A Feature-based Interpretation of the Behavior of /a/ in Vowel Harmony Languages

Planting, Manon

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Manon Planting

S2623390

University of Leiden

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Thesis supervisor: Dr. E. D. Botma

Second reader: Prof. dr. J. Grijzenhout

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Abstract

In vowel harmony, all vowels in (roughly) a word agree with one another regarding one of their features. Vowels in such languages can harmonize with regard to backness, rounding, height, and tongue root position. Vowels can be described in terms of phonological features. Some feature combinations are 'preferable' to others, as Archangeli and Pulleyblank (1994) argue in Grounding Theory. Based on these feature relationships, the low vowel /a/ in particular may show interesting behavior in vowel harmony. This thesis therefor examined the following research question: How can a feature-based interpretation account for the behavior of /a/ in vowel harmony languages? In order to research this, data from Tuvan (backness), Kirghiz (rounding), C'lela (height), and Maasai (tongue root position) have been used. Findings show that a feature-based interpretation can account for the behavior of /a/ in vowel harmony languages. /a/ alternates in some languages, and fails to harmonize in others. When /a/ participates in vowel harmony, it has to seek its counterpart slightly higher in the vowel triangle, as predicted by Grounding Theory. Feature relationships show that some combinations of features are preferable, and thus result in successful harmony, while others are avoided. These 'poor' combinations of features often result in failure to harmonize. All in all, a feature-based interpretation can account for the behavior of /a/ in vowel harmony languages. These findings suggest that the behavior of /a/ is predictable by a feature-based interpretation.

Keywords: feature relationships, /a/, vowel harmony, Grounding Theory

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A Feature-based Interpretation of the Behavior of /a/ in Vowel Harmony Languages

1. Introduction

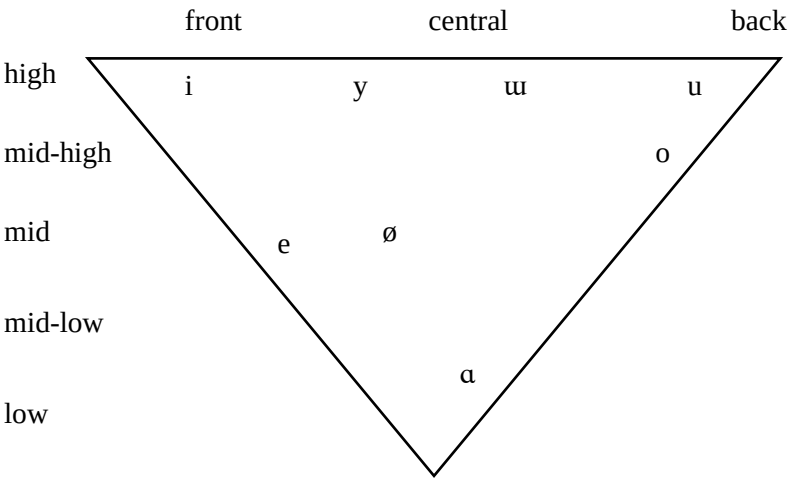
Vowel harmony is the process in which "all vowels in (roughly speaking) a word are required to agree with each other with respect to one of their properties" (Polgárdi, 1998: 193). Vowels in vowel harmony languages can harmonize with regard to backness, rounding, height, and tongue root position (van der Hulst, 2016).

Phonetically, vowel sounds are described in terms of acoustic and articulatory properties, and phonologically, these vowel sounds can be described in terms of features. Some combinations of phonological features are more common than others (Archangeli & Pulleyblank, 1994; Kaun, 2009; Ladefoged & Maddieson, 1996). Based on these feature relationships, the low vowel /a/ in particular may show interesting behavior in vowel harmony (see page 10). This essay will therefore examine the following research question: How can a feature-based interpretation account for the behavior of /a/ in vowel harmony languages? In order to research this, data from Tuvan (backness), Kirghiz (rounding), C'lela (height), and Maasai (tongue root position) will be used to describe and compare the behavior of /a/. Then, the research will examine how a feature-based interpretation may account for this behavior.

In vowel harmony, some vowel feature combinations are more common than others. Vowels may be described phonetically and phonologically. A phonetic description is based on the individual speech sounds and their acoustic and articulatory properties, while a phonological description focuses on how these speech sounds behave in language. Vowels can be described articulatorily and acoustically (through formants). Articulatory gestures can be described in terms of place of articulation. Differences in vowels are produced by movement of the lips and tongue. The place of the tongue is often (roughly) described in terms of relative vowel qualities as shown in (1) (Ladefoged & Johnson, 2015).[1] [2]

[1] The vowel triangles in (1) and (2) have been adapted from Ladefoged and Johnson, 2015: 46 to show the vowels of the Turkish inventory, as chapter 2 explains vowel harmony through Turkish harmony.
[2] The vowel diagrams are represented as a triangle rather than a quadrilateral shape. Only less than 10 percent of languages, among which is English, has a quadrilateral vowel system (Skandera & Burleigh, 2005).

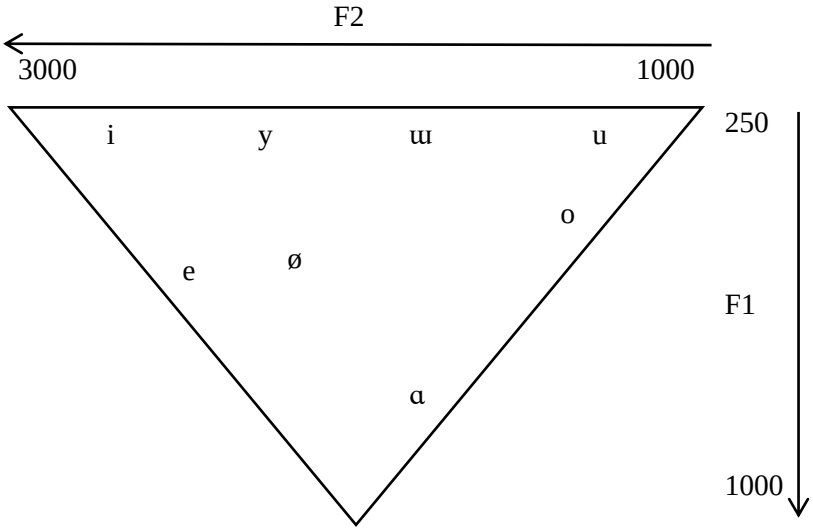
(1)



