣi	'bird'

[21]No words have been included here in which the vowel following *e:* is a high vowel. This is due to the fact that in the orthographic system adopted in Lebedev's dictionary, the "soft" *vs.* "hard" distinction is not marked for high vowels. Thus, it is not possible to know if a given vowel is high or lower high unless Lebedev clarifies the matter somewhere in the text of the grammar, or if the vowel occurs in a word where the other vowels' harmonic class is reflected directly in the orthography.

e.	gɛlun	'sly'
f.	nɛmkun	'thin'
g.	hilɛs	'dew'
h.	imsɛ	'fat, grease'
i.	uɣɛ	'long stick'
j.	bullɛ	'dry'

(123) [+RTR] Words

a.	bakan	'a find'
b.	gačar	'insatiable'
c.	gaytiŋ	'changing'
d.	da:li	'near, close'
e.	ba:tur	'brave'
f.	ilan	'three'
g.	iŋa	'pebble'
h.	isaɣ	'forest'
i.	nisa	'beads'
j.	urat	'tree bark'
k.	kuma	'ringed seal'
l.	kuču	'sleeping bag'

As mentioned above, the non-high rounded vowels *o*, *ọ* are severely limited in their distribution: They are found principally in initial syllables.

(124) [-RTR] Containing Initial *o*

a.	gorgɛ	'depression, dip'
b.	kokɛdɛy	'mouth (animal)'
c.	monkɛ	'mallow'
d.	nokčɛ	'fringe'
e.	ɲo:čɛ	'plant'
f.	ŋo:kɛ	'wolf'
g.	korin	'naughty child'
h.	go:ŋin	'call (n.)'

(125) [+RTR] Words Containing Initial *o*

a.	bọsta	'bud, kidney'
b.	gọrap	'old'
c.	dọ:la	'inside'
d.	nọnan	'beginning'
e.	bọdị	'fire'
f.	ọmị	'deer (adj.)'
g.	gọrụ	'long'
h.	bọkụn	'delay'

The behavior of *o* and *ọ* is asymmetric, however, in the following sense. The [-RTR] vowel *o* occurs only in initial syllables, and for a majority of words in which this vowel occurs, an alternate pronunciation is listed in which the initial syllable contains the high [-RTR] vowel *u*. Some examples of such variants are given in (126).

(126) Words Containing [-RTR] *o* in the Initial Syllable

a.	oɣɛr / uɣer	'top (adj.)'
b.	okɛrɛ / ukɛrɛ	'suckling'
c.	oyin / uyin	'above'
d.	ostɛy / ustɛy	'to pull strongly'
e.	o:gɛy / u:gɛy	'recently'
f.	o:r / u:r	'sleeve'
g.	o:si / u:si	'doorman'
h.	bokun / bukun	'icing up, icing over'
i.	doktɛ / duktɛ	'alder'
j.	morun / murun	'footwear'
k.	noki / nuki	'arrow'
l.	bo:rgɛn / bu:rgɛn	'return (n.)'
m.	go:n / gu:n	'utterance'
n.	do:ɣurɛn / du:ɣurɛn	'removing'
o.	mo: / mu:	'water'

Words containing the [+RTR] vowel *ọ*, by contrast, do not have an alternate containing a high rounded vowel in place of the non-high rounded vowel. Nonetheless, we find that alternate pronunciations exist for many words containing *ọ* in the initial syllable and a non-high vowel in subsequent syllables: Rounding harmony is optionally observed in many such words. A list of such words is given here:[22]

(127) Words Containing [+RTR] *o* in the Initial Syllable

a.	bọlanị / bọlọnị	'in the midst of autumn'
b.	bọlanịvay / bọlọnịvay	'for autumn to set in'
c.	dọlbanị / dọlbọnị	'night'
d.	ọlla / ọllọ	'fish
e.	ọrandan / ọrọndan	'deer ride'
f.	ọrapčị / ọrọpčị	'rich with deer'
g.	ọrar / ọrọr	'deer'
h.	ọyalta / ọyọltọ	'small column'

To summarize, vowels within a word are divided into two harmonic sets in Oxots Even - the [-RTR] vowels *{i, u, ɛ, o}* and the [+RTR] vowels *{ị, ụ, a, ọ}*.

[22]Based upon the limited information available, it appears likely that these alternative forms represent a distinct dialect. I am unable to state this for certain, however.

These two sets are mutually exclusive, i.e. a word cannot contain vowels from both sets. We saw that in addition to these vowels, there exists a diphthong *i̯e* which may occur with vowels of either harmonic class. Of particular interest to us here is the distribution of the non-high rounded vowels. In general, these occupy initial syllables only. Furthermore, in the majority of cases, words with the [-RTR] vowel *o* are listed as having an alternate pronunciation in which *o* is replaced with *u*. The [+RTR] vowel *ọ* displays a different phenomenon: In many words containing [+RTR] *ọ* in the initial syllable and a non-high vowel in the following syllable, an alternate pronunciation is listed in which both vowels are rounded.

2.9 Conclusions: Mongolian & Tungusic

We have seen here one prevailing rounding harmony pattern in Mongolian and Tungusic. Non-high rounded vowels trigger rounding of subsequent non-high vowels. The statement of Buriat rounding harmony is complicated slightly by the fact that short *u* and *ʊ* also function as harmony triggers. Also, in Oxots Even we find optional rounding harmony in [+RTR] words and no rounding harmony in [-RTR] words. In fact, the [-RTR] vowel *o* in Oxots Even is quite marginal and appears to be merging with the [-RTR] vowel *u*.

One interesting difference between Mongolian and Tungusic involves transparency. While high rounded vowels block rounding harmony in all of the relevant languages, high unrounded vowels are transparent to harmony in the Mongolian dialects that we have discussed. In Tungusic, by contrast, high unrounded vowels are opaque. This issue is taken up in Chapter 7.

From Mongolian and Tungusic we see a basic rounding harmony pattern that is entirely absent in Turkic: same-height harmony involving only only non-high vowels.

Chapter 3 A Statement of Rounding Harmony Typology

3.1 A Brief Look at Other Language Families

Languages from other geographic and genetic groups exhibit patterns resembling those found in Turkic, Mongolian & Tungusic. The pattern exhibited by Turkish and a number of other Turkic languages, whereby high and non-high vowels serve as rounding harmony triggers but only high vowels are targets of harmony, is also observed in Nawuri, a Kwa language spoken in Ghana (Casali 1993a), in the Uto-Aztecan language Southern Paiute (Sapir 1930) and in dialects of Sierra Miwok (Broadbent 1964, Callaghan 1987, Sloan 1991). The Mongolian and Tungusic pattern, whereby both the trigger and the target of rounding harmony must be non-high, is also found in Murut, an Idahan language of Malaysia (Prentice 1971, Asmah 1983). The pattern found in Kachin, by which the trigger and target of rounding harmony must both be high vowels, is also found in Hixkaryana, a Carib language of northern Brazil (Derbyshire 1985), and in Tsou, a Formosan language spoken in Southern Taiwan (Hsu 1993). In addition, we find a similar pattern in Australian languages such as Warlpiri (Nash 1979) and Nyangumata (O'Grady 1964). A well-known case of rounding harmony is found in Yawelmani Yokuts (Newman 1944, Kuroda 1967, Archangeli 1984) as well as Wikchamni Yokuts (Gamble 1978). In Yokuts, rounding harmony occurs when the trigger and target agree in height.[1] My survey of rounding harmony phenomena yielded no other patterns.

[1]Due to a process of long vowel lowering in Yokuts, harmonic sequences surface in which the trigger is non-high and the target is high. This issue is addressed in Chapter 7.

3.2 Backness-Neutral Types

The survey of rounding harmony patterns from 27 languages yields a surprisingly small number of rounding harmony types. In six of these types, rounding harmony is either unconditioned, or the conditions which are imposed on its application make reference only to the height of the participating vowels. That is, in those languages in which rounding contrasts are found among both the front vowels and the back vowels, the front and back vowels pattern alike with respect to rounding harmony.

To represent the domain of harmony in these backness-neutral systems, I will employ the schematic notation given in (1).

(1) Schematic Representation: Backness-neutral Rounding Harmony

I = high vowel
A = non-high vowel

II:	trigger is [+high], target is [+high]
AA:	trigger is [-high], target is [-high]
IA:	trigger is [+high], target is [-high]
AI:	trigger is [-high], target is [+high]

The symbol 'I' represents a high vowel. 'A' represents a non-high vowel. The trigger is represented on the left, and the target is represented on the right. So the sequence 'II' represents a system in which rounding harmony is observed when the trigger and target are both high vowels; 'IA' represents a system in which [round] spreads from a high vowel onto a neighboring non-high vowel, and so on.

The first six rounding harmony types are given here, with representative languages listed for each type:

(2) Rounding Harmony Types 1-6

TYPE	DOMAIN	DESCRIPTION	LANGUAGES
Type 1	II, AA, AI, IA	*Harmony unrestricted*	Kirgiz-A (§2.1, Comrie 1981)
Type 2	II, AI	*Target must be [+high]*	Nawuri (Casali 1993a), Southern Paiute (Sapir 1930), Sierra Miwok dialects (Callaghan 1987, Broadbent 1964, Sloan 1991), Turkish (§2.3.2, Lewis 1967), Tuvan (§2.3.3, Krueger 1977)
Type 3	AA	*Trigger and target must both be [-high]*	Eastern Mongolian dialects (§2.7.3-5 Svantesson 1985, Rialland & Djamouri 1984), Murut (Prentice 1971), Tungusic languages (§2.8.1-3, Ard 1981, Sunik 1985, Avrorin & Lebedeva 1978), Galab (Steriade 1981)
Type 4	II	*Trigger and target must both be [+high]*	Hixkaryana (Derbyshire 1979), Kachin Khakass (§2.4.1 Korn 1969), Tsou (Hsu 1993)
Type 5	II, AA, AI	*Trigger and Target must agree in height or target must be [+high]*	Yakut (§2.4.2 Kreuger 1962)
Type 6	II, AA	*Trigger and Target must agree in height*	Yokuts (Newman 1944, Kuroda 1967, Archangeli 1984, Gamble 1978, see also Chapter 5)

In the remaining rounding harmony types, all of which are found exclusively within languages of the Turkic family, an asymmetry is observed between the front vowels and the back vowels. In these languages we find that harmony is unrestricted when the trigger and target are front. When the trigger and target are back, conditions similar to those found in types 2-6 are imposed on the application of harmony.

Across-the-board harmony among front vowels has been analyzed as an instance of parasitic harmony (Steriade 1981). The term parasitic is chosen in order to express the notion that the application of harmony is parasitic on (or *dependent* on) the presence of some shared feature specification. In the case of rounding harmony types 7-9, the shared feature specification under a parasitic harmony analysis is [-back]. I will return to this analytic device in Chapter 8, where I review a variety of rule-based approaches to rounding harmony typology.

3.3 Non-backness-neutral types

In order to catalogue the three non-backness-neutral types, I will use Ü to represent a high front vowel and Ö to represent a non-high front vowel. The symbol U is used to represent a high back vowel and O, to represent a non-high back vowel. The remaining three types are listed here:

(3) Rounding Harmony Types 7-9

TYPE	DOMAIN	DESCRIPTION	LANGUAGES
Type 7	ÜÜ ÖÖ ÜÖ ÖÜ UU OU	*Harmony unrestricted among [-back] vowels; among [+back] vowels, target must be [+high]*	Kazakh (§2.5.1, Korn, 1969), Chulym Tatar (Korn 1969), Karakalpak (Menges 1947)
Type 8	ÜÜ ÖÖ ÜÖ ÖÜ UU	*Harmony unrestricted among [-back] vowels; among [+back] vowels, trigger and target must both be [+high]*	Kyzyl Khakass (Korn 1969)
Type 9	ÜÜ ÖÖ ÜÖ ÖÜ UU OO OU	*Harmony unrestricted among [-back] vowels; among [+back] vowels , trigger and target must agree in height, or target must be [+high]*	Kirgiz-B (§2.5.2, Herbert & Poppe 1963), Altai (Korn 1969)

Types 7-9 are alike in that among front vowels, rounding harmony applies across the board. When the vowels in question are back, however, we find that each of these three types exhibits one of the patterns observed in types 1-6. When the vowels are back, the type 7 pattern is identical to that observed in type 2; rounding harmony targets only high vowels but is triggered by both high and non-high vowels. The back vowel pattern of type 8 is identical to that of type 4; rounding harmony is triggered only by high vowels and targets only high vowels. When the vowels in question are back in type 9, we find the type 5 pattern; rounding harmony is observed when the trigger and target agree in height, or when the target is high.

3.4 The Typology

The nine attested types are represented in the following chart:

(4) <u>Attested Rounding Harmony Patterns</u>

Type 1:	II	AA	IA
AI			
Type 2:	II		
AI			
Type 3:		AA	
Type 4:	II		
Type 5:	II	AA	
AI			
Type 6:	II	AA	
Type 7:	UU		
OU			
	ÜÜ	ÖÖ	ÜÖ
ÖÜ			
Type 8:	UU		
	ÜÜ	ÖÖ	ÜÖ
ÖÜ			
Type 9:	UU	OO	
OU			
	ÜÜ	ÖÖ	ÜÖ
ÖÜ			

Let us consider now the patterns which emerge from the typology in (4). How does the application of rounding harmony correlate with the height and backness dimensions? Stated differently, what conditions favor the application of rounding harmony? First, it is apparent that cross-height harmony (i.e. harmony in which the

trigger and target disagree in height) is disfavored. In types 3 and 4, for instance, we find no instances of cross-height harmony whatsoever. Furthermore, there exist no rounding harmony types which *require* that the trigger and target disagree in height. That is, in all instances in which some cross-height harmony is allowed, we find that some or all configurations in which the trigger and target agree in height are exploited as harmony configurations as well. We can thus conclude that harmony is favored when the trigger and target agree in height.

Cross-height harmony in the AI configuration is apparently preferred over cross-height harmony in the configuration IA. Types 2, 5, 7 and 9 exhibit harmony triggered by a non-high vowel and targeted by a high vowel, but not vice-versa.[2] The only types which exhibit cross-height harmony when the trigger is high and the target is non-high are types 7-9 which exhibit harmony in this configuration only when the vowels in question are front, and type 1, in which rounding harmony applies across-the-board. This cross-height asymmetry can be stated with a universal implication: Harmony in the configuration IA implies harmony in the configuration AI, but not vice-versa. From this we can conclude that high vowels are preferred as targets of rounding harmony over non-high vowels. By the same token, non-high vowels are preferred as triggers of rounding harmony over high vowels.

Finally, we find patterns like those observed in types 7-9 in which rounding harmony is observed among front vowels while, in certain of the analogous back-vocalic contexts, rounding harmony fails to apply. The reverse scenario is unattested, however. That is, we do not find languages in which rounding harmony applies

[2]In types 7 and 9, of course, cross-height harmony is observed among front vowels regardless of the height specifications of the trigger and target, since in these types rounding harmony is unrestricted among front vowels. When the vowels in question are back, however, we see that when the potential trigger and target disagree in height, harmony is observed only in the configuration AI, never in the configuration IA.

unconditionally among back vowels, while certain conditions are imposed on the application of harmony when the vowels in question are front.

To summarize, the application of rounding harmony is correlated with the height and backness dimensions as follows:

(5) Conditions Favoring the Application of Rounding Harmony

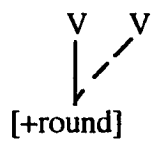
a. Rounding harmony is favored when the trigger and target agree in height.
b. Rounding harmony is favored when the target is high.
c. Rounding harmony is favored when the trigger is non-high.
d. Rounding harmony is favored when the trigger (and target) are front.

Chapter 4 Against a Rule-Based Approach to the Typology of Rounding Harmony

In traditional autosegmental analyses of vowel harmony, e.g. Clements & Sezer (1982), Archangeli (1985), Cole & Trigo (1988), the harmonic feature is represented as an autosegment occupying its own tier. By virtue of the fact that the harmonic feature occupies its own tier, it is allowed to function independently of all other featural specifications. Similarly, any other features which must be mentioned in the structural description of a vowel harmony rule are themselves represented as autosegments and reside on their own tiers as well.

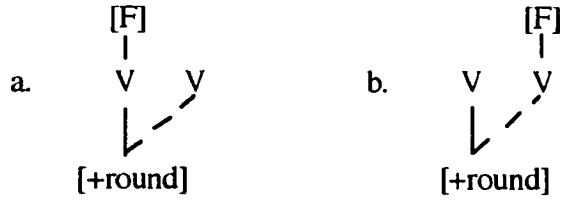
Thus, a rounding harmony rule in which the feature [+round] spreads rightward from vowel to vowel, regardless of how the trigger and target segments are specified for other features, will have the representation shown in (1):

(1) <u>Unconditioned Rounding Harmony: Autosegmental Analysis</u>



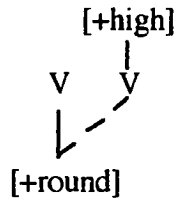
A rounding harmony rule in which some condition on the *trigger* is imposed, e.g. that the trigger must be associated with the feature [F], is represented as shown in (2a), while a rounding harmony rule which requires that the *target* be associated with the feature [F] has the representation in (2b):

(2) Conditioned Rounding Harmony: Autosegmental Analysis



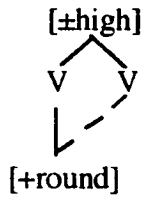
Within this representational framework, certain rounding harmony systems receive a very simple analysis. For instance, the simple rule in (1) characterizes type 1 harmony in which rounding spreads from the vowel of the initial syllable of a word to all subsequent vowels. Type 2 harmony, in which [round] spreads from any rounded vowel onto a high vowel in a subsequent syllable, is also characterized very simply, the rule being that given in (3):

(3) Rule for Type 2: Autosegmental Analysis



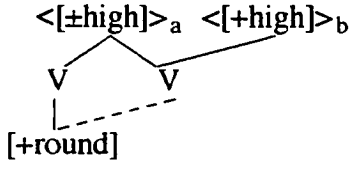
Systems in which the trigger and target must agree in height, e.g. types 3, 4, and 6, may be represented as shown in (4). In these rules, the trigger and target are multiply-linked to a single [±high] autosegment:

(4) Schematic Rule for Types 3 & 4: Autosegmental Analysis



Other types require more complex analyses. For instance, consider type 5. In type 5, rounding harmony applies when the trigger and target agree in height or when the target is [+high]. Thus, to characterize this system we need both the rule in (3) which states that rounding harmony targets high vowels, and the rule in (4) which states that rounding harmony applies when the trigger and target agree in height. Assuming that one wishes to characterize rounding harmony as a unified phenomenon in a type 5 language, one might formulate a single, albeit complicated, rule such as that given in (5). The rule will of necessity refer to disjunctive environments, which are represented here as conditions on the application of the rule. This rule states that the feature [+round] spreads from vowel to vowel provided one of two conditions is met: (a) when the target is [+high], or (b) when the trigger and target agree in height.

(5) Rule for Type 5: Autosegmental Analysis

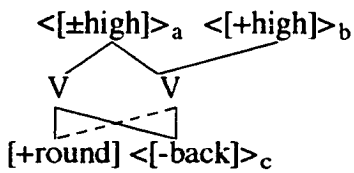


Condition: a or b

An even more complex rule is required for type 9. Recall that in type 9, rounding harmony applies across the board when the trigger and target are front.

When the trigger and target are back, rounding harmony applies if they agree in height or if the target is high. Thus, in type 9, rounding harmony is observed when one of the two conditions operative in type 5 is met, or when a third condition which states that the trigger and target must both be [-back] is met. The rule for type 9 is given in (6):

(6) <u>Rule for Type 9: Autosegmental Analysis</u>



Condition: a, b, or c

Assuming a correct version of feature theory, the autosegmental model can in principle characterize the class of elements available for spreading, and presumably [+round] is a member of that class. In addition, the theory provides a means by which to represent conditions on spreading. Several such conditions were formalized in the rules given above, for example. However, conditions on the trigger and target of spreading rules are not constrained in any principled way within this model. Thus, no predictions are made regarding what the observed range of conditions on harmony rules is expected to be, apart from the incorrect prediction: that based on simplicity.

Therefore, while rules can be written characterizing each of the nine types which constitute the typology of rounding harmony, a great many additional rounding harmony patterns can be characterized as well. Since the range of conditions which may be imposed on a given spreading rule is unconstrained, and since for a given language the harmony rule may involve more than one conditional statement, it

follows that any conceivable rounding harmony pattern can be characterized within this model.

Consider the basic Turkic vowel inventory in which vowels are either high or non-high, back or front, and rounded or unrounded. Given such a system, the trigger and target of a rounding harmony rule will each bear a specification for [±back] and [±high]. Thus, solely on the basis of backness and height, the number of trigger-target combinations is 16:

(7) 16 Trigger + Target Combinations

	Trigger		Target	
	[±back]	[±high]	[±back]	[±high]
1	+	+	+	+
2	-	+	+	+
3	+	-	+	+
4	+	+	-	+
5	+	+	+	-
6	-	-	+	+
7	+	-	-	+
8	+	+	-	-
9	-	-	-	+
10	-	-	-	-
11	+	-	-	-
12	-	+	-	-
13	-	-	+	-
14	-	+	+	-
15	+	-	+	-
16	-	+	-	+

We know that given the availability and necessity of disjunctive rules (i.e. rules in which one or several conditions must be met in order for a rule to apply), any conceivable subset of the configurations listed in (7) may be targeted by a single rule. Therefore, 2^{16} rules are expressible within this model. A very small subset of these is shown here:

(8) Subset of the Expressible Rounding Harmony Rules: Autosegmental Analysis

Trigger-Target Configuration	Rule A	Rule B	Rule C	Rule D	Rule E	Rule F	etc...
1	yes	no	yes	no	yes	yes	yes/no
2	yes	yes	no	yes	yes	no	yes/no
3	yes	yes	yes	no	no	yes	yes/no
4	yes	yes	yes	yes	yes	yes	yes/no
5	yes	yes	yes	yes	yes	yes	yes/no
6	yes	yes	yes	yes	yes	yes	yes/no
7	yes	yes	yes	yes	yes	yes	yes/no
8	yes	yes	yes	yes	yes	yes	yes/no
9	yes	yes	yes	yes	yes	yes	yes/no
10	yes	yes	yes	yes	yes	yes	yes/no
11	yes	yes	yes	yes	yes	yes	yes/no
12	yes	yes	yes	yes	yes	yes	yes/no
13	yes	yes	yes	yes	yes	yes	yes/no
14	yes	yes	yes	yes	yes	yes	yes/no
15	yes	yes	yes	yes	yes	yes	yes/no
16	yes	yes	yes	yes	yes	yes	yes/no

Rule E in (8) is the null case by which there is no domain in which rounding harmony applies. If we subtract the null case, we are left with $2^{16}-1$ (= 65,535) rounding harmony rules.

This may be compared with the typological results of Chapter 3 which showed that only nine patterns are attested. One might object to this criticism on the grounds that a great many of the 65,545 possible rules would be absurdly baroque and that presumably some complexity metric would be available to rule them out. This argument does not go through, however, since it implicitly assumes that a simpler rule will be more widely attested than a more complex rule. This assumption is clearly incorrect, since the simplest rounding harmony rule of all - spread [+round] from vowel to vowel - is typologically very rare.

In addition to the fact that the autosegmental analysis predicts a large number of nonoccurring rules, the theory suffers from another serious flaw: it provides no account of the patterns observed at the end of Chapter 3. At the end of that chapter, we concluded that a number of factors contribute to the likelihood that rounding

harmony will apply within a given domain. It was determined that non-high vowels are preferred as triggers of rounding harmony, whereas high vowels are preferred as targets. Rounding harmony is preferred when the participating vowels are front and when its output yields a sequence of rounded vowels which agree in height. Within the autosegmental framework, these patterns have no formal status and hence can only be understood as the manifestations of universal tendencies. For instance, to explain the fact that high vowels are the preferred targets of rounding harmony, one might cite the following claim, made by Ultan (1973), which relates the susceptibility of high vowels to harmony to their relative low degree of sonority, vis-à-vis non-high vowels:

> The less sonorous a vowel (or class of vowels) the more prone it will be to assimilate; and conversely, the more sonorous it is the more resistant it will be to assimilation. (Ultan, p. 44)

Nonetheless, the fact that the languages of the world select from a very small set of rounding harmony rules is not built-in to the formal account and thus remains unanalyzed.

In the following chapters, I outline an optimality theoretic approach to rounding harmony typology which I will show provides a superior fit with the typological facts. Chapter 5 presents the phonetic motivation for the optimality theoretic constraints which I propose, and the constraints themselves are laid out in Chapter 6, along with an introduction to optimality theory. In Chapter 8, specific rule-based approaches to rounding harmony typology are discussed and are shown to be incompatible with the typology as a whole.

Chapter 5 The Phonetic Motivation of the Constraints

The theory which I present here characterizes harmony as a perceptually-driven phenomenon. A perceptually-based approach to harmony is taken in the works of Suomi (1983), and more recently to other phonological phenomena in Jun (1995), Silverman (1995) and Flemming (1995). Harmony is viewed as a means by which to enhance the probability that a given contrast or set of contrasts will be accurately perceived by the hearer. Suppose that two competing representations for a given string are available, those given in (a) and (b):

The decision to prefer (b) over (a) has the positive consequence that it provides the listener with increased exposure to the feature value in question. In (a), acoustic cues for each value of feature [F] span roughly a single syllable, whereas in (b), the acoustic cues of [F] span the entire word. Thus, harmony gives rise to the perceptual enhancement of the [±F] contrast by extending its duration, although it does so at the cost of reducing the set of distinct representations.

The harmonic structure in (b) has an additional advantage over the structure in (a). Suppose the listener knows that a given feature is harmonic and thus that over some span the value of that feature will remain constant. Over that span, then, the feature value must be identified only once. If the identification is made early on in the string, the acoustic dimension associated with the harmonic feature need no longer be

attended to, and attention may be focused on other aspects of the acoustic signal. If only a tentative identification of the harmonic feature value is made early on, additional input is available in the remainder of the string for verification. Finally, if the acoustic cues of the feature in question are somehow obscured in the early portion of the string, the feature value is still potentially recoverable from information carried in the latter portion of the string.

With respect to the claim that harmony is a means of facilitating the correct identification of the triggering vowel, an additional point should be made. It is well known that vowels exert a coarticulatory effect on neighboring vowels. Both anticipatory and carryover coarticulatory effects have been documented for languages such as English (Bell-Berti & Harris 1976), Russian (Purcell 1979), and Catalan (Recasens 1984). In a given V_iCV_j utterance, the articulation of V_i will typically affect that of V_j, and vice-versa. It seems reasonable to assume that in VCV utterances in which the vowels are identical or similar, coarticulatory effects will be either non-existant or fairly minor. If the goal is to maximize the perceptibility of a given vowel, then by insisting that vowels in neighboring syllables be identical or similar to that vowel, the effects of coarticulation will be eliminated or at least reduced. Thus, the presence of harmony in the grammar of a language reinforces the perception of the harmony trigger in two ways.

5.1 Positional Neutralization (Steriade 1993, 1995)

Steriade (1993) surveys a range of cases in which feature contrasts are limited to certain positions in a word. These include (i) languages in which laryngeal contrasts are limited to onset consonants, as in German, Russian, and Maidu; (ii) languages such as Guarani in which the nasal vs. oral contrast in vowels is found only

in stressed syllables; (iii) languages such as Diola Fogny and Japanese in which place of articulation contrasts among nasals are found only in onset position; as well as (iv) languages, such as those discussed in Chapter 2, in which contrastive rounding is limited to initial syllables.

One widely-held view, shared by analysts such as Itô (1986), Goldsmith (1990), Itô & Mester (1993), and Itô, Mester & Padgett (1994), is that such restrictions should be characterized in terms of prosodic licensing. Under the prosodic licensing account of distributional restrictions such as those referred to above, grammars may contain statements to the effect that a given contrast must be licensed by some prosodic position or category. As Steriade points out, this analytic strategy implies that it is prosodic structure *per se* which makes possible the occurrence of certain featural contrasts. Steriade challenges this implication, suggesting instead that where we find distributional generalizations such as "the contrast F is found only in position P," what is making possible the occurrence of F is "some property available in P." She suggests that such a property is one which serves to enhance the contrast F, either articulatorally, perceptually or both.

Also problematic for the prosodic licensing account of positional neutralization, according to Steriade, is the existence of many licensing contexts which are not statable in prosodic terms alone, or worse, not statable in prosodic terms at all. For example, in Hindi contrastive nasality among vowels is licensed in long nuclei as well as in open syllables. In Hausa, the [±high] contrast among vowels is licensed in long nuclei as well as in word final position. Thus, there is no unique prosodic category which could be said to license the occurrence of [±nasal] in Hindi or the occurrence of [±high] in Hausa. Steriade lists a number of cases of positional neutralization in which no prosodic category can be invoked as a licenser, such as the

case of Klamath in which contrastive glottalization and aspiration are licensed only in the presence of a following sonorant, regardless of the position of syllable boundaries. Similarly, contrastive retroflexion in many languages of India and Australia is licensed in consonants only when a vowel precedes, again regardless of the position of syllable boundaries. The relevant acoustic cue for retroflexion is apparently to be found in the formant transitions from the vowel into the coronal consonant. It is thus post-vocalic position in which contrastive retroflexion is observed: a distribution which defies statement in terms of prosodic licensing.

Thus, positional neutralization is characterized by Steriade as "the limitation of perceptually difficult contrasts to positions where they can be identified more reliably" (Steriade 1993). By way of example, she cites the frequently observed restriction on place features among nasals by which nasals may contrast for place features in onset position but not in coda position. The claim is that place contrasts among nasals are perceptually relatively difficult, more so than among oral consonants, for instance (here Steriade cites Ohala 1975).[1] Furthermore, the clearest acoustic cues signaling place of articulation among nasals, which typically lack a prominent burst, reside largely in the transition from the consonant into a following vowel (here, Steriade cites Ohala 1990). Thus, place of articulation distinctions among nasals stand a better chance of being identified correctly in onset position than in coda position.

Among vowels, Steriade cites a range of contrasts which in some languages are subject to positional neutralization. By hypothesis, these are contrasts which are perceptually relatively difficult. These include contrastive nasality and contrastive rounding, mentioned above, as well as laxness contrasts which are subject to positional neutralization in languages such as Italian and Brazilian Portuguese;

[1] Ohala, in turn, cites Malécot (1960).

backness contrasts, which are distributionally restricted in the Uralic and Altaic languages; and subtle distinctions of height, which are found to be subject to positional neutralization in many Bantu languages.

Steriade's survey yielded as the most common positions to which such contrasts are limited the following: word-peripheral position (i.e. in either word-initial or word-final syllables), metrically strong positions, and under length. She suggests that these positions share a common property, namely relatively greater duration. It is the greater duration of these positional licensers, Steriade argues, which facilitates the contrasts in question:

> For the listener, extra duration means extra exposure to a dubious vowel quality and thus a better chance to identify it correctly. For the speaker, extra duration means the ability to complete a gesture rather than fall short of the articulatory target. (Steriade 1993)

Thus, in Steriade's terms, length is both a perceptual facilitator as well as an articulatory facilitator. Note, however, that articulatory facilitation can be viewed, ultimately, as a vehicle for meeting perceptual needs, since a more fully articulated gesture will almost always give rise to stronger perceptual cues.

Now, if Steriade's conclusions regarding the nature of vowel contrast licensers is correct, it follows that duration is a grammatically relevant factor in the distribution of vowel features. This conclusion then lends credence to the view of harmony for which I am arguing in this study, namely that vowel harmony is a mechanism for temporally extending perceptually difficult qualities.

5.2 Suomi's Perceptual Motivation Theory (1983)

In the preceding section I have attempted to establish a link between positional neutralization and harmony, claiming that both are grammatical means by which to insure that a phonologically relevant contrast can be adequately maintained. Suomi (1983) takes a different line from the one proposed here. Suomi characterizes harmony as a means to facilitate the perception of weak vowels in positions lacking prominence by rendering the occurrence of such vowels predictable. Thus, what Suomi's theory accounts for is the neutralization of feature contrasts in positions in which their identifiability might be jeopardized. In Suomi's theory, the driving force behind harmony is to render the quality of weak vowels contextually predictable. The quality of these vowels is non-distinctive, however, thus this goal would appear to be functionally unmotivated, given the communicative task which faces speakers. In the theory advocated here, by contrast, the objective which drives harmony is that of insuring that contrastive features are correctly identified.

Despite this difference, however, the conceptualization of harmony proposed here derives much from Suomi's perceptual theory of palatal vowel harmony. Suomi advocates a substantively-based approach to the phenomenon of vowel harmony in the Uralic and Altaic languages. This approach is based on the notion that certain vowels are perceptually less salient than others and that harmony serves to enhance the perceptibility of such vowels.

Suomi notes that the Uralic and Altaic languages displaying palatal vowel harmony (harmony based on the feature [back]) share a common feature. In each of these languages, the vowel inventory includes cross-linguistically common vowels alongside relatively uncommon vowels such as the front rounded vowels *ü* and *ö* and the high back unrounded vowel *ɨ*. In his analysis of harmony in Finnish, the vowels

are divided broadly into two categories on the basis of their typological distribution. The *weak* vowels are those which are relatively rare cross linguistically, including the front vowels *ü, ö* and *æ*. The *strong* vowels of Finnish are those which are typologically more common, including *i, e, u, o* and *a*. Suomi argues that the cross-linguistic popularity of the strong vowels vis-à-vis the relative rarity of the weak vowels is a perceptual effect:[2]

> "It is generally agreed that the primary vowels are typologically more common because they form the set of vowels that are perceptually maximally distinct from one another." (Suomi 1983, p. 6)

The strong vowels of Finnish are further subdivided on the basis of their perceptual similarity to the weak vowels. The strong vowels *u* , *o* and *a* are claimed to bear a crucial similarity to the weak vowels *ü* , *ö* and *ä* respectively, and constitute the class of *bounded* strong vowels. The strong vowels *i* and *e*, by contrast, bear no such similarity to the weak vowels, and thus constitute the class of *unbounded* strong vowels.[3]

It is the weak vowels and the bounded strong vowels which are subject to palatal vowel harmony restrictions in Finnish, whereas the unbounded strong vowels are freely distributed. Restrictions on the distribution of the weak vowels and those vowels which are potentially confusable with them, i.e. the bounded strong vowels,

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[2]Citing Lindblom (1972), Suomi argues that the drive to maximize *articulatory* ease is not the primary factor underlying recurring cross-linguistic vowel inventory patterns.