Here, [i] is a high front vowel, while [ɑ] is a low back vowel and [u] is a high back vowel. This diagram is a rough representation of vowel height and backness, rather than a literal one, and does not show lip rounding. Gestures by the tongue and lips affect the acoustic properties of vowel sounds. The acoustic entities of phonetic vowel sounds are described in terms of the frequencies of the overtones of the pitch or fundamental frequency. These overtones are called formants, and the formants distinguish between vowel sounds. As can be seen in (2), the first formant (F1) is shown on the vertical axis, and the second formant (F2) is shown on the horizontal axis, both measured in Hz. The vowels are plotted onto the vowel diagram, showing the dispersion of vowels, resulting in a diagram that is strikingly similar to (1). [i] for example has low F1 and high F2, while [ɑ] has high F1 and low to mid F2. [u] is low in both F1 and F2 (Ladefoged & Johnson, 2015: 207).[3]

[3] The vowels as shown in (2) and in the vowel diagrams throughout the rest of this thesis represent the rough formant values and locations in the diagram, since the exact formant values vary between languages and between speakers.

(2)



Phonologically, differences between vowels can be formalized in terms of features (Trubetskoy, 1958). These features allow for characterization of classes of sounds (e.g. all high vowels, or all back vowels). The features also allow for descriptions of the behavior of these classes. The four main features that are used to describe vowel sounds are [±high], [±back], [±ATR], and [±round]. To describe mid and central vowels, the features [±low] and [±front] may be added. In (3) a feature specification for some vowels is given (taken from Carr & Montreuil, 2013: 61). The vowels shown are those relevant to this thesis.

(3)

	i	ɪ	e	ɛ	a	ɑ	ɔ	o	ʊ	u	ɯ	y	ø	ɨ
high	+	+	-	-	-	-	-	-	+	+	+	+	-	+
low	-	-	-	-	+	+	-	-	-	-	-	-	-	-
ATR	+	-	+	-	-	-	-	+	-	+	+	+	+	+
back	-	-	-	-	-	+	+	+	+	+	+	-	-	-
front	+	+	+	+	-	-	-	-	-	-	-	+	+	-
round	-	-	-	-	-	-	+	+	+	+	-	+	+	-

Using features, [a] is specified as a [-high, +low, -ATR, -back, -front, -round] vowel. When describing a vowel in a particular language, only the contrastive features are used. That is, if a language only has high vowels and one low vowel, the feature [-high] suffices to describe this vowel. In this thesis, this binary phonological feature system will be used in line with Archangeli and

Pulleyblank (2007), van der Hulst (2016), and van der Hulst and van de Weijer (1995). This binary system proposed by Chomsky and Halle (1968) is based mostly on articulatory gestures.[4]

As Archangeli and Pulleyblank note, some of these features overlap, and others do not combine frequently. For example, generally, if a sound is a vowel, giving it the feature [-cons], then it is also [+voice]. In fact, vowels are physically correlated with voicing. Archangeli and Pulleyblank refer to these physically determined feature combinations as Grounding Theory, since the conditions are physically grounded. These implicational statements may be positive or negative. If [-cons], then [+voice], also implies that if [-cons] then *not* [-voice]. Grounding Theory may also account for certain specific aspects of harmony systems. In Turkish, for example, there is only one low vowel, which happens to also be [+back]. In Turkish, it can therefore be stated that if [-high], then [+back].

Using Grounding Theory, some preferences for and restrictions on feature combinations can be expressed. For example, [±back] and [±round] is a salient combination of vowels. It is not commonly restricted. Combinations of [±back] and [±high], and [±ATR] and [±high], on the other hand, are often avoided. The cause of restrictions on feature combinations is found in the articulation and the acoustics. Tongue root height (represented by [±ATR], which stands for advanced tongue root) and tongue body height ([±high]) are physically connected, so that if the tongue body is high, the tongue root is often also high. Archangeli and Pulleyblank (1994: 175-176) list the implications of this combination as follows:

(4)
[+high] implies [+ATR], not [-ATR]
[+low] implies [-ATR], not [+ATR]
[+ATR] implies [+high], not [-high]
[-ATR] implies [-high], not [+high]

Indeed, languages with an [ATR] contrast in low vowels appear to be rare, showing that there is, in general, an avoidance for [-ATR, +low] vowels based on speech gestures.

[4] Alternatively, other sources use a monovalent system such as Element Theory as proposed by Backley, 2011. For discussions of vowel harmony using monovalent systems, see Polgárdi (1998) Rose and Walker (2011) and Krämer (2003).

Acoustically, features with opposite effects on the formants are less likely to co-occur (Ladefoged & Maddieson, 1996). Below, the effect of each of the gestures and their corresponding features on the first and second formants is shown.[5]

(5)

	F1	F2
[+high]	↓	
[-high]	↑	
[+back]		↓
[-back]		↑
[+round]	↓	↓
[-round]	-	-
[+ATR]	↓	
[-ATR]	↑	

Some features are antagonistic (listed in (6)). These opposing effects account for the restrictions on feature combinations.

(6) Antagonistic

[-high]	[+round]
[+high]	[-ATR]
[-high]	[+ATR]
[-back]	[+round]

An example of these antagonistic features is the effect of the features [-high] and [+round]. While [-high] represents a high F1, the feature [+round] lowers the F1. These features have opposite effects, and this combination is therefore likely to be avoided in the phonology of languages. Kaun (2009) shows that in the majority of rounding harmony languages, rounding is found to be restricted by height, so that only the [+high] vowels participate in rounding harmony. Similarly, there is an avoidance of antagonistic specifications for [ATR] and [high]. Articulatorily, there is an avoidance for the same tongue root and tongue base height. Backness and rounding are generally common combinations with few restrictions (Ladefoged & Maddieson, 1996). However, [-back] and [+round] do form an opposition acoustically. As a result, front rounded vowels, for example [y, ø], are not very

[5] The feature [-round] represents the lack of a gesture, i.e. the lips are not rounded, and therefore it has no additional effect on the formants.

common across language inventories. These opposing acoustic effects and articulatory effects account for the restrictions on feature combinations.

It is therefore no surprise that the features with complementary effects (see (7)) are those combinations that yield the most common vowels.