[3]Given the acoustic features which Suomi assumes (or for that matter any standard set of distinctive features), it is not made clear why the strong vowel *i* is any less similar to the weak vowel *ü* than *u* is. Likewise, *e* might be expected to be no less similar to *ö* than *o* is. Nonetheless, *i* and *e* are said to be *unbounded* while *u* and *o* are *bounded*. The motivation for treating these two sets of vowels differently is apparent, since Suomi's *bounded* vowels enter into harmonic alternations and are subject to harmonic restrictions in Finnish, while the *unbounded* vowels are not. However, apart from phonological patterning, no principled distinction between the two sets of vowels falls out from Suomi's framework.

make their occurrence to a large extent predictable. As a consequence, the hearer's task is made easier.

Suomi's analysis focuses on the distribution of vowels in non-initial syllables, i.e. in the positions targeted by harmony. As stated, the palatal vowel harmony rules of combinability characterize harmony as a means of rendering the quality of vowels occurring in non-initial syllables predictable on the basis of the vowel quality occurring in the initial syllable. Implicit in this approach is the assumption that the relevant perceptual contrasts are more readily discerned in positions of prominence, e.g. in the initial syllable of a word, and that the goal of harmony is to facilitate perception in positions lacking prominence. In my view, this is incorrect, however. It seems unlikely that a grammatical phenomenon such as harmony would be in place in order to facilitate the accurate perception of qualities which carry no contrastive information. Harmony should instead be viewed as a means of enhancing the perceptibility of the triggering element where correct lexical identification is at stake.

5.3 What Constitutes a "Perceptually Difficult Contrast"

Up to this point, I have assumed that certain vocalic contrasts are more perceptually difficult than others. The notion of perceptual difficulty must of course be made explicit. This enterprise runs the risk of becoming circular if, having adopted the hypothesis that those contrasts which are sometimes subject to harmony restrictions constitute the set of perceptually difficult contrasts, we then cite the fact that a given contrast is sometimes subject to harmony restrictions as evidence for that contrast's relative perceptual difficulty. In the sections which follow, I will argue for the relative perceptual difficulty of certain contrasts on the basis of facts independent of harmonic patterning.

5.3.1 F1 vs. F2

There is reason to believe that vocalic contrasts which are acoustically manifested in the frequency of F1 are perceptually more salient than those whose acoustic manifestations involve the frequency of F2. That is, it is arguably the case that height contrasts are perceptually more robust than backness and rounding contrasts. One indication of this is the primacy of height distinctions over backness and rounding distinctions in cross-linguistic vowel inventory patterns.

There are, apparently, no vowel inventories lacking phonological oppositions involving height.[4] However, inventories are attested in which vowel height alone is distinctive, to the exclusion of oppositions based on backness and rounding. Trubetzkoy (1958, trans. by Baltaxe, 1969) cites Adyghe, Abkhas and Ubyk as instantiating this possibility. In these languages, the vowels have been analyzed as being distinctively opposed on the basis of height but receive their rounding and backness characteristics from neighboring consonants. Donegan (1985) adds to this list Kabardian (Kuipers 1960), Higi (Mohrlang 1971), Gude (Hoskison 1974) and Marshallese (Bender 1971, Choi 1992).

That height contrasts should be more basic than contrasts of backness and rounding requires explanation. Lindblom argues that if F1 and F2 are assumed to contribute equally to perceptual distance, one would expect the backness and rounding dimension to allow for a greater number of contrasts than the height dimension.

[4]Trubetzkoy challenges J. van Ginneken's (1932) claim that Lak, an East Caucasian language of Central Daghestan, lacks phonemic oppositions based on height. This language has apparently three vowel phonemes which are in general realized as *i*, *u*, and *a*. Van Ginneken characterizes these oppositions purely in terms of backness and rounding, where *i* is front unrounded, *u* is back rounded and *a* is back unrounded. Trubetzkoy points out, however, that when these sounds occur adjacent to strongly palatalized consonants, the otherwise high vowels are lowered, and all vowels are fronted; *i* surfaces as *e*, *u* surfaces as *ö*, and *a* surfaces as *ä*. Thus, in the palatalization context there exists between /i/ and /a/ an opposition based on height.

According to Lindblom's (1975) model, the distance between the high vowels *i* and *u*, expressed in mels (a perceptual scale of frequency), was determined to be 850, far greater than that between *i* and *a* (675) and between *u* and *a* (only 550). Nonetheless, surveys such as Sedlak (1969) and Crothers (1978) indicate that the typologically preferred number of vowels situated between *i* and *u* is zero. By contrast, inventories most often recruit one additional vowel to occupy the space between between *i* and *a* and between *u* and *a*.

The important acoustic difference between F1 and F2 appears to be relative intensity. F1 has a greater inherent intensity than F2 (as well as the higher formants). Lindblom (1986) invokes this acoustic asymmetry to explain the primacy of the height dimension over the backness and rounding dimensions in vowel inventory patterns:

> ...the dimension of F1 (a major correlate of articulatory opening and vowel height) is favored in vowel contrasts over higher formants (related mainly to front-back and rounding). Lindblom (1975) argues that if vowel systems had developed security margins guaranteeing a certain amount of perceptual differentiation in communication under noisy conditions, they would be expected to exploit F1 (height and sonority) more than the other formants, since, according to acoustic theory, F1 is more intense and thus statistically more resistant to noise. (Lindblom 1986, p. 22)

To conclude this section, evidence from the design of vowel inventories suggests that oppositions based on height are more basic than oppositions based on backness and rounding. Lindblom proposes a perceptual explanation for this asymmetry on the basis of the acoustic dimension of intensity. Lindblom's explanation, if correct, indicates that contrasts which are acoustically cued by the frequency of F2 are perceptually less salient than contrasts whose acoustic cues are carried by F1. Furthermore, we know from cross- linguistic inventory patterns that this difference plays a role in the organization of phonological systems. Therefore,

given that F2 distinctions are less salient than F1 distinctions, I submit that height contrasts are less likely to be subject to positional neutralization and harmony than are backness and rounding contrasts.[5]

5.3.2 Enhancement

The perceptual difficulty of F2 contrasts is predicted to increase when the features associated with F2 (i.e. [±back] and [±round]) function contrastively, independently of one another. I refer here to the phenomenon known as enhancement (Stevens, Keyser & Kawasaki 1986). Stevens, Keyser & Kawasaki study the relationship between distinctive and redundant features in phonological systems, identifying two types of redundancy. One type is intrinsic redundancy whereby certain features are articulatorally constrained so as to occur only in the presence of certain other features. The features [nasal] and [sonorant] are cited as instantiating intrinsic redundancy: "The feature [+sonorant] is required if the sound is to contain the property that indicates the feature [+nasal]" (Stevens, Keyser & Kawasaki 1986, p. 428). The second type of redundancy identified by Stevens, Keyser & Kawasaki is pertinent to our discussion. This type of redundancy obtains when a certain feature which is not distinctive in a given language is invoked under some or all circumstances to enhance the acoustic properties associated with some feature which is used distinctively. Backness and rounding features are most often mutually enhancing in just this way.

[5]Height harmony is attested in Bantu (Clements 1991) as well as in Pasiego (Penny 1969, 1970). These languages share the property of having a relatively height-crowded vowel inventory with three degrees of contrastive height among the front unrounded vowels as well as among the back rounded vowels. The issue of inventory crowding and harmony is discussed in §7.6.

Typically, the [±round] opposition and the [±back] opposition are mutually enhancing: front vowels are unrounded; back non-low vowels are rounded. When we say that [round] enhances [back], and vice-versa, what we mean is the following: The presence of lip-rounding in the articulation of a vowel induces a lowering of all formants. At the same time, the acoustic cue associated with back vowels is a relatively low F2 value. Therefore, the presence of lip-rounding reinforces the cue that a back vowel is indeed back. By the same token, the acoustic cue associated with front vowels is a relatively high F2 value, so the absence of lip rounding enhances the cue that a front vowel is indeed front. More to the point, perhaps, is the fact that the combination of backness and lip-rounding produces an acoustic entity [u] which is maximally distinct from that produced by the combination of frontness without lip-rounding, namely [i].

Back-round enhancement is exploited in the great majority of languages, where we find lip rounding accompanying the articulation of the non-low back vowels, the *u*- and *o*-type vowels, and the absence of lip-rounding - indeed, in some languages active lip-*spreading* - accompanying the articulation of the *i*- and *e*-type vowels.

However, in a minority of languages backness and rounding are independently contrastive. The hypothesis is that in languages in which the [±round] opposition and the [±back] opposition do not stand in a relationship of mutual enhancement, the perceptual cues available for recovering the backness and rounding values of a given vowel will be relatively weak. And indeed, we find that backness harmony and rounding harmony are very frequently found in languages in which the features [±round] and [±back] are not mutually enhancing. For instance, backness harmony is observed in Hungarian and Finnish. In these languages lip-rounding enhances

[+back], but among the front vowels, the rounding and backness dimensions function independently of one another. Both backness harmony and rounding harmony are observed in many Turkic languages. In these languages the roundness and backness dimensions are never mutually enhancing: rounding contrasts obtain among both the front vowels and the back vowels.

The point then is as follows. The backness and roundness dimensions are usually coordinated in such a way so that [+round] accompanies [+back]. Stevens, Keyser & Kawasaki attribute this robust tendency to perceptual saliency. If this explanation is correct, then we know that the goal of maximizing the perceptual distance in F2 is relevant to the organization of phonological systems. It is therefore reasonable to suppose that where this goal is not met by inventory restrictions, it may instead by achieved by other grammatical strategies, such as positional neutralization and harmony.

Historically, we find numerous instances in which a crowded vowel inventory has led to the neutralization of vowel contrasts. Donegan (1985) cites many such cases, including the merger of the front rounded vowels with the front unrounded vowels in Darstadt German as well as Alsatian, and the merger of *ɪ* and *ʌ* with *i* and *e* , respectively, in Yellow Lahu. Chomsky and Halle (1968, p. 352) cite a similar case in Viennese German in which *i* and *ü* are neutralized to *i* before *r*, as in the words *vier* and *für* , both realized as [fîr]. In French, many younger speakers are exhibiting a merger of *œ̃* and *ɛ̃* and in current American English, many speakers are have merged *a* and *ɔ*.

5.4 Lip Rounding and the Height and Backness Dimensions

I will suggest that an additional factor which contributes to the perceptual difficulty of a given contrast is that of relative articulatory magnitude. The claim will be that the magnitude of the lip-rounding gesture is not equivalent for all rounded vowels.

Linker's (1982) data indicate that non-high rounded vowels tend to be less rounded than high rounded vowels. And similarly, front rounded vowels tend to involve less lip-rounding and/or protrusion than the analogous back rounded vowels (Linker 1982).[6] The hypothesis, then, is that in contexts in which the articulatory manifestations of the [±round] opposition are relatively small, they will give rise to relatively small acoustic differences. As a consequence, weaker perceptual cues will be available for determining whether a given vowel is rounded or unrounded.

5.4.1 The Articulation of Rounded Vowels: Linker (1982)

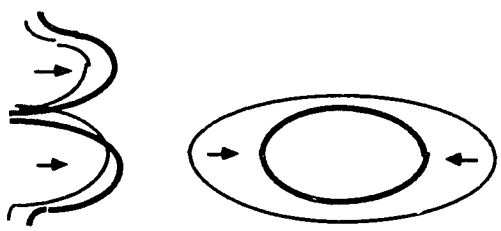
Linker (1982) studied labial activity in vowels for five different languages: English, Cantonese, Finnish, French and Swedish. One of her goals was to identify the linguistically significant parameters of lip position in vowel articulations. The set of languages was selected on the basis of a number of criteria. First, the languages are genetically fairly diverse. Also, four of these five languages (i.e. all save English) have both front and back rounded vowels of varying heights. Thus, the data set allowed for the comparison of labial activity in back versus front rounded vowels, as well as a comparison of the labial articulation of high versus non-high rounded vowels.

[6]This is very clearly the case among high vowels. Among non-high vowels, languages appear to differ with respect to the degree of lip-rounding associated with front versus back vowels. This issue is discussed in depth below.

Linker's data involved measurements of 24 distinct dimensions taken from still photographs of the side and front view of the mouth.[7] Using a factor analysis algorithm called PARAFAC (Harshman 1970, Harshman, Ladefoged & Goldstein 1977, Harshman & Berenbaum 1980), Linker identified the articulatory dimensions of lip position which are relevant for distinguishing vowels within each of the languages studied. These dimensions typically involved horizontal opening, vertical opening, lip protrusion, or some combination thereof. Additionally, by means of a computer program called CANON (Goldstein, n.d.), Linker was able to isolate a set of canonical factors of lip position relevant to all of the languages studied.

Two canonical factors were found. The first involves horizontal opening and, to a lesser extent, lip protrusion. A diagram is shown in (1):

(1) <u>The Effects of Canonical Factor 1</u> (Based upon Linker's Fig. 37, p. 84)

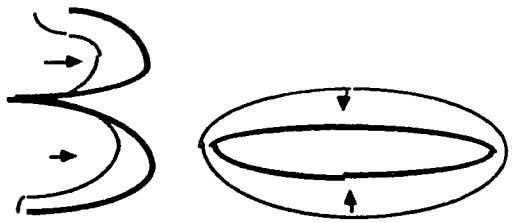


Given any two vowels, the vowel with a higher value for Canonical Factor 1 will involve relatively decreased horizontal opening and slightly increased protrusion relative to the vowel whose value of Canonical Factor 1 is lower.

The second factor involves vertical opening and protrusion, as shown in the diagram in (2):

[7]For each language, data from eight male subjects were obtained. Photographs were taken simultaneously with audio recordings.

(2) The Effects of Canonical Factor 2 (Based upon Linker's Fig. 38, p. 84)



A relatively higher value of Canonical Factor 2 reflects decreased vertical opening and increased protrusion.

The vowels of each of the languages studied are arranged along a continuum for both Canonical Factors. In all languages, the rounded vowels are clustered at the higher end of both scales, while the unrounded vowels are distributed at the lower end of the scales. This result is reassuring given that we expect rounded vowels to involve greater labial activity than unrounded vowels. Consider the distribution of the vowels of Finnish, shown in (3) and (4). I use the vowel symbols chosen by Linker, including [y] to represent the high front rounded vowel which is transcribed elsewhere in the present work as [ü]:

(3) Loadings along Canonical Factor 1: Finnish

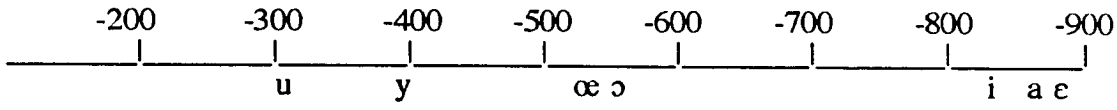
-200	-300	-400	-500	-600	-700	-800	-900
u	y	o	ø		ɑ	i æ e	

(4) Loadings along Canonical Factor 2: Finnish

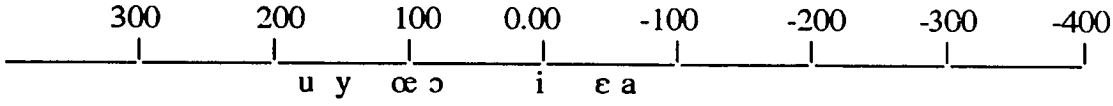
300	200	100	0.00	-100	-200	-300	-400
	u	y o ø		ɑi e æ			

In addition to this coarse division, further regularities emerge from a comparison of the four languages which contain both front and back rounded vowels, i.e. Finnish, Cantonese, French and Swedish. In all of the languages studied, the high rounded vowels have a higher value for both of the Canonical Factors than do the non-high rounded vowels. This is true in (3) and (4) above which indicate the Finnish results, as well as in (5) and (6) below which show the Cantonese values:

(5) Loadings along Canonical Factor 1: Cantonese

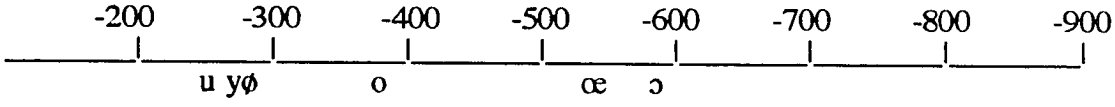


(6) Loadings along Canonical Factor 2: Cantonese

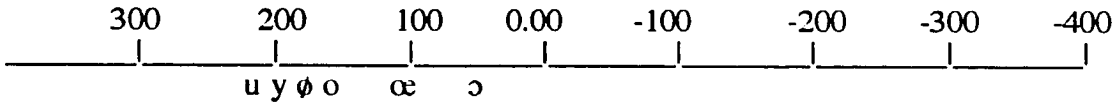


The remaining languages display the same pattern. For clarity, I include only the rounded vowels:

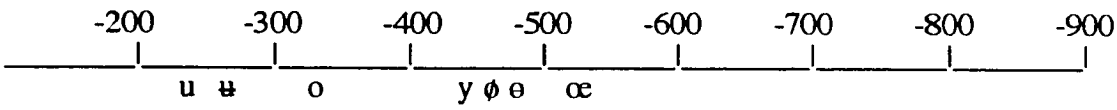
(7) Loadings along Canonical Factor 1: French



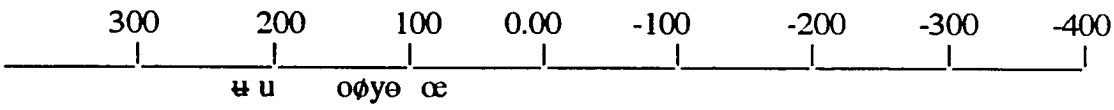
(8) Loadings along Canonical Factor 2: French



(9) Loadings along Canonical Factor 1: Swedish



(10) Loadings along Canonical Factor 2: Swedish



Note that in Swedish, the back vowels are all situated on the higher end of the scales relative to the front vowels. Nonetheless, within the class of back rounded vowels, the higher vowels show an increased value of the Canonical Factors relative to the non-high vowels.

The separation between the front and back vowels in Swedish brings us to the next important observation. In general, back rounded vowels display greater values of Canonical Factor 1 and Canonical Factor 2 than the corresponding front rounded vowels. That is to say, they involve more extreme lip-rounding gestures. This is true across the board in Swedish. In the remaining languages, this pattern is invariably observed among the high vowels; that is, *u* is always located higher on the scales than *y*. Among the non-high vowels, the languages in Linker's study differ with one another. In Finnish and Swedish, the front rounded vowels are lower on both scales

than the corresponding back vowels. In Cantonese and French, by contrast, the non-high front vowels are situated above the non-high back vowels.

On the basis of Linker's analysis, therefore one may reach the following conclusions. Two factors involving lip position are relevant for distinguishing rounded vowels from unrounded vowels. In all of the languages studied, the articulation of high rounded vowels involves a greater degree of these factors than the articulation of non-high rounded vowels; that is, in a sense the high rounded vowels are "more rounded" than the non-high rounded vowels. Furthermore, the articulation of *u*-type vowels always involves a greater degree of both rounding factors than does the articulation of *y*-type vowels.

To summarize, vowel height strongly influences the degree of lip-rounding associated with a given vowel, with high vowels involving relatively greater magnitude lip-rounding gestures. Where languages agree with respect to the influence of backness on the degree of lip-rounding, it is the back vowels which have a relatively greater magnitude lip-rounding gesture vis-à-vis the front vowels.

5.4.2 The Perception of Rounded Vowels (Terbeek 1977)

I have suggested that one source of relative perceptual difficulty is related to relative articulatory magnitude. The hypothesis is that where the articulation associated with a given phonological contrast is realized with a relatively low-magnitude gesture, the acoustic cues available to the listener will be relatively subtle. As a result, the perceptual task with be comparatively difficult. Above, we saw experimental evidence indicating that the degree of lip-rounding associated with rounded vowels is dependent upon the dimensions of height and backness. Specifically, high vowels are more rounded than non-high vowels, and back vowels

tend to be more rounded than front vowels. If the relative magnitude hypothesis is correct, then high vowels should be perceived as more rounded than non-high vowels, and back vowels should be perceived as more rounded than front vowels.

The hypothesis advanced above is supported by the results obtained in Terbeek's (1977) investigation of the factors which contribute to perceptual distances in the vowel space. Terbeek's study investigated the perceptual distance among 10 monophthongs. The monophthongs studied were {i, y, e, ø, ɪ, u, a, o, æ, and ɚ}. Speakers of five languages served as subjects: English, German, Thai, Turkish, and Swedish. For each of these subjects, some but not all of the monophthongs were similar to vowels occurring in the listener's native language.

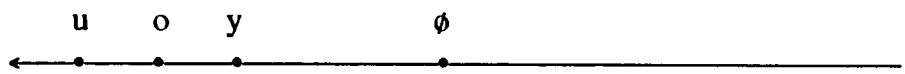
One of Terbeek's primary goals was to identify the perceptual attributes according to which listeners perceive vowels. The data consisted of triadic comparisons of the test vowels in the context [bəb__]. The task was to determine which of the three stimuli sounded the most distinct from the others. From the responses collected, dissimilarity matrices were constructed, and these were submitted to a PARAFAC factor analysis algorithm (Harshman 1970, Harshman, Ladefoged & Goldstein 1977, Harshman & Berenbaum 1980). Terbeek's PARAFAC analysis yielded a 6-dimensional solution, indicating that six factors are relevant to the identification of vowels within a multi-dimensional space. These six dimensions correlate more or less with the standard phonological oppositions shown in (11):

(11) Dimensions of Vowel Identification (Terbeek, 1977)

Dimension 1:	Back vs. Nonback (1)
Dimension 2:	Back vs. Nonback (2)[8]
Dimension 3:	Low vs. Nonlow
Dimension 4:	High vs. Nonhigh
Dimension 5:	Round vs. Nonround
Dimension 6:	Peripheral vs. Central

The results of Terbeek's investigation indicate that along the Round versus Nonround continuum, the rounded vowels are arranged as shown schematically here (relative distance is approximated):

(12) The Round vs. Nonround Continuum (Terbeek, 1977)



This arrangement indicates that non-high vowels and front vowels are perceived as relatively nonround: The high vowels lie on the higher end of the scale relative to the non-high vowels, and the back vowels lie on the higher end of the scale relative to the front vowels.

The results of Terbeek's perceptual study thus support the relative articulatory magnitude hypothesis. Those vowels which were found in Linker's study to involve a relatively small lip rounding gesture, i.e. the non-high vowels and the front vowels, are perceived as being relatively less rounded than those vowels whose articulation involves comparatively greater articulatory magnitude. Therefore, it is plausible to

[8]Back vs. Nonback (1) separated the front and back vowels with one exception. On the basis of this factor, the vowel [ɪ] was grouped with the front vowel cluster. The vowel [ɚ] fell between the back and front vowel clusters. Back vs. Nonback (2) grouped the vowel [ɪ] with the cluster of back vowels and placed [ɚ] at the low end of the scale along with {ø, i, e, and y}.

conclude that contrastive rounding among non-high vowels is perceptually more subtle than contrastive rounding among high vowels, and, by the same token, that contrastive rounding among front vowels is perceptually more subtle than contrastive rounding among back vowels. This being the case, we expect to find instances in which rounding harmony is triggered by non-high vowels and not high vowels, and we expect to find cases where rounding harmony is triggered by front vowels and not back vowels, since the function of harmony is to improve the listener's chances at correctly discerning a subtle featural contrast.

5.5 *ROLO

In Chapter 6, I will introduce a constraint labeled *ROLO which states a dispreference for vowels in which lip-rounding combines with relatively low jaw position. We saw above in §5.4.1 that non-high rounded vowels are articulated with a smaller degree of lip-rounding than high rounded vowels; this suggests that lip-rounding and jaw-lowering are in some sense antagonistic gestures. Linker's Canonical Factor 2 is based on two positional criteria: lip protrusion and vertical opening. Thus, unsurprisingly, rounded vowels have greater protrusion and lesser vertical opening than unrounded vowels. Clearly, a lowered jaw position compromises the potential for achieving a small vertical opening.

The dispreference for rounded vowels in the lower region of the vowel space is manifested in at least two cross-linguistic vowel inventory patterns. In Maddieson's *Patterns of Sounds* (1984), phonetically low rounded vowels are found to be extremely rare. Of the 523 low vowels listed in UPSID (the UCLA Phonetic Segment Inventory Database, which contains the segment inventories of 317 languages), only

37, or 7%, are rounded. The remaining 93% are unrounded. A further asymmetry emerges from Maddieson's survey. This asymmetry involves vowels in the mid region of the vowel space. We find that mid back rounded vowels are often recorded as being higher than their front unrounded counterparts. A selection of such inventories from UPSID are given below in (15)-(31). The reverse scenario, whereby the mid back vowel is recorded as being lower than its front unrounded counterpart, is strikingly rare. Only two such inventories appear in UPSID, shown in (32)-(33)

In my survey of this asymmetry, I did not include inventories in which an additional vowel in either the front or back series was present (or absent) and could be argued to "push" one of the mid vowels to a position either higher or lower than otherwise expected. For instance, Seneca was not included among those languages in which the mid front vowel was unexpectedly higher than the corresponding mid back vowel. Seneca was excluded because an extra vowel, namely *æ*, is present in the inventory. Arguably, the presence of this low front vowel induces a shift of the vowel *e* to a higher point in the vowel space in order to avoid crowding:

(13) <u>Seneca</u>

high	i		u
high mid	e		
mid			o
low		æ	a

Similarly, the Ojibwa long vowel inventory was not included among those cited as reflecting the common back-front asymmetry among mid vowels, even though the mid back vowel is recorded as being higher than its front counterpart. This is due to the fact that the inventory lacks a high back vowel. This gap, rather than a general principle dictating against the combination of lip-rounding and comparatively low jaw

position, could be argued to be responsible for the relative height of the back mid vowel. Stated differently, the Ojibwa vowel *o:* is not obviously the counterpart of *e:* any more than it is the counterpart of *i:*:

(14) <u>Ojibwa</u>

high	i:		
high mid			o:
mid		e:	
low			a:

Some of the UPSID inventories in which the mid back vowel is recorded as being higher than its mid front counterpart are listed here:

(15) Tarascan

high	i	u
higher mid		o
lower mid	ɛ	
low	a	

(16) Dakota

high	i	u
mid		o
lower mid	ɛ	
low	a	

(17) Ocaina

high	i	ɯ
higher mid		o
lower mid	ɛ	
low	a	

(18) Kunjen

high	i	u
mid		o
lower mid	ɛ	
low	a	

(19) Batak

high	i	u
mid		o
lower mid	ɛ	
low	a	

(20) Maori

high	i	u
mid		o
lower mid	ɛ	
low	ɑ	

(21) Kan

high	i,y		u
mid		ə	o
lower mid	ɛ		
low		a	

(22) Hawaiian

high	i	u
mid		o
lower mid	ɛ	
low	a	

(23) Yagaria

high	i	u
mid		o
lower mid	ɛ	
low	a	

(24) Selepet

high	i	u
higher mid		o
lower mid	ɛ	
low	a̯a	

(25) Nasioi

high	i	u
higher mid		o
lower mid	ɛ	
low	a	

(26) Yagaria

high	i	u
mid		o
lower mid	ɛ	
low	a	

(27) Zoque

high	i	u
mid		o
lower mid	ɛ	
low	a	

(28) Komi

high	i		u
higher mid			o
mid	e	ə	
low		a	

(29) Songhi

high	i		u
higher mid			o
mid	e		
low		a	

(30) Hebrew

high	i		ʊ
mid			o
lower mid	ɛ		
low		a	

(31) Margi

high	i			u
mid			ə	o
lower mid		ɛ		
low			a	

Those inventories which show the reverse asymmetry are listed here:

(32) Kharia

high	i		u
higher mid	e		
lower mid			ɔ
low		a	

(33) Asmat

high	i			u
higher mid	e			
mid			ə	
lower mid				ɔ
low			a	

Therefore, from Maddieson's survey we may draw the following conclusions. First, low rounded vowels are typologically extremely rare. Second, among vowels within the mid region, rounded vowels are often higher than their unrounded counterparts. These two observations lend support to the claim that lip-rounding in combination with relatively low jaw position is dispreferred.

5.6 Uniformity

In Chapter 6, Iwill introduce a constraint labeled UNIFORM[RD] which states that the autosegment [+round] may not be multiply-linked to vowel positions which are distinctly specified for height.[9] This constraint refers to the phonology-phonetics

[9]This constraint appears to dictate only that vowels multiply linked to a single [+round] autosegment may not be distinct in *height*. It must say nothing about other features, in particular backness, because

interface and implicitly suggests that phonological autosegments are interpreted in the phonetics as instructions to reach some gestural target. With respect to the typological patterns observed in rounding harmony, UNIFORM[RD] characterizes formally the fact that in many systems, sequences of rounded vowels differing in height are not found as the output of harmony.

I suggest that uniformity constraints reflect a requirement that a given articulatory instruction, or autosegment, have a uniform execution mechanism throughout its span of association. In other words, a single autosegment should be interpreted phonetically as an instruction to achieve a single target configuration. The preceding sections have presented evidence that the lip-rounding gesture accompanying rounded vowels is not equivalent for all vowels: the labial activity involved in the articulation of lower rounded vowels and to some extent front rounded vowels is relatively small.

There is also reason to believe that the lip-rounding gestures associated with high and non-high vowels are in fact qualitatively different. I would argue that a single feature [+round] should not be rejected as a phonological primitive due to the fact that rounded vowels constitute a natural class. The phonological feature [+round] does not correspond to an invariant articulatory event, however. Consider for instance the two factors found by Linker to be linguistically relevant for Finnish.[10] Finnish Factors 1 and 3 differ in that Factor 1 involves vertical opening, while Factor 3 involves lip protrusion.[11] How the vowels are arranged along these Factor scales is

in Shuluun Höh where this constraint is ranked high and is often decisive, sequences of rounded vowels disagreeing in backness are allowed to surface. For a discussion, see Chapter 7.

[10]These are the Finnish-specific Factors, along with which the Factors specific to Cantonese, French, Swedish and English were fed into the CANON program. By means of the CANON program, the Canonical Factors discussed in §6.3 were discovered.

[11]PARAFAC yielded a 3-Factor solution for Finnish; however, only Factors 1 and 3 appear to be linguistically significant. Factor 2 yields virtually no segregation of the vowel set.

shown in (34) and (35). The rounded vowels are in a larger typeface to enhance their visibility:

(34) Loadings along Factor 1: Finnish

```
300       400       500       600       700       800       900       1000
|         |         |         |         |         |         |         |
          u         y         ɑ i       OeŒ       æ
```

(35) Loadings along Factor 3: Finnish

```
-200      -100      0.00      100       200       300       400       500
|         |         |         |         |         |         |         |
          uyo       œ                                     ɑæ        ei
```

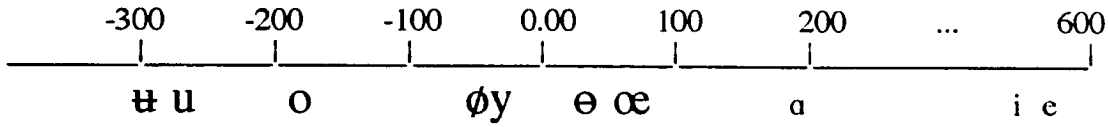
These distributions indicate that while the high rounded vowels of Finnish involve a considerably smaller vertical opening than the lower rounded vowels (Factor 1), the degree of lip protrusion is virtually the same for all rounded vowels in Finnish (Factor 3). Thus, in Finnish the labial gesture associated with high rounded vowels involves an approximation of the lips as well as lip protrusion, whereas the labial gesture associated with lower vowels involves merely protrusion.

Let us consider now the factors relevant for Swedish which emerge from Linker's study. Swedish Factors 2 and 3 differ in that Factor 2 is correlated with horizontal opening, whereas Factor 3 is correlated with vertical opening.[12] Factor 2 divides the vowels roughly into four groups, as shown here:

---

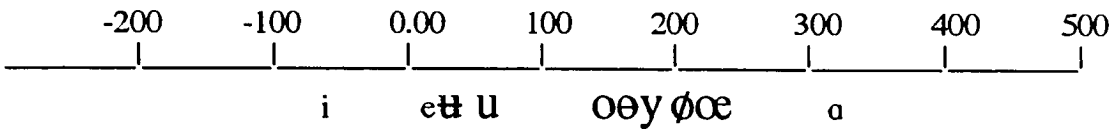
[12]Swedish Factor 1, like Finnish Factor 2, is apparently linguistically insignificant.

(36) Loadings along Factor 2: Swedish



As indicated, the lowest of the Swedish rounded vowels (*ɵ* and *œ*) have the greatest degree of horizontal opening, followed by the high and mid front rounded vowels (*ø* and *y*). The least degree of horizontal opening is observed in the high back and central rounded vowels (*ʉ* and *u*), with back rounded *o* lying toward the low end of the scale. Swedish Factor 3 divides the rounded vowels into only two clusters:

(37) Loadings along Factor 3: Swedish



The high rounded vowels (with the exception of *y*) show the least degree of vertical opening. The entire class of non-high rounded vowels has a greater degree of vertical opening with relatively little differentiation among the higher and lower members of that class. Thus, while small height distinctions among Swedish vowels are related to the degree of horizontal lip opening, only gross distinctions of height strongly influence the degree of vertical opening.[13]

[13]For Cantonese, only one Factor was found to be linguistically significant. This Factor involved horizontal opening and front view area. For French, two Factors were found to be linguistically relevant. The first involved horizontal opening and front area view, while the second involved vertical opening and lower lip protrusion. The effects of height and backness were essentially equivalent for both of these Factors.

This experimental evidence suggests that both the degree and the quality of the labial activity associated with a given rounded vowel is dependent on the other articulatory dimensions of that particular vowel. It is therefore reasonable to claim that where a phonological representation contains a single autosegment [+round] associated to positions which differ in their specification for the height and/or backness dimensions, that autosegment will of necessity correspond in the phonetics to an instruction to achieve more than one rounding target. The claim, then, is that this situation is not optimal. A constraint of the uniformity family is, by the very nature of constraints, surface-violable (see Chapter 6 for a discussion of the theory of constraints and constraint interaction). And indeed, we see many instances in the typology of rounding harmony in which it is violated. Thus, the claim boils down to a hypothesis about the relationship between phonological elements, in particular autosegments, and the phonetic implementation component. Under this hypothesis, autosegments in the phonology are interpreted as instructions to achieve a gestural target in the phonetics. Uniformity thus states a preference for direct phonology-to-phonetics mapping.

5.6.1 Multiple Linking in Phonology and Phonetics (Boyce, 1988)

I have suggested that there exists a constraint (or family of constraints) dictating that a single phonological specification should correspond, phonetically to a uniform execution mechanism. I have labeled this *uniformity*. The uniformity hypthesis would appear fairly inplausible if it turned out to be the case that features multiply linked in phonological representation were phonetically interpreted as discrete features or gestures at the segmental level. That is, one might expect that the phonological structure in (38a) is mapped to the phonetic representation in (38b):

(38) <u>Possible Phonology-Phonetics Mapping</u>

a. Phonological Representation b. Phonetic Representation

```
C  V  C  V  C  V        ⇒   C  V  C  V  C  V
   \   |   /                 |     |     |
    [+round]                [+round][+round][+round]
```

If it turned out to be the case that a feature multiply linked in the phonology were rendered as a set of independent segmental specifications, as shown in (38), then a putative constraint dictating that a single phonological autosegment should have a uniform phonetic realization would appear unmotivated.