(7) Complementary

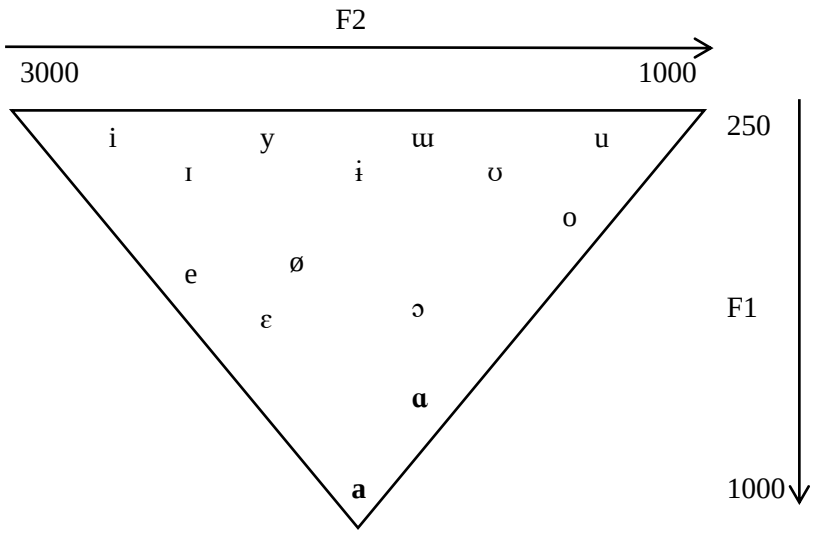
[+high]	[+round]	u
[-high]	[-ATR]	a
[+back]	[+round]	u o
[+round]	[+ATR]	o u
[+high]	[+ATR]	i u

The features that have similar effects on the formants are cross-linguistically common feature combinations such as those seen in /a/, /i/, and /u/ (Becker-Kristal, 2010). It is likely that these feature relationships are also reflected in vowel harmony, since vowels harmonize with regard to a feature, as will be seen in chapter 2.

This thesis will examine what the behavior of the low vowel /a/ is in vowel harmony languages, given the feature relationships. The low vowel /a/ is worth zooming in on for several reasons. First, the feature [±high] is a part of three of the four restricted combinations, making it likely that /a/ will behave in various interesting ways. Additionally, /a/ is interesting because of its location in the vowel diagram. Articulatorily and acoustically, /a/ is low, providing it with little room to find a harmonic counterpart that agrees in all features but the harmonic. This is also evident when looking at the feature specifications in (3), where /a/ and /ɑ/ are the only [+low] vowels. Additionally, it is relatively far removed from other vowels in the triangle in (8).[6] These interrelated reasons might cause /a/ to show interesting behavior in vowel harmony languages.

[6] Here, both /a/ and /ɑ/ are depicted. In some languages, /a/ may be phonetically more like [ɑ].

(8)



This introductory chapter has shown that there are reasons to believe that a feature-based interpretation may account for the behavior of vowels in vowel harmony processes. The low vowel /a/, in particular, might show interesting behavior, due to its low location in the vowel triangle. It is also worth focusing on due to the feature relationships. Since /a/ is specified as [-high], it is likely to be restricted when interacting with other features like [+round] and [+ATR]. The main question this thesis sets out to answer is: How can a feature-based approach account for the behavior of /a/ in vowel harmony languages?

The remainder of the thesis is organized as follows. First, the process of vowel harmony is detailed. After this, each vowel harmony type is exemplified by a corresponding language. These languages include Tuvan (backness), Kirghiz (rounding), C'lela (height), and Maasai (tongue root position). For each language, a description of the vowel harmony process is given, after which the behavior of /a/ is examined. It is then examined how phonological properties and feature relationships can account for the behavior of /a/ in vowel harmony languages. These findings are discussed, and some suggestions are made for future research based on these findings.

2. Vowel Harmony

Vowel harmony is a process in which "all vowels in (roughly speaking) a word are required to agree with each other with respect to one of their properties" (Polgárdi, 1998: 193). Vowels in vowel harmony languages can harmonize with regard to backness, rounding, tongue root position and height (van der Hulst, 2016). These various types of vowel harmony will be discussed in more detail in section 2.6. Chapter 2 will use Turkish vowel harmony as an example to introduce key aspects of vowel harmony. These aspects are then further detailed in the remainder of the second chapter. Unless otherwise specified, the following overview of the basic properties of vowel harmony is based on Archangeli and Pulleyblank (2007), Casali (2008), Ewen and van der Hulst (2001), Hyman (2002), Krämer (2003), Polgárdi (1998), Rose and Walker (2011), van der Hulst (2016), and van der Hulst and van de Weijer (1995). Turkish data and analyses are based on Clements and Sezer (1982) and Ewen and van der Hulst (2001), except where stated differently.

2.1 Key Aspects of Vowel Harmony

Turkish has fronting and rounding harmony. The Turkish vowel inventory shows that there are vowel pairs in terms of roundness and backness forming a symmetric set of vowels (see (9)). This is referred to as a symmetric vowel inventory. In an asymmetric harmony system, one or more vowels lack a harmonic counterpart (data from Ewen and van der Hulst, 2001: 46).

(9)

	[-back]		[+back]	
	[-round]	[+round]	[-round]	[+round]
[+high]	i	y	ɨ	u
[-high]	e	ø	ɑ	o

Turkish backness harmony dictates that if a vowel in the root of the word is [+back], the vowels to the right of this vowel are also [+back], and if a root vowel is [-back], the vowels to its right are also [-back]. This is illustrated by the pluralizing suffix in (10). The suffix alternates between /ler/ and /lɑr/ to form plural nouns, depending on the preceding vowel. /ler/ occurs after front vowels (10a), while /lɑr/ follows back vowels (10b); data from Clements & Sezer, 1982: 216).

(10)		Singular noun	Plural noun	
	a.	ip	ip-ler	‘rope’
		jyz	jyz-ler	‘face’
		el	el-ler	‘hand’
		køj	køj-ler	‘village’
	b.	kɨz	kɨz-lɑr	‘girl’
		pul	pul-lɑr	‘stamp’
		sɑp	sɑp-lɑr	‘stalk’
		son	son-lɑr	‘end’

As illustrated in (11), the Turkish word for ‘rope’, /ip/, has a [-back] vowel, causing it to spread the feature [-back] onto the suffix vowel, so that it surfaces as /ler/.[7] The representation in (11) is an autosegmental representation. It shows that the feature [back] is autosegmental, meaning that it is (to some extent) independent of the segments. This allows the feature to spread from the root vowel /i/, to the suffix vowel /e/.