If, on the other hand, a single feature multiply-linked in phonological representation could be shown to correspond to a single phonetic feature (or gesture), then uniformity would appear quite plausible:

(39) <u>Alternative Phonology-Phonetics Mapping</u>

a. Phonological Representation b. Phonetic Representation

```
C  V  C  V  C  V        ⇒   C  V  C  V  C  V
   \   |   /                 \   |   /
    [+round]                  [+round]
```

If the mapping in (39) turned out to be accurate, then uniformity could be stated as in (40):

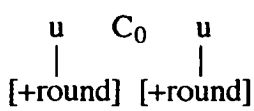
(40) UNIFORMITY *A single autosegment in the phonology corresponds to a single gesture in the phonetics; the need for articulatory adjustments in the execution of a single articulatory gesture should be avoided.*

Experimental evidence in support of the hypothesis that there is indeed a one-to-one relationship between phonological features and phonetic features is to be found in Boyce's (1988) study of coarticulation in English and Turkish.

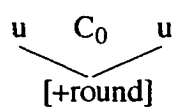
Boyce studied vowel-to-vowel coarticulation in English and Turkish uC_0u utterances. These two languages were chosen for comparison because there is good reason to believe that segmentally identical sequences may be assigned distinct phonological representations in these languages. Turkish, as a rounding harmony language, arguably represents uC_0u sequences as containing a single [+round] autosegment multiply-linked to both vocalic positions. English, which lacks rounding harmony, would plalusibly be expected to represent the same sequence with two independent [+round] specifications:

(41) <u>uC_0u Sequences in English and Turkish</u>

a. English



b. Turkish



The question investigated by Boyce was whether the distinct phonological representations shown in (41) correspond to distinct articulatory patterns, and in fact her results clearly indicate that they do.

The English articulatory pattern, based upon measurements of lip activity and position, yielded a "trough"-like pattern, shown schematically in (42). The tracing represents lip protrusion (especially of the lower lip):

(42) <u>English "Trough" Pattern</u>

u C_0 u

As indicated, the lips attained a position of protrusion in the articulation of the first rounded vowel, then receded during the articulation of the consonantal sequence, then once again attained a position of protrusion for the second rounded vowel.

The Turkish articulatory pattern was qualitatively different. The results obtained by Boyce showed a "plateau"-like pattern in the articulation of uC_0u sequences by Turkish speakers. This is shown schematically in (43):

(43) <u>Turkish "Plateau" Pattern</u>

u C_0 u

In the Turkish articulation, as shown, the lips attained a position of protrusion during the articulation of the first rounded vowel and remained protruded throughout the utterance. One plausible interpretation of these experimental findings is the following: whereas the English speakers executed two lip-rounding movements, the Turkish speakers executed only one. This suggests that the distinct phonological

representations appropriate for English and Turkish give rise to distinct phonetic behavior. A single [+round] autosegment in the phonology corresponds to a single lip-rounding gesture in the phonetics.

To summarize, I have claimed that uniformity refers to the phonology-to-phonetics mapping: A singe phonological specification corresponds to a single phonetic event. The constraint, then, is operative in the phonology but refers to the phonetic interpretation of phonological structure.[14]

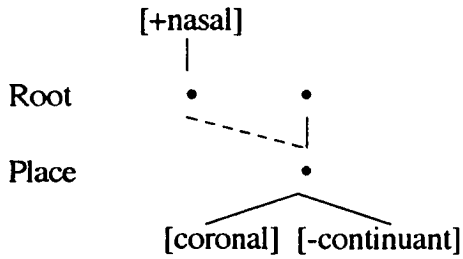
5.6.2 Excursus: Another Uniformity Effect

If uniformity, as discussed thus far, is the correct analysis of the frequently observed avoidance of cross-height harmony in rounding harmony systems, one might expect to find instances in which uniformity of features other than [+round] plays a role in limiting multiple association. In this section I suggest one such case.

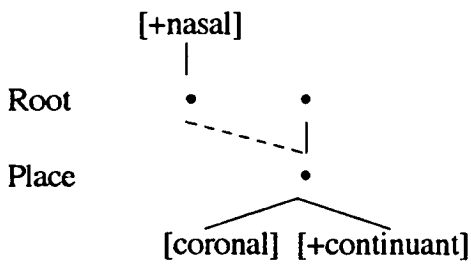
Padgett (1991) has observed that while nasal assimilation to stops is prevalent, nasal assimilation to fricatives is typically avoided. Padgett cites such asymmetries in English, Zoque, Lithuanian, Aguaruna, and Attic Greek, among other languages. Under Padgett's analysis, [±continuant] is a dependent of the place node, and the failure of nasals to assimilate to fricatives is the result of universal marking conditions which disallow nasal fricatives. If [±continuant] is a dependent of the place node, then when place spreads, continuancy by necessity does as well:

[14]Similarly, the alignment family of constraints (McCarthy & Prince 1993b) refers to the phonology-morphology interface. Alignment constraints require that certain phonological domains be co-extensive with certain morphological domains. Uniformity and alignment therefore bear a certain similarity: both state a preference for a transparent mapping of the elements of phonological representation onto the representational elements of some other component of grammar.

(44) Assimilation in N+t Sequence



(45) Assimilation in N+s Sequence



Citing the cross-linguistic absence of contrastively nasalized continuant consonants, Padgett appeals to the existence of a universal condition which prohibits nasalized fricatives, stated in (46):

(46) [+nasal, +cons] → [-cont]

It is the universal condition in (46) which rules out assimilation of nasals to continuants, under Padgett's analysis.

However, Padgett cites a number of cases in which nasals do in fact assimilate to continuants, including Icelandic, Kikongo and Swahili. The existence of such counter-examples substantially weakens the claim that the absence of nasal assimilation to continuants is due to a universal marking convention which disallows the feature combination *[+nasal, +cons, +cont].

The correct insight in Padgett's proposal, I think, is the notion that continuancy and place of articulation are phonetically related. Specifically, the constriction formed in the articulation of a nasal stop is essentially the same as that formed in the articulation of a homorganic oral stop. By contrast, the constrictions associated with a nasal stop and an oral continuant are distinct, both in degree and in shape.

I suggest that the failure of nasals to assimilate to continuants is a uniformity effect, the relevant constraint being UNIFORM[PL]. Consider for instance the sequence n+s. Both consonants involve a coronal articulation. The articulations are not uniform, however. For the nasal stop, the tongue is sealed around the sides and front of the palate, whereas for the oral fricative, the center of the tongue is grooved and there is no seal across the front of the palate. By contrast, the oral gesture involved in the articulation of the nasal stop and the oral stop in a n+t sequence are equivalent. I submit that it is UNIFORM[PL] which is responsible for the fact that nasals tend not to assimilate to continuants in place of articulation. As an optimality-theoretic constraint, however, UNIFORM[PL] is violable, as evidenced in such languages as Icelandic, Kikongo and Swahili.

Chapter 6 An Optimality-theoretic Account of the Typology of Rounding Harmony

In this chapter, I present an optimality-theoretic account of the typology laid out in Chapter 3. I formulate a set of constraints and show how these constraints interact to yield the empirically observed typology. The groundwork for these constraints was laid out in Chapter 5. The substance of Chapter 5 demonstrates that the constraints proposed here are grammatical articulations of functionally motivated principles, rather than arbitrary formal constructs. The purpose of this chapter is thus to introduce the form and content of the proposed constraints and to show how they function together to yield an explicit and predictive optimality-theoretic account of the typology of rounding harmony.

6.1 Optimality Theory

Optimality theory (Prince & Smolensky 1993, McCarthy & Prince 1993 a,b) has at its roots the notion that cross-linguistic regularities in phonological phenomena are to be found in *output* configurations rather than in *input* configurations or in the formal details of rules. Specifically, the theory seeks to account for how representational well-formedness determines the assignment of grammatical structure. To this end, researchers working within the framework of optimality theory are concerned with developing a theory of *constraints*. Within this theory the phonological *rule* as such has no formal status.

Optimality-theoretic constraints differ from traditional well-formedness constraints in two fundamental respects. First, constraints are not necessarily mutually consistent. That is, in response to a given representation, constraints may

return conflicting decisions. Optimality-theoretic constraints are therefore violable, since a particular representation can in principle satisfy one set of constraints while violating others. In other words, the constraints of optimality theory are not of necessity surface-true. What is always true, however, is that in cases constraints convlict, it is the highest-ranked constraint which is decisive.

Furthermore, the theory maintains that constraints on representational well-formedness form the substance of universal grammar. Individual grammars consist of a particular ranking of this fixed set of constraints. This ranking has the property of strict dominance by which a given constraint takes priority over all constraints ranked lower. The function of the grammar then is to identify which surface representation best satisfies the constraint hierarchy. For a given input, or underlying representation, a variety of plausible outputs are evaluated. The degree to which they satisfy the constraint hierarchy is denoted as their relative "harmony." (Note that this use of the term "harmony" is distinct from that which has been used up until now in reference to vowel-to-vowel assimilation.) The function of the constraint hierarchy is thus to find the most harmonic output representation for a given input.

An optimality-theoretic grammar is structured as shown in (1):

(1) <u>The Structure of a Grammar</u> (Prince & Smolensky 1993, p. 4)

a. Gen (In_k) $\rightarrow$ $\{Out_1, Out_2, ...\}$
b. H-Eval (Out_i, $1 \leq i \leq \infty$) $\rightarrow$ Out_{real}

The grammar consists of two components: Gen (for Generator) and H-Eval (for Harmonic Evaluation). Both are functions. Gen operates on input representations (In_k), generating a large set of output representations (Out_1, Out_2, ...). These outputs are referred to as *candidates*. Competing candidates are evaluated by H-Eval which

rates each one in terms of its harmony. The candidate with the highest degree of harmony is the candidate, or output, which surfaces. In the scheme above, this is Out_{real}.

Given that optimality theoretic constraints are claimed to be universal while their ranking relative to one another is decided mostly language-specifically, it is clear that optimality theory is inherently a model of linguistic typology. A possible grammar is some ranking of a fixed set of universal constraints and all legal rankings are possible grammars.

6.2 Preliminary Constraint Set

I will begin by proposing four constraints, each of which reflects one of the observations made in Chapter 3. Recall that the typological facts yielded the following generalizations:

(2) <u>Generalizations from Chapter 3</u>

a. Rounding harmony is favored when the trigger and target are [-back].
b. Rounding harmony is favored when the trigger and target agree in height.
c. Rounding harmony is favored when the target is [+high].

Generalization (c) followed from the fact that cross-height harmony is frequently observed when the trigger is non-high and the target is high, whereas in the reverse configuration, harmony is very often blocked. It was also suggested that this asymmetry indicates that non-high vowels are preferred over high vowels as triggers of harmony. I believe both interpretations of the typological patterns are in fact relevant, and discuss constraints on trigger height in §6.6 and in Chapter 7.

To the list in (2), one must of course add the observation that rounding harmony is a cross-linguistically observed phenomenon. I will assume that from the

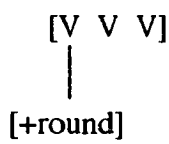
perceptual standpoint, it is advantageous to extend the duration of *all* phonological features. Thus, a general constraint which we can label EXTENDα is operative - all features want to spread. The feature we focus on here is [round], thus the relevant instantiation of EXTENDα will be labeled EXTEND[RD][1]. EXTEND[RD] dictates that within the domain of a word, any instance of the feature [+round] must be associated with all available vocalic positions. Note that no reference is made here to directionality, so in principle EXTEND constraints may give rise to bidirectional spreading. The issue of directionality is taken up briefly in §7.8.

(3) EXTEND[RD]: *The autosegment [+round] must be associated to all available vocalic positions within a word.*

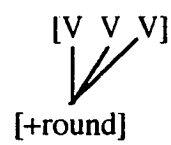
The configuration in (a) thus incurs an EXTEND[RD] violation, whereas those in (b) and (c) do not:

(4) <u>EXTEND[RD] Decisions</u>

a. Violates EXTEND[RD]



b. Satisfies EXTEND[RD]



c. Satisfies EXTEND[RD] (no instance of [RD] in the representation)

[V V V]

[1]In Chapter 7, I evaluate the possibility of characterizing harmony in terms of alignment (Smolensky 1993, McCarthy & Prince 1993b), where the domain of some harmonic feature is forced into alignment with certain morphological domains, predominantly the prosodic word. I conclude there that alignment is not the appropriate formal means by which to characterize harmony.

The structure in (a) violates EXTEND[RD] because only one of the three vowels in the word is [+round], while (b) and (c) satisfy it because they contain all round or non-round vowels respectively.

The claim that all else equal, all features should spread, that is the claim that there exists a general constraint EXTENDα, is a strong one. Clearly the theory must address the question of why some features are more prone to spreading than others. Within the framework of optimality theory, this problem will be understood by means of constraint interaction: constraints on faithfulness and articulatory ease will be called upon to mediate the effects of the perceptually motivated EXTENDα. The development of a more fully articulated theory of EXTENDα is left for further study at this point.

The preference for rounding harmony when the vowels in question are front suggests an additional EXTEND constraint which dictates that the feature [round], when it occurs in combination with the feature [-back], should be extended throughout the domain of the word. Recall from Chapter 5 that there is reason to believe that rounding contrasts among front vowels are perceptually more subtle than rounding contrasts among back vowels. The relevant constraint is stated in (5):

(5) EXTEND[RD]if[-BK]: *The autosegment [+round] must be associated to all available vocalic positions within a word when simultaneously associated with [-back].*

EXTEND[RD]IF[-BK] dictates that [round] must be multiply-linked when that feature occurs in combination with a [-back] specification, whether or not [-back] is multiply-linked. Thus, under the proposal that I am advancing, the application of rounding harmony is not characterized as being a function of backness harmony.

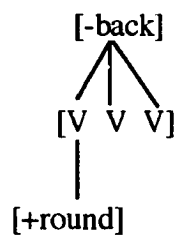
Compare Steriade's (1979) metrical analysis, discussed in Chapter 8, in which rounding harmony in the relevant cases is dependent on the existence of backness harmony. The fact that the relevant cases always involve backness harmony as well as rounding harmony is not an accident, however. It is my view that both types of harmony share a common motivation - the extension of a vowel quality whose perception is both linguistically significant and acoustically subtle.

The constraint `EXTEND[RD]IF[-BK]` ranks high in the grammars of those languages which exhibit a front-back asymmetry in their systems of rounding harmony.

This constraint will assign violations to the configuration in (6):

(6) <u>Violates `EXTEND[RD]IF[-BK]`</u>

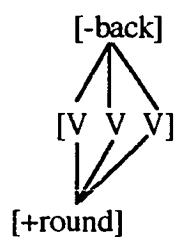
a.



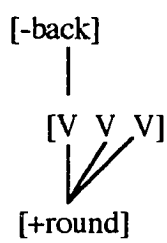
The configurations in (7) satisfy `EXTEND[RD]IF[-BK]`:

(7) <u>Structures Satisfying `EXTEND[RD]IF[-BK]`</u>

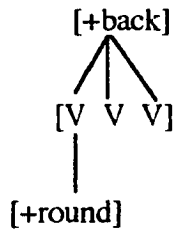
a.



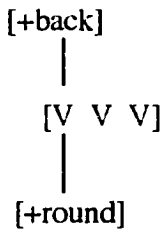
b.



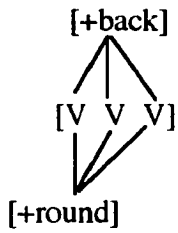
c.



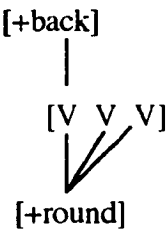
d.



e.



f.



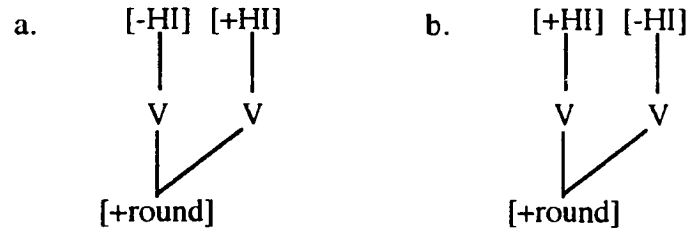
A third constraint must be proposed to reflect the dispreference for rounding harmony when the trigger and target disagree in height. I suggest that the relevant constraint rejects instances of the multiple-association of a given feature when the positions to which that feature is associated bear specifications for mutually conflicting features. I will label this constraint `UNIFORM[RD]`:

(8) `UNIFORM[RD]`: *The autosegment [+round] may not be multiply linked to slots bearing distinct feature specifications.*[2]

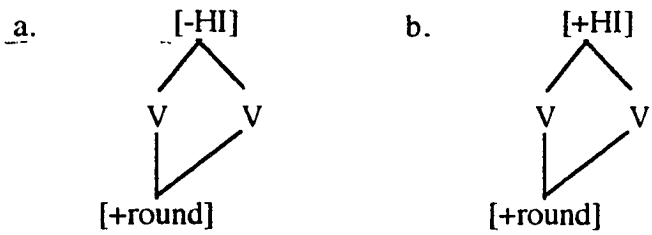
Thus, ignoring the backness tier for the moment, `UNIFORM[RD]` will assign a violation to the configurations in (9), but not to those in (10):

[2]The facts from Shuluun Höh (see the discussion in §7.3) suggest that `UNIFORM[RD]` requires only that vowels multiply-linked to a single [+round] specification must agree with respect to height. This is due to the fact that while this constraint is clearly operative in Shuluun Höh, harmonic sequences of rounded vowels need not agree with respect to backness in that language.

(9) Structures in Violation of UNIFORM[RD]



(10) Structures Satisfying UNIFORM[RD]



Uniformity, as discussed in Chapter 5, is related to the phonology-to-phonetics mapping. It dictates that a single specification in the phonology should correspond to a uniform articulatory setting or gesture. Linker's (1982) study of labial activity in vowels showed that there is a clear difference between the lip-rounding gesture associated with high vowels and that associated with non-high vowels. From Boyce's (1988) study of lip activity in English and Turkish, we saw that there is support for the notion that a single multiply-linked feature in the phonology corresponds to a single feature in the phonetics.[3]

[3]Uniformity, as I have characterized it, evaluates specific feature combinations in multiply-associated structures. It may well turn out that the actual constraint evaluates phonological representations endowed with considerably greater phonetic detail than has traditionally been assumed to be present phonologically. here, I claim that the degree and or nature of lip-rounding in high vowels differs from that of non-high vowels, and that this difference is phonologically relevant. The correct analysis might then encode more than one type of lip-rounding in phonological representations. I do not pursue this issue here.

In Chapter 3, we saw that while in many cases cross-height rounding harmony is avoided, some instances of cross-height rounding harmony are observed. For those systems in which some or all cross-height contexts give rise to rounding harmony, it must be the case that some EXTEND constraint outranks UNIFORM[RD].

Finally, we concluded in Chapter 3 that high vowels are preferred as rounding harmony targets over non-high vowels. As proposed in Chapter 5, this pattern is the consequence of an articulatorally motivated constraint which dictates against the combination of lip-rounding with relatively low jaw position. The relevant constraint is labeled *ROLO (Kirchner 1993). Under the formulation of *ROLO which I would like to suggest, a violation is assigned to any vowel whose phonological specification gives rise to lip-rounding accompanied by lowered jaw position in its phonetic implementation.

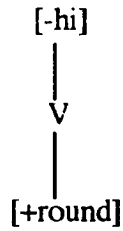
(11) *ROLO: *Vowels should not be simultaneously specified [+round] and [-high].*

Kirchner (1993) introduced the constraint *ROLO, which he characterizes as disallowing the feature combination [+round, +low], to characterize the absence of rounding harmony targeting non-high vowels in Turkish.

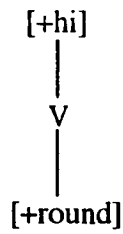
I assume that the articulation of any non-high vowel involves sufficiently low jaw position so as to fall under the jurisdiction of *ROLO. For a single vowel, the interpretation of this constraint is unambiguous. The representation in (12a) violates *ROLO whereas that in (12b) does not:

(12) <u>*ROLO Decisions: Single Vowels</u>

a. Violates *ROLO

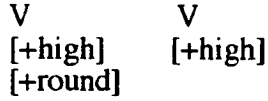


b. Satisfies *ROLO



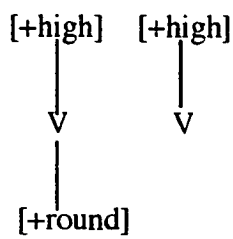
In the context of harmony, *ROLO will assign violations to configurations containing vocalic positions linked simultaneously to both [+round] and [-high]. Thus, when the potential trigger and the potential target are both specified [+high], *ROLO will be indifferent to whether or not rounding harmony obtains:

(13) <u>Input Representation</u>

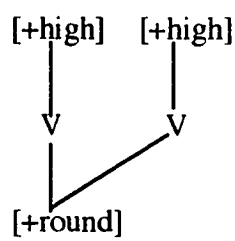


(14) <u>Candidates</u>

a. Satisfies *ROLO



b. Satisfies *ROLO



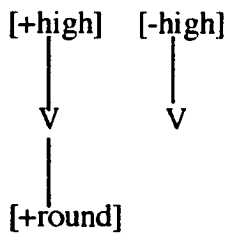
Were the potential target to be non-high, however, *ROLO would dictate against harmony since the candidate which includes multiple association of the feature [+round] would of course contain a vowel position linked simultaneously to [+round] and [-high]:

(15) Input Representation

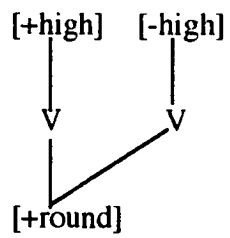
```
V          V
[+high]    [-high]
[+round]
```

(16) Candidates

a. Satisfies *ROLO



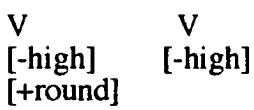
b. Violates *ROLO



In (16a), no violation of *ROLO is incurred since the only vocalic position linked to the feature [+round] is simultaneously linked to the feature [+high]. On the other hand, the candidate in (16b) does incur a *ROLO violation.

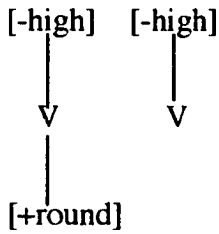
Where both the potential trigger and the potential target of harmony are specified [-high], *ROLO dictates against harmony since the candidate exhibiting multiple association will incur two *ROLO violations, while the singly-linked candidate will incur only one violation:

(17) Input Representation

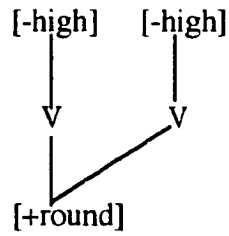


(18) Candidates

a. Violates *ROLO once



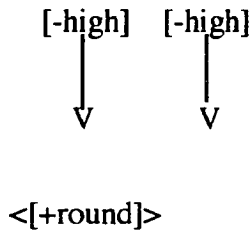
b. Violates *ROLO twice



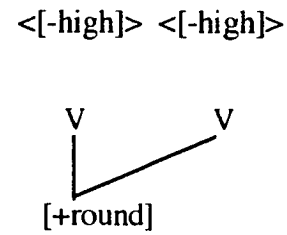
In principle, additional candidates must also be entertained. These are the candidates which fully satisfy *ROLO by failing to parse one or the other of the features whose combination is prohibited by *ROLO. Both of the candidates in (19) fully satisfy *ROLO in this manner. The structure in (a) contains an unparsed [+round] specification while the structure in (b) contains unparsed [-high] specifications. By "unparsed" I mean that a specification present in the input is absent in the output. (Angled brackets represent unparsed material):

(19) Underparsed Candidates

a. Satisfies *ROLO, but violates PARSE



b. Satisfies *ROLO, but violates PARSE



Failing to parse features is of course not without cost. The candidates in (19) incur violations of PARSE which states that material present in the input representation must be present in the output representation (Prince & Smolensky 1993, McCarthy & Prince). If in a given system either of the candidates in (19) is found to be the most harmonic analysis of the input in (18), it must be the case that *ROLO outranks PARSE, i.e. that the desire to avoid the combination {[+round], [-high]} takes priority over the requirement that an output representation be faithful to the content of the input.

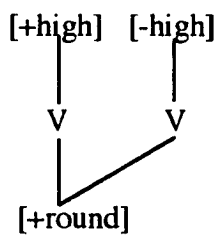
It thus follows that in such systems, non-high rounded vowels will never be found in surface representations. Since all known rounding harmony languages *do* tolerate non-high rounded vowels on the surface (though often in quite limited distribution), we may assume that PARSE is highly ranked in the relevant systems. Thus, we will disregard underparsed candidates such as those in (19) in the remainder of this discussion.

One type of rounding harmony pattern in which the effects of *ROLO are clearly observable is that in which cross-height harmony is asymmetric. In many rounding harmony systems, a [-high] [+high] sequence undergoes harmony, giving rise to a sequence such as *o-u*, whereas a sequence [-high] [+high] does not, and *u-a* surfaces in

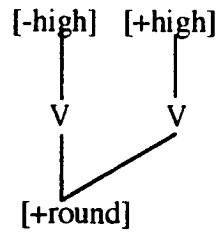
preference to *u-o. In these languages, UNIFORM[RD] must be ranked lower than one or both of the EXTEND constraints since vowels need not agree in height to harmonize. *ROLO must outrank the relevant EXTEND constraint(s), however, preventing harmony where it would give rise to an offending non-high rounded vowel. *ROLO will of course be non-decisive when all competing candidates violate this constraint to the same degree. Consider for instances the representations in (20b). Both structures violate *ROLO exactly once. Nonetheless, it is a fact that in a number of languages the structure in (b), which represents a sequence such as o-u, will be allowed to surface, while the structure in (a), which represents a sequence such as u-o, will not:

(20) <u>Cross-Height Harmonic Sequences</u>

a. Violates *ROLO



b. Violates *ROLO



This cross-height asymmetry can be captured quite simply by invoking a specific form of PARSE which, for many of the rounding harmony systems that we have seen, can be stated as:

(21) PARSE[RD]^{Init} — *A feature [+round] affiliated with an initial syllable must be parsed in phonological structure.*

Such a constraint is clearly required independently in the Altaic languages, where contrastive rounding is often limited to initial syllables. If this PARSE constraint outranks *ROLO, then a structure such as that in (20b) will potentially surface. Under the same constraint ranking, the structure in (a) will not be allowed to surface. The manner in which these constraints interact to characterize the observed cross-height asymmetry is explained here. The relevant ranking is that shown in (22), where a constraint to the left of a double arrow (>>) outranks all constraints listed to the right:

(22) PARSE[RD]^{Init} >> *ROLO >> EXTEND[RD]

Where the input configuration contains a high vowel in the initial syllable followed by a non-high vowel in the subsequent syllable, the violation assigned by *ROLO will be decisive and a non-harmonic structure will surface. An asterisk indicates a constraint violation, and the arrow in the leftmost column identifies the winning candidate. Here we see that it is possible to satisfy PARSE, the highest ranking constraint, and still avoid violating *ROLO:

(23) Tableau: u-a > u-o

I A | [+R]	PARSE[RD]^{Init}	*ROLO	EXTEND[RD]
I A <[+R]>	*		
→ I A | [+R]			*
I A | [+R]		*	

Where the initial syllable contains a non-high vowel and the subsequent syllable contains a high vowel, the two candidates which satisfy the highest ranked constraint, PARSE, tie with respect to *ROLO. In this case, EXTEND[RD] is decisive; thus, *o-u* surfaces in preference to *o-ɪ*:

(24) Tableau: o-u > o-ɪ

A I | [+R]	PARSE[RD]^{Init}	*ROLO	EXTEND[RD]
A I <[+R]>	*		
A I | [+R]		*	*
A I | → [+R]		*	

The analysis of the cross-height asymmetry is therefore characterized as follows. While an *o-u* and *u-o* sequences each incur the same number of *ROLO violations, the fact that the former is often allowed to surface in languages where the latter is not is nonetheless attributable to the constraint *ROLO. More precisely, this asymmetry results from the interaction between *ROLO and PARSE.

To summarize, in addition to the PARSE constraint given in (25), I have proposed four constraints, each of which is motivated by the typological patterns observed in Chapter 3:

(25) Summary of Proposed Constraints

a. EXTEND[RD]
b. EXTEND[RD]IF[-BK]
c. UNIFORM[RD]
d. *ROLO

These constraints are motivated by the typological patterns of Chapter 3, but just as importantly, they are phonetically motivated as well, as shown in Chapter 5. The important point here is that the typological data lead us to posit a particular set of constraints, and it turns out that those constraints can be shown to be functionally grounded. Therefore, the optimality theoretic model allows us to connect the typology directly to functional principles while providing a formal account of the typological facts.

6.3 Constraint Decisions

In this section, we will see how the proposed constraints interact to yield many of the typologically observed patterns. I will be illustrating the harmony patterns by means of a system of vocalic oppositions in which rounding is contrastive among both the front vowels and the back vowels, and in which two degrees of height are phonologically contrasted. For simplicity, I will represent all potential trigger-target pairs as agreeing with regard to backness. This is meant only as a means for simplifying the discussion; it is not the case that harmonic sequences of rounded vowels *must* agree with respect to rounding in all rounding harmony languages.[4]

[4]Harmonic sequences of rounded vowels do very frequently agree with respect to backness since, outside of Turkic, in most rounding harmony languages all rounded vowels are back. Within Turkic, rounding harmony exists alongside backness harmony, so all vowel sequences (within native roots and across morpheme boundaries) agree in backness. In Shuluun Höh Mongolian, discussed in some depth in Chapter 7, we find rounding harmony but no backness harmony. Furthermore, this language has both

The potential trigger-target combinations which we will consider in this chapter are those listed in (26). In the course of this discussion, the triggering vowel will be shown on the left, while the potential target will be the vowel on the right, each vowel representing the peaks of adjacent syllables:

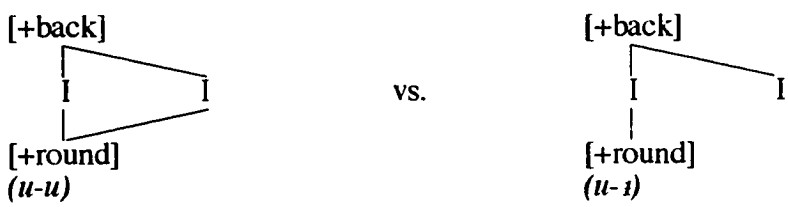
(26) Trigger-Target Combinations

u-u	ɔ-ɔ	ɔ-u	u-ɔ
ü-ü	ö-ö	ö-ü	ü-ö

I will assume throughout that the PARSE constraint given in (21) is highest ranked; thus, the trigger will always surface as [+round]. The candidates for comparison, shown schematically, will then be those shown in (27), where a given configuration may either be harmonic or non-harmonic, as shown:

(27) Candidates

a.



b.

front and back rounded vowels. Harmonic sequences of rounded vowels which disagree in backness do indeed surface in Shuluun Höh.

c. [+back] A I [+round] *(ɔ-ɨ)* vs. [+back] A I [+round] *(ɔ-ɪ)*

d. [+back] I A [+round] *(u-ɔ)* vs. [+back] I A [+round] *(u-a)*

e. [-back] I I [+round] *(ü-ü)* vs. [-back] I I [+round] *(ü-i)*

f. [-back] A A [+round] *(ö-ö)* vs. [-back] A A [+round] *(ö-ɛ)*

g. [-back] A I [+round] *(ö-ü)* vs. [-back] A I [+round] *(ö-i)*

h. [-back] I A [+round] *(ü-ö)* vs. [-back] I A [+round] *(ü-ɛ)*

In a standard optimality theoretic tableau, these candidates are listed in the first column, with the various constraints occupying the columns on the right. The

constraints are shown in descending order, the most highly ranked appearing the furthest to the left, e.g.:

(28) Sample Tableau

CANDIDATES	CONSTR 1	CONSTR 2	CONSTR 3
CAND 1			
CAND 2			

The candidate structures are evaluated on the basis of each constraint, and constraint violations are indicated with asterisks. By way of example, consider the sample tableau in (29) in which hypothetical constraint violations have been filled in:

(29) Sample Tableau Indicating Hypothetical Constraint Violations

CANDIDATES	CONSTR 1	CONSTR 2	CONSTR 3
→ CAND 1		*	*
CAND 2	*	*	

Of the two competing candidates A and B, A satisfies constraint 1 but incurs violations of constraints 2 and 3. Candidate B satisfies constraint 3 but incurs violations of constraints 1 and 2. The winning candidate is indicated with an arrow. Candidate A wins since the most highly ranked constraint which it violates is

constraint 2. The competing candidate, Candidate B, violates a higher-ranked constraint, namely constraint 1. An exclamation point is indicated next to the violation mark which is fatal, i.e. that violation which eliminates the candidate in question from competition. In the tableau in (29), Candidate B's violation of constraint 1 is fatal, as indicated. Thus, while both candidates violate the same number of constraints, one candidate is preferred over the other by virtue of the fact that the constraints are ranked relative to one another.

It is conventional practice to indicate with shading those constraint violations which are non-decisive in Harmonic Evaluation (H-Eval). Incorporating shading to indicate which constraints play a decisive role in determining the optimal candidate, the tableau in (29) may be rendered as shown in (30):

(30) <u>Sample Tableau Indicating Hypothetical Constraint Violations</u>

	CANDIDATES	CONSTR 1	CONSTR 2	CONSTR 3
→	CAND 1		*	*
	CAND 2	*!		

Let us now consider each of the constraints proposed in §6.2. EXTEND[RD] assigns a violation to any configuration in which the feature [+round], if present, is not multiply-linked. This constraint will thus dictate in favor of harmony in all of the trigger-target combinations listed above. To represent the candidates as shown in (27) will be excessively cumbersome in discussing the effects of each constraint with respect to the entire range of trigger-target combinations. Instead, I will use the short-

hand shown in (31). This chart indicates that the constraint EXTEND[RD] dictates in favor of harmony for each of the trigger-target pairs:

(31) Harmony Decisions: EXTEND[RD]

		EXT[RD]
→	u-u	
	u-ɪ	*
→	ɔ-ɔ	
	ɔ-a	*
→	ɔ-u	
	ɔ-ɪ	*
→	u-ɔ	
	u-a	*
→	ü-ü	
	ü-i	*
→	ö-ö	
	ö-ɛ	*
→	ö-ü	
	ö-i	*
→	ü-ö	
	ü-ɛ	*

Therefore, if left to its own devices, EXTEND[RD] will always choose a harmonic sequence over a non-harmonic sequence.

EXTEND[RD]IF[-BK] assigns violations only to those configurations in which the feature [+round] is not multiply linked *and* it is associated with a vocalic position to which the feature [-back] is also associated. Therefore EXTEND[RD]IF[-BK] makes no decisions for the back vocalic trigger-target sequences. I represent this indifference by leaving the relevant cell empty. For front vocalic trigger-target sequences, EXTEND[RD]IF[-BK] dictates in favor of harmony. For back-vocalic trigger-target sequences, EXTEND[RD]IF[-BK] assigns no violations and is thus non-decisive (this non-decisiveness is indicated by the absence of an arrow (→)):

(32) Harmony Decisions: EXTEND[RD]IF[-BK]

		EXT[RD] IF[-BK]
	u-u	
	u-ɨ	
	ɔ-ɔ	
	ɔ-a	
	ɔ-u	
	ɔ-ɨ	
	u-ɔ	
	u-a	
→	ü-ü	
	ü-i	*
→	ö-ö	
	ö-ɛ	*
→	ö-ü	
	ö-i	*
→	ü-ö	
	ü-ɛ	*

UNIFORM[RD] assigns violations only to cross-height harmonic sequences, as shown in (33). Thus, it dictates against harmony in the sequences *ɔ-u, u-ɔ, ö-ü, ü-ö*. For all height-identical sequences, namely *u-u, ɔ-ɔ, ü-ü, ö-ö,* UNIFORM[RD] is indifferent, as shown:

(33) Harmony Decisions: UNIFORM[RD]

		UNI[RD]
	u-u	
	u-ɨ	
	ɔ-ɔ	
	ɔ-a	
	ɔ-u	*
→	ɔ-ɨ	
	u-ɔ	*
→	u-a	
	ü-ü	
	ü-i	
	ö-ö	
	ö-ɛ	
	ö-ü	*
→	ö-i	
	ü-ö	*
→	ü-ɛ	

Note that unlike the EXTEND constraints, UNIFORM[RD] never dictates in favor of harmony. Its function is instead to record a dispreference for harmony in certain contexts, indicated in (33). In the absence of multiple-linking, or where the trigger and target agree in height, UNIFORM[RD] assigns no violations.

*ROLO decisions are shown in (34). One *ROLO violation is assessed for each offending vowel. This means that to the candidates being compared here, *ROLO may assign no violations, a single violation, or two violations. The preferred candidate will be that which violates *ROLO the least. Therefore, as shown, it is possible for a candidate to incur a constraint violation and still be found to be the optimal candidate by virtue of that constraint. For this to be the case, the competing candidate must incur a greater number of violations of the constraint in question:

(34) Harmony Decisions: *ROLO

		*ROLO
	u-u	
	u-ɪ	
	ɔ-ɔ	**
→	ɔ-a	*
	ɔ-u	*
	ɔ-ɪ	*
	u-ɔ	*
→	u-a	
	ü-ü	
	ü-i	
	ö-ö	**
→	ö-ɛ	*
	ö-ü	*
	ö-i	*
	ü-ö	*
→	ü-ɛ	

As shown, although *ROLO issues violations in a variety of configurations, it is decisive only when the target is non-high.

6.4 Preliminary Typological Predictions

In the preceding section, I have shown the violations which each of the four proposed constraints assigns to the trigger-target pairs under consideration. It is of course the case that these constraints are not mutually consistent. That is, for certain trigger-target pairs, certain of these constraints conflict with one another. EXTEND[RD], for instance, dictates in favor of harmony when the trigger and target are both non-high, yielding *ɔ-ɔ* in preference to *ɔ-a*. *ROLO, by contrast, dictates against harmony in this context, preferring *ɔ-a* over*ɔ-ɔ*. One defining feature of optimality theory is that constraints on surface representations need not be surface true and may conflict

with one another. Where constraints are in conflict, it is the higher ranking constraint which prevails. Therefore, in order to characterize the typology of rounding harmony by means of the constraints proposed here, we must consider how the constraints interact with one another.

Four constraints can be ranked in 24 (4 !) orders. All of these distinct constraint rankings are listed in (35). Thus, for instance, the first hierarchy ranks EXTEND[RD] above EXTEND[RD]IF[-BK], whis is ranked above *ROLO. UNIFORM[RD] is ranked lowest.:

(35) <u>24 Unique Orderings of 4 Constraints</u>

EXT[RD]>	EXT[RD]IF[-BK]>	*ROLO>	UNIFORM[RD]
EXT[RD]>	EXT[RD]IF[-BK]>	UNIFORM[RD]>	*ROLO
EXT[RD]>	*ROLO>	EXT[RD]IF[-BK]>	UNIFORM[RD]
EXT[RD]>	*ROLO>	UNIFORM[RD]>	EXT[RD]IF[-BK]
EXT[RD]>	UNIFORM[RD]>	EXT[RD]IF[-BK]>	*ROLO
EXT[RD]>	UNIFORM[RD]>	*ROLO>	EXT[RD]IF[-BK]
EXT[RD]IF[-BK]>	EXT[RD]>	*ROLO>	UNIFORM[RD]
EXT[RD]IF[-BK]>	EXT[RD]>	UNIFORM[RD]>	*ROLO
EXT[RD]IF[-BK]>	*ROLO>	EXT[RD]>	UNIFORM[RD]
EXT[RD]IF[-BK]>	*ROLO>	UNIFORM[RD]>	EXT[RD]
EXT[RD]IF[-BK]>	UNIFORM[RD]>	EXT[RD]>	*ROLO
EXT[RD]IF[-BK]>	UNIFORM[RD]>	*ROLO>	EXT[RD]
*ROLO>	EXT[RD]>	EXT[RD]IF[-BK]>	UNIFORM[RD]
*ROLO>	EXT[RD]>	UNIFORM[RD]>	EXT[RD]IF[-BK]
*ROLO>	EXT[RD]IF[-BK]>	EXT[RD]>	UNIFORM[RD]
*ROLO>	EXT[RD]IF[-BK]>	UNIFORM[RD]>	EXT[RD]
*ROLO>	UNIFORM[RD]>	EXT[RD]>	EXT[RD]IF[-BK]
*ROLO>	UNIFORM[RD]>	EXT[RD]IF[-BK]>	EXT[RD]
UNIFORM[RD]>	EXT[RD]>	EXT[RD]IF[-BK]>	*ROLO
UNIFORM[RD]>	EXT[RD]>	*ROLO>	EXT[RD]IF[-BK]
UNIFORM[RD]>	EXT[RD]IF[-BK]>	EXT[RD]>	*ROLO
UNIFORM[RD]>	EXT[RD]IF[-BK]>	*ROLO>	EXT[RD]
UNIFORM[RD]>	*ROLO>	EXT[RD]>	EXT[RD]IF[-BK]
UNIFORM[RD]>	*ROLO>	EXT[RD]IF[-BK]>	EXT[RD]

Each of these 24 patterns generates some rounding harmony pattern. It is not the case, however, that each pattern generated is unique. For instance, it is clear that

any ordering in which EXTEND[RD] is the most highly ranked constraint will give rise to a rounding harmony pattern in which harmony is observed across-the-board. Thus, the six orderings listed in (36) all give rise to the rounding harmony pattern given in (37):

(36) EXTEND[RD] > All other constraints

EXT[RD]>	EXT[RD]IF[-BK]>	*ROLO>	UNIFORM[RD]
EXT[RD]>	EXT[RD]IF[-BK]>	UNIFORM[RD]>	*ROLO
EXT[RD]>	*ROLO>	EXT[RD]IF[-BK]>	UNIFORM[RD]
EXT[RD]>	*ROLO>	UNIFORM[RD]>	EXT[RD]IF[-BK]
EXT[RD]>	UNIFORM[RD]>	EXT[RD]IF[-BK]>	*ROLO
EXT[RD]>	UNIFORM[RD]>	*ROLO>	EXT[RD]IF[-BK]

(37) Resulting Rounding Harmony Pattern (Type 1)

u-u	*ɔ-ɔ*	*ɔ-u*	*u-ɔ*
ü-ü	*ö-ö*	*ö-ü*	*ü-ö*

Furthermore, any ordering in which EXTEND[RD] and EXTEND[RD]IF[-BK] (the two constraints which dictate in favor of harmony) outrank *ROLO and UNIFORM[RD] (the two constraints which dictate against harmony) will similarly give rise to the across-the-board pattern shown in (37). Thus, to the list in (36) must be added the orderings in (38) which characterize across the board rounding harmony as well:

(38) EXT[RD]IF[-BK]> EXTEND[RD]> All other constraints

EXT[RD]IF[-BK]>	EXT[RD]>	*ROLO>	UNIFORM[RD]
EXT[RD]IF[-BK]>	EXT[RD]>	UNIFORM[RD]>	*ROLO

Where *ROLO is highest-ranked, a number of patterns emerge. The first of these is the type 2 pattern, shown in (39), in which only high vowels are targeted by rounding harmony:

(39) Resulting Rounding Harmony Pattern (Type 2)

u-u	[illegible]	*ɔ-u*	[illegible]
ü-ü	[illegible]	*ö-ü*	[illegible]

This pattern is generated by three distinct constraint rankings, including those two in which *ROLO is the only constraint outranking EXTEND[RD]. Also yielding this pattern is the ordering in which *ROLO is highest ranked and UNIFORM[RD] is lowest ranked:

(40) Orderings which Yield the Pattern in (39)

*ROLO>	EXT[RD]>	EXT[RD]IF[-BK]>	UNIFORM[RD]
*ROLO>	EXT[RD]>	UNIFORM[RD]>	EXT[RD]IF[-BK]
*ROLO>	EXT[RD]IF[-BK]>	EXT[RD]>	UNIFORM[RD]

The manner in which the constraints interact to yield the pattern in (39) is shown in the tableau in (41), as well as that in (42). In both, the decisive ruling is indicated with an arrow, and those constraints ranked too low to be decisive are separated by dotted lines to indicate that relative to one another, they are unranked:

(41) *ROLO> EXTEND[RD]

		*ROLO	EXT[RD]	UNI[RD]	EXT[RD] IF[-BK]
→	u-u				
	u-ɨ		*		
	ɔ-ɔ	**!			
→	ɔ-a	*			
→	ɔ-u	*			
	ɔ-ɨ	*	*!		
	u-ɔ	*!			
→	u-a				
→	ü-ü				
	ü-i		*!		
	ö-ö	**!			
→	ö-ɛ	*			
→	ö-ü	*			
	ö-i	*	*!		
	ü-ö	*!			
→	ü-ɛ				

(42) *ROLO> EXTEND[RD]IF[-BK], EXTEND[RD]

		*ROLO	EXT[RD] IF[-BK]	EXT[RD]	UNI[RD]
→	u-u				
	u-ɨ			*!	
	ɔ-ɔ	**!			
→	ɔ-a	*			
→	ɔ-u	*			
	ɔ-ɨ	*		*!	
	u-ɔ	*!			
→	u-a				
→	ü-ü				
	ü-i		*!		
	ö-ö	**!			
→	ö-ɛ	*			
→	ö-ü	*			
	ö-i	*	*!		
	ü-ö	*!			
→	ü-ɛ				

Thus, whenever *ROLO and EXTEND[RD] are at the top of the constraint hierarchy with *ROLO outranking EXTEND[RD], the same pattern emerges. This is the type 2 pattern.

There exist three remaining rankings in which *ROLO is rankest highest. These are listed in (43):

(43) *ROLO Ranked Highest

```
*ROLO>  EXT[RD]IF[-BK]>  UNIFORM[RD]>     EXT[RD]
*ROLO>  UNIFORM[RD]>     EXT[RD]>         EXT[RD]IF[-BK]
*ROLO>  UNIFORM[RD]>     EXT[RD]IF[-BK]>  EXT[RD]
```

The first of these rankings gives rise to an unattested rounding harmony pattern. The tableau in (44) shows how this ranking gives rise to the harmony pattern shown in (45):

(44) Tableau

		*ROLO	EXT[RD] IF[-BK]	UNI[RD]	EXT[RD]
→	u-u				
	u-ɨ				*!
	ɔ-ɔ	**!			
→	ɔ-a	*			
	ɔ-u	*		*!	
→	ɔ-ɨ	*			
	u-ɔ	*!			
→	u-a				
→	ü-ü				
	ü-i		*!		
	ö-ö	**!			
→	ö-ɛ	*			
→	ö-ü	*			
	ö-i	*	*!		
	ü-ö	*!			
→	ü-ɛ				

(45) First Unattested Rounding Harmony Pattern

u-u			
ü-ü		*ö-ü*	

In this unattested pattern, an asymmetry is observed among the front and back vowels. This is not the usual front-back asymmetry, however. In this pattern, only a subset of front vocalic sequences admits harmony where in the analogous back vocalic sequences, harmony is not observed. In point of fact, however, in all attested front-back asymmetries, the entire range of front vocalic sequences admits harmony. As we will see below, the system of constraints which I am proposing predicts three rounding harmony patterns which, to my knowledge, are unattested. Two of these share the property that stricter restrictions are imposed on harmony among back vowels than among front vowels, while harmony among front vowels is subject to certain restrictions. It would appear that this small set of unattested patterns constitutes a natural gap.

The remaining two constraint hierarchies listing *ROLO at the top characterize the type 4 pattern. In the type 4 pattern, harmony is observed only when the trigger and target are both high:

(46) The Type 4 Pattern

u-u	
ü-ü	

As shown in the following tableaux, type 4 is generated by any constraint hierarchy in which *ROLO and UNIFORM[RD] outrank the EXTEND constraints. Two tableaux are included to demonstrate the type 4 pattern:

(47) Tableau

		*ROLO	UNI[RD]	EXT[RD] IF[-BK]	EXT[RD]
→	u-u				
	u-ɨ				*
	ɔ-ɔ	**!			
	ɔ-a	*			
	ɔ-u	*	*!		
→	ɔ-ɨ	*			
	u-ɔ	*!			
→	u-a				
→	ü-ü				
	ü-i			*!	
	ö-ö	**!			
→	ö-ɛ	*			
	ö-ü	*	*!		
→	ö-i	*			
	ü-ö	*!			
→	ü-ɛ				

(48) Tableau

		UNI[RD]	*ROLO	EXT[RD]	EXT[RD] IF[-BK]
→	u-u				
	u-ɪ			*!	
	ɔ-ɔ		**!		
→	ɔ-a		*		
	ɔ-u	*!			
→	ɔ-ɪ				
	u-ɔ	*!			
→	u-a				
→	ü-ü				
	ü-i			*!	
	ö-ö		**!		
→	ö-ɛ		*		
	ö-ü	*!			
→	ö-i				
	ü-ö	*!			
→	ü-ɛ				

From the six orderings in which UNIFORM[RD] is the most highly ranked constraint, three patterns emerge. Two of these rankings generate the type 4 pattern just discussed. These are the rankings which correspond to two of the constraint hierarchies

represented in (48), namely the constraint hierarchies shown in (49):

(49) Additional Constraint Hierarchies Characterizing Type 4

```
UNIFORM[RD]>     *ROLO>   EXT[RD]>          EXT[RD]IF[-BK]
UNIFORM[RD]>     *ROLO>   EXT[RD]IF[-BK]>   EXT[RD]
```

The second pattern generated by ranking UNIFORM[RD] highest is that shown in (50), whereby rounding harmony occurs only when the trigger and target agree in height. In Chapter 3, this pattern was labeled type 6:

(50) The Type 6 Pattern

u-u	*ɔ-ɔ*	
ü-ü	*ö-ö*	

The rankings which generate the type 6 pattern are all of those in which UNIFORM[RD] is the highest-ranked constraint, and *ROLO is ranked lower than EXTEND[RD]. As shown in (51)-(53), three distinct rankings each give rise to the same rounding harmony pattern:

(51) Tableau

		UNI[RD]	EXT[RD]	EXT[RD] IF[-BK]	*ROLO
→	u-u				
	u-ɨ		*!		
→	ɔ-ɔ				
	ɔ-a		*!		
	ɔ-u	*!			*
→	ɔ-ɨ		*		*
	u-ɔ	*!			
→	u-a				
→	ü-ü				
	ü-i		*!		
→	ö-ö				
	ö-ɛ		*!		
	ö-ü	*!			
→	ö-i				
	ü-ö	*!			
→	ü-ɛ				

(52) Tableau

		UNI[RD]	EXT[RD]	*ROLO	EXT[RD] IF[-BK]
→	u-u				
	u-ɨ		*!		
→	ɔ-ɔ				
	ɔ-a		*!		
	ɔ-u	*!			
→	ɔ-ɨ				
	u-ɔ	*!			
→	u-a				
→	ü-ü				
	ü-i		*!		
→	ö-ö				
	ö-ɛ		*!		
	ö-ü	*!			
→	ö-i				
	ü-ö	*!			
→	ü-ɛ				

(53) Tableau

		UNI[RD]	EXT[RD] IF[-BK]	EXT[RD]	*ROLO
→	u-u				
	u-ɨ			*!	
→	ɔ-ɔ				
	ɔ-a			*!	
	ɔ-u	*!			
→	ɔ-ɨ				
	u-ɔ	*!			
→	u-a				
→	ü-ü				
	ü-i		*!		
→	ö-ö				
	ö-ɛ		*!		
	ö-ü	*!			
→	ö-i				
	ü-ö	*!			
→	ü-ɛ				

One final ranking places UNIFORM[RD] at the top of the hierarchy. This ranking is shown in (54), with the pattern it generates following in (55). This pattern is unattested:

(54) Tableau

		UNI[RD]	EXT[RD] IF[-BK]	*ROLO	EXT[RD]
→	u-u				
	u-ɨ				*!
	ɔ-ɔ			**!	
→	ɔ-a			*	
	ɔ-u	*!			
→	ɔ-ɨ				
	u-ɔ	*!			
→	u-a				
→	ü-ü				
	ü-i		*!		
→	ö-ö				
	ö-ɛ		*!		
	ö-ü	*!			
→	ö-i				
	ü-ö	*!			
→	ü-ɛ				

(55) 2nd Unattested Pattern

u-u	*ɔ-ɔ*	*ɔ-ɨ*	*u-ɔ*
ü-ü	*ö-ö*	*ö-ɨ*	*ü-ö*

This predicted but unattested pattern suffers from the same flaw as that listed in (45) above. It reflects a front-back asymmetry while still restricting in some way those front vocalic environments in which rounding harmony obtains, whereas cases known to me which involve a front-back asymmetry exhibit across-the-board harmony in front vowel contexts. As before, I suggest that this is a natural gap. In this case as

well as in the other unattested patterns which the model predicts to be possible, the trigger-target pairs which are excluded from harmonic interaction form a class which is excluded in one or more actually occurring harmony systems.

We have yet to consider four final orderings, all of which place at the top of the hierarchy the constraint `EXTEND[RD]IF[-BK]` highest. These are listed in (56):

(56) Constraint Hierarchies

EXT[RD]IF[-BK]>	*ROLO>	EXT[RD]>	UNIFORM[RD]
EXT[RD]IF[-BK]>	*ROLO>	UNIFORM[RD]>	EXT[RD]
EXT[RD]IF[-BK]>	UNIFORM[RD]>	EXT[RD]>	*ROLO
EXT[RD]IF[-BK]>	UNIFORM[RD]>	*ROLO>	EXT[RD]

The first of these rankings generates a final unattested rounding harmony pattern whereby harmony is observed among the front vowels regardless of the height of the trigger and target, whereas among the back vowels the trigger and target must agree in height. This pattern, represented in (57), is generated by the constraint hierarchy in (58).

(57) 3rd Unattested Pattern

u-u	*ɔ-ɔ*		
ü-ü	*ö-ö*	*ö-ü*	*ü-ö*

(58) Tableau

		EXT[RD] IF[-BK]	UNI[RD]	EXT[RD]	*ROLO
→	u-u				
	u-ɨ			*!	
→	ɔ-ɔ				
	ɔ-a			*!	
	ɔ-u		*!		
→	ɔ-ɨ				
	u-ɔ		*!		
→	u-a				
→	ü-ü				
	ü-i	*!			
→	ö-ö				
	ö-ɛ	*!			
→	ö-ü				
	ö-i	*!			
→	ü-ö				
	ü-ɛ	*!			

The final three orderings give rise to attested patterns, the first of which is the type 7 pattern, shown in (59). This pattern is generated by the ordering in (60) in which *ROLO is outranked only by EXTEND[RD]IF[-BK] and UNIFORM[RD] is lowest ranked:

(59) The Type 7 Pattern

u-u	*ɔ-ɔ*	*ɔ-u*	*u-ɔ*
ü-ü	*ö-ö*	*ö-ü*	*ü-ö*

(60) Tableau

		EXT[RD] IF[-BK]	*ROLO	EXT[RD]	UNI[RD]
→	u-u				
	u-ɨ			*!	
	ɔ-ɔ		**!		
→	ɔ-a		*	*	
→	ɔ-u		*		*
	ɔ-ɨ		*	*!	
	u-ɔ		*!		*
→	u-a			*	
→	ü-ü				
	ü-i	*!		*	
→	ö-ö		**		
	ö-ɛ	*!	*	*	
→	ö-ü		*		*
	ö-i	*!	*	*	
→	ü-ö		*		*
	ü-ɛ	*!		*	

Where UNIFORM[RD] is ranked above EXTEND[RD], the type 8 pattern emerges; rounding harmony is observed across-the-board among front vowels but when the vowels in question are back the trigger and target must both be [+high]. Two constraint hierarchies give rise to the type 8 pattern, as shown in (62) and (63). These are the hierarchies in which EXTEND[RD]IF[-BK] is highest ranked and EXTEND[RD] is lowest ranked:

(61) The Type 8 Pattern

u-u	*ɔ-ɔ*	*ɔ-u*	*u-ɔ*
ü-ü	*ö-ö*	*ö-ü*	*ü-ö*

(62) Tableau

		EXT[RD] IF[-BK]	*ROLO	UNI[RD]	EXT[RD]
→	u-u				
	u-ɨ				*!
	ɔ-ɔ		**!		
	ɔ-a		*		
	ɔ-u		*	*!	
→	ɔ-ɨ		*		
	u-ɔ		*!		
→	u-a				
→	ü-ü				
	ü-i	*!			
→	ö-ö				
	ö-ɛ	*!			
→	ö-ü				
	ö-i	*!			
→	ü-ö				
	ü-ɛ	*!			

(63) Tableau

		EXT[RD] IF[-BK]	UNI[RD]	*ROLO	EXT[RD]
→	u-u				
	u-ɨ				*!
	ɔ-ɔ			**!	
→	ɔ-a			*	
	ɔ-u		*!		
→	ɔ-ɨ				
	u-ɔ		*!		
→	u-a				
→	ü-ü				
	ü-i	*!			
→	ö-ö				
	ö-ɛ	*!			
→	ö-ü				
	ö-i	*!			
→	ü-ö				
	ü-ɛ	*!			

6.5 Summary: Preliminary Constraint Set

Thus far, we have examined the interactions of a preliminary constraint set consisting of four constraints. Nine patterns were predicted, of which three are apparently unattested. These patterns are listed in (64):

(64) Unattested Patterns

Unattested Pattern 1

u-u			
ü-ü		*ö-ü*	

Unattested Pattern 2

u-u			
ü-ü	*ö-ö*		

Unattested Pattern 3

u-u	ɔ-ɔ		
ü-ü	*ö-ö*	*ö-ü*	*ü-ö*

Six attested patterns were predicted, and these are listed in (65):

(65) Attested Patterns: Predicted

Type 1

u-u	ɔ-ɔ	ɔ-*u*	*u*-ɔ
ü-ü	*ö-ö*	*ö-ü*	*ü-ö*

Type 2

u-u		ɔ-*u*	
ü-ü		*ö-ü*	

Type 4

u-u			
ü-ü	*ö-ö*		

Type 6

u-u	ɔ-ɔ		
ü-ü	*ö-ö*	*ö-u*	

Type 7

u-u	*ɔ-ɔ*	*ɔ-u*	*u-ɔ*
ü-ü	*ö-ö*	*ö-ü*	*ü-ö*

Type 8

u-u	*ɔ-ɔ*	*ɔ-u*	*u-ɔ*
ü-ü	*ö-ö*	*ö-ü*	*ü-ö*

Three patterns are missing from this predicted typology, namely types 3, 5 and 9. In all three of these types, the problematic harmony domain involves a non-high trigger:

(66) <u>Attested Patterns: Not Predicted</u>

Type 3

u-u	*ɔ-ɔ*	*ɔ-u* / *u-ɔ*
ü-ü	*ö-ö*	*ö-ü* / *ü-ö*

Type 5

u-u	*ɔ-ɔ*	*ɔ-u*	*u-ɔ*
ü-ü	*ö-ö*	*ö-ü*	*ü-ö*

Type 9

u-u	*ɔ-ɔ*	*ɔ-u*	*u-ɔ*
ü-ü	*ö-ö*	*ö-ü*	*ü-ö*

The four constraints proposed above cannot generate the type 3 pattern because although UNIFORM[RD], if ranked high enough, will dictate against harmony in the cross-height sequences *ɔ-u, u-ɔ, ö-ü, ü-ö* and will dictate against harmony where the trigger and target are non-high, thus ruling out *ɔ-ɔ, ö-ö,* neither of the constraints which dictate against harmony in certain configurations can conspire to block harmony when the trigger and target are both high vowels, i.e. ruling out the sequences *u-u, ü-ü*. The type 3 pattern is discussed further in Chapter 7, where I

suggest that this is in fact a sub-case of type 6, where trigger and target must agree with respect to height.

Types 5 and 9 constitute a minimal pair. In type 5, harmony is blocked when the potential trigger is high and the potential target is non-high. In type 9, harmony is blocked in that configuration only when the vowels in question are back. Among front vowels, harmony applies across the board. This pattern is not generated by any ranking of the constraints discussed above. This cross-height asymmetry may at first glance seem explainable in terms of UNIFORM[RD] and *ROLO. The non-harmonic sequences involve a trigger and target of distinct heights, in violation of UNIFORM[RD]. The potential target is non-high, in violation of *ROLO. The problem is that if UNIFORM[RD] is ranked highest, then *all* cross-height harmony will be ruled out. If *ROLO is ranked highest, then the illicit cross-height configuration will be ruled out, but same-height harmony targeting a non-high vowel will be ruled out as well. In the discussion earlier in this section, I demonstrated the patterns generated by each ranking in which these two constraints rank highest, and none of those yielded the type 5 and 9 patterns. One additional constraint is required to account for these types.

6.6 An Additional Constraint

The pattern found in types 5 and 9 suggests an additional constraint which dictates that [+round] should spread from a non-high trigger. Recall from Chapter 5 that there is reason to believe that rounding contrasts among non-high vowels are perceptually more subtle than rounding contrasts among high vowels. The relevant constraint is given in (67):

(67) <u>Constraint 5</u>: EXTEND[RD]IF[-HI]

In type 5, the configurations II, AA, and AI are all harmonic, yielding the sequences *u-u*, *o-o*, and *o-u*. Only IA is non-harmonic; thus, *u-a* surfaces in preference to *u-o*. Exactly this pattern emerges from any ranking in which EXTEND[RD]IF[-HI] is ranked highest, followed immediately by either UNIFORM[RD] or *ROLO. This follows from the fact that EXTEND[RD]IF[-HI] dictates in favor of harmony in the configurations AA and AI, while both UNIFORM[RD] and *ROLO serve to block harmony in the configuration IA. One such ranking is given in (68):

(68) A Constraint Hierarchy for Type 5

		EXT[RD] IF[-HI]	UNI[RD]	*ROLO	EXT[RD]	EXT[RD] IF[-BK]
→	u-u					
	u-ɨ				*!	
→	ɔ-ɔ					
	ɔ-a	*!				
→	ɔ-u					
	ɔ-ɨ	*!				
	u-ɔ		*!			
→	u-a					
→	ü-ü					
	ü-i				*!	
→	ö-ö					
	ö-ɛ	*!				
→	ö-ü					
	ö-i	*!				
	ü-ö		*!			
→	ü-ɛ					

The entire set of rankings which give rise to the type 5 pattern is shown in (69). In each of these orderings, EXTEND[RD]IF[-HI] is ranked highest, followed immediately by either *ROLO or UNIFORM[RD].

(69) Orderings Generating the Type 5 Pattern

EXT[RD]IF[-HI] > *ROLO > EXT[RD] > EXT[RD]IF[-BK] > UNI[RD]

EXT[RD]IF[-HI] > *ROLO > EXT[RD] > UNI[RD] > EXT[RD]IF[-BK]

EXT[RD]IF[-HI] > *ROLO > EXT[RD]IF[-BK] > EXT[RD] > UNI[RD]

EXT[RD]IF[-HI] > *ROLO > EXT[RD]IF[-BK] > UNI[RD] > EXT[RD]

EXT[RD]IF[-HI] > *ROLO > UNI[RD] > EXT[RD] > EXT[RD]IF[-BK]

EXT[RD]IF[-HI] > *ROLO > UNI[RD] > EXT[RD]IF[-BK] > EXT[RD]

EXT[RD]IF[-HI] > UNI[RD] > EXT[RD] > EXT[RD]IF[-BK] > *ROLO

EXT[RD]IF[-HI] > UNI[RD] > EXT[RD]IF[-BK] > EXT[RD] > *ROLO

EXT[RD]IF[-HI] > UNI[RD] > EXT[RD]IF[-BK] > *ROLO > EXT[RD]

EXT[RD]IF[-HI] > UNI[RD] > *ROLO>EXT[RD] > EXT[RD]IF[-BK]

EXT[RD]IF[-HI] > UNI[RD] > *ROLO > EXT[RD]IF[-BK] > EXT[RD]

Type 9 is the same as type 5, except that across-the board harmony is found among front vowels. Thus, in type 9, both EXTEND[RD]IF[-HI] and EXTEND[RD]IF [-BK] must be ranked highest. Immediately following must be either *ROLO or UNIFORM[RD]. A tableau demonstrating constraint interaction under one such ordering is shown in (70):

(70) A Constraint Hierarchy for Type 9

		EXT[RD] IF[-HI]	EXT[RD] IF[-BK]	*ROLO	UNI[RD]	EXT[RD]
→	u-u					
	u-ɨ					*!
→	ɔ-ɔ					
	ɔ-a	*!				
→	ɔ-u					
	ɔ-ɨ	*!				
	u-ɔ			*!		
→	u-a					
→	ü-ü					
	ü-i		*!			
→	ö-ö					
	ö-ɛ	*!				
→	ö-ü					
	ö-i	*!				
→	ü-ö					
	ü-ɛ		*!			

The entire set of rankings which give rise to the type 9 pattern is shown in (71). In each of these orderings, EXTEND[RD]IF[-HI] and EXTEND[RD]IF[-BK] are ranked highest, followed immediately by either *ROLO or UNIFORM[RD]:

(71) Constraint Hierarchies Generating the Type 9 Pattern

EXT[RD]IF[-HI] > EXT[RD]IF[-BK] > *ROLO > EXT[RD] > UNI[RD]

EXT[RD]IF[-HI] > EXT[RD]IF[-BK] > *ROLO > UNI[RD] > EXT[RD]

EXT[RD]IF[-HI] > EXT[RD]IF[-BK] > UNI[RD] > EXT[RD] > *ROLO

EXT[RD]IF[-HI] > EXT[RD]IF[-BK] > UNI[RD] > *ROLO > EXT[RD]

EXT[RD]IF[-BK] > EXT[RD]IF[-HI] > *ROLO > EXT[RD] > UNI[RD]

EXT[RD]IF[-BK] > EXT[RD]IF[-HI] > *ROLO > UNI[RD] > EXT[RD]

EXT[RD]IF[-BK] > EXT[RD]IF[-HI] > UNI[RD] > EXT[RD] > *ROLO

EXT[RD]IF[-BK] > EXT[RD]IF[-HI] > UNI[RD] > *ROLO > EXT[RD]

The addition of EXTEND[RD]IF[-HI] to the constraint set increases to 120 (5 factorial) the number of logically possible constraint rankings. No new types apart from types 7 and 9 are admitted under this expanded constraint set, however, as indicated in the Appendix. With this set of proposed rankings, 11 rounding harmony types are predicted. Of those predicted, eight are attested, and only one attested system is not predicted purely by means of these five proposed constraints, namely type 3. I will demonstrate, however, that this pattern is in fact identical to type 6 with respect to the constraint hierarchy. Where type 3 languages differ from type 6 languages is in the structure of their respective vowel inventories and how features combine to specify the vowels which surface. This distinction is discussed in detail in Chapter 7.

The constraint-based analysis presented here characterizes the observed typological patterns as resulting from the interaction of substantive functional principles. It accounts for the attested range of facts while over-generating only very modestly.

Chapter 7 Implementation

In this chapter I address a number of issues which arise in the course of implementing the constraints proposed in Chapter 6 within individual languages, particularly those rounding harmony systems discussed in Chapters 2 and 3 which require height agreement between the harmony trigger and target. These include Mongolian and Tungusic, discussed extensively in Chapter 2, which exhibit harmony when the trigger and target are both non-high, and the Yokuts dialects, to be discussed below, which exhibits harmony when the trigger and target agree in height. The rounding harmony patterns found in these languages raise a number of issues which bear on the optimality theoretic treatment of vowel harmony proposed in this thesis and on the nature and role of the principles and constraints which I have claimed give rise to the phenomenon of vowel harmony.

Some of these are issues which must be addressed in any theory of vowel harmony, such as the transparent behavior of *i* in Mongolian, the form and content of underlying (or input) representations, and the formal mechanism of harmony. Authors such as Kirchner (1993), Smolensky (1993), and Cole & Kisseberth (1994) have argued that harmony is driven by constraints of the alignment family (McCarthy & Prince 1993). Citing data from Hungarian (§7.2), I will argue that it is inappropriate to characterize harmony in terms of alignment.

These issues will be addressed in the sections to follow. One issue specific to the theory proposed in this thesis arises in the analysis of Yokuts, where the height identity condition imposed on harmony holds only of lexical representations. That is, harmonic trigger-target combinations of distinct heights are found in surface representations. In the static, non-derivational approach to harmony advocated here

where the mechanism of rule-ordering is unavailable, an appropriate means of distinguishing underlying height specifications from surface height specifications is required. A solution to this problem is proposed in §7.5. Apart from this formal complication, the Yokuts pattern poses a challenge to the claim that same-height harmony is driven by a uniformity constraint dictating that a single phonological specification should correspond to a uniform articulatory setting. In Yokuts, uniformity must be understood as being evaluated on a more abstract level. I return to this problem below.

7.1 Harmony as Alignment: Smolensky's Analysis of Finnish Transparency

Smolensky (1993) presents an analysis of transparency in Finnish vowel harmony which seeks to account for the behavior of the neutral vowels (*i, e*), in particular their transparency to backness harmony. His analysis, like those of Kirchner (1993) and Cole & Kisseberth (1994), characterizes harmony as the alignment of a harmonic domain with the edges of a morphological constituent, usually the word. A brief discussion of Smolensky's analysis of Finnish is presented in this section. In §7.2, I cite data from Hungarian loanwords (Ringen & Kontra (1989), Kontra & Ringen (1986)) which poses serious problems for the alignment analysis. In that section, and in §7.3, I propose an account of transparency in terms of *extension* as opposed to *alignment*.