(11)

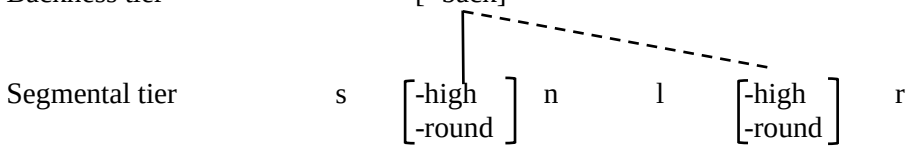
	[ip-ler]	‘rope.PL’				
Backness tier		[-back]				
Segmental tier		[+high -round]	p	l	[-high -round]	r

In (12), /son/ spreads [+back] to the suffix, so that the surface form /lɑr/ is generated, resulting in the final form /sonlɑr/. In both (11) and (12), the features [high] and [round] are already specified. The backness of the vowel is predictable, because it is defined by that of the preceding vowel. Therefore, the suffix vowel can be analyzed as being unspecified for [back].

[7] See appendix A for a list of abbreviated morphological terminology like PL.

(12)

[son-lɑr] ‘end.PL’



From these autosegmental representations it also becomes apparent that vowel harmony only targets the vowels. Consonants are skipped by the harmony process. Because the feature is autosegmental, it can affect other non-adjacent phonemes. Though this appears to be a non-local process, vowel harmony is in fact local. Since the feature [back] can be attached to vowels only, it ignores the consonants, and spreads to vowel sounds. The issue of locality will receive further attention in section 2.2.

(11) and (12) also show that both [-back] and [+back] features spread from the root to the suffix. In the case of Turkish, features are spread from left to right. In other languages, this may also occur from right to left, or bidirectionally. In languages like Turkish, the root vowels control the suffix vowels, making it a root-controlled harmony system. In languages where harmony spreads bidirectionally, the feature is often dominant, so that it spreads regardless of whether it originated in the root or in an affix. Such harmony is called dominant-recessive. Root-controlled and dominant-recessive patterns will receive further attention in section 2.3.

Though most roots in Turkish are harmonic (13a), there are also some Turkish morphemes with disharmonic roots, meaning the vowels in the root do not harmonize with regard to [back] (13b) (data from Clements & Sezer, 1982: 222 and Ewen & van der Hulst, 2001: 47). Such disharmonic roots are commonly loan words.

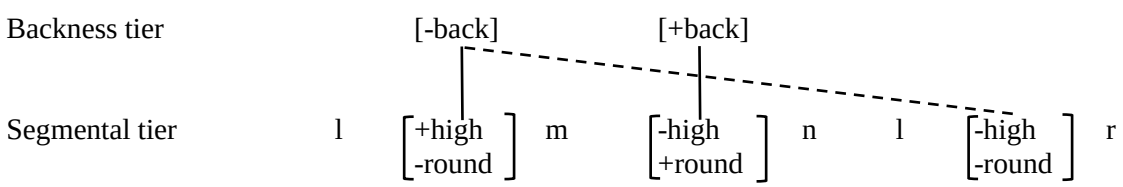
(13) a. dere ‘river’
yty ‘iron’
inek ‘cow’
boru ‘pipe’

b. hamsi ‘anchovies’
anne ‘mother’
polis ‘police’
model ‘model’
muhit ‘neighborhood’

When a disharmonic root is followed by a suffix, the suffix vowel is determined by the final root vowel. The first vowel maintains its own value. For example, for the loan word /limon/, ‘lemon’, /i/ is [-back], while /o/ is [+back]. As can be seen in (14), */limon-ler/ is not possible due to the no-crossing constraint, which dictates that association lines may not be crossed (Goldsmith, 1976). Instead, the [+back] feature is spread onto the suffix vowel, resulting in /limonlɑr/ (15).

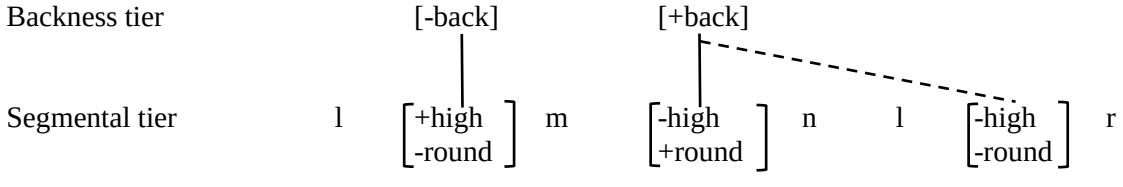
(14)

*[limon-ler] ‘lemon.PL’



(15)

[limon-lɑr] ‘lemon.PL’



In addition to backness harmony, Turkish also has rounding harmony. The genitive noun is followed by a suffix which alternates between [un], [yn], [ɨn], and [in]. The suffix vowel is specified for height as [+high], but harmonizes with regard to backness and roundness, depending on the preceding suffix (see (16); data from Clements & Sezer, 1982: 216).

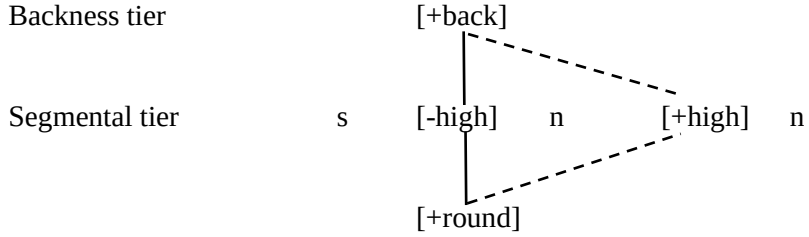
(16)

NOM.SG	NOM.PL	GEN.SG	GEN.PL	
ip	ip-ler	ip-in	ip-ler-in	‘rope’
kɨz	kɨz-lɑr	kɨz- ɨn	kɨz-lɑr- ɨn	‘girl’
jyz	jyz-ler	jyz-yn	jyz-ler-in	‘face’
pul	pul-lɑr	pul-un	pul-lɑr- ɨn	‘stamp’
el	el-ler	el-in	el-ler-in	‘hand’
sɑp	sɑp-lɑr	sɑp- ɨn	sɑp-lɑr- ɨn	‘stalk’
köj	køj-ler	køj- yn	køj-ler-in	‘village’
son	son-lɑr	son-un	son-lɑr- ɨn	‘end’

Since fronting and rounding are predictable, the vowel in the suffix can be left underspecified. The root vowel in /son/, for example, is [+back] and [+round], causing the suffix vowels to take on these properties. The features [back] and [round] are both on an autosegmental tier, and may spread independently of the segments (see (17)). Since it is already specified for height, the singular genitive noun surfaces as /sonun/.