Citing the following passage from Itô, Mester & Padgett (1994), Smolensky (1993) explores the means by which optimality theory might capture the observation that unmarked elements are relatively inactive, phonologically:

> It is commonly observed that redundant phonological features in language are inert, neither triggering phonological rules nor interfering with the workings of contrastive features. ... This distinction between 'active' contrastive and 'inactive' redundant features is expressed in the theory through the notion of (under)specification of features in phonology. (Itô, Mester & Padgett 1994)

Smolensky suggests that this effect is the consequence of the fact that constraints dictating against the presence of unmarked elements in phonological representations will tend to be low-ranked in comparison to those which disfavor marked elements. As a result, constraints referring to marked elements will tend to interact with other constraints with more frequency, since it is relatively high-ranking constraints which are decisive in harmonic evaluation (H-Eval). Smolensky links his view of markedness as manifested in the constraint hierarchy to the inert status of unmarked features. He thus eschews the mechanism of phonological underspecification as a means of explaining the inactivity of unmarked elements, and in fact advocates some version of full specification.

Among the cases cited in Smolensky (1993) is transparency in the backness harmony system of Finnish. He asserts that the absence of [+back] counterparts for the vowels *i* and *e* in Finnish reflects the relatively high ranking of markedness constraints disallowing the feature combinations which characterize the vowels ɨ and ʌ. The analysis he presents in fact addresses only the issue of *i*-transparency, and it is this analysis which I will outline here. The claim is that the constraints which shape the underlying vowel inventory are markedness statements and are universally ranked relative to one another. The relevant constraints are shown in (1):

(1) Universal Dominance Relations (Smolensky, p. 9)

*+B/I >> *-B/I	*The feature [+back] is worse than the feature [-back] in combination with the features [-round, +high, -low].*
*-B/O >> *+B/O	*The feature [+back]is worse than the feature [-back] in combination with the features [+round, -high, -low].*

B stands for [back]; I stands for the feature combination [-round & +high & -low], and O stands for the feature combination [+round & -high & -low]. Thus, the dominance relations in (1) characterize the fact that a high back unrounded vowel *ɨ* is more marked than a high front unrounded vowel *i*, and that a mid front rounded vowel *ö* is more marked than a mid back rounded vowel *o*. In Finnish, which has *i*, *o*, and *ö* but lacks *ɨ*, the constraint *+B/I is surface unviolated, whereas the other constraints listed in (1) are surface-violated.

Now although the dominance relations in (1) are claimed to be universal, the overall constraint hierarchy which characterizes a particular grammar may separate the markedness constraints with independent constraints which do not refer to feature combination markedness. That is, while a universal dominance relation holds of certain classes of markedness constraints, these constraints are not necessarily ranked consecutively in grammars.

Two constraints intervene between `*+B/I` and `*-B/I` in Smolensky's analysis. These are the faithfulness constraints PARSE and FILL, which, with respect to the analysis of Finnish vowel harmony, are specifically PARSE^{B} (the feature [back] must be parsed into phonological structure) and FILL^{B} (the feature [back] must not be introduced into phonological structure).

Smolensky represents harmony in terms of bracketed domains which are labeled with the harmonic feature in question. For instance, the harmonic sequence *ooo* will be represented as shown in (2):

(2) Representation of *ooo*

$[_{+B}$ O O O]

Harmony is achieved by means of a constraint from the alignment family (McCarthy & Prince 1993) which dictates that the right edge of a [+back] domain must be aligned with the right edge of a word:

(3) ALIGN[+B] (Smolensky, p. 10)

Align right edge of a [+back] domain with right word edge.

Transparency is represented by means of embedded harmonic domains. For instance, in the representation of *oio*, a [-back] domain is nested within a [+back] domain:

(4) Nested Domains: *oio*

$[_{+B}$O $[_{-B}$I] O]

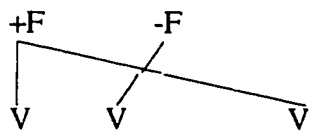
In order to account for the fact that not all vowel harmony systems exhibit transparency effects, Smolensky suggests that domain-embedding comes at a cost, namely that of incurring a violation of a constraint which he calls *EMBED:

(5) *EMBED (Smolensky, p. 10):

A root node is parsed into a non-embedded [±back] domain.

*EMBED is not simply a notational variant of the ban on crossed association lines (Goldsmith 1976, Clements 1977, etc.). Consider the representation in (6), where association lines cross once. This representation is to be compared with that in (7) which will be assessed one *EMBED violation. These representations are essentially equivalent and reflect the attested transparency configuration in which one element is transparent to spreading from a trigger on one side and a target on the other side:

(6) Crossed Association Lines Structure

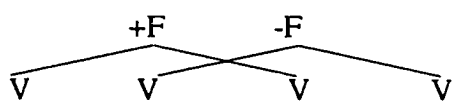


(7) Embedded Structure

$[_{+F}\ V\ [_{-F}\ V\ ]\ V\ ]$

In (8) and (9) we see representations of a considerably more exotic and probably unattested configuration. Two features are multiply-linked. In the association of each feature a single position is skipped over, i.e. a single vowel is transparent:

(8) Crossed Association Lines Structure



(9) Embedded Structure

$[_{+F}\ V\ [^{-F}\ [\ V\ ]\ [\ V]_{+F}]\ V\ ^{-F}]$

Evaluated in terms of crossed association lines, the structure in (8) is no worse than that shown in (6); association lines cross once in both representations. Evaluated in terms of *EMBED, (9) is worse than (7) in that (9) will be assigned two violations of *EMBED, whereas (7) will be assigned only one.

These constraints allow for the representation of *i*-transparency, as shown in the tableau in (10). Crucially, the markedness constraint which disallows high front unrounded vowels (*-B/I) is highly ranked, guaranteeing that an underlying sequence such as OIO will not be parsed as a single +B domain, yielding **oɤo*. Also crucially, ALIGN outranks *EMBED, giving rise to transparency in Finnish:

(10) Tableau: *o i o* (from Smolensky, p. 10)

O I O | | +B -B	*+B/I	PARSE^{B}	*-B/I	ALIGN^{+B}	*EMBED	*-B/O	*+B/O
→[+B^{O}[-B^{I}]O] *oio*[1]			*		*		**
[+B^{O} I O] *oɤo*	*!	*					**
[+B[-B^{I} O]] *oiö*			*		**!	*	*
[+B^{O}][-B^{I} O] *oiö*			*	*IO![2]		*	*
[-B^{O} I O] *öiö*		*!	*			**	

The vowel *i* not only fails to undergo backness harmony, but it is also transparent to backness harmony. Thus, *oio* is selected in preference to *oiö*. Smolensky points out that by reversing the ranking of ALIGN and *EMBED, a system differing from that of Finnish by treating *i* as opaque to backness harmony would be derived.

[1]The italicized sequences shown following each candidate output are meant to indicate how each output will surface. They are not part of the formal representation.

[2]Here, IO refers to the sequence which separates the right bracket of the [+back] domain from right-bracket of the word domain.

7.2 Against Harmony as ALIGNMENT: Data from Hungarian

Kontra & Ringen (1986), Ringen (1988), and Ringen & Kontra (1989) present evidence from loanwords that in a variety of contexts, the so-called neutral vowels of Hungarian do not exhibit parallel behavior. I will show that this disparate behavior poses a serious problem for the alignment theory of harmony and transparency outlined in §7.1. I instead propose a theory according to which harmony is driven by constraints requiring the extension of certain qualities. I will further suggest that the appearance of strings of transparent segments is subject to continuity constraints which dictate that a temporal span associated with a given feature should be uninterrupted.

The phonetic vowel inventory of standard Hungarian is listed in (11):

(11) Hungarian Vowels (from Ringen & Kontra, p. 182)

i, i:	ü, ü:	u, u:
e:	ö, ö:	o, o:
ɛ		a, a:

In general, the back vowels {*u, u:, o, o:, a, a:*} do not co-occur with the front vowels {*ü, ü:, ö, ö:*}. The front vowels {*i, i:, e:*} are described as being neutral to backness harmony because they occur in what are typically referred to as mixed vowel roots. Examples are shown in (12):

(12) Mixed Vowel Roots (from Ringen (1988), p. 328)[3]

a.	radi:r	'eraser'
b.	kavics	'pebble'
c.	ta:nye:r	'plate'
d.	radi:r-nak	'eraser-DAT'
e.	kavics-nak	'pebble-DAT'
f.	ta:nye:r-nak	'plate-DAT'

As shown in (d-f), suffixes occurring with mixed vowel roots are back harmonic. For instance, *radi:rnak* occurs rather than **radi:rnek*. Therefore, the neutral vowels are allowed to co-occur with back vowels within roots and are transparent to root-to-suffix backness harmony.

The status of the front vowel *ɛ* is controversial. I will follow Ringen & Kontra in assuming that it is a front harmonic vowel.

The loanword patterns discovered by Ringen & Kontra are interesting and somewhat complex. Essentially, the neutral vowels fall into two classes, the first consisting of *i* and *i:*. These vowels exhibit the greatest degree of transparency. The second class consists of the vowel *e:* which also displays a certain degree of transparency in loanwords, but less than that exhibited by the high vowels *i* and *i:*. A further finding which will turn out to be of special importance is the fact that sequences of two neutral vowels are typically opaque to harmony.

In Ringen and Kontra's experimental work, subjects were given sentences containing uninflected roots and were asked to supply the appropriate suffixes. The relevant test words were loanwords containing one of the neutral vowels in the final syllable preceded by a back vowel somewhere in the word. The vowels *i* and *i:* were transparent to backness harmony, i.e. they occurred with back vocalic suffixes in the

[3]I adopt Hungarian orthographic conventions with one exception. Whereas long vowels are orthographically represented with acute accents, I will indicate length with a colon. For example, instead of *radír* 'eraser,' I will write *radi:r*.

vast majority of the subjects' responses. Some of the roots which show this pattern are listed in (13). These are taken from the discussion in Ringen & Kontra (1989, p. 184):

(13) Transparency in Loanwords: *i, i:* (+ back-vowel suffixes)

a.	akti:v	'active'
b.	kurzi:v	'italic'
c.	szala:mi	'salami'
d.	konstrukti:v	'constructive'
e.	pantomim	'pantomime'
f.	imperati:v	'imperative'
g.	neolit	'neolithic'
h.	vegetati:v	'vegetative'
i.	illusztris	'illustrious'

Of interest is the observation that *i* and *i:* were treated as transparent vowels in disyllabic as well as polysyllabic words.

A different pattern emerged from the subjects' treatment of the vowel *e:*. The vowel *e:* was typically treated as transparent in the cases where the root was disyllabic. The examples shown in (14) are from Ringen & Kontra (1989, p. 187):

(14) Transparency in Loanwords: *e:* (+ back-vowel suffixes)

a.	ka:ve:	'coffee'
b.	trape:z	'trapeze'
c.	anke:t	'meeting'
d.	kokte:l	'cocktail'
e.	konkre:t	'concrete'
f.	szomsze:d	'neighbor'

In polysyllabic words, the vowel *e:* was virtually always treated as opaque with respect to backness harmony. That is, in polysyllabic words in which the final vowel was *e:* and a back vowel preceded somewhere within the root, subjects chose front vocalic suffixes in the overwhelming majority of cases. This was true regardless of

the backness of the vowel in the initial syllable. Some examples from Ringen & Kontra (1989, p. 187) are cited in (15) and (16):

(15) Initial Vowel is Front (+ front-vowel suffixes)

a.	hidroge:n	'hydrogen'
b.	szingale:z	'Singhalese'
c.	krizante:m	'chrysanthemum'

(16) Initial Vowel is Back (+ front-vowel suffixes)

a.	majone:z	'mayonnaise'
b.	autoge:n	'autogenous'
c.	homoge:n	'homogenous'

Thus, in disyllabic words *i, i:* and *e:* behaved identically with respect to their harmonic patterning: All were usually transparent to root-to-suffix backness harmony. In polysyllabic words the high vowels *i* and *i:* were transparent to backness harmony, whereas *e:* was opaque.

An additional finding made by Ringen & Kontra involved sequences of neutral vowels. It was overwhelmingly the case that *front* vocalic suffixes were selected when the test words ended in a sequences of two neutral vowels. Nearly all of Ringen & Kontra's data involved sequences of *i* and or *i:*. Some examples from Ringen & Kontra (1989, p. 188) are shown in (17)[4]:

(17) Two Neutral Vowels (+ front-vowel suffixes)

a.	harakiri	'hari-kari'
b.	alibi	'alibi'
c.	parali:zis	'paralysis'
d.	bronchitisz	'bronchitis'
e.	poe:zis	'poetry'

[4]A similar pattern was discovered for Finnish by Heinämäki & Ringen (1994).

An analysis of transparency in Hungarian should therefore account for the facts listed in (18):

(18) Transparency / Opacity Facts

a. The vowel *e:* is transparent to backness harmony in disyllabic words; otherwise, it is opaque.
b. A single occurrence of *i* or *i:* is transparent to backness harmony.
c. Sequences of two neutral vowels are opaque to backness harmony.

At this point, I would like to outline an alignment analysis of the facts listed in (18). As I will show, the constraints required in order to account for the transparency and opacity facts of Hungarian are numerous.

We begin by addressing the asymmetry which obtains between the high neutral vowels *i* and *i:* and the mid neutral vowel *e:*. Harmony in Finnish is analyzed by Smolensky (1993) as being driven by a constraint which dictates that a +B-domain must be aligned with the right edge of a word. Given that it is [-back] vowels which are transparent to [+back] harmony in Hungarian, we will assume that the same constraint holds here:

(19) ALIGN^{+B} *Align the right edge of a +B-domain with the right edge of a word.*

Transparency is achieved by Smolensky via two types of constraints. The first records the fact that the [+back] counterparts of the Finnish neutral vowels are not among the surface vowels of the language. The same is true of Hungarian which lacks *ɪ, ɪ:* (the [+back] counterparts of *i, i:*) and *ʌ:* (the [+back] counterpart of *e:*). Therefore, we will

assume that essentially the same constraints on feature co-occurrence are operative in Hungarian as those proposed by Smolensky for Finnish[5]:

(20) Constraints on Feature Co-occurrence

`*B/I`	*The feature [+back] does not combine with the features [+high, -low, -round]*
`*B/E`	*The feature [+back] does not combine with the features [-high, -low, -round]*

Given that transparency is allowed in Hungarian, just as it is in Finnish, the constraint on embedded domains given in (21) will be relatively low-ranked:

(21) `*EMBED` *A root node is parsed into a non-embedded B-domain.*

Now, we saw that in Hungarian, the high neutral vowels *i, i:* are transparent to backness harmony whether the trigger occurs in an initial syllable or in a non-initial syllable. In each case the assumed trigger is underlined. Note that the data are shown without suffixes. We see here only the triggers of harmony and the transparent elements which follow:

(22) Trigger is Initial (+ back-vowel suffixes)

a.	akti:v	'active'
b.	kurzi:v	'italic'

[5]Smolensky does not in fact formulate the constraint which dictates against the co-occurrence of the features specifying the vowel ʌ:.

(23) Trigger is Non-initial (+ back-vowel suffixes)

a.	szala:mi	'salami'
b.	konstrukti:v	'constructive'
c.	pantomim	'pantomime'
d.	imperati:v	'imperative'
e.	neolit	'neolithic'
f.	vegetati:v	'vegetative'
g.	illusztris	'illustrious'

The analysis will be essentially identical to that proposed by Smolensky for Finnish. Following Smolensky, the input representations will contain backness specifications for all root vowels and no backness specification for suffixal vowels. Therefore, the root *akti:v*, when occurring with a suffix will have the input representation shown in (24). I arbitrarily represent the suffix as A: - a non-high vowel which is unspecified for backness:

(24) Input Representation: *akti:v-A*

```
AktI:v-A
|   |
+B -B
```

Candidate output structures are represented with backness domains rather than multiply-linked autosegments, as shown in (25). In Smolensky's analysis consonants are left out of the representation. Consonants are included in the representations given in (25) and, for concreteness, B-domain boundaries are placed at syllable boundaries:

(25) Candidate Structures

	a.	$[_{+B}$Ak$]$ $[_{-B}$tI:v-A$]$	*akti:v-ɛ*
	b.	$[_{+B}$AktI:v-A$]$	*aktɪ:v-a*
	c.	$[_{+B}$Ak$]$ $[_{-B}$tI:$]$ $[_{-B}$v-A$]$	*akti:v-ɛ*
→	d.	$[_{+B}$Ak $[_{-B}$tI:v$]$ -A$]$	*aktɪ:v-a*

The candidate in (a) represents treatment of *i:* as a harmonic vowel. This candidate will be ruled out by virtue of its failure to conform to ALIGN^{+B}. The candidate in (b) represents the case in which the neutral vowel actually *undergoes* backness harmony, surfacing as *ɪ:*. This structure will be ruled out by virtue of its failure to parse an underlying occurrence of the feature [-back]. Thus, PARSE^{B} must rank fairly high. The candidate in (c) represents the case in which a feature value is assigned to the suffixal vowel independently of the root specifications. The identity of suffixal vowels is clearly dependent on that of the root vowels; thus, this structure must be eliminated from competition. This may be achieved by ranking FILL^{B} relatively high in the constraint hierarchy. The candidate in (d) corresponds to the observed data. Thus, while it incurs a violation of *EMBED, it nonetheless is deemed the optimal candidate. This indicates that *EMBED ranks relatively low.

The manner in which the constraints interact to select the candidate in (d) over those in (a-c) is shown in the tableau in (27). The constraints must be ranked as shown in (26): PARSE^{B}, FILL^{B}, and ALIGN^{+B} outrank *EMBED.

(26) Partial Constraint Hierarchy

PARSE^{B}, FILL^{B},ALIGN^{+B} >> *EMBED.

(27) Tableau

AktI:v-A | | +B -B	PARSE^{B}	FILL^{B}	ALIGN^{+B}	*EMBED
[$_{+B}$Ak] [$_{-B}$tI:v-A]			*!	
[$_{+B}$AktI:v-A]	*!			
[$_{+B}$Ak] [$_{-B}$tI:] [$_{-B}$v-A]		*!	*	
→ [$_{+B}$Ak [$_{-B}$tI:v] -A]				*

The behavior of *e:* is rather different. We saw that this vowel typically exhibits transparency only when it occupies the second syllable of a word. Some examples are shown in (28), where the trigger is underlined:

(28) Trigger is Initial; *e:* is Transparent

a.	ka: ve:	'coffee'
b.	trape:z	'trapeze'
c.	kokte:l	'cocktail'
d.	konkre:t	'concrete'

If the behavior of *e:* paralleled that of *i, i:*, we would expect transparency to backness harmony in the words in (29) as well. Instead, *e:* is analyzed as being opaque in these forms and front vocalic suffixes are chosen:

(29) Trigger is Non-initial; *e:* is Opaque

a.	hidroge:n	'hydrogen'
b.	szingale:z	'Singhalese'
c.	krizante:m	'chrysanthemum'
d.	majone:z	'mayonnaise'
e.	autoge:n	'autogenous'
f.	homoge:n	'homogenous'

In order to account for this pattern, one might posit two alignment constraints, the first of which forces left and right alignment of a +B-domain.

(30) ALIGN^{+B}L,R *Align left and right edges of a +B-domain with left and right word edges.*

A second alignment constraint will refer only to right-alignment. This is the constraint stated above in (19) and restated here in (31):

(31) ALIGN^{+B}R *Align the right edge of a +B-domain with the right edge of a word.*

Thus, we have one constraint dictating that a +B domain should be right- *and* left-aligned, and a second constraint dictating that a backness domain should be right-aligned. The next move is to posit some constraint which intervenes between these alignment constraints in the hierarchy. The effect of this constraint must be to block harmony across *e:* but not across *i, i:*. In other words, this constraint must disallow an embedded *e:* while allowing an embedded *i, i:*. One possibility is to separate *EMBED into two constraints, one dictating against embedded *e:* and the other dictating against embedded *i, i:*. We would thus have two *EMBED constraints, as listed in (32) and (33)[6]:

(32) *EMBED^{I} *A root node dominating the features of I is parsed into a non-embedded B-domain.*

(33) *EMBED^{E} *A root node dominating the features of E is parsed into a non-embedded B-domain.*

[6]Appealing to sonority, we might instead state the *EMBED constraints in terms of vowel height: a [+high] transparent vowel incurs a lower-ranked *EMBED violation than a [-high] transparent vowel. The idea would then be that it is worse to skip over a more sonorous (non-high) vowel than it is to skip over a less sonorous (high) vowel.

The constraint $*\text{EMBED}^{E}$ will rank higher than $*\text{EMBED}^{I}$, since *i, i:* transparency is observed in a broader range of contexts than *e:* transparency. The constraint hierarchy will thus be as shown in (34):

(34) Partial Constraint Hierarchy

$\text{PARSE}^{B}, \text{FILL}^{B}, \text{ALIGN}^{+B}\text{R,L} >> *\text{EMBED}^{E} >> \text{ALIGN}^{+B}\text{R} >> *\text{EMBED}^{I}$

For a word like *ka:ve:*, the input representation with a suffixal vowel unspecified for backness will be as shown in (35). Candidate output structures are listed in (36):

(35) Input Representation: *ka:ve:-A*

```
kA:vE:-A
 |   |
+B  -B
```

(36) Candidate Structures

	a.	$[_{+B}$kA:$]$ $[_{-B}$vE:-A$]$	*ka:ve:-ɛ*
	b.	$[_{+B}$kA:vE:-A$]$	*ka:vʌ:-a*
	c.	$[_{+B}$kA:$]$ $[_{-B}$vE:$]$ $[_{-B}$-A$]$	*ka:ve:-ɛ*
→	d.	$[_{+B}$kA: $[_{-B}$vE:$]$ -AS$]$	*ka:ve:-a*

The candidate in (a) violates both alignment constraints and is thus eliminated from competition. The candidate in (b) will be disqualified on the basis of its violation of the highly ranked PARSE^{B} constraint. Candidate (c) violates FILL^{B} which is at the top of the constraint hierarchy. The optimal candidate, that shown in (d), violates the higher ranked of the $*\text{EMBED}$ constraints, namely $*\text{EMBED}^{E}$. This violation is motivated by the fact that the structure avoids violation of the still higher ranking $\text{ALIGN}^{B}\text{R,L}$. A

tableau showing the constraint interaction yielding (d) as the optimal parse for suffixed *ka:ve:* is shown in (37):

(37) Tableau

AktI:v-A +B -B	PARSE^{B}	FILL^{B}	ALGN^{+B} R,L	*EMBD^{E}	ALGN^{+B} R	*EMBD^{I}
[$_{+B}$kA:] [$_{-B}$vE:-A]			*!		*	
[$_{+B}$kA:vE:-A]	*!					
[$_{+B}$kA:] [$_{-B}$vE:] [$_{-B}$-A]		*!			*	
→ [$_{+B}$kA: [$_{-B}$vE:] -A]				*		

The context in which *e:* is opaque to backness harmony, namely when it occurs past the second syllable of the word, allows us to see how the interleaving of two different alignment constraints and two different *EMBED constraints functions to yield *e:* opacity. The input representation associated with a suffixed form of *mayone:z* 'mayonnaise' will be that shown in (38):

(38) Input Representation: *mayone:z -A*

mAyOnE:z-A
+B +B -B

A variety of plausible candidate output structures should be compared in order to show how the system will work:

(39) Candidate Output Structures: *mayone:z-A*

→	a.	$[_{+B}$mA$]$ $[_{+B}$yO$]$ $[_{-B}$nE:z-A$]$	*mayone:z-ε*
	b.	$[_{+B}$mA$]$ $[_{+B}$yOnE:z-A$]$	*mayonʌ:z-a*
	c.	$[_{+B}$mAyOnE:z-A$]$	*mayonʌ:z-a*
	d.	$[_{+B}$mA$]$ $[_{+B}$yO$]$ $[_{-B}$nE:$]$ $[_{+B}$z-A$]$	*mayone:z-a*
	e.	$[_{+B}$mA$]$ $[_{+B}$yO $[_{-B}$nE:$]$ z-A$]$	*mayone:z-a*

The candidate in (a) violates both alignment constraints. Nonetheless, it is this candidate which is selected as most optimal. Candidates such as those in (b) and (c) will be eliminated as a consequence of their violation of the highly ranked PARSE constraint: (b) violates PARSE once, and (c) violates PARSE twice. The candidate in (d) incurs a FILL violation and is thus ruled out. The candidate in (e) is the most interesting because it must not be found to be the most optimal candidate parse, despite the fact that when the embedded domain contains a high vowel *i, i:*, the candidate analogous to that in (e) is the preferred candidate. To see how (e) is rejected for an input such as *mayone:z*, consider the tableau in (40):

(40) Tableau

mAyOnE:z-A +B +B -B	PAR^B	$FILL^B$	ALN^{+B} R,L	$*EMB^E$	ALN^{+B} R	$*EMB^I$
→ $[_{+B}$mA$]$ $[_{+B}$yO$]$ $[_{-B}$nE:z-A$]$			*		**	
$[_{+B}$mA$]$ $[_{+B}$yOnE:z-A$]$	*!					
$[_{+B}$mAyOnE:z-A$]$	*!*					
$[_{+B}$mA$][_{+B}$yO$][_{-B}$nE:$][_{+B}$z-A$]$		*!				
$[_{+B}$mA$]$ $[_{+B}$yO $[_{-B}$nE:$]$ z-A$]$			*	*!	*	

In order to account for the fact that a sequence of two neutral vowels will be opaque to backness harmony, we must propose a third *EMBED constraint. To show that this is so, let us consider the representation of the suffixed forms of *alibi* to which the subjects of Ringen & Kontra's study assigned [-back] vocalic suffixes. The input representation will be as shown in (41), and some plausible candidate output structures are listed in (42):

(41) Input Representation: *alibi-A*

```
A l I b I - A
|   |   |
+B -B  +B
```

(42) Candidate Output Structures: *alibi-A*

a.	$[_{+B}$A] $[_{-B}$l I] $[_{-B}$bI -A]	*alibi-ɛ*
b.	$[_{+B}$A] $[_{-B}$lI bI - A]	*alibi-ɛ*
c.	$[_{+B}$A lI bI - A]	*alıbı-a*
d.	$[_{+B}$A] $[_{-B}$l I] $[_{-B}$bI] $[_{+B}$ -A]	*alibi-a*
e.	$[_{+B}$A $[_{-B}$l IbI] -A]	*alibi-a*
f.	$[_{+B}$A $[_{-B}$l I] $[_{-B}$bI] -A]	*alibi-a*

Output candidate (a), which corresponds to the true output form, violates both alignment constraints. The candidate in (b) violates both alignment constraints, as well as PARSE^{B}. The candidate in (c), while fully satisfying the alignment constraints, will be assigned two violations of PARSE^{B}. The candidate in (d) violates both alignment constraints and also violates FILL^{B} because it introduces a backness specification not present in the input. The candidate in (e) violates PARSE^{B} once, and since two high vowels are parsed in an embedded B-domain, this candidate also violates *EMBED^{I} twice. The structure in (f) should be the optimal candidate because

it violates only the lowest ranking constraint, namely *EMBED^{I}. The tableau shows how the constraint hierarchy we have established fails to select the correct output in the case of a word such as *alibi-A* in which the suffix is preceded by two neutral vowels:

(43) Tableau

A l I b I - A | | | +B -B -B	PAR^{B}	FILL^{B}	ALN^{+B} R,L	*EMB^{E}	ALN^{+B} R	*EMB^{I}
[$_{+B}$A] [$_{-B}$l I] [$_{-B}$bI -A] *alibi-ɛ*			*!			
[$_{+B}$A] [$_{-B}$l I bI - A] *alibi-ɛ*	*!					
[$_{+B}$A l I bI - A] *alibɪ-a*	*!*					
[$_{+B}$A] [$_{-B}$l I] [$_{-B}$bI] [$_{+B}$ -A] *alibi-a*		*!				
[$_{+B}$A [$_{-B}$l I bI] -A] *alibi-a*	*!					**
→ [$_{+B}$A [$_{-B}$l I] [$_{-B}$bI] -A] *alibi-a*						**

The incorrect results which this constraint hierarchy yields suggest the need for a third constraint on embedding which must outrank both alignment constraints. Its purpose is to rule out embedding of two vowels (or two syllables). A problem arises in the formulation of this third constraint on embedding. Smolensky's original statement of *EMBED was that shown in (44), repeated from (21) above:

(44) *EMBED *A root node is parsed into a non-embedded B-domain.*

The new constraint must rule out a structure such as the schematic one shown in (45), where F stands for some feature:

(45) [$_{F}$ [$_{F}$] [$_{F}$]]

Thus, it is evident that the new constraint on embedding cannot be stated in terms of the element that is parsed into an embedded domain. The elements "X" in (46) and (47) are all parsed into an embedded domain, so by virtue of *EMBED, these structures should be evaluated as follows: (46) is assessed one *EMBED violation, whereas (47) is assessed two. Unless candidates are otherwise tied with respect to the higher ranking constraints two *EMBED violations are no worse than one:

(46) $[_F \quad [_F X \ ] \quad]$

(47) $[_F \quad [_F X \ ] \ [_F \ X \ ] \quad]$

We saw, however, that while a single violation of *EMBED is tolerated, multiple violations are not. The new constraint on embedding must therefore be qualitatively different from *EMBED. The constraint in (48) would rule out any instances of multiple embedding:

(48) *MULTI-EMBED *No more than one domain may be embedded within a larger domain.*

If *MULTI-EMBED outranks the alignment constraints in Hungarian, then *alibi-A* will not be assigned the parse in (49) because this representation contains two embedded domains, and it is more important to avoid multiple domain-embedding than it is to satisfy alignment:

(49) $[_{+B}A \ [_{-B}l \ I] \ [_{-B}bI] \ -A]$ *alibi-a*

To summarize thus far, we have proposed two independent alignment constraints and three constraints on embedding. These constraints are listed in (50). As we will see below, further constraints on embedding will be required to account for the transparency facts of Hungarian.

(50) Proposed Constraints (Preliminary)

*MULTI-EMBED
*EMBED^{E}
*EMBED^{I}
ALIGN^{B}L,R
ALIGN^{B}R

Let us now consider mixed roots in which the final vowel is front and non-neutral. The non-neutral front vowels in Hungarian are {*ɛ, ü, ü:, ö, ö:*}. Some words from Ringen and Kontra's study include those listed in (51):

(51)	a.	partner	'partner'
	b.	amulett	'amulet'
	c.	szüfrazsett	'suffragette'
	d.	sofö:r	'chauffeur'

These words were assigned front vocalic suffixes by Ringen and Kontra's subjects. However, the constraints in (50), ranked as we have been assuming thus far, will predict back vocalic suffixes for words such as these. Consider for example a suffixed form of *partner*, which will have the input representation in (52), and the plausible candidate output structures listed in (53):

(52) Input Representation: *partner-A*

pArtnAr-A
| |
+B -B

(53) Candidate Output Structures

a.	$[_{+B}$pArt$]$ $[_{-B}$nAr-A$]$	*partnɛr-ɛ*
b.	$[_{+B}$pArtnAr-A$]$	*partnar-a*
c.	$[_{+B}$pArt$]$ $[_{-B}$nAr$]$ $[_{+B}$-A$]$	*partnɛr-a*
d.	$[_{+B}$pArt $[_{-B}$nAr$]$ -A$]$	*partnɛr-a*

The appropriate candidate is that shown in (a). However, (a) violates both alignment constraints. The candidates in (b) and (c) are ruled out because they violate the faithfulness constraints PARSE^{B} and FILL^{B}, respectively. The candidate in (d) should be the optimal candidate, given the constraints and the constraint hierarchy we have thus far postulated. The *EMBED constraints refer only to embedded high and mid vowels. (Recall that orthographic *e* represents the phonetically low vowel ɛ.)

Words such as *partner*, *amulett*, and *szüfrazsett*, with opaque phonetic ɛ, suggest the need for an additional *EMBED constraint:

(54) *EMBED^{A} *A root node dominating the features of A is parsed in a non-embedded domain.*

The word *soför*, which is also assigned front vocalic suffixes, suggests the need for a fifth *EMBED constraint, perhaps this one:

(55) *EMBED^{Ö} *A root node dominating the features of Ö is parsed in a non-embedded domain.*

It is clear where this discussion is leading. In order to make the alignment analysis of harmony and transparency go through, we in essence will need separate *EMBED constraints for each one of the opaque vowels, in addition to the constraint dictating against multiple embedding.

If these constraints are all independent of one another, then in principle we predict that they can be arranged in any logically possible ranking. If this is right, then we expect to find some constraint hierarchies which give rise to rather odd transparency patterns. Suppose for instance that all but one *EMBED constraint are ranked fairly high - above all of the alignment constraints. Now, if the one *EMBED constraint which ranks low is *EMBEDö, we have a system like Hungarian except that only the mid front rounded vowel is transparent to harmony. Furthermore, no principle rules out ranking *MULTI-EMBED beneath all alignment constraints. Thus, we should expect to find vowel harmony systems in which potentially very long strings of vowels (or syllables) are transparent. No such vowel harmony systems are known to me.

In point of fact, the constraints needed to account for the attested facts of Hungarian predict that any subset of the vowels - and strings of any length - could exhibit transparency in some language. This result cannot be correct. In Finnish and Hungarian, it is the high front unrounded vowel *i, i:* and, to some extent, the mid front unrounded vowel *e:* which exhibits transparency. In Mongolian (to be discussed below), it is the high unrounded vowel which displays transparency to rounding harmony.

A proponent of the alignment theory might counter this criticism by claiming the existence of a universal hierarchy of *EMBED constraints. Suppose that the *EMBED constraints are always organized as shown in (56):

(56) Universal *EMBED Hierarchy

*MULTI-EMBED >> *EMBED^{A} >> *EMBED^{Ö} >> *EMBED^{U} >> *EMBED^{E} >> *EMBED^{I}

The idea would be that while other constraints may be ranked between elements in this hierarchy, these constraints' hierarchical ranking relative to one another is fixed. I will in fact be suggesting an approach rather like this below.

The general theory of harmony and transparency which I have outlined here can be characterized as stated in (57):

(57) Statement of the Alignment Theory of Harmony & Transparency

a. Harmonic spans are characterized as domains subject to alignment constraints.

b. The relevant alignment constraints dictate that the edges of phonological domains should coincide with the edges of morphological domains.

c. In order to satisfy alignment, a given domain may be embedded within a larger harmony domain.

d. Domain embedding may be checked by constraints (*EMBED, *MULTI-EMBED) dictating against the appearance of a given segment type or number of segments in an embedded domain.

The problem with this theory, in my view, lies in the answers it provides to the following questions:

(58) Questions & Answers

Q: *Why does vowel harmony exist?*

A: Constraints dictate that the edges of harmonic domains must coincide with the edges of morphological domains.

Q: *Why does transparency exist?*

A: Transparency (i.e. domain-embedding) exists in order to satisfy alignment constraints.

Q: *What determines whether a given vowel will be transparent?*

A: A given vowel will be transparent (i) if, by parsing it in an embedded domain, some alignment constraint is satisfied, and (ii) if that alignment constraint outranks the constraint which dictates against the embedding of that particular vowel.

According to the alignment theory, harmony and transparency exist in response to a requirement that the domains of certain phonological features should coincide with certain morphological domains. Opacity then constitutes the failure of alignment. The constraints which give rise to opacity are the *EMBED constraints which state that certain vowels should not be parsed into embedded domains. We suggested that there must exist a *EMBED hierarchy which reflects the fact that a single vowel is more likely to occur in an embedded domain than a string of vowels (or syllables), and a high front vowel is more likely to be embedded than a lower vowel or a rounded vowel.

The question which then arises is the following: If the goal of harmony is to line up the edges of a featural span with the edges of the word, then why should the number and quality of intervening segments matter? That is, if the alignment theory of harmony is correct, then the left and/or right edge of a harmony domain should be

crucial, but the intermediate material should be of no import. To characterize the Hungarian situation, if the goal is to insure that the right and left edge of a +B-domain are aligned with the right and left edge of the word, the quantity and quality of intervening vowel should be irrelevant. We saw that this is not the case, however.

7.3 Harmony as EXTENSION: Hungarian

The theory of transparency which I would like to propose draws a direct correlation between the *goals* of harmony and the class of elements that are sometimes transparent to harmony. As outlined in Chapter 5, there is reason to believe that the features involved in harmony systems are features which mark relatively subtle perceptual contrasts. I have argued that the goal of harmony is to extend the temporal span of these features in an effort to facilitate perception. The relevant constraints should thus be labeled as such, namely as EXTEND constraints.

The position I am taking rejects the notion that harmony is driven by grammatical statements dictating that the edges of harmonic spans should be aligned with the edges of morphological domains such as the word. If we analyze harmony by means of a set of EXTEND constraints, then we are in a position to understand why certain classes of segments exhibit transparency effects while others do not. I would like to suggest that transparent elements are those elements which may occur during the span of some feature while still allowing for the interpretation of that span as a cohesive phonetic event. Stated differently, the purpose of harmony is to extend the duration of some feature. Elements or strings of segments may exhibit transparency if their occurrence does not constitute a substantial interruption of the signal associated with the extended feature.

I will begin by proposing two distinct but related EXTEND constraints for Hungarian. My constraints refer to *contrastive* backness, since it makes no sense to suppose that a feature will be subject to EXTEND constraints meant to facilitate its perceptibility when that feature does not enter into any phonological opposition, let alone a perceptually difficult one.

The first EXTEND constraint refers to position in the initial syllable, a fact which may at first glance appear somewhat *ad hoc*.

(59) EXTEND^{B}[$_{PrWd}$ *A contrastive [±back] specification associated with an initial syllable should be extended to all available vowel positions.*

It is the case, however, that the initial syllable has a degree of primacy in Hungarian, as in Turkic and Mongolian. In the native roots of all of these languages, certain features are contrastive (unpredictable) only in initial syllables. In post-initial syllables, the value of harmonic features is in general predictable on the basis of the identity of the vowel occupying the initial syllable. In addition to the constraint in (59), we will also have the constraint in (60) which does not refer to position within a word:

(60) EXTEND^{B} *A contrastive [±back] specification should be extended to all available vowel positions.*

A further constraint will be labeled SPECIFY^{B}. This constraint dictates that vowels should be specified for backness. In the case of suffixal vowels, which I assume to lack lexical specification for backness, this constraint will have the effect of insuring that suffixal vowels are specified for backness in output representations:

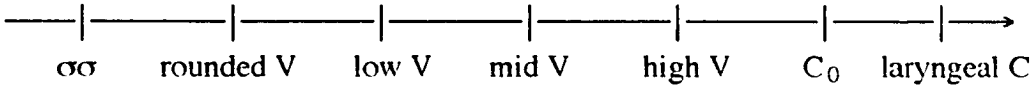
(61) SPECIFY^{B} *Vowels are specified for backness.*

As we know, suffixal vowels in Finnish and Hungarian agree in backness with one of the root vowels, that is, they are not simply assigned a backness value at random or by default. This indicates that FILL^{B} will play a role in the analysis of harmony in these languages:

(62) FILL^{B} *Output representations do not contain backness specifications absent in the input.*

Finally, we must explain why certain segments or strings of segments may be transparent to backness harmony. Here, I would like to propose a transparency continuum. At one end, we find those elements which are most readily treated as transparent for the reasons outlined above. At the other end, we find those elements (or strings of elements) which are most likely to be opaque. To my knowledge, no cases are cited in the literature in which rounded vowels are transparent to vowel-to-vowel feature sharing phenomena. Low *a*-type vowels are typically opaque, blocking ATR harmony (Casali 1993b) as well as Bantu height assimilation in Bantu (Clements 1991). Casali notes that while neutral *a*-type vowels are normally opaque to ATR harmony, in KiBudu, a Bantu language of Zaire, the neutral vowel *a* is transparent. Flemming (1993) also notes that the low vowel *a* is reported as being transparent to height harmony in Pasiego (Penny 1969, 1970). Based on these typological tendencies, I will propose the transparency continuum in (63):

(63) Transparency Continuum



The transparency continuum is provisional, and should be understood as being a first attempt to characterize the relative likelihood that a given element will be allowed to interrupt the extended span of some vocalic feature. The claim is that in some cases, vowel features may extend across a laryngeal consonant but not across any element(s) lying further to the left on the continuum. This is the case in languages such as Acoma and Nez Perce, for instance (Steriade 1987). Similarly, many vowel harmony systems allow a consonant (or sequence of consonants) to interrupt the span of some extended feature, while all vowels must either undergo harmony or block harmony. In terms of the transparency continuum, this pattern may be characterized in terms of a sort of cut-off point; nothing to the left of C_0 is allowed to interrupt a shared vocalic feature. Note that the transparency continuum is at least in part a sonority hierarchy. Elements higher on the sonority hierarchy are characterized by relatively greater intensity and, at least among vowels, they are characterized by relatively greater duration. These properties lend credence to the hypothesis that elements lying toward the left of the transparency continuum would constitute a relatively more substantial (or salient) interruption.

Constraints may refer to the transparency continuum. Such constraints will be labeled CONTINUITY. Continuity constraints identify cut-off points on the transparency continuum. For example, CONTINUITY^{C0} states that any element to the

left of C_0 on the transparency continuum may not interrupt the domain of association of some feature. For Hungarian, the constraints are listed in (64-65):

(64) $\text{CONTINUITY}^{\text{high V}}$ — *No element to the left of "high V" may interrupt an extended feature domain.*

(65) $\text{CONTINUITY}^{\text{mid V}}$ — *No element to the left of "mid V" may interrupt an extended feature domain.*

To summarize, I have proposed the following constraints to account for the facts of Hungarian discussed in §7.2:

(66) Summary of Proposed Constraints

$\text{EXTEND}^{B}[_{\text{PrWd}}$
EXTEND
SPECIFY^{B}
FILL^{B}
$\text{CONTINUITY}^{\text{highV}}$
$\text{CONTINUITY}^{\text{midV}}$

To show how these constraints interact to characterize the Hungarian transparency and opacity facts, let us begin with disyllabic words. When the root contains two harmonic vowels, it is the vowel of the second syllable which determines the backness of a subsequent suffixal vowel. The examples cited in Ringen & Kontra (1989) include those shown in (67):

(67) Disyllabic Roots; Two Harmonic Vowels

a. könüv 'book'
b. sofö:r 'chauffeur'
c. büro 'bureau'
d. partner 'partner'
e. Joszef 'Joseph'

Of relevance is the fact that the vowel in the initial syllable in words such as these does *not* determine the backness value of a suffixal vowel despite the preferences of $\text{EXTEND}^{B}[_{\text{PrWd}}$. This fact indicates that $\text{CONTINUITY}^{\text{midV}}$ must outrank $\text{EXTEND}^{B}[_{\text{PrWd}}$; that is, a low vowel *(ɛ)* or a rounded vowel is situated too low on the transparency continuum and is thus not allowed to be skipped. In words such as these, the backness value of the suffixal vowel is dependent on the backness of the final root vowel. Thus FILL^{B} must rank high. However, the suffixal vowels are specified for backness; thus, SPECIFY^{B} must rank high as well. The constraint hierarchy in (68) will allow us to account for harmony in words such as those listed in (67):

(68) Preliminary Constraint Hierarchy

SPECIFY^{B}, FILL^{B}, $\text{CONTINUITY}^{\text{midV}}$ >> $\text{EXTEND}^{B}[_{\text{PrWd}}$

The tableau in (69) illustrates how this hierarchy yields a front suffixal vowel following *soför*. The and candidate is ruled out by SPECIFY^{B}, while the second candidate violates the faithfulness constraint FILL^{B} and is thereby eliminated from consideration.

(69) Tableau: *soför-A*

sOfOr-A +B -B	SPEC^{B}	FILL^{B}	$\text{CONT}^{\text{midV}}$	$\text{EXT}^{B}[_{\text{PrWd}}$
sOfOr- A +B -B	*!			
sOfOr- A +B -B +B		*!		
sOfOr- A +B -B			*!	
→ sOfOr- A +B -B				*

The third candidate is ruled outnot by the ban on crossed association lines, but by CONTINUITY^{midV}, since a rounded vowel intervenes in the span of an extended feature, and "rounded vowel" falls to the left of "mid vowel" on the transparency continuum.[7] The final candidate is optimal, despite the fact that it fails to conform to EXTEND^{B}[$_{PrWd}$.

In (70) the tableau for a suffixed form of the disyllabic word *ka:ve:* is shown. For clarity, I represent the (non-contrastive) backness specifications of the neutral vowels in parentheses. The first two candidates are eliminated by SPECIFY^{B} and FILL^{B}, respectively:

(70) Tableau: *ka:ve:-A*

kA:vE:-A +B -B	SPEC^{B}	FILL^{B}	CONT^{midV}	EXT^{B}[$_{PrWd}$
kA:vE:- A +B (-B)	*!			
kA:vE:- A +B (-B)+B		*!		
→ kA:vE:- A +B (-B)				
kA:vE:- A +B (-B)				*!

The third candidate satisfies CONTINUITY^{midV} since the element which is skipped does not fall to the left of the continuity cut-off (Mid Vowel). Thus, the decision is left up to EXTEND^{B}[$_{PrWd}$, which is satisfied by the third candidate, but not the fourth candidate. Therefore *ka:ve:-a,* in which the initial vowel dictates the backness value of the suffixal vowel, surfaces.

[7]The appropriateness of association lines in these representations is clearly questionable. To avoid this problem, one might instead employ bracketed domains, following Smolensky (1993). I use association lines here merely in order to bring into focus the analysis as involving *extension* rather than *alignment.*

Similarly, the candidate corresponding to *akti:v-a*, with a back vocalic suffixal vowel, is selected as the output form of suffixed *akti:v*:

(71) Tableau: *akti:v-A*

akti:v-A +B -B	SPEC^{B}	FILL^{B}	CONT^{midV}	EXT^{B}[$_{PrWd}$
akti:v- A +B (-B)	*!			
akti:v- A +B (-B) +B		*!		
→ akti:v- A +B (-B)				
akti:v- A +B (-B)				*!

Since the transparent vowel is high (and unrounded), the decision is left up to EXTEND^{B}[$_{PrWd}$.

Let us now consider cases in which EXTEND^{B} is decisive. These include forms in which the transparent vowel occurs past the second syllable of the word. Only *i, i:* is transparent in this context. Thus, it must be the case that CONTINUITY^{highV} outranks EXTEND^{B}, since nothing further to the left of "high vowel" is transparent in the relevant situations. To show how harmony will work for roots such as *mayone:z* (to which front suffixal vowels are added) and *pantomim* (to which back suffixal vowels are added), consider first the tableau in (72). The top-ranking constraints SPECIFY^{B} and FILL^{B} have been left out in order to leave room for the remaining constraints and, for the sake of brevity, candidates in violation of these constraints are not listed here:

(72) Tableau *mayone:z-A*

mAyOnA:z- A +B +B (-B)	...	CONT^{midV}	EXT^{B}[$_{PrWd}$	CONT^{highV}	EXT^{B}
mAyOnA:z- A +B +B (-B)		*!			
mAyOnA:z- A +B +B (-B)			*	*!	*
→ mAyOnA:z- A +B +B (-B)			*		**

In the first candidate the initial backness value is extended to the suffixal vowel. This candidate cannot surface due to its violation of CONTINUITY^{midV}. The sequence of elements which has been skipped lies to the left of "mid vowel' on the transparency continuum, yielding a CONTINUITY^{midV} violation. Thus, although this form satisfies EXTEND^{B}[$_{PrWd}$, it violates a higher ranking constraint and is thus eliminated from consideration. The remaining two candidates both violate EXTEND^{B}[$_{PrWd}$. The decision between them is left up to the next highest ranking constraint, namely CONTINUITY^{highV}. As shown, even though the final candidate violates EXTEND^{B} while the second candidate does not, it is the final candidate which is selected, due to the decision of CONTINUITY^{highV}. The mid neutral vowel is therefore opaque in a polysyllabic word such as *mayone:z*, and it is with this vowel that the suffix vowel agrees in backness.

In (73) the tableau is shown for a suffixed form of *pantomim*. In this case, it is the final candidate which is found to be optimal. Both the second and third candidates violate EXTEND^{B}[$_{PrWd}$. In fact, both violate EXTEND^{B} as well. The difference is in the number of violations of EXTEND^{B} violations incurred by these competing candidates, as shown:

(73) Tableau *pantomim-A*

pAntOm Im- A +B +B (-B)	...	CONT^{midV}	EXT^{B}[$_{PrWd}$	CONT^{highV}	EXT^{B}
pAntOm Im- A +B +B (-B)		*!		*	*
→ pAntOm Im- A +B +B (-B)			*		*
pAntOmIm- A +B +B (-B)			*		**!

Based on this tableau, a word such as *pantomim* should therefore occur with back vocalic suffixes, and indeed Ringen & Kontra's subjects assigned back vocalic suffixes in cases such as this.

The final case which must be discussed is the case in which a sequence of neutral vowels is opaque to backness harmony, regardless of the height of those neutral vowels. Skipping a sequence of more than one syllable peak is avoided due to the fact that doing so would substantially violate continuity. The tableau for *alibi-A* is shown in (74):

(74) Tableau *alibi-A*

a l i bi- A +B (-B)(-B)	...	CONT^{midV}	EXT^{B}[$_{PrWd}$	CONT^{highV}	EXT^{B}
a l i bi- A +B (-B)(-B)		*!		*	
→ a l i bi- A +B (-B)(-B)			*		*
→ a l i bi- A +B (-B)(-B)			*		*

Based on the four constraints shown in (74), it is not possible to tell which candidate surfaces; the second and third candidates are in a tie. Of course, they are phonetically indistinguishable, both realized as *alibi-a*. Presumably the second candidate would be ruled out by a relatively low-ranking $\text{CONTINUITY}^{\text{CO}}$; however, this constraint does not play a critical role in Hungarian otherwise. The first constraint listed is ruled out by $\text{CONTINUITY}^{\text{midV}}$, because the transparent element lies lower on the transparency continuum than "mid vowel". In essence, this amounts to saying that two syllable peaks, albeit high unrounded syllable peaks, constitute an interruption of the harmonic span which is excessively substantive.

The analysis proposed here establishes a connection between the goal of harmony and the class of elements which may be transparent in a harmonic configuration. In §7.4, I lay out the transparency and opacity facts of Mongolian and Tungusic, showing that these two language groups constitute a minimal pair with respect to transparency. The analysis invokes constraints of the types proposed in this section for Hungarian.

7.4 Transparency & Opacity: Mongolian & Tungusic

As van der Hulst & Smith (1988) note, Mongolian and Tungusic constitute a minimal pair with respect to the transparency of *i* in rounding harmony domains. The specific data they use to illustrate the point are different from those shown here. Nonetheless, the relevant point is the same. In Khalkha Mongolian and Shuluun Höh, the high front unrounded vowel *i* (as well as its [-ATR] counterpart *ɪ* in Shuluun Höh) is transparent to rounding harmony, as shown in (75) and (76):

(75) *i* Transparent to Rounding Harmony: Khalkha Mongolian

a.	očidor *očider	'yesterday'
b.	xɔt-i:xɔ: *xɔt-i:xa:	'town (REFL GEN)'
c.	nɔir-i:xɔ: *nɔir-i:xa:	'sleep (REFL GEN)'
d.	tomr-i:xo: *tomr-i:xe:	'iron (REFL GEN)'

(76) *{i, ɪ}* Transparent to Rounding Harmony: Shuluun Höh

a.	očidor *očidər	'yesterday'
b.	gɔt-ɪ:xɔ: *gɔt-ɪ:xa:	'town (REFL GEN)'
c.	nœ:r-ɪ:xɔ: *nœ:r-ɪ:xa:	'sleep (REFL GEN)'
d.	tomr-i:xo: *tomr-i:xə:	'iron (REFL GEN)'

The high rounded vowels, by contrast, are opaque to harmony in Mongolian. They not only fail to trigger harmony, but they block harmony when they intervene between a viable trigger and a potential non-high target, as shown in (77) and (78):

(77) *{ʊ, u}* Opaque to Rounding Harmony: Khalkha Mongolian

a.	ɔr	'enter'
b.	ɔr-ɔ:d	'enter (PERF)'
c.	ɔr-ʊ:l	'enter (CAU)'
d.	ɔr-ʊ:l-a:d	'enter (CAU, PERF)'
	*ɔr-ʊ:l-ɔ:d	
e.	tor	'be born'
f.	tor-o:d	'be born (PERF)'
g.	tor-u:l	'be born (CAU)'
h.	tor-u:l-e:d	'be born (CAU, PERF)'
	*tor-u:l-o:d	

(78) *{u, ʊ}* Opaque to Rounding Harmony

a.	ɔr	'enter'
b.	ɔr-ɔ:d	'enter (PERF)'
c.	ɔr-ʊ:l	'enter (CAU)'
d.	ɔr-ʊ:l-a:d	'enter (CAU, PERF)'
	*ɔr-ʊ:l-ɔ:d	
e.	tor	'be born'
f.	tor-o:d	'be born (PERF)'
g.	tor-u:l	'be born (CAU)'
h.	tor-u:l-ə:d	'be born (CAU, PERF)'
	*tor-u:l-o:d	

In Tungusic, however, all high vowels are opaque to rounding harmony, as shown in (79) and (80):

(79) High Vowels Block Rounding Harmony: Oroch

a.	oggiča	'dried out'
	(*oggičo)	
b.	do:kčina	'to hear'
	(*do:kčino)	
c.	obbụla	'to give as a daughter's dowry'
	(*obbụlo)	
d.	gosụla	'to quarrel'
	(*gosụlo)	

(80) <u>High Vowels Block Rounding Harmony: Ulcha</u>

a.	ọyịlavụ	'leggings'
	*ọyịlọvu	
b.	ọmịra	'uterus'
	*ọmịrọ	
c.	ọrkịqtala	'uncomfortably'
	*ọrkịqtọlọ	
d.	dọ:kịla	'inside'
	*dọ:kịlọ	
e.	bọlọdʒụvamị	'as soon as it becomes Autumn'
	*bọlọdʒụvọmi	
f.	dʒọmbụdʒụvambụvụ	'to remind'
	*dʒọmbụdʒụvọmbụvu	
g.	kọ:vụlavụ	'to raise a mast (naut.)'
	*kọ:vụlọvu	
h.	kọrụka	'pike (fish) skin'
	*kọrụkọ	

In order to understand the difference between the Mongolian pattern and the Tungusic pattern, we need simply rank the CONTINUITY constraints in the appropriate positions relative to the other constraints; that is, we acknowledge the fact that with respect to transparency, Mongolian and Tungusic have different cut-off points. In Tungusic, only sequences of consonants may be transparent to rounding harmony. All vowels are either targets or blockers. In Mongolian, by contrast, a high unrounded vowel may be transparent. Thus, $\text{CONTINUITY}^{\text{highV}}$ will outrank the relevant EXTEND constraints in Mongolian. In Tungusic, the more strict constraint $\text{CONTINUITY}^{\text{CO}}$ will outrank the relevant EXTEND constraint.

The result will then be as follows: If warranted by the other constraints (principally $\text{UNIFORM}^{\text{R}}$), $\text{EXTEND}^{\text{R}}\text{if}^{-\text{HI}}$ will be allowed to prevail even where a high unrounded vowel intervenes between the non-high trigger and the non-high target in Mongolian. In Tungusic, however, $\text{EXTEND}^{\text{R}}\text{if}^{-\text{HI}}$ will be allowed to prevail only when consonants intervene between the trigger and the target of harmony. All vowels

which cannot be targets will block harmony. Schematic tableaux are shown in (81) and (82). We will first consider the Mongolian tableau:

(81) Tableau: Mongolian Transparency

A I A [+R]	CONT^{highV}	UNIFORM^{R}	EXTEND^{R}if^{-HI}	Cont^{CO}
A I A [+R]		*!		
A I A [+R]		*!		
A I A [+R]			*!	
→ A I A [+R]				*

The same candidate output structures will be submitted for evaluation in Tungusic. Due to the Tungusic transparency cut-off which is represented by the high ranking of a stricter CONTINUITY constraint, namely CONTINUITY^{CO}, harmony will be blocked when a high vowel intervenes between the potential trigger and target of harmony. The schematic tableau is shown in (82):

(82) Tableau: Tungusic Opacity

A I A [+R]	CONT^{highV}	CONT^{CO}	UNIFORM^{R}	EXTEND^{R}if^{-HI}
A I A [+R]			*!	
A I A [+R]			*!	
→ A I A [+R]				*
A I A [+R]	*!	*		

7.5 Against Harmony as Alignment: Shuluun Höh

Shuluun Höh appears, at first glance, to provide an argument for the treatment of harmony as *alignment* rather than *extension*. In Shuluun Höh, two distinct morphological domains are relevant to the distribution of front and back rounded vowels. Alignment, but not extension, by its very nature involves explicit reference to morphological domains. It turns out, however, that the facts of Shuluun Höh pose a serious challenge to the alignment analysis, as I show here. The analysis which invokes EXTEND constraints is comparatively straightforward.

In Shuluun Höh, the harmonic behavior of back vowels differs from that of front vowels. Harmony yields back rounded vowels in root and affix syllables, while front rounded vowels surface only in root syllables:

(83) Root Targets

toro̱-	'be born'
ɔrɔ̱-	'enter'
joro̱xølo̱xč-	'president'
nɔxœ̱:-	'dog'

(84) Affix Targets

doro:-go̱:r	'stirrup -INSTR'
mœrj-ɔ̱:r	'horse -INSTR'
obs-te̱:	'grass-COMIT'
(*obs-tø̱:)	
ɔd-tæ̱:	'star -COMIT'
(*ɔd-tœ̱:)	

It might appear that this asymmetry could be captured elegantly by means of alignment. Alignment constraints dictate that a given phonological constituent must coincide with a given morphological constituent. The alignment analyses presented in §7.1-2 characterized harmonic domains as bracketed structures, with constraints of the alignment family forcing the alignment of harmonic domains with the right and/or left edge of a word. To account for the distributional facts of Shuluun Höh, we might propose two separate alignment constraints, one requiring the alignment of a [+round] domain with *Root* edges, and the other requiring the alignment of [+round] to *Prosodic Word* edges:

(85) Alignment Constraints in Shuluun Höh

ALIGN^{R}Root,R: Align {[+round] domain, R, Root, R}

ALIGN^{R}PrWd,R: Align {[+round] domain, R, PrWd, R}

In order to characterize the fact that front rounded vowels are banned in suffixal syllables while back rounded vowels are allowed, one might appeal to a universal constraint (or constraints) dictating that front vowels should not be rounded. In an effort to be consistent with Smolensky's account of Finnish presented above, I will represent the relevant constraints as *R/I which dictates that the feature [+round] is incompatible with the feature combination [+high, -back], and *R/E which dictates that the feature [+round] is incompatible with the feature combination [-high, -back]. Suppose these constraints are ranked in Shuluun Höh as shown in (86):

(86) <u>Shuluun Höh Constraint Sub-hierarchy</u>

*R/I >> ALIGN^{R}Root,R >> *R/E >> ALIGN^{R}PrWd,R

The idea would then be as follows. If these constraints are ranked as shown in (87), the marked status of the vowels œ and ø should be irrelevant to harmony within the domain of the root, since alignment to the right edge of a root takes priority over the avoidance of the marked combination [+round, -back, -high]. Within suffix syllables, however, *B/E will prevail and prevent the marked vowels from appearing. In their place, we will instead find æ and e.

We expect the low-ranked ALIGN^{R}PrWd,R to have observable effects, however. In particular, we want this constraint to rule in favor of back rounded vowels in suffix syllables. Such is not the case, however, as demonstrated in the tableaux in (87) and (88). In the candidate structures shown here, square brackets ([...]) represent a phonological domain, and a straight bracket (|) represents a morphological boundary. I assume also that the faithfulness constraint PARSE^{R} is highly ranked, as shown:

(87) Tableau *nɔxœ:-tæ:* 'dog-INSTR'

nAxE:-tE: | +R	PARSE^R	ALIGN^R/Root	*R/E	ALIGN^R/PrWd
[+$_R$nA]xE: |tE:| *nɔxæ:-tæ:*		*!		*
→ [+$_R$nAxE:] |tE:| *nɔxœ:-tæ:*			*	*
[+$_R$nAxE:|tE:] | *nɔxœ:-tœ:*		*!	*!	
nAxE: |tE: | *naxæ:-tæ:*	*!			

As demonstrated in (87), this system correctly chooses [*nɔxœ:-tæ:*] as the most harmonic candidate for 'dog-INSTR'. However, due to the nature of alignment and its requirement that *edges* of domains coincide, the system incorrectly chooses [*doro-gə:r*] as the most harmonic candidate for 'stirrup-INSTR', as shown in (88):

(88) Tableau *doro-go:r* 'stirrup-INSTR'

dArA-gA:r | +R	PARSE^R	ALIGN^R/Root	*R/E	ALIGN^R/PrWd
[+$_R$dA]rA | gAr | *dorə-gə.r*		*!	*!	*
→ [+$_R$dArA] | gAr | *doro-gə:r*			**	*
(→) [+$_R$dA rA | gAr] | *doro-go.r*		*!	***	
dA rA | gAr | *dərə-gə.r*	*!			

Clearly the problem is that if we analyze harmony in terms of alignment, we are claiming that the *edges* of harmonic domains are forced into alignment with the *edges* of morphological domains. The correct output for (88), indicated with an arrow in parentheses, violates the higher ranking of the two alignment constraints. In the correct surface form, the right edge of the [+round] domain does not coincide with the right edge of the root.

One conceivable solution is to claim that two distinct constraint hierarchies comprise the phonology of Shuluun Höh, the first of which evaluates candidates containing only root material, and the second of which evaluates candidates containing roots and affixes, i.e. the Prosodic Word. McCarthy & Prince (1993a) adopt a multi-leveled solution for Axininca Campa where at what they term the *prefix* level, FILL outranks PARSE, while at the *suffix* level, PARSE outranks FILL. The model is derivational in that the output of one level serves as the input to the subsequent level. Candidates evaluated by the Prosodic Word hierarchy will all contain in them the optimal parse of the root and will vary only in how the affixal material is parsed and how the string as a whole is parsed.

The necessary hierarchies will be those shown in (89). In the Root hierarchy, alignment has priority over the need to avoid occurrences of the vowels œ and ø. In the Prosodic Word hierarchy, these constraints are ranked in reverse order, and the avoidance of the vowels œ and ø takes precedence over alignment:

(89) <u>Shuluun Höh Constraint Hierarchies</u>

a.	Root Hierarchy	ALIGN^R	>>	*R/E
b.	Prosodic Word Hierarchy	*R/E	>>	ALIGN^R

To show how the two-level model would work for Shuluun Höh, let us first consider the case in which *R/E dictates against rounding of a suffixal vowel, as in *nɔxœ:-tæ:* 'dog-INSTR'. Crucially, the marked vowel *œ* is allowed to surface within the root, but is not allowed to surface in the suffix. Thus, the Root hierarchy will function as shown in (90):

(90) Root Hierarchy *nɔxœ:tæ:* 'dog-INSTR'

nAxE: | +R	PARSE^R	ALIGN^R/Root	*R/E
[$_{+R}$nA]xE: | *nɔxæ:*		*!	
→ [$_{+R}$nAxE:] | *nɔxœ:*			*
nAxE: | *naxæ:*	*!		

The Prosodic Word hierarchy evaluates candidates which contain the optimal parse from the Root hierarchy, as shown in (91):

(91) Prosodic Word Hierarchy *nɔxœ:tæ:* 'dog-INSTR'

[$_{+R}$nAxE:] - tE:	PARSE^R	*R/E	ALIGN^R/PrWd
→ [$_{+R}$nAxE:] - tE: *nɔxe:-tæ-*		*	*
[$_{+R}$nAxE: - tE:] *nɔxœ:-tœ:*		**!	

The Root hierarchy would operate as shown in (92) for the word containing back vocalic targets of rounding harmony:

(92) Root Hierarchy *doro:go:r* 'stirrup-INSTR'

dArA | +R	PARSE^{R}	ALIGN^{R}/Root	*R/E
[$_{+R}$dA]rA| *dorə*		*!	
→ [$_{+R}$dArA] | *doro*			
dArA| *dərə*	*!		

The Prosodic Word hierarchy evaluates candidates which contain the optimal parse from the Root hierarchy, as shown in (93):

(93) Prosodic Word Hierarchy *doro:go:r* 'stirrup-INSTR'

[$_{+R}$dArA] - gA:r	PARSE^{R}	*R/E	ALIGN^{R}/PrWd
[$_{+R}$dArA] - gA:r *dorogæ:r*			*!
→ [$_{+R}$dArA - gA:r] | *dorogo:r*			

The alignment analysis thus required the postulation of two distinct (though presumably largely overlapping) constraint hierarchies for Shuluun Höh; one relevant only to roots and the other relevant to entire words. My view is that to the extent possible, one should avoid postulating multiple levels, since at the current time at least, we have no theory of the extent to which the constraint hierarchies relevant at distinct levels can differ from one another. In principle, we might expect to find wildly different constraint hierarchies operative at distinct levels. This prediction is probably undesirable.

An EXTEND solution need not appeal to a multi-leveled grammar because EXTEND constraints make no reference to the edges of the harmonic span; rather, EXTEND constraint dictate that a harmonic feature should be extended to all available positions.

One possibility then is to propose two distinct EXTEND constraints, the first stating that the feature [+round] should be extended to all available positions within the root, and the second stating that the feature [+round] should be extended to all available positions within the word. A constraint stating a dispreference for front rounded vowels will intervene in the Shuluun Höh constraint hierarchy. The constraints are stated informally in (94):

(94) $\text{EXTEND}^{R,Root}$ >> *front rounded vowels >> $\text{EXTEND}^{R,Word}$

Where the suffixal vowel is [+back], both EXTEND constraints can be satisfied. Where the suffixal vowel is [-back], however, only the higher ranking $\text{EXTEND}^{R,Root}$ can be satisfied. Satisfaction of $\text{EXTEND}^{R,Word}$ will force a violation of the higher ranking constraint banning front rounded vowels. Crucially, it will be possible for a word like *doro:gor* to surface in satisfaction of both EXTEND constraints because EXTEND does not refer to the edges of a harmonic span. EXTEND constraints simply enforce maximal association.

7.6 Height Identity Harmony and Inventory Crowding

As shown above, rounding harmony in Mongolian and Tungusic is triggered by non-high vowels and targets non-high vowels. Thus, the trigger and target must

agree in height and they must be non-high. The same pattern is found in Murut (Prentice 1971). Rounding harmony systems are attested, however, in which the trigger and target must agree in height but may be either high or non-high. The best known example of this is Yokuts, of which the two dialects Yawelmani and Wikchamni have been discussed extensively in the phonological literature. Furthermore, rounding harmony systems exist in which the trigger and target must agree in height and must be high. This is the system found in Hixkaryana, Tsou, and Kachin Khakass. The purpose of this section is to explain why these three types exist alongside one another.

The answer to this question will lie in the structure of the vowel inventories of the languages in question, and in the notion of *crowding*. Consider the chart in (95) which presents the underlying vowel inventories arranged by harmony type:

(95) Vowel Inventories

a. AA harmony	b. II harmony	c. AA II harmony[8]
Khalkha Mongolian	Hixkaryana	Wikchamni
i u	ɨ u	i ɨ u
ʊ		
e o	ɛ ɔ	
a ɔ	æ	a ɔ
Murut	Tsou	
i u	i ɨ u	
a o	e a o	
Oroch	Kachin Khakass	
i u	i ü ɨ u	
ụ		
ə		
æ a ɔ	e ö a ɔ	

The important observation to make on the basis of this table is the difference between the inventories of the AA languages and the languages of the other two groups. In the AA languages in which rounding harmony is observed only between non-high vowels, note that the high portion of the vowel space is relatively uncrowded; that is, high vowels are either front and unrounded or back and rounded, meaning that they are maximally separated in the vowel space. The lower portion of the vowel space in these languages is considerably more crowded. In Khalkha and Murut, there is a contrast between back unrounded *a* and back rounded *ɔ*, and in the Tungusic language Oroch, there is a three-way vowel contrast between front unrounded, back unrounded, and back rounded.

[8]How Yawelmani fits in is discussed below.

Now, compare this with the vowel spaces of the II languages and the AA II language. In both of these groups, the top halves and the lower halves of the vowel spaces are both relatively crowded. That is, the languages of neither group oppose two and only two maximally distinct vowel qualities. Hixkaryana displays a contrast between high back unrounded *ɨ* and high back rounded *u*. Tsou has a three-way contrast among high vowels, and in Kachin Khakass, the upper portion of the vowel space is crowded indeed, with four contrastive qualities.

According to the functionally motivated view of harmony which I have been developing throughout the course of this thesis, vowel harmony serves to extend the listener's exposure to a vowel quality which is potentially difficult to identify accurately. Here we see rounding harmony among high vowels only when the high portion of the vowel space is relatively crowded. Where the high portion of the vowel space includes only two qualities and those qualities are maximally distinct (front unrounded *vs.* back round), the contrast is likely to be readily discernible. Thus, from a functional perspective, the need to invoke harmony as a means of reducing a potential perceptual difficulty faced by the listener will arise only when some substantive difficulty presents itself. Here, we find rounding harmony among high vowels only when the two high vocalic qualities which are phonologically opposed in the language are less than maximally distinct (Hixkaryana), or when there are three or more high vocalic qualities which must be perceived as being distinct.