(17)

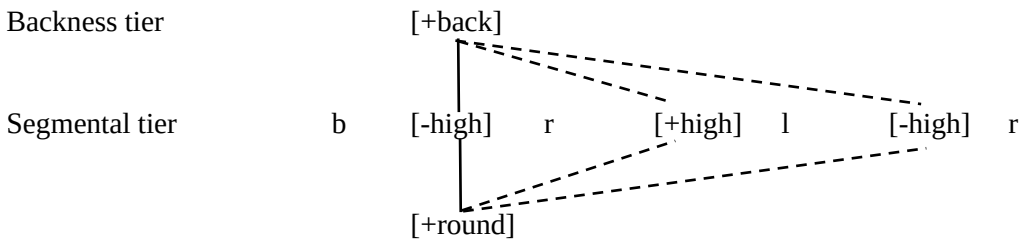
[sonun] ‘end.GEN’



There are also some suffix vowels that do not behave as expected. It was previously noted that the pluralizing suffix alternates between /ler/ and /lɑr/. However, when taking into account rounding and fronting harmony, root nouns like /boru/ and /yty/ are predicted to produce plural forms /borulor/ and /ytylør/ in (18). Nevertheless, as can be seen in (19), /boru/ and /yty/ are followed by /ler/ and /lɑr/ (data from Ewen & van der Hulst, 2001: 48).

(18)

*[borulor] ‘pipe.PL’



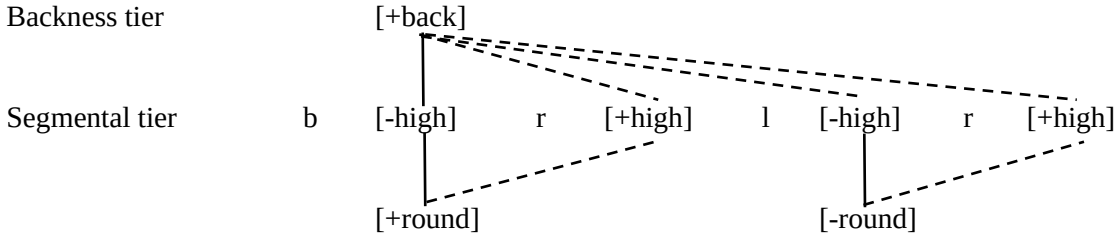
(19)

ABS.SG	ABS.PL	POSS.PL	
boru	borulɑr	borulɑrɨ	‘pipe’
yty	ytyler	ytyleri	‘iron’

So, even though the word /boru/ ends in a rounded back vowel, the plural suffix surfaces as /lɑr/. Moreover, the unrounded vowel appears to block spreading to the following vowels as well (20). The possessive plural suffix, which is realized as either [i] or [ɨ], surfaces as the unrounded version [ɨ], as the result of spreading of the [-round] feature of the preceding low vowel.

(20)

[boru-lɑr-ɨ] ‘pipe.POSS.PL’

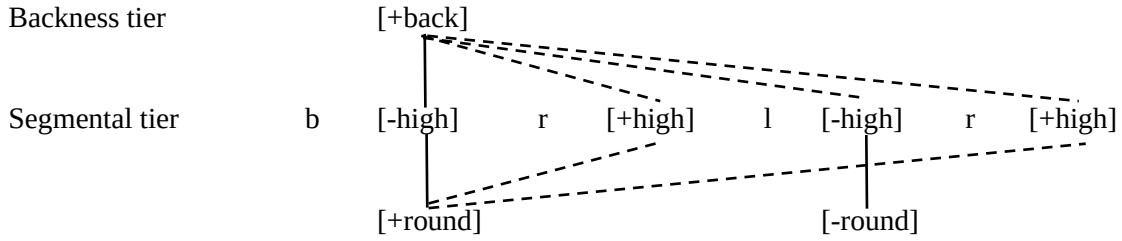


This example shows that in Turkish, the low vowel is ‘opaque’ for roundness. It blocks spreading of [±round], while still allowing for the feature [back] to be spread. Opaque vowels are vowels that do not participate in vowel harmony, and block any further spreading to other vowels. Instead, opaque vowels continue to spread their own feature specifications. Other languages in which vowels do not harmonize as expected, might have transparent vowels. Here, a vowel does not block spreading, but instead it is ignored by the harmony process. If /ɑ/ in Turkish were transparent for rounding – which it is not – the spreading of [+round] would continue beyond /ɑ/, resulting in the

surface form /*boru-lɑr- u/. In this case, /ɑ/ would remain unaffected by rounding, but the vowels following /ɑ/ would harmonize, as shown in (21).

(21)

[*boru-lɑr- u] ‘pipe.POSS.PL’



Opaque and transparent vowels are referred to as neutral vowels. These remain neutral while the other vowels harmonize (see section 2.5).

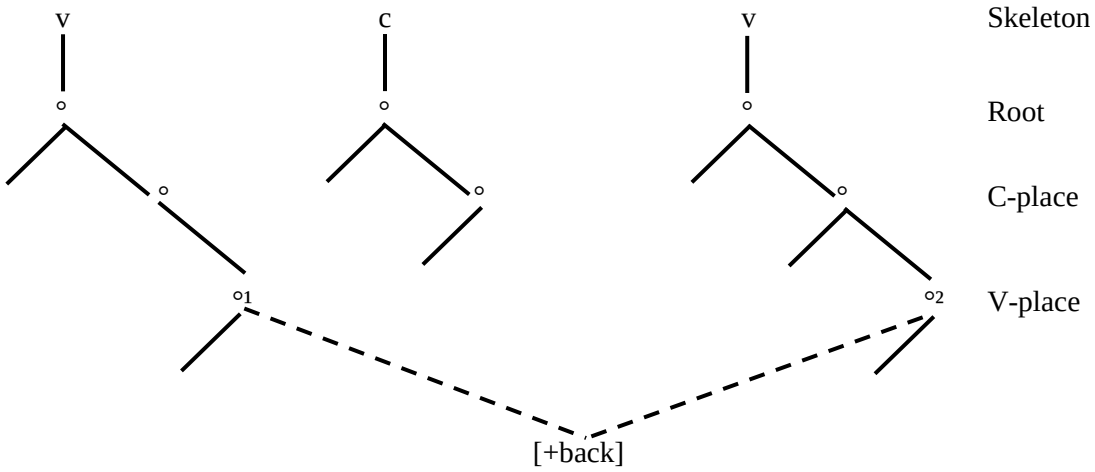
Although Turkish is a clear example of vowel harmony processes, some aspects of vowel harmony deserve further attention. The rest of this chapter will consider a number of aspects of vowel harmony in more detail.