Formally, we will capture the distinction by means of the statement of the relevant EXTEND constraints. Here, I will need to clarify my assumptions regarding the nature of underlying representations and the role of underspecification. Following Steriade (1994), I will assume that short of trivial underspecification (e.g., consonants are not specified for [±ATR], vowels are typically not specified for [constricted

glottis] or [spread glottis]), there is no systematic featural underspecification. However, I will claim that constraints may refer to contrastiveness. For our purposes, EXTEND constraints operating on the feature [+round] (or in Finnish and Hungarian, the feature [±back]) may dictate that only contrastive values of a given constraint are subject to extension.[9]

In all same-height harmony languages, UNIFORM^R will play an important role, ruling out any instances of cross-height harmony. In the type 4 languages where both the harmony trigger and the harmony target must be [+high], *ROLO plays a decisive role as well, ruling out harmony where the target is non-high. In type 3 languages, namely Mongolian and Tungusic, harmony will be triggered only by non-high vowels, since it is only among non-high vowels that rounding is contrastive. Among the high vowels, rounding is predictable on the basis of backness; that is, EXTEND constraints will only enforce the extension of [+round] when that feature plays an entirely independent contrastive role. As stated in §7.3 above, this interpretation of EXTEND constraints is compatible with the functional motivation which I claim underlies the existence of EXTEND constraints. EXTEND constraints reflect a means by which the task of correctly identifying a perceptually subtle contrast is made easier. In a vowel system with only *i* and *u* in the high region, the round *vs.* unround distinction presumably poses no serious perceptual challenge.

One system appears to contradict the proposed relation between inventory crowding and the likelihood and nature of harmony. Yawelmani Yokuts (Newman 1944, Kuroda 1967, Archangeli 1984) is typically analyzed as having four underlying vowel qualities:

[9]It appears to be the case that in general, only contrastive feature specifications are subject to EXTEND constraints. However, in Yawelmani Yokuts, which I discuss below, non-contrastive [+round] and contrastive [+round] are both subject to the relevant EXTEND constraints.

(96) Yawelmani Underlying Vowel Inventory

i		u
	a	o

Despite the lack of crowding in the high portion of the vowel space, this language displays same height harmony among both the high vowels and the low vowels, just like in the Wikchamni dialect. High suffixal vowels are rounded following a high rounded root vowel but surface as *i* following a non-high root vowel whether it is rounded or not.[10] Similarly, any non-high suffixal vowel will surface as rounded following an underlying *o* in the root. Following an underlyingly high vowel in the root, however, a non-high suffixal vowel invariably surfaces as *a*:

(97) Suffixal Alternations: Yawelmani (data from Kuroda, pp. 10 and 14)

High Suffixal Vowel

a.	giy'-hin	'touch-AORIST'
b.	muṭ-hun	'swear-AORIST'
c.	xat-hin	'eat-AORIST'
d.	gop-hin	'take care of an infant-AORIST'

Non-high Suffixal Vowel

e.	xat-taw	'eat-NONDIRECTIVE GERUND'
f.	gop-tow	'take care of an infant-NONDIRECTIVE GERUND'
g.	giy'-taw	'touch-NONDIRECTIVE GERUND'
h.	muṭ-taw	'swear-NONDIRECTIVE GERUND'

This pattern appears to stand in direct conflict with the claim made regarding the relationship between vowel space crowding and the likelihood of harmony. The lower half of the Yawelmani vowel space counts as "crowded" by my criteria, due to

[10]Additionally, a long high vowel in a root will surface as mid, i.e. either as *e:* or *o:*. I return to this issue below.

the fact that the vowels are not maximally separated along the backness and rounding dimension. The upper half of the vowel space by no means qualifies as being crowded, however, the vowels *i* and *u* being maximally separated.

I would like to suggest that the functional principles which I have claimed account for the harmony patterns we have thus far observed were indeed relevant at an earlier stage of the language. Note that Yawelmani and Wikchamni are very closely related. It appears that Wikchamni reflects the system of vowel contrasts present in the ancestral language (Newman 1944) while Yawelmani (and other Yokuts dialects (Gamble 1978, p. 22)) innovated a vowel merger, merging **ɨ* and **u*.

Now the fact that rounding harmony in synchronic Yawelmani is no longer functionally motivated to the extent that it is in synchronic Wikchamni does not discredit the notion that functional principles provide the foundation of grammar. Indeed, the merger of **ɨ* and **u* reflects a response to the same perceptual principle which I claim underlies the phenomenon of vowel harmony. These two vowels are acoustically very similar, and thus their distinction is dangerously subtle, perceptually.

For the analysis of synchronic Yawelmani, it must be the case that the EXTEND constraints refer to all instances of [+round], not just those which are minimally contrastive. As I will suggest below in §7.6, the existence of vowel raising and vowel lowering phenomena in Yawelmani gives rise to an often rather opaque relationship between the underlying and surface representations of vowels. In fact, under certain circumstances underlying vowel contrasts are entirely neutralized on the surface. Rounding harmony to some extent removes the ambiguities created by raising and lowering. So while the merger of **ɨ* and **u* should have removed the perceptual advantage of having rounding harmony among the high vowels, it is by no means the case that rounding harmony among high vowels in Yawelmani is entirely gratuitous.

7.7 Uniformity & Abstractness: Yokuts

One final point deserves mention, particularly in light of the comments just made. It is the case that rounding harmony in Yawelmani and Wikchamni requires underlying height identity of the trigger and target. On the surface, however, harmonic sequences disagreeing in height are found frequently. In addition, surface sequences where one would expect to find harmony, but where one does not, are also found. Some examples from Yawelmani are shown here:

(98) Yawelmani Harmonic Sequences (Data from Kuroda, p. 10, 14)

a.	wo:w-lut	'smell-PASSIVE AORIST'
b.	ṣudo:-k'ut	'remove-PASSIVE AORIST'
c.	c'uyo:-taw	'urinate-NONDIRECTIVE GERUND'

Similar sequences arise in Wikchamni:

(99) Wikchamni Harmonic Sequences (Data from Gamble, p. 17)

a.	č'uto:-šu	'urinate-AORIST'
b.	tuʔo:-huy	'play-CONSEQUENT ADJUNCT'
c.	tuyo:-na	'eat-FUTURE'

These sequences arise because in both dialects, underlying *i* and *u* surface as mid whenever they would occur long. That is, long *i:* and *u:* normally do not occur on the surface.

Formally, we could account for this pattern in a number of ways. We could postpone the lowering effect to the phonetic interpretation component with a statement that long, non-low vowels are pronounced as mid. Under this analysis, UNIFORM^{R}

would always be satisfied in the phonological component.[11] Alternatively, we could propose two separate constraint hierarchies for Yokuts, as was suggested above in the alignment analysis of Shuluun Höh. In the first, UNIFORM^{R} would rank high, and candidates containing long high vowels would not be assessed any special violation marks. In the second hierarchy, which would evaluate candidates containing the optimal parse from the first instance of H-Eval, UNIFORM^{R} would rank low, and a constraint dictating that long vowels must be non-high would be ranked relatively high in the constraint hierarchy.[12]

A third alternative which appears to me to be the most responsible is to capitalize on the fact that there are only two degrees of *lexically contrastive* height in Yokuts. The idea will be that the contrastive height specifications will be encoded in the phonological representation differently from the non-contrastive third degree of height. For the purpose of assessing UNIFORM^{R} violations, it will be the contrastive representations which are relevant. One possible formal representation of this distinction is shown in (100):

(100) a. [$_{+R}$U I] b. [$_{+R}$U I]
|
[-hi]

The [+round] domain brackets elements of identical height, thus satisfying UNIFORM^{R} at the level required.

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[11] This account is not only unsatisfying, but also probably wrong. Due to a shortening effect which occurs in closed syllables, some instances of lowered *i:* and *u:* in fact surface as short *e* and *o*. I will not address this complication any further here, but acknowledge that one would need to do so in a full formal account of harmony and length in Yokuts.

[12] The constraint responsible for long vowel lowering could be construed as creating a sonority match: Lower vowels are more sonorous than higher vowels, and longer vowels are more sonorous than shorter vowels. I will not attempt to formalize this constraint here.

More interesting than the formal articulation of the role of height in the Yokuts harmony system are the consequences that this issue has for uniformity as I have characterized it. If UNIFORM^R is a functionally motivated principle which states that a single [+round] autosegment should correspond to a single rounding gesture, than how can the Yokuts form in (100b) be said to satisfy this constraint?

It is my view that while constraints are functionally motivated, they also comprise part of an abstract, formal system. This system may conspire to undo the functional benefits of constraints, even when those constraints are highly enough ranked so as to be visibly operative. I suggest that the role of UNIFORM^R in Yokuts is just such a situation.

One final point should be raised in relation to the fact that certain output structures may be required to satisfy UNIFORM^R only at a rather abstract level. Stated in derivational terms, two processes effect vowel height in Yokuts, both of which have the potential to neutralize underlying contrasts. One of these is lowering, by which under certain circumstances the contrast between underlying /u:/ and underlying /o:/ is neutralized. The other is raising, which, if stated as a rule, raises /o/ to /u/ when the subsequent syllable contains the vowel *i*. Examples of both lowering and raising in Wikchamni are shown in (101), where the underlined vowels have undergone either raising or lowering:

(101) <u>Wikchamni Neutralization</u>

Raising

a. /hutu/ 'know' → hut-šu 'know-AORIST'
b. /t'oyox/ 'doctor' → t'<u>u</u>yix-ši 'doctor-AORIST'
c. /toʔoṭ/ 'head' → t<u>u</u>ʔṭ'-iyin 'head-INTENSIVE POSSESSOR'
d. /ʔoṭ'ow/ 'hair' → ʔ<u>u</u>t'w-iyin 'hair-INTENSIVE POSSESSOR'

Lowering

a. /hoyo:/ 'name' → hoyo:-ši 'name-AORIST'
b. /č'utu:/ 'urinate' → č'uto:-šu 'urinate-AORIST'

Although the underlying contrast between /u/ and /o/ may be neutralized due to the effects of lowering and raising, note that no ambiguity arises. The form of the suffix will always reflect the *underlying* height of the root vowel. If the suffix vowel agrees with the root vowel in rounding, then the underlying root vowel must agree in height with the suffixal vowel, as in *č'uto:-šu*, 'urinate-AORIST'. If the suffixal vowel and the root vowel disagree in rounding, then their underlying heights must be distinct, as in *t'uyix-ši*, 'doctor-AORIST'.

Therefore, the fact that UNIFORM^R need only be satisfied at an abstract level may appear to challenge the claim that constraints are statements of functional principles, given that this constraint has been characterized as being articulatorally motivated. However, it should not go unnoticed that by requiring satisfaction of UNIFORM^R at the underlying rather than surface level, a separate and useful function is served - that of aiding in the recoverability of the lexical identity of root morphemes.

7.8 Directionality

Up until this point I have not made explicit my analysis of directionality in rounding harmony. On the whole, rounding harmony is found to proceed rightward. This is the general case in Turkic, Mongolian, Tungusic and Yokuts. I will argue that directionality comes as an automatic consequence of positional neutralization and that

directionality is not encoded in the statement of EXTEND constraints or, indeed, anywhere.

In Turkic, Mongolian and Tungusic contrastive [±round] is in general limited to initial syllables, while in Yokuts, contrastive [±round] is limited to stem syllables. All of these languages are suffixing, thus it is strings of vowels located to the right of a syllable specified [+round] which are potential targets of rounding harmony. The grammatical means by which positional neutralization can be characterized is in terms of licensing (Steriade 1995), as given in the constraints shown in (102):

(102) a. [+round] must be licensed by association to the initial syllable.

b. [+round] must be licensed, in at least one segment, by association to the initial syllable.

The licensing constraint in (102a) dictates that [+round] may be associated *only* with an initial syllable. This reflects the state of affairs in Bashkir (Steriade 1993), where rounded vowels are found only in initial syllables and no rounding harmony is observed. The licensing constraint in (102b) dictates that [+round] must be associated with an initial syllable while not ruling out additional associations. This reflects the state of affairs in the rounding harmony languages discussed in this thesis, where a [+round] specification is associated with an initial anchor and, subject to the decisions of various constraints, potentially associated with subsequent syllables as well.

In Akan (Clements 1977) contrastive [ATR] values occur only in root morphemes. Unlike the Uralic and Atalic languages, however, Akan possesses prefixes as well as suffixes. Consequently, [ATR] harmony in this language is bi-directional, with values spreading from the stem leftward onto prefixes as well as

rightward onto suffixes. Galab (Steriade 1981) is reported to be a rounding harmony type 3 language (i.e., rounding harmony is triggered by only non-high vowels and targets only non-high vowels). In this language, both prefixes and suffixes are present and both are subject to rounding harmony. Thus, as in Akan, harmony is bi-directional. In languages such as these, the relevant licensing constraint will be stated as in (103), where F represents the harmonic feature:

(103) [F] must be licensed, in at least one segment, by membership in the stem.

The basic scenario will thus be that directionality is a by-product of positional neutralization. Where the harmonic featural contrast is licensed only in a word-peripheral position, harmony will be uni-directional. Where the harmonic featural contrast is licensed in a position which is potentially (or always) word-medial, harmony will be bi-directional. Both language types share the neutralization of a particular feature in positions in which it is not readily discernible (Steriade 1993), and both employ the perceptually-motivated strategy of extending the temporal span of that feature in order to increase the probability that it will be identified correctly. Directionality is therefore captured not by means of explicit statements in the grammar, but by the interaction between (non-directional) EXTEND constraints and licensing constraints.

Chapter 8 Other Approaches to Rounding Harmony

In this chapter, I consider a range of rule-based approaches to the typology presented in Chapter 3. Some of the models discussed here have been proposed specifically to analyze some subset of the rounding harmony typology. These include Steriade (1981), Odden (1991) and Vaux (1993). Others, such as the generic autosegmental analysis discussed in Chapter 4 and Selkirk's Major Articulator Theory, are examined from the perspective of rounding harmony typology for the first time here.

With respect to its ability to characterize the typology in Chapter 3, each model will be shown to have certain advantages over the others. I will also show, however, that none of these models paints a coherent picture of the observed range of rounding harmony patterns. Equally seriously, none of these models attempts in any substantive way to *explain* the existence of vowel harmony phenomena. That is, the only apparent motivation for harmony is that these models provide a formal mechanism for the expression of vowel harmony rules.

8.1 The Metrical Theory of Vowel Harmony (Steriade 1981)

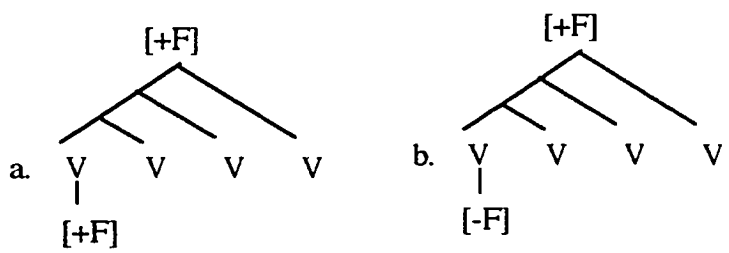
The metrical theory of vowel harmony presented in Steriade (1981) treats in detail the issue of rounding harmony typology and proposes analyses of two important characteristics of the typology. The first of these is the fact that rounding harmony in the domain AI (i.e. triggered by a non-high vowel and targeting a high vowel) is far more widely attested than harmony in the domain IA (i.e. triggered by a high vowel

and targeting a non-high vowel). Secondly, Steriade proposes a formal analysis of the existence of the front-back asymmetry in certain languages whereby harmony is unrestricted among front vowels but is subject to height-sensitive constraints among back vowels.

Within Steriade's metrical theory, which builds on and proposes amendments to that of Halle & Vergnaud (1980), a vowel harmony rule is stated parametrically and refers, among other things, to the domain of harmony. Harmonic domains are metrical feet headed by the harmonizing feature, and within most harmony systems, all vowels are projected for foot construction.

The mechanism of harmony involves the percolation of the harmonic feature to all elements within the foot, subject to a filter which dictates that the harmonizing feature must match the specification of the most deeply embedded segment - the Designated Terminal Element. Suppose that the harmonizing feature is [+F], and compare the tree structures in (1):

(1) <u>Sample Harmony Trees</u>



Harmony will apply to the structure in (a), since the harmonizing feature matches the specification of the Designated Terminal Element. Thus, the specification [+F] will percolate to all vowels within the foot. Harmony will not apply to the structure in (b), however, since in (b) the harmonizing feature (listed at the root of the tree) does not

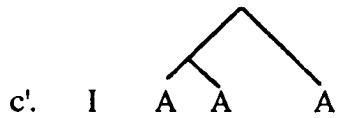
match the specification of the Designated Terminal Element. In the structure in (b), therefore, harmony will not be observed.

Steriade relates the asymmetry between the domains AI and IA to the fact that non-high vowels are more sonorous than high vowels. She proposes that harmonic foot construction rules may be sensitive to various prominence dimensions including stress, association to high tone, and sonority (where low vowels are of greater sonority than high vowels). Compare the trees in (2).

(2) <u>Harmony Trees</u>: (A = non-high vowel, I = high vowel)

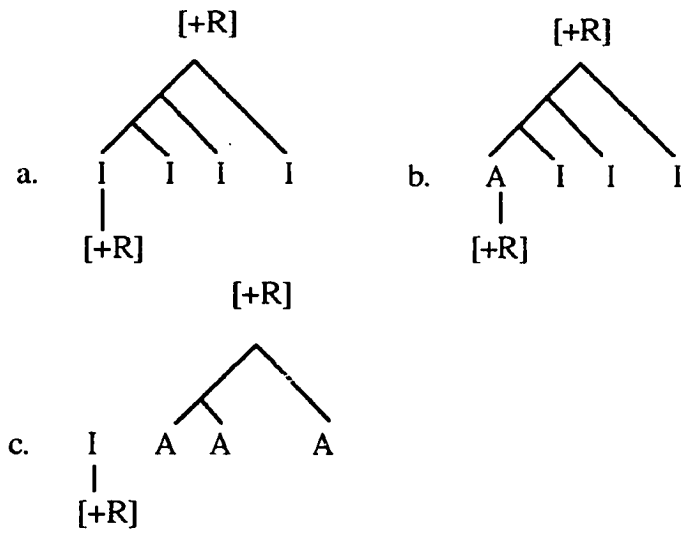
In the tree in (a), each element within the harmony foot is of equal sonority. In the tree in (b), there is a sonority discrepancy, and the more sonorous segment is that which has been assigned to the position of Designated Terminal Element. In (c) we find a segment of lesser sonority in the Designated Terminal Element position. Steriade proposes that where a foot construction rule is quantity-sensitive, it will construct the trees in (a) and (b), but (c) will instead be footed as shown in (3), where the more sonorous vowel demarcates the left edge of the harmony foot:

(3) Unmarked Quantity-sensitive Footing for Tree (2c)



Let us suppose that the harmonic feature is [+round]. If the initial vowel of each sequence bears a specification for [+round] in underlying representations, rounding harmony will apply in the configurations in (4a) and (4b) but will be blocked in (4c):

(4) Rounding Harmony Trees



In (a) and (b), the feature [+round] is allowed to percolate to all segments within the harmony foot because the tree label matches the feature specification of the Designated Terminal Element. In (c), however, harmony is blocked because the tree label does not match the feature specification of the Designated Terminal Element.

Here, the Designated Terminal Element in fact has no specification for the harmonic feature.

To summarize, the fact that AII is an often attested rounding harmony domain, whereas IAA is rarely attested, is linked to the sonority dimension: non-high vowels are of greater sonority than high vowels, and as such they may sometimes be chosen over high vowels to demarcate the edge of a quantity-sensitive harmony foot.

I would like to suggest two problems with this analysis. The first is a technical matter which relates to the fact that in some rounding harmony types, namely types 4 and 8, harmony is observed only when the trigger and target are both [+high].[1] Steriade states that "...the presence of AII domains in a RH [rounding harmony] system implies that of III domains" (p. 37). However, the proposed parameters of foot construction rules do not predict that where III is parsed as a single harmony foot, in some cases AII is not. It would seem, therefore, that the reverse implication is also true, i.e. that the presence of III domains implies the presence of AII domains. This issue is not addressed explicitly, though Steriade cites languages of types 4 and 8 in her survey of rounding harmony phenomena. Thus, an additional ingredient not available in Steriade's framework is needed. Steriade's analysis provides an explanation for why harmony often applies within the AI domain and rarely within the IA domain, but we still do not understand why in some instances neither domain is harmonic.

The second problem involves the quantity-sensitivity parameter. Tree construction rules may be either quantity-sensitive or quantity-insensitive. For Steriade's analysis of harmony in Turkic to go through, the tree construction rules for all backness harmony processes must be quantity-insensitive, and the tree construction

[1]This is true of type 8 only when the participating vowels are [+back].

rules for all rounding harmony processes must be quantity-sensitive. Within the proposed model, however, quantity sensitivity is a parameter entirely independent of the parameter which determines the identity of the harmonic feature. The theory therefore predicts that we should find four basic types of Turkic languages:

(5) Predicted Vowel Harmony Typology for Turkic

Type	Harmonic Feature = [-back]	Harmonic Feature = [+round]
A	quantity-sensitive	quantity-sensitive
B	quantity-insensitive	quantity-insensitive
C	quantity-sensitive	quantity-insensitive
D	quantity-insensitive	quantity-sensitive

At least two of these types are entirely absent, however. Type D is the normal Turkic case, where backness harmony has as its domain the entire word, whereas rounding harmony domains are height sensitive. Kirgiz-A, in which both backness harmony and rounding harmony apply across the board, instantiates type B. However, no instantiations of types A or C are attested. What this boils down to is the fact that the tree construction rules for backness harmony are always quantity-insensitive, while tree construction rules for rounding harmony are frequently quantity-sensitive. Within Steriade's model, this correlation between quantity-sensitivity and the identity of the harmonic feature is accidental.

Steriade introduces the term *parasitic harmony* to refer to the phenomenon found in certain Turkic languages whereby across-the-board rounding harmony is observed in front-vocalic words. The analysis capitalizes on the fact that in these languages, a harmony tree spanning the entire word is made available by the operation of backness harmony. That same tree is claimed to be responsible for the percolation of [+round] in those languages which choose the re-labeling option in (6):

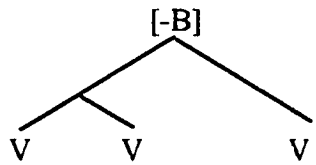
(6) <u>Re-labeling Option</u> (Steriade, p. 45)

Re-label a tree [α F].

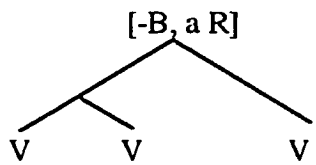
If the re-labeling option is chosen, a root labeled [-back], such as that in (7a), may be relabeled [-back, α round], as in (7b):

(7) <u>Parasitic Harmony as Root Re-labeling</u> (lower case a = α)

a.



b.



The consequences of the re-labeling in (b) will be as follows. If the Designated Terminal Element is specified [-back], its [-back] value along with its [±round] value will percolate to all vowels within the harmony foot. If the Designated Terminal Element is specified [+back], however, no percolation will occur, and the default values [+back] and [-round] will be spelled out for all non-initial vowels.

Under this analysis, the Turkic languages which evidence some form of rounding harmony will fall broadly into two categories: those which exploit the re-labeling option and those which ignore it. Independently of the re-labeling option, each of these languages will have a parameterized rule to account for non-parasitic rounding harmony. However, notice that since re-labeling and rounding harmony are

formally represented as being independent of one another, it need not be the case that those languages which exploit the re-labeling option must have in their grammar a separate rounding harmony rule. That is, the model predicts that languages should exist in which rounding harmony is observed only when it is parasitic to backness harmony. No such languages are attested, however. As shown in Chapter 6, the optimality theoretic analysis proposed in Chapter 6 correctly does not predict the existence of such a pattern.

By the same token, the formal mechanisms proposed in the metrical analysis do not provide a principled account of why rounding harmony parasitic on backness harmony is fairly wide-spread, whereas backness harmony parasitic on rounding harmony is unattested. That is, we do not find cases in which a tree such as that in (8a) is re-labeled to give the tree in (8b):

(8) <u>Unattested Root Re-labeling</u>

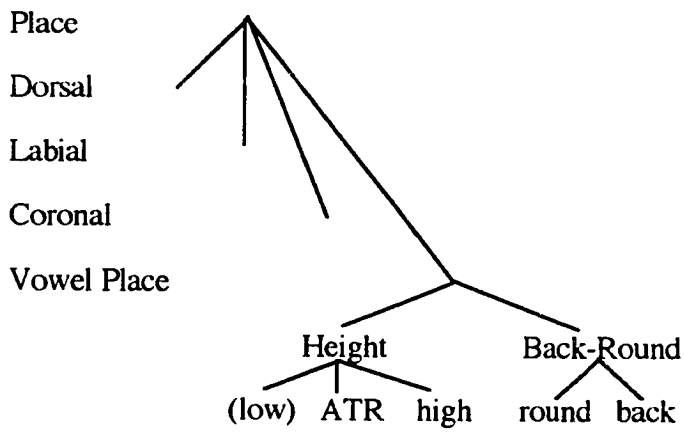
The analysis proposed in Chapter 6 does not characterize "parasitic" harmony as such. That is, the co-existence of rounding harmony and backness harmony in the Turkic languages is not derived formally, but is explained functionally. In the extremely crowded inventory of Turkic, both backness contrasts and rounding contrasts are potentially in jeopardy, perceptually. Thus, they are both likely to show up in high-ranking alignment constraints with the goal of easing the task faced by the listener.

Finally, Steriade's analysis of Turkic assumes that backness harmony rules refer only to the specification [-back]. In the absence of such an assumption, the model predicts that reverse front-back asymmetries in which rounding harmony parasitic on [+back] should occur. No such cases are found. This assumption implicitly relies on the existence of a theory of underspecification by which [-back], but not [+back], will be available to backness harmony rules. And, according to Steriade (1994), no principled theory which makes this prediction is likely to be forthcoming.

8.2 Back/Round Constituency (Odden 1991)

As does the metrical theory discussed above, the geometry of vowel features proposed by Odden (1991) provides a mechanism for explaining why in some Turkic languages, across-the-board rounding harmony is observed among front vowels but not among back vowels. In his model, the features [back] and [round] form a constituent independent of the height features. Odden argues for a V-Place (Vocalic-Place) node separate from C-Place (Consonantal-Place) node. V-Place dominates two nodes, a Height node and a Back-Round node:

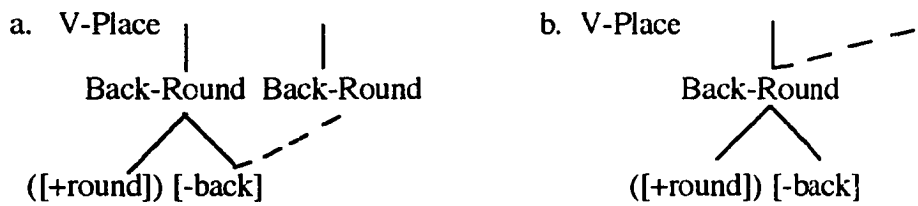
(9) Odden's Geometry (1991, p. 265)



Odden cites both acoustic and phonological evidence for the constituency of [back] and [round]. He points out that the primary acoustic correlate of these features involves the frequency of the second formant (F2), whereas the height features are correlated acoustically with the frequency of the first formant (F1). In arguing for a Back-Round node, Odden cites the existence of a number of phenomena whereby the features [back] and [round] appear to spread together in assimilation rules. The most convincing of these is the analysis of Eastern Cheremiss in which suffixal *e* alternates with *ö* and *o*. The front rounded alternant occurs when the final vowel of the stem is front rounded, whereas the back rounded alternant occurs when the final vowel of the stem is back rounded. According to Wessels (1992), the same harmonic pattern is found within roots and among short or reduced vowels. Under her analysis, height is non-contrastive among short vowels. Among long vowels, [±high] contrasts are limited to the initial syllable of a word. On the basis of this distribution, Eastern Cheremiss falls into type 1, whereby rounding spreads onto any eligible vowel regardless of the height or backness of the trigger and target.

Let us consider the extent to which Odden's geometry is capable of capturing the front-back asymmetry observed among Turkic rounding harmony patterns. Suppose we assume, as Steriade (1981) does, that frontness harmony involves spreading the feature [-back], and that [+back] is introduced later in the derivation as the default value. Given this assumption, two rules are available within Odden's geometry:

(10) <u>Two Turkic Backness Harmony Rules: Odden's Geometry</u>



Rule (a) states that the terminal node [-back] spreads rightward from vowel to vowel. In rule (b), the entire back-round node spreads rightward from vowel to vowel, just in case it dominates the terminal feature [-back]. The availability of these two rules predicts two Turkic patterns: one in which rounding harmony is entirely independent of backness harmony (rule (a)), and one in which rounding harmony is observed across the board when the vowels involved are [-back] (rule (b)). This result is consistent with the harmony facts of Turkic outlined above in Chapter 2.

Several criticisms may be made of this approach to backness asymmetries in Turkic, however. As with Steriade's parasitic harmony analysis, the Odden-style analysis relies crucially on the assumption that in frontness harmony (at least in Turkic), [-back] is the active feature value. If [+back] were the value which spreads,

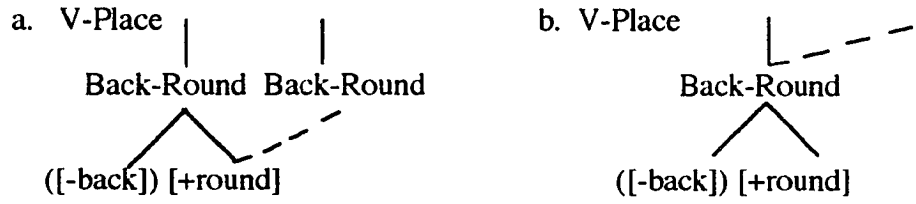
we would expect to find reverse asymmetries in which rounding harmony among back vowels is unrestricted, whereas among front vowels, rounding harmony is either constrained by trigger or target conditions or absent entirely. Such reverse asymmetries are not found. Thus, both the metrical analysis and an analysis invoking Odden's vowel feature geometry can be maintained only if [+back] is unavailable for spreading in Turkic.

The Odden-style analysis, along with the metrical analysis, both incorrectly predict the existence of systems in which rounding harmony applies only among front vowels. No such system exists. Thus, while we find Turkic languages such as Bashkir in which rounded vowels occur only in word-initial syllables and in which no rounding harmony is observed, all Turkic languages which evidence some form of rounding harmony do so in some or all back-vocalic contexts.

In addition, both the Odden-style analysis and the metrical analysis may be viewed as flawed in that in those rounding harmony systems displaying a front-back asymmetry, (at least) two separate rounding harmony rules must be posited - one for rounding harmony in front-vocalic contexts and one or more for rounding harmony in back-vocalic contexts.

A final criticism regarding the Odden-style analysis of front-back asymmetries in Turkic involves an unattested but predicted pattern. The analysis hinges upon the availability of two frontness harmony rules - one which spreads only the terminal feature [-back] and one which spreads the Back-Round node. Nothing in the theory dictates that one of the terminal features [±back] and [±round] is in any way subordinate to the other. Therefore, since two backness harmony rules are available and both are exploited, it must be the case that two rounding harmony rules are also available:

(11) Two Turkic Rounding Harmony Rules: Odden's Geometry



Despite the availability of these two rounding harmony rules, we find that rule (b) is never exploited. That is, we never find cases of parasitic harmony in which frontness spreads just in case rounding also spreads.

Incorporated into the metrical theory was an explicit proposal regarding the correlation of rounding harmony processes with vowel height. The analysis is appealing in that it relates vowel height features to sonority and, in turn, relates a given vowel's sonority to its ability to demarcate the beginning of a metrical foot. Thus, the formal analysis is in part phonetically motivated. We saw that this aspect of the analysis is capable of generating some, though not all, of the desired results. On the other hand, the relationship between the features [-back] and [+round] is in no way phonetically motivated: The proposition that a [-back] tree could be re-labeled {[-back], [αround]} is presented purely as a formal mechanism.

By contrast, Odden's geometry presents as phonetically motivated the relationship between the features [back] and [round]. And indeed, as we saw, Odden's geometry does provide for the split within Turkic, whereby in one group of languages rounding harmony functions entirely independently of backness harmony, whereas in another group the operation of rounding harmony is dependent on the backness class of the word.

With respect to the relationship between rounding harmony and the height dimension, however, it is clear that within Odden's framework the small range of attested patterns, as well as an enormous range of logically possible but unattested patterns, can all be represented formally, and the theory is unequipped to discern among them. Thus, in terms of the interactions between height and rounding harmony, Odden's geometry fares no better than the simple autosegmental analysis discussed in Chapter 4.

A rather different geometry of vowel features is proposed in Selkirk (1991). This geometry, along with a proposal for constraining multiple association, are considered in §8.3. Within Selkirk's model, the features representing the roundness and height dimensions bear a more direct relationship to one another than they do in Odden's model. Thus, unlike Odden's geometry, Selkirk's model makes certain predictions regarding the relationship between rounding harmony and the height dimension. In addition, Selkirk's model allows for two geometric relations to hold between the features corresponding to [round] and [back] - one in which the features are sisters and one in which they stand in a dominance relation. In §8.3, the availability of these two options is considered with regard to the front-back asymmetries observed among Turkic rounding harmony systems.