2.2 Locality

The first aspect of vowel harmony that deserves attention is locality. In the examples of Turkish vowel harmony in the previous section, it became apparent that consonants are (usually) transparent. It also became clear that, although vowel harmony appears to be non-local, it is in fact local, because the features that are spread in vowel harmony do not affect consonants. As Archangeli and Pulleyblank (2007: 353) point out, harmony systems require “that two or more not-necessarily-adjacent segments must be similar in some way”. In vowel harmony, only the vowels are targeted, while the consonants are transparent. The idea of a distinction between assimilation of adjacent and non-adjacent segments is referred to as *locality*. Though vowel harmony is commonly seen as a non-local association, this idea must be “addressed with suspicion”, since few assimilatory processes are in fact non-local (van der Hulst & van de Weijer, 1995: 507). Feature sharing must somehow be local. A particular mechanism is required for vowel harmony which accounts for locality in vowel harmony, but does not overgenerate. Van der Hulst and van de Weijer (1995) suggest that this locality is

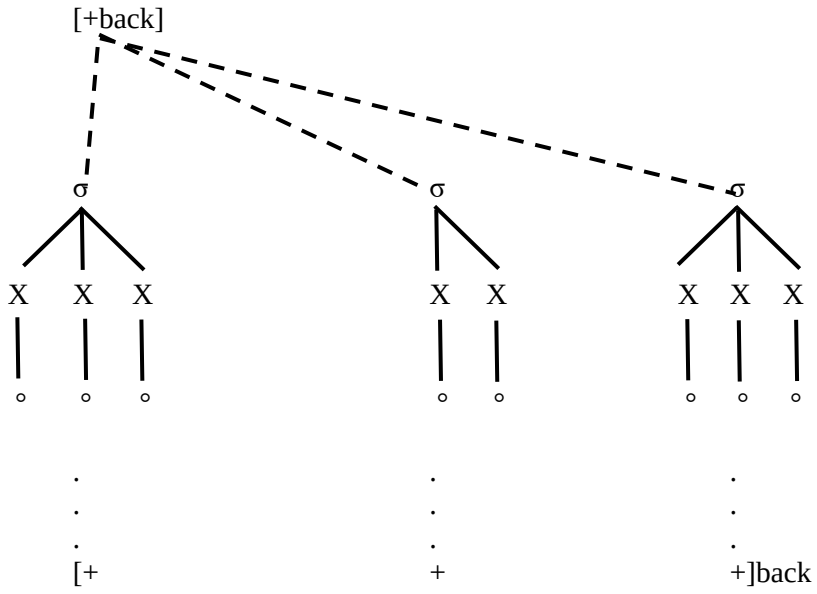
constructed through a geometrical approach, or a syllable-head approach. In the geometrical approach, the place nodes connect the targeted vowels (22). Here, spreading takes place from segment to segment, so that the V-place tier is considered local. The segments on the C-place tier are skipped, because they are non-local.

(22) A geometrical approach to locality



In the syllable-head approach (23) the same principle accounts for vowel harmony. The harmony process operates on the level of syllable heads, so that all other segments are unaffected by harmony.

(23) A syllable-head approach to locality



Both the geometrical approach and the syllable-head approach are ways in which the locality of vowel harmony can be explained. The issue of locality will not receive further attention in this thesis. For other discussions regarding locality in vowel harmony, see Nevins (2010) and Krämer (2003). For the purpose of this research, it will be assumed that vowels are local.

2.3 Directionality

The next aspect of vowel harmony that deserves attention is directionality. In section 2.1 it was illustrated that Turkish has rightward (progressive) vowel harmony. Vowel harmony can also be regressive (leftward), or bidirectional.

It is widely accepted that the directionality of harmony is determined by the morphology (Anderson, 1980; Archangeli & Pulleyblank, 2007; Baković, 2000; Rose & Walker, 2011; van der Hulst, 2016). Archangeli and Pulleyblank (2007: 366) argue that in many cases "root segments serve as triggers and affix segments serve as targets", so that strictly prefixing languages have regressive harmony, while strictly suffixing languages have progressive harmony. The process in which the root affects the affixes is called root-controlled harmony. In languages where the vowels in the affixes can control the root, the process is bidirectional. This is referred to as a dominant, or dominant-recessive harmony process. Van der Hulst (2016) argues that bidirectionality is commonly found in vowel harmony languages, and Hyman (2002) says that the unmarked direction is right to left.

As demonstrated in (11) and (12) in section 2.1, in Turkish vowel harmony, the vowels in the root of the word determine the form of the vowels in the affixes. Since root vowels control the affixes, Turkish has root-controlled vowel harmony.

An example of bidirectional harmony can be found in Akan (Clements, 1976; Hyman, 2008; Stewart, 1983), a language with ATR harmony spoken in Ghana. The inventory of Akan (Carr & Montreuil, 2013: 114) is given in (24).[8]

[8] The general convention puts front vowels to the left and back vowels to the right of the inventory. In this thesis, the order of the vowels in the inventories has been maintained from their original sources. A phonetically more accurate representation of the inventories of the four languages studied will be given in chapters 3 through 6 in the form of vowel triangles.

(24)

	[+ATR]		[-ATR]	
	[-back]	[+back]	[-back]	[+back]
[+high, -low]	i	u	ɪ	ʊ
[-high, -low]	e	o	ɛ	ɔ
[-high, +low]				ɑ

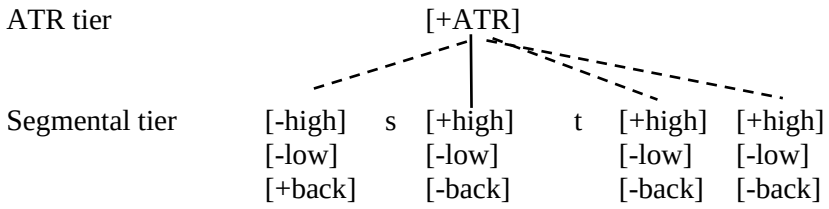
In Akan, the dominant feature [+ATR] spreads bidirectionally. [+ATR] spreads regardless of whether the triggering vowel is part of the root or the suffix. In (25a), there are no [+ATR] vowels, so that the entire surface representation is [-ATR]. In (25b), the ATR root vowels /i/ and /u/ spread [+ATR] to the root and the prefix of the word. This is illustrated more clearly in (26) (data from Clements, 1981: 114).

(25)

a.	[ɔ-čɪrɛ-ɪ]	‘he showed it’
	[ɛ-bʊ-ɔ]	‘stone’
b.	[o-siti-i]	‘he pierced it’
	[e-bu-o]	‘nest’

(26)

[o-siti-i] ‘he pierced it’



Since [+ATR] spreads regardless of morphological boundaries, Akan forms an example of dominant-recessive harmony.

2.4 Domain

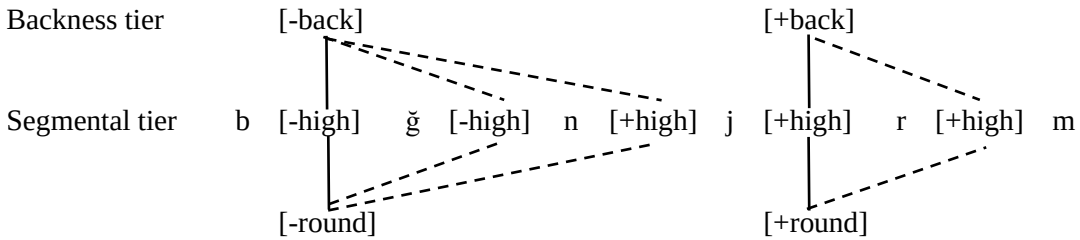
Section 2.1 considered various examples of Turkish vowel harmony in which the harmony occurred inside a word. The domain is “the maximal constituent to which harmony is confined” (Rose & Walker, 2011: 282). Even though the domain commonly operates within a word, domains may also be larger or smaller. For example, some Turkish suffixes and clitics end the harmonic domain, since they do not harmonize along with the root vowel features. Kabak and Vogel (2000) demonstrate that some

suffixes and clitics resist harmony and create a new domain throughout which harmony features are spread. The example in (27) shows that [-back, -round] harmony occurs in the root of the word (data from Kabak & Vogel, 2000: 344). Then, a new domain is formed by the disharmonic suffix /ijor/ 'progressive', with [+back, +round]. These features are spread to the following suffix, which is then realized as /um/. Kabak and Vogel (2000: 344) note that

> precisely the same blocking mechanism used for disharmonic roots (…) accounts for the spreading of features up to, but not including, a lexically specified vowel in a suffix or clitic, and the subsequent spreading of the new set of features.

(27)

[beğen-ijor-um] 'I like (it).'



The size of a domain can be restricted morphologically. The domain is determined by the root, affixes, and the word boundaries. Though rare, Somali shows that domains may reach across morpheme boundaries, covering entire clauses (see Krämer, 2003). More commonly, vowel harmony is bounded by morpheme boundaries. In Ngbaka, the domain is delimited by the root of the word, so that affix vowels do not harmonize (Archangeli & Pulleyblank, 1994, 2007; Rose & Walker, 2011; Stanton, 2022). The domain in Ngbaka is therefore smaller than the word. In disyllabic roots there are three options for harmony. The vowels may be identical as seen in (28a), or consist of a high vowel and /a/ as in (28b) (data from Archangeli & Pulleyblank, 2007: 365). Vowels may also agree in terms of tongue root position, when there are two distinct mid vowels (28c). However, as Archangeli and Pulleyblank (2007: 365) note, "importantly, this pattern does not extend beyond the domain of the root. Affix vowels do not alternate" (as can be seen in (28d)).

(28) Root-restricted harmony in Ngbaka

a.	jèlè	‘stranger’
	kamá	‘sibling’
b.	títa	‘grandparent’
	dúká	‘shoulder’
c.	sekò	‘chimpanzee’
	kɔndɛ̀	‘heart’
d.	zì-bɔ̀lɔ̀	‘what is right’

Other morpheme-based domains include Yoruba (Benue-Congo) harmony domains, which depend on the type of clitic. In some dialects of Yoruba, subject clitics harmonize, while in standard Yoruba, the subject clitics are not affected (Akinlabi & Liberman, 2000). Another domain is found in Kinande (Bantu) harmony, which has a process in which the triggering vowel in bidirectional harmony forms the center, so that the vowels farthest away from the trigger are least likely to harmonize (Archangeli & Pulleyblank, 2007; Mutaka, 1995).

2.5 Neutral Vowels

In section 2.1 it became clear that in Turkish, the low vowel is opaque to rounding harmony. In vowel harmony, vowels are either harmonizing or neutral (opaque or transparent).

Opaque vowels block harmony. An opaque vowel does not participate in vowel harmony, and keeps the feature from spreading to the following vowels. Instead, “an opaque vowel starts a harmonic domain of its own, in this way breaking up the harmonic unity of the word”(Polgárdi, 1998: 132). As demonstrated in (20), /ɑ/ in the Turkish word /boruloɑrɨ/ is opaque for roundness. While the feature [+back] is spread through the entire word, /ɑ/ blocks the spreading of [+round], and continues to spread [-round] instead.

In his analysis of opacity, van der Hulst (2016) uses the asymmetric vowel inventory of the Nigerian language Tangale see (29) (van der Hulst, 2016: 5).

(29)

	[+ATR]		[-ATR]	
	[-back]	[+back]	[-back]	[+back]
[+high, -low]	i	u	ɪ	ʊ
[-high, -low]	e	o	ɛ	ɔ
[-high, +low]				a

He argues that the Tangale inventory shows that the reason why opaque vowels fail to harmonize is that they have no alternating counterpart. However, this does not explain why the opaque vowel prevents harmony from spreading any further. Furthermore, this analysis falls short when examining symmetric languages like Turkish, where a [+round] counterpart of the low vowel is available in the inventory in the form of /o/ (see (9)).

Transparent vowels are passed through by harmony, so that the vowel harmony may occur in the vowels before and after the transparent vowel, but the transparent vowel remains unaffected. Finnish is a well-known example of this. Finnish has eight vowels, each of which may be long or short (see (30); data from Anderson, 1975, as referenced by van der Hulst & van de Weijer, 1995: 498).