8.3 Constraints on Multiple Association (Selkirk 1991)

In Selkirk's Major Articulator Theory of Vowels (1991), a unified set of features is used to characterize both vowels and consonants. The vowel features [±high], [±low], [±back], and [±round] are replaced with the articulator labels

traditionally employed to represent consonantal place of articulation. They are divided into two subgroups, namely the *color* features and the *sonority* features:

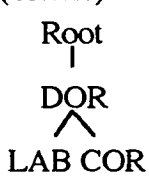
(12) Major Articulators for Vowel Place (Selkirk 1991)

a. Color:	LABIAL	(replaces the traditional feature [+round])
	CORONAL	(replaces the traditional feature [-back])
b. Sonority:	PHARYNGEAL	(replaces the traditional feature [+high])
	DORSAL	(replaces the traditional feature [+low])

The position of these two groups of articulators within the feature tree is parameterized such that a language may be color-dependent or sonority-dependent. Furthermore, within a given class, features may either be sisters of one another, or a dominance relation between them may obtain. In (13), some of the available options for representing a high front rounded vowel [ü] are shown:[2]

(13) Possible Vowel Articulators Geometries

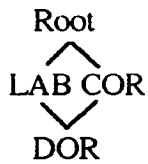
a. Color-dependent (Sisters)



b. Color-dependent (Dominance)

[2]The decision to represent LABIAL dependent on CORONAL, rather than the other way around, will turn out to be convenient in the discussion below. It should be noted, however, that within Selkirk's model, either dependence relation is well-formed, and the choice between one or the other is claimed to be language-specific.

c. Sonority-dependent (Sisters)



d. Sonority-dependent (Dominance)

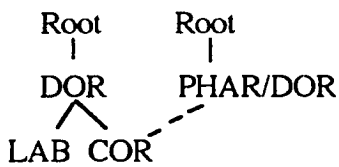
In (a) and (b), the representations are color-dependent. Thus, the DORSAL articulator reflecting a sonority value equivalent to the traditional feature [+high] is at the top of the place hierarchy. In (a), the dependent color features are sisters, LABIAL corresponding to the traditional feature [+round] and CORONAL to the traditional feature [-back]. The structures in (c) and (d) are sonority-dependent. Thus, the color features LABIAL and CORONAL are at the top of the hierarchy, and the dominated sonority feature DORSAL is at the bottom of the hierarchy. In (c), the color features are sisters, whereas in (d), they stand in a dominance relation, CORONAL dominating LABIAL. A tree similar to that in (d) - differing only in that LABIAL dominates CORONAL - is also licit within Selkirk's framework.

To begin, let us consider the manner in which this geometric parameterization handles the front-back asymmetry observed among Turkic rounding harmony systems. Within Odden's model, it was suggested above that two backness harmony rules are available in Turkic - one in which the feature [-back] spreads, and one in which the entire back-round node spreads. Adopting for the moment Selkirk's model, let us suppose that Turkic languages are all color-dependent, but that in some, the color features are sisters of one another, while in others the color features stand in a dominance relation. This means that in some systems LABIAL and CORONAL will

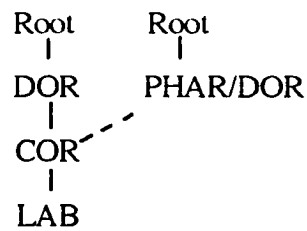
be sisters, while in others CORONAL will dominate LABIAL. We may then say that there is a single backness harmony rule which spreads the feature CORONAL from vowel to vowel. Backness harmony in the two geometric configurations given in (14) will have different consequences:

(14) <u>The Consequences of Backness Harmony in Two Geometric Configurations</u>

a. <u>Sisters</u>



b. <u>Dominance</u>



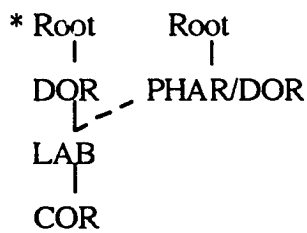
When the rule applies in the configuration in (a) in which LABIAL and CORONAL are sisters, the output is a multiply linked CORONAL articulator. This characterizes backness harmony without concomitant rounding harmony. When the rule applies in (b), however, the output is a multiply linked CORONAL articulator which dominates the articulator LABIAL. As shown, when backness harmony applies within this dominance configuration, parasitic rounding harmony is observed. Within this model, then, the difference between Turkic languages which exhibit a front-back asymmetry and Turkic languages which do not is explained on the basis of the sisterhood versus dominance parameter.[3]

Under Selkirk's proposal, the front-back dimension is represented by the privative feature CORONAL, with no feature corresponding to the traditional feature

[3]This analysis resembles that of Mester (1986).

[+back]. Consequently, there is no need to explain the absence of reverse front-back asymmetries: Since the only feature available for characterizing backness harmony is the feature CORONAL, across-the-board rounding harmony among back vowels alongside conditioned rounding harmony among front vowels is predicted to not occur. That is, since the traditional feature [+back] has no formal equivalent in Selkirk's model, the LABIAL articulator can never get a "free ride" on backness harmony in back vocalic contexts. In order to explain the absence of systems in which backness harmony is parasitic on rounding harmony, we might claim that among the color features, the only dominance relation available is that in which CORONAL dominates LABIAL:

(15) <u>Unattested Parasitic Backness Harmony</u>



This analysis shares one drawback with those of Steriade and Odden, however. In each of these systems, the asymmetric behavior of rounding harmony among front vs. back vowels cannot be characterized without positing at least two rounding harmony rules. Assuming that these rules are indeed separate, we have no way of understanding why one never finds languages in which rounding harmony is observed exclusively among front vowels.

In the previous section, I pointed out that within Odden's geometry, the height features are represented entirely independently of the feature [round]. From this we concluded that the geometry makes no predictions regarding how rounding harmony and the height dimension will be related. Within Selkirk's geometry, however, the height features (i.e. *sonority*) and rounding stand in a relation of dominance relative to one another, and thus may be expected to interact. I will consider here the observation made in Chapter 3 that rounding harmony is often disallowed when its application would yield a sequence of rounded vowels of distinct heights.

This phenomenon is apparently one which Selkirk would ascribe to the Multiple Linking Constraint:

> "... it is proposed that the multiple linking of a feature in phonological representation is constrained by the identity of the elements which dominate the multiply linked feature in the representation, and moreover that the constraints on adjacency in wellformed multiple linkings are a function of these identity restrictions." (p. 39)

Under Selkirk's theory, identity may be computed in one of two ways, both of which refer to the heads to which a given feature is multiply-linked. The heads may be subject to strict identity, or they may be subject to class identity. That is, for a given rule one of two clauses of the Multiple Linking Constraint will be operative, clause (i) or clause (ii):

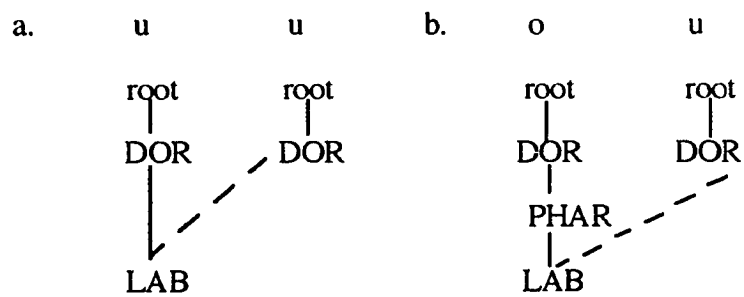
(16) <u>Selkirk's Multiple Linking Constraint (paraphrased)</u>

A multiply-linked feature must be dominated by

(i) Identical heads
(ii) Heads belonging to the same class

Let us consider rounding harmony types 2 and 4 which differ minimally. In both types only high vowels are targets. In type 2, however, the trigger and target may disagree in height, whereas in type 4, the trigger and target must agree in height. In (a), we see the representation of a harmonic *u-u* sequence. In (b), a harmonic *o-u* sequence is represented. For both, I have assumed a color-dependent geometry in which articulators within a class are related by dominance:

(17) <u>*u-u* and *u-o* as the Output of Rounding Harmony</u>

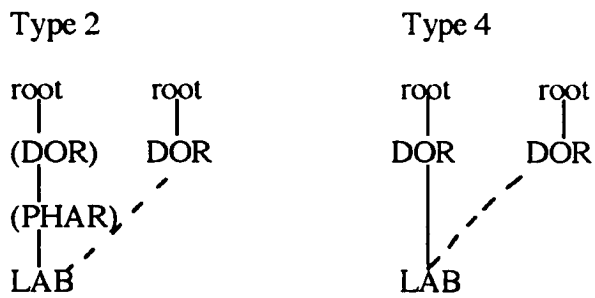


If clause (i) of the Multiple Linking Constraint is invoked, only the representation in (a), in which the heads are identical, will be allowed to surface. This is due to the fact that in the representation of *u-u*, the multiply linked instance of LABIAL is associated with identical heads (both DORSAL). In the representation of *o-u*, by contrast, the heads are not identical (PHARYNGEAL vs. DORSAL), and clause (i) of the Multiple Linking Constraint is violated. If the Multiple Linking Constraint's more lenient clause (ii) is invoked, then both representations will be licit, since in both cases the multiply linked feature is associated with heads belonging to the same class, namely the class of sonority features. Thus, under a Multiple Linking Constraint analysis, the difference between types 2 and 4 need not be reflected in the structural descriptions of the rounding harmony rules. Rather, the difference may be characterized as a function of which clause of the Multiple Linking Constraint is

imposed on the rule: For type 2, clause (ii) is imposed, whereas for type 4, clause (i) is imposed.

Notice, however, that we need not appeal to the availability of two distinct Multiple Linking Constraint clauses to explain the difference between types 2 and 4. Instead, the constraints on trigger and target height could just as well be written directly into the structural description of the rule:

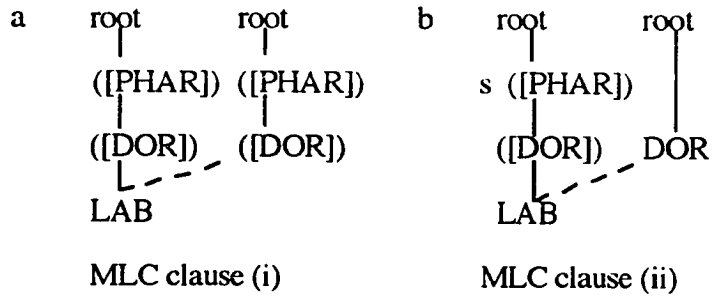
(18) <u>Distinct Rules for Types 2 & 4</u>



Both rules specifically target [+high] (DORSAL) vowels. In addition, the type 4 rule is triggered only by [+high] (DORSAL) vowels. Thus, while the Multiple Linking Constraint would appear to be on the right track for expressing the existence of minimal pairs such as types 2 and 4, it is not clear that the constraint in fact has any role to play at all, given the available geometry and assumptions about the information content that may be present in phonological rules.

Consider now type 5 in which rounding harmony applies when the trigger and target agree in height, or when the target is high. To capture this system, we need two rules, one sensitive to clause (i) of the Multiple Linking Constraint, and the other sensitive to clause (ii):

(19) Rules for Type 5



In rule (a), LABIAL spreads from vowel to vowel provided that the output conforms to clause (i) of the Multiple Linking Constraint. This gives us harmony where the trigger and target agree in height. In rule (b), rounding harmony targets only high vowels, and the output need only satisfy clause (ii) of the Multiple Linking Constraint. Notice that this analysis suffers from the same problem faced by Steriade's and Odden's analyses and by the simple autosegmental analysis from section 4.1: Multiple rules are required to characterize what we would like to view as a unified phenomenon. Here, for instance, we find that high vowels undergo contextual rounding regardless of the height of the triggering vowel. Yet we are forced to say that the rule responsible for contextual rounding of high vowels when the triggering vowels is also high is not the same rule as that which gives rise to contextual rounding of high vowels when the triggering vowels are non-high.

To summarize, we have examined two aspects of Selkirk's Major Articulator model in light of the typology of rounding harmony. The first of these involved the relation between the sonority features and the color features, and the claim that within a class, features may either be in a dominance relation with one another, or they may be sisters. We saw that if we assume the Turkic languages are color-dependent and that within the color class CORONAL universally dominates LABIAL (unless

CORONAL and LABIAL are sisters), we derive the two categories observed within Turkic: those languages in which rounding harmony applies across the board in front-vocalic words but only conditionally in back-vocalic words, versus those languages in which no front-back asymmetry obtains within the rounding harmony system. Two assumptions are crucial to this analysis. The first involves class dependency. Selkirk claims that the choice between color-dependency and sonority-dependency is made on a language-by-language basis; thus, we expect to find sonority-dependent Turkic-type languages in which backness and/or rounding harmony give rise to concomitant height harmony. Such systems are unattested, however.

Similarly, we assumed that when the color features stand in a dominance relation, CORONAL universally dominates LABIAL. By making this assumption we ruled out the possibility of Turkic-type systems in which backness harmony is observed only parasitic on rounding harmony. It is important to note, however, that nothing in the theory dictates that in some languages LABIAL does not dominate CORONAL. For instance, Selkirk argues that while in Kimatuumbi DORSAL dominates PHARYNGEAL, in Ngbaka the reverse dominance relation must be posited, that is PHARYNGEAL must dominate DORSAL. Thus, the claim among the color features, LABIAL may never dominate CORONAL, is purely a stipulation.

Second, we considered the Multiple Linking Constraint as a formal device for understanding the fact that in many instances rounding harmony is avoided when the trigger and target are of distinct heights. Two problems were noted. The first involved redundancy in the system. We saw that minimal differences in rules could be captured either by imposing different Multiple Linking Constraint clauses on the same rule or by incorporating the difference directly into the structural descriptions of the rules. More seriously, we saw that for some systems, multiple rules were required

to represent what is arguably a single phenomenon. This problem is shared by all rule-based analyses.

8.4 Markedness (Vaux 1993, Calabrese 1993)

In a paper by Vaux (1993), a subset of rounding harmony phenomena are analyzed within the markedness theory proposed in Calabrese (1993). In his paper, Vaux treats rounding harmony which targets non-high vowels, which he labels *labial attraction*, as a phenomenon distinct from rounding harmony which targets high vowels, which he terms *labial harmony*.[4] Vaux analyzes only labial attraction. The decision to separate these phenomena appears to be motivated by facts from the history of Altaic: While labial harmony is reconstructable for Proto-Turkic (Menges 1947), labial attraction emerged only later and only in certain geographical areas. In this section I will briefly present Vaux's analysis of the typology of labial attraction, then consider whether this analysis may be successfully extended to the typology of labial harmony.

In analyzing the typology of Labial Attraction, Vaux advances the following claim:

> "...certain features within certain feature configurations are marked or complex, and phonological rules can be sensitive only to these marked features, and not to unmarked features." (p. 234)

The prediction then is that the feature [+round] will spread onto a neighboring non-high vowel when its occurrence in the trigger configuration is marked. Uncontroversially, Vaux assumes that [+round] is marked in the configurations {___, [+low]} and {___, [-back]}.

[4]Vaux's use of the terms labial harmony and labial attraction follows the traditional useage found in literature on Turkic linguistics (e.g., Menges 1968).

Labial attraction by definition always targets non-high vowels. However, the set of triggering vowels differs from language to language. Vaux's typology, modified slightly so as to avoid confusion with the typology presented in Chapter 3, is given in (20).

(20) Vaux's Typology of Labial Attraction

Type	Triggers	Languages
A	o, ö, u, ü	Kirgiz-A
B	o, ö, ü	Kirgiz-B, Altai
C	o, ö	Yakut[5]
D	ö, ü	Karakalpak, Chulym Tatar, Kyzyl Khakass

In all of these languages, rounding is contrastive among both front and back vowels. Thus, in all of these languages, *ü* and *ö* are predicted to trigger labial attraction, since they are specified with a marked occurrence of [+round], {___, [-back]}.

Vaux points out, however, that these languages differ along the height dimension. In types A-C, there are arguably only two phonological degrees of height, which Vaux assumes are represented with the features [+high] and [+low]. In type D languages, with the exception of Kyzyl Khakass, the front unrounded vowels display a three-way height contrast *{i-e-ä}*. The three heights are thus represented phonologically as [+high], [-high, -low] and [+low]. Therefore, within the markedness theory, *o* in types A-C will also be expected to trigger labial attraction, since it is specified with a marked occurrence of [+round], {___ [+low]}. In type D,

[5]Additionally, Vaux cites dialects of Eastern Mongolian in which only non-high vowels trigger labial attraction.

however, [+low] must be reserved to represent the vowel *ä*, while the height features for the vowels *o* and *ö* are {[-high], [-low]}. Thus, for type D languages (with the exception of Kyzyl Khakass), *o* will not be expected to trigger labial attraction since its [+round] specification does not occur in a marked configuration. The vowel *o* in type D languages is represented as {[+round], [-high], [-low]}.

Three problems with this analysis present themselves immediately. The first of these involves Kyzyl Khakass in which we expect the vowel *o* to trigger labial attraction. This language, like the languages of types A-C, has only a two-way height contrast. Thus, given Vaux's analysis of types A-C, the Kyzyl Khakass vowels *o* and *ö* should be specified as [+low], giving rise to a marked occurrence of [+round]. Although Vaux does consider Kyzyl Khakass in his typology, he does not explain why in this language the vowel *o* fails to trigger labial attraction.

Secondly, no explanation on the basis of markedness can be forwarded to explain why in Yakut (type C), the high vowel *ü* does not trigger labial attraction, since it is specified with a marked occurrence of [+round], {___, [-back]}. Vaux suggests that a parasitic harmony analysis may be necessary to account for type C and cites Steriade (1981). He does not discuss whether his markedness analysis and Steriade's metrical analysis are to any extent mutually compatible, however.

Finally, the fact that the vowel *u* triggers labial attraction in type A is unexplained under a markedness account. Vaux suggests that in Kirgiz-A, labial attraction has become "generalized." Clearly, the possibility of this sort of generalization runs contrary to the essential claim advanced by Vaux, namely that phonological rules can be sensitive only to marked feature values. Calabrese (1993) suggests that in type A, the rule of labial attraction is sensitive to *contrastive* feature

specification, whereas in types B-D the rule is sensitive only to *marked* feature specifications.

This move constitutes a substantial weakening of the theory advocated by Vaux. I make a similar move in the discussion of Yawelmani rounding harmony triggered by *u* (Chapter 7). I claim that while EXTEND constraints typically refer to contrastive feature specifications, they do under some circumstances refer to non-contrastive feature specifications. My claim is that due to historical shifts within the segment inventory, it is possible for an EXTEND constraint to refer to a feature which is no longer contrastive. In the Vaux-Calabrese model, under normal circumstances assimilation rules are claimed to spread only marked feature values. In some exceptional cases *contrastive* features values may spread (the implication being that unmarked non-contrastive feature values will never be spread in assimilation rules). These two positions of course make different predictions since markedness and contrastiveness are by no means the same thing. With respect to what Vaux terms "labial harmony" (targeting high vowels), it is clear that contrastiveness and *not* markedness is the relevant property of features involved in rounding harmony.

We consider now how Vaux's account of the typology of labial attraction can be extended to the domain of labial harmony, i.e. to rounding assimilation which targets high vowels. With the exception of type 3, all of the rounding harmony types discussed in Chapter 3 exhibit harmony when the potential trigger and target are both high vowels. Thus, the sequences *üCü* and *uCu* are found as the output of rounding harmony in nearly all of the attested systems. Within the markedness framework proposed by Vaux & Calabrese, we are not surprised to find *üCü* sequences as the output of harmony: The vowel *ü* is specified with a marked occurrence of the feature [+round]. The sequence *uCu* is not expected within the markedness account, however,

since the feature [+round] is clearly unmarked in the configuration {___, [+high], [+back]}. Therefore, we are forced to conclude that while labial attraction is often (though not always) subject to Vaux's markedness constraint on triggers, labial harmony is virtually never subject to this constraint. The markedness constraint on triggers must thus be viewed as a property of labial attraction systems, not as a property of assimilation rules in general.

Finally, I will return to the criticism which has by now become quite familiar. If it is correct to view vowel-to-vowel assimilation involving propagation of the feature [+round] as a unified phenomenon, all rule-based approaches will require that rounding harmony in certain languages be represented by means of multiple rules. Vaux explicitly rejects the proposition that labial attraction and labial harmony constitute a unified phenomenon. Whether or not his position on this matter is justified, and I am obviously of the opinion that it is not, I presume that Vaux would view contextual rounding of high vowels (i.e. labial harmony) as a unified phenomenon. We saw above that the markedness theory in no way accounts for the typology of labial harmony and thus leaves a substantial portion of the typology presented in Chapter 3 unanalyzed.

And in fact, none of the rule-based approaches discussed here accounts for the observed typological facts. The optimality-theoretic analysis proposed earlier in this thesis, by contrast, constitutes an explicit formal system based on the interaction of substantive phonetic principles. Its success vis-à-vis the observed facts suggests that substantive approaches to phonology such as that presented here are worth pursuing further.

Appendix

All 120 constraint hierarchies containing the five proposed constraints are listed here, followed by the rounding harmony pattern which each one characterizes. The three unattested patterns are designated UA 1-3:

1.EXT[RD]>EXT[RD]IF[-BK]>*ROLO>UNI[RD]>EXT[RD]IF[-HI] *type 1*

2.EXT[RD]>EXT[RD]IF[-BK]>*ROLO>EXT[RD]IF[-HI]>UNI[RD] *type 1*

3.EXT[RD]>EXT[RD]IF[-BK]>UNI[RD]>*ROLO>EXT[RD]IF[-HI] *type 1*

4.EXT[RD]>EXT[RD]IF[-BK]>UNI[RD]>EXT[RD]IF[-HI]>*ROLO *type 1*

5.EXT[RD]>EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>*ROLO>UNI[RD] *type 1*

6.EXT[RD]>EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>UNI[RD]>*ROLO *type 1*

7.EXT[RD]>*ROLO>EXT[RD]IF[-BK]>UNI[RD]>EXT[RD]IF[-HI] *type 1*

8.EXT[RD]>*ROLO>EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>UNI[RD] *type 1*

9.EXT[RD]>*ROLO>UNI[RD]>EXT[RD]IF[-BK]>EXT[RD]IF[-HI] *type 1*

10.EXT[RD]>*ROLO>UNI[RD]>EXT[RD]IF[-HI]>EXT[RD]IF[-BK] *type 1*

11.EXT[RD]>*ROLO>EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>UNI[RD] *type 1*

12.EXT[RD]>*ROLO>EXT[RD]IF[-HI]>UNI[RD]>EXT[RD]IF[-BK] *type 1*

13.EXT[RD]>UNI[RD]>EXT[RD]IF[-BK]>*ROLO>EXT[RD]IF[-HI] *type 1*

14.EXT[RD]>UNI[RD]>EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>*ROLO *type 1*

15.EXT[RD]>UNI[RD]>*ROLO>EXT[RD]IF[-BK]>EXT[RD]IF[-HI] *type 1*

16.EXT[RD]>UNI[RD]>*ROLO>EXT[RD]IF[-HI]>EXT[RD]IF[-BK] *type 1*

17.EXT[RD]>UNI[RD]>EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>*ROLO *type 1*

18.EXT[RD]>UNI[RD]>EXT[RD]IF[-HI]>*ROLO>EXT[RD]IF[-BK] *type 1*

19.EXT[RD]>EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>*ROLO>UNI[RD] *type 1*

20.EXT[RD]>EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>UNI[RD]>*ROLO *type 1*

21.EXT[RD]>EXT[RD]IF[-HI]>*ROLO>EXT[RD]IF[-BK]>UNI[RD] *type 1*

22.EXT[RD]>EXT[RD]IF[-HI]>*ROLO>UNI[RD]>EXT[RD]IF[-BK] *type 1*

23.EXT[RD]>EXT[RD]IF[-HI]>UNI[RD]>EXT[RD]IF[-BK]>*ROLO *type 1*

24.EXT[RD]>EXT[RD]IF[-HI]>UNI[RD]>*ROLO>EXT[RD]IF[-BK] *type 1*

25.EXT[RD]IF[-BK]>EXT[RD]>*ROLO>UNI[RD]>EXT[RD]IF[-HI] *type 1*

26.EXT[RD]IF[-BK]>EXT[RD]>*ROLO>EXT[RD]IF[-HI]>UNI[RD] *type 1*

27.EXT[RD]IF[-BK]>EXT[RD]>UNI[RD]>*ROLO>EXT[RD]IF[-HI] *type 1*

28.EXT[RD]IF[-BK]>EXT[RD]>UNI[RD]>EXT[RD]IF[-HI]>*ROLO *type 1*

29.EXT[RD]IF[-BK]>EXT[RD]>EXT[RD]IF[-HI]>*ROLO>UNI[RD] *type 1*

30.EXT[RD]IF[-BK]>EXT[RD]>EXT[RD]IF[-HI]>UNI[RD]>*ROLO *type 1*

31.EXT[RD]IF[-BK]>*ROLO>EXT[RD]>UNI[RD]>EXT[RD]IF[-HI] *type 7*

32.EXT[RD]IF[-BK]>*ROLO>EXT[RD]>EXT[RD]IF[-HI]>UNI[RD] *type 7*

33.EXT[RD]IF[-BK]>*ROLO>UNI[RD]>EXT[RD]>EXT[RD]IF[-HI] *type 8*

34.EXT[RD]IF[-BK]>*ROLO>UNI[RD]>EXT[RD]IF[-HI]>EXT[RD] *type 8*

35.EXT[RD]IF[-BK]>*ROLO>EXT[RD]IF[-HI]>EXT[RD]>UNI[RD] *type 7*

36.EXT[RD]IF[-BK]>*ROLO>EXT[RD]IF[-HI]>UNI[RD]>EXT[RD] *type 8*

37.EXT[RD]IF[-BK]>UNI[RD]>EXT[RD]>*ROLO>EXT[RD]IF[-HI] *UA 3*

38.EXT[RD]IF[-BK]>UNI[RD]>EXT[RD]>EXT[RD]IF[-HI]>*ROLO *UA 3*

39.EXT[RD]IF[-BK]>UNI[RD]>*ROLO>EXT[RD]>EXT[RD]IF[-HI] *type 8*

40.EXT[RD]IF[-BK]>UNI[RD]>*ROLO>EXT[RD]IF[-HI]>EXT[RD] *type 8*

41.EXT[RD]IF[-BK]>UNI[RD]>EXT[RD]IF[-HI]>EXT[RD]>*ROLO *UA 3*

42.EXT[RD]IF[-BK]>UNI[RD]>EXT[RD]IF[-HI]>*ROLO>EXT[RD] *UA 3*

43.EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>EXT[RD]>*ROLO>UNI[RD] *type 1*

44.EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>EXT[RD]>UNI[RD]>*ROLO *type 1*

45.EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>*ROLO>EXT[RD]>UNI[RD] *type 9*

46.EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>*ROLO>UNI[RD]>EXT[RD] *type 9*

47.EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>UNI[RD]>EXT[RD]>*ROLO *type 9*

48.EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>UNI[RD]>*ROLO>EXT[RD] *type 9*

49.*ROLO>EXT[RD]>EXT[RD]IF[-BK]>UNI[RD]>EXT[RD]IF[-HI] *type 2*

50.*ROLO>EXT[RD]>EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>UNI[RD] *type 2*

51.*ROLO>EXT[RD]>UNI[RD]>EXT[RD]IF[-BK]>EXT[RD]IF[-HI] *type 2*

52.*ROLO>EXT[RD]>UNI[RD]>EXT[RD]IF[-HI]>EXT[RD]IF[-BK] *type 2*

53.*ROLO>EXT[RD]>EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>UNI[RD] *type 2*

54.*ROLO>EXT[RD]>EXT[RD]IF[-HI]>UNI[RD]>EXT[RD]IF[-BK] *type 2*

55.*ROLO>EXT[RD]IF[-BK]>EXT[RD]>UNI[RD]>EXT[RD]IF[-HI] *type 2*

56.*ROLO>EXT[RD]IF[-BK]>EXT[RD]>EXT[RD]IF[-HI]>UNI[RD] *type 2*

57.*ROLO>EXT[RD]IF[-BK]>UNI[RD]>EXT[RD]>EXT[RD]IF[-HI] *UA 1*

58.*ROLO>EXT[RD]IF[-BK]>UNI[RD]>EXT[RD]IF[-HI]>EXT[RD] *UA 1*

59.*ROLO>EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>EXT[RD]>UNI[RD] *type 2*

60.*ROLO>EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>UNI[RD]>EXT[RD] *type 2*

61.*ROLO>UNI[RD]>EXT[RD]>EXT[RD]IF[-BK]>EXT[RD]IF[-HI] *type 4*

62.*ROLO>UNI[RD]>EXT[RD]>EXT[RD]IF[-HI]>EXT[RD]IF[-BK] *type 4*

63.*ROLO>UNI[RD]>EXT[RD]IF[-BK]>EXT[RD]>EXT[RD]IF[-HI] *type 4*

64.*ROLO>UNI[RD]>EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>EXT[RD] *type 4*

65.*ROLO>UNI[RD]>EXT[RD]IF[-HI]>EXT[RD]>EXT[RD]IF[-BK] *type 4*

66.*ROLO>UNI[RD]>EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>EXT[RD] *type 4*

67.*ROLO>EXT[RD]IF[-HI]>EXT[RD]>EXT[RD]IF[-BK]>UNI[RD] *type 2*

68.*ROLO>EXT[RD]IF[-HI]>EXT[RD]>UNI[RD]>EXT[RD]IF[-BK] *type 2*

69.*ROLO>EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>EXT[RD]>UNI[RD] *type 2*

70.*ROLO>EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>UNI[RD]>EXT[RD] *type 2*

71.*ROLO>EXT[RD]IF[-HI]>UNI[RD]>EXT[RD]>EXT[RD]IF[-BK] *type 2*

72.*ROLO>EXT[RD]IF[-HI]>UNI[RD]>EXT[RD]IF[-BK]>EXT[RD] *type 2*

73.UNI[RD]>EXT[RD]>EXT[RD]IF[-BK]>*ROLO>EXT[RD]IF[-HI] *type 6*

74.UNI[RD]>EXT[RD]>EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>*ROLO *type 6*

75.UNI[RD]>EXT[RD]>*ROLO>EXT[RD]IF[-BK]>EXT[RD]IF[-HI] *type 6*

76.UNI[RD]>EXT[RD]>*ROLO>EXT[RD]IF[-HI]>EXT[RD]IF[-BK] *type 6*

77.UNI[RD]>EXT[RD]>EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>*ROLO *type 6*

78.UNI[RD]>EXT[RD]>EXT[RD]IF[-HI]>*ROLO>EXT[RD]IF[-BK] *type 6*

79.UNI[RD]>EXT[RD]IF[-BK]>EXT[RD]>*ROLO>EXT[RD]IF[-HI] *type 6*

80.UNI[RD]>EXT[RD]IF[-BK]>EXT[RD]>EXT[RD]IF[-HI]>*ROLO *type 6*

81.UNI[RD]>EXT[RD]IF[-BK]>*ROLO>EXT[RD]>EXT[RD]IF[-HI] *UA 2*

82.UNI[RD]>EXT[RD]IF[-BK]>*ROLO>EXT[RD]IF[-HI]>EXT[RD] *UA 2*

83.UNI[RD]>EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>EXT[RD]>*ROLO *type 6*

84.UNI[RD]>EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>*ROLO>EXT[RD] *type 6*

85.UNI[RD]>*ROLO>EXT[RD]>EXT[RD]IF[-BK]>EXT[RD]IF[-HI] *type 4*

86.UNI[RD]>*ROLO>EXT[RD]>EXT[RD]IF[-HI]>EXT[RD]IF[-BK] *type 4*

87.UNI[RD]>*ROLO>EXT[RD]IF[-BK]>EXT[RD]>EXT[RD]IF[-HI] *type 4*

88.UNI[RD]>*ROLO>EXT[RD]IF[-BK]>EXT[RD]IF[-HI]>EXT[RD] *type 4*

89.UNI[RD]>*ROLO>EXT[RD]IF[-HI]>EXT[RD]>EXT[RD]IF[-BK] *type 4*

90.UNI[RD]>*ROLO>EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>EXT[RD] *type 4*

91.UNI[RD]>EXT[RD]IF[-HI]>EXT[RD]>EXT[RD]IF[-BK]>*ROLO *type 6*

92.UNI[RD]>EXT[RD]IF[-HI]>EXT[RD]>*ROLO>EXT[RD]IF[-BK] *type 6*

93.UNI[RD]>EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>EXT[RD]>*ROLO *type 6*

94.UNI[RD]>EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>*ROLO>EXT[RD] *type 6*

95.UNI[RD]>EXT[RD]IF[-HI]>*ROLO>EXT[RD]>EXT[RD]IF[-BK] *type 6*

96.UNI[RD]>EXT[RD]IF[-HI]>*ROLO>EXT[RD]IF[-BK]>EXT[RD] *type 6*

97.EXT[RD]IF[-HI]>EXT[RD]>EXT[RD]IF[-BK]>*ROLO>UNI[RD] *type 1*

98.EXT[RD]IF[-HI]>EXT[RD]>EXT[RD]IF[-BK]>UNI[RD]>*ROLO *type 1*

99.EXT[RD]IF[-HI]>EXT[RD]>*ROLO>EXT[RD]IF[-BK]>UNI[RD] *type 1*

100.EXT[RD]IF[-HI]>EXT[RD]>*ROLO>UNI[RD]>EXT[RD]IF[-BK] *type 1*

101.EXT[RD]IF[-HI]>EXT[RD]>UNI[RD]>EXT[RD]IF[-BK]>*ROLO *type 1*

102.EXT[RD]IF[-HI]>EXT[RD]>UNI[RD]>*ROLO>EXT[RD]IF[-BK] *type 1*

103.EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>EXT[RD]>*ROLO>UNI[RD] *type 1*

104.EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>EXT[RD]>UNI[RD]>*ROLO *type 1*

105.EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>*ROLO>EXT[RD]>UNI[RD] *type 9*

106.EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>*ROLO>UNI[RD]>EXT[RD] *type 9*

107.EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>UNI[RD]>EXT[RD]>*ROLO *type 9*

108.EXT[RD]IF[-HI]>EXT[RD]IF[-BK]>UNI[RD]>*ROLO>EXT[RD] *type 9*

109.EXT[RD]IF[-HI]>*ROLO>EXT[RD]>EXT[RD]IF[-BK]>UNI[RD] *type 5*

110.EXT[RD]IF[-HI]>*ROLO>EXT[RD]>UNI[RD]>EXT[RD]IF[-BK] *type 5*

111.EXT[RD]IF[-HI]>*ROLO>EXT[RD]IF[-BK]>EXT[RD]>UNI[RD] *type 5*

112.EXT[RD]IF[-HI]>*ROLO>EXT[RD]IF[-BK]>UNI[RD]>EXT[RD] *type 5*

113.EXT[RD]IF[-HI]>*ROLO>UNI[RD]>EXT[RD]>EXT[RD]IF[-BK] *type 5*

114.EXT[RD]IF[-HI]>*ROLO>UNI[RD]>EXT[RD]IF[-BK]>EXT[RD] *type 5*

115.EXT[RD]IF[-HI]>UNI[RD]>EXT[RD]>EXT[RD]IF[-BK]>*ROLO *type 5*

116.EXT[RD]IF[-HI]>UNI[RD]>EXT[RD]>*ROLO>EXT[RD]IF[-BK] *type 5*

117.EXT[RD]IF[-HI]>UNI[RD]>EXT[RD]IF[-BK]>EXT[RD]>*ROLO *type 5*

118.EXT[RD]IF[-HI]>UNI[RD]>EXT[RD]IF[-BK]>*ROLO>EXT[RD] *type 5*

119.EXT[RD]IF[-HI]>UNI[RD]>*ROLO>EXT[RD]>EXT[RD]IF[-BK] *type 5*

120.EXT[RD]IF[-HI]>UNI[RD]>*ROLO>EXT[RD]IF[-BK]>EXT[RD] *type 5*

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