(30)

	[-back]		[+back]	
	[-round]	[+round]	[-round]	[+round]
[+high][-low]	i	y		u
[-high][-low]	e	ø		o
[-high][+low]	æ		a	

Like Turkish, Finnish (Kiparsky, 1973; van der Hulst & van de Weijer, 1995) has backness harmony that spreads from left to right. In Finnish, root vowels must agree with regard to backness (see (31a)). There are no prefixes in Finnish, so harmony is spread from the root to the suffixes (see (31b)).

In the inventory in (30), there are two vowels that lack a harmonic counterpart. The front vowels /i/ and /e/ are transparent in Finnish, meaning that these vowels can occur in both [-back] and [+back] domains (31c). In contrast to the opaque round vowels in Turkish, the non-low unrounded front vowels in Finnish do not block spreading. Instead, the spreading of [+back] continues after /i/ and /e/. When a disharmonic root like /palttina/ with both [-back] and [+back] vowels is suffixed, this means the feature [+back] is spread, ignoring the front vowels (31d) (Kiparsky, 1973; data from van der Hulst & van de Weijer, 1995: 498-499).[9]

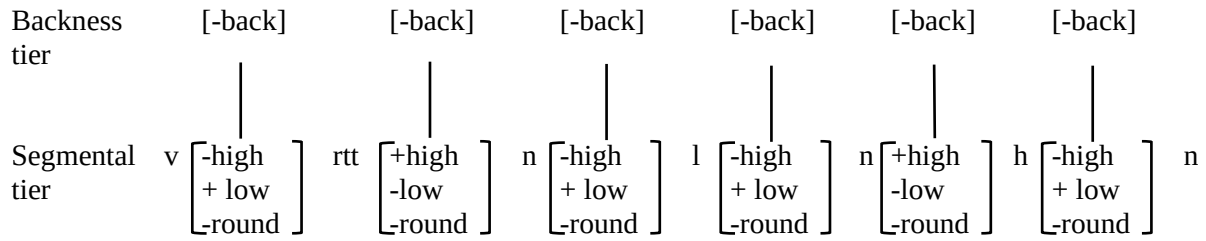
[9] Here, the low back vowel is transcribed as /a/, in keeping with van der Hulst and van de Weijer (1995). In other sources, the [+low][+back] vowel has also been transcribed as /ɑ/.

(31)	a.	pøyta	‘table’
		pouta	‘fine weather’
	b.	tyhmæ-stæ	‘stupid.ILL’
		tuhma-sta	‘naughty.ILL’
	c.	værttinæ	‘spinning wheel’
		palttina	‘linen cloth’
	d.	værttinæ-llæ-ni-hæn	‘with spinning wheel, as you know’
		palttina-lla-ni-han	‘with linen cloth, as you know’

The transparency of /i/ and /e/ is demonstrated in (32) and (33). While the [-back] root /værttinæ/ and its suffixes in (32) entirely agree in terms of backness, the disharmonic root /palttina/ in (33) spreads [+back] to its suffixes, ignoring the intervening /i/.[10] [11]

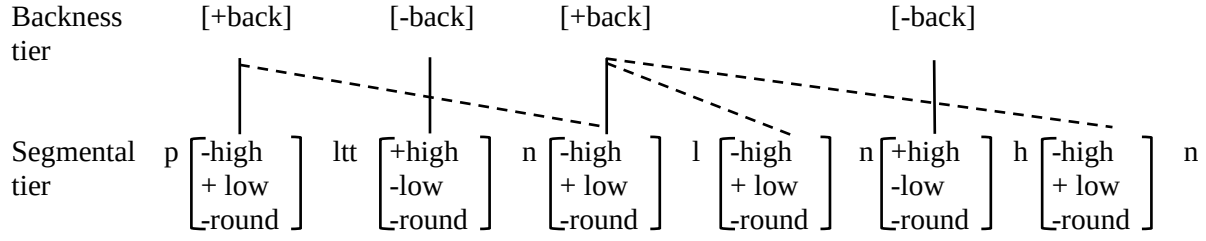
(32)

[værttinæ-llæ-ni-hæn] ‘with spinning wheel, as you know’



(33)

[palttina-lla-ni-han] ‘with linen cloth, as you know’

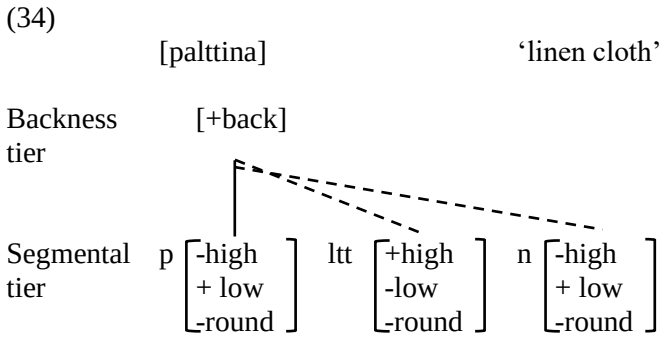


[10] Here, [-back] is represented as an assigned value to show that all vowels are [-back], and thus agree in backness. This representation is not intended make any statements about whether the vowels in /værttinæ-llæ-ni-hæn / are underlyingly [-back] or whether they have become so through spreading

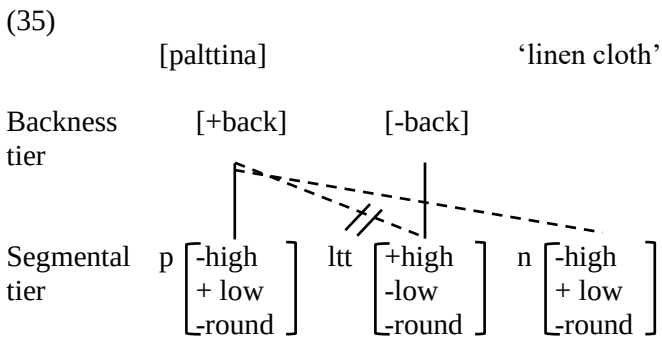
[11] It must be noted that the representation as shown in (33) is problematic in autosegmental phonology, since crossing association lines is not permitted (Goldsmith, 1976).

To account for transparency one possible approach is that of Baković (2000), which relies on rule ordering. Consider, for example, the transparent [i] in /palttina/ in (34) and (35). First, the vowel harmony rule causes all vowels, including the transparent vowel, to be [+back] (34). This allows for vowels that follow the transparent vowel to harmonize too. After this, a repair rule removes all ungrammatical forms, so that the transparent vowel in the final representation is un-harmonized, resulting in /palttina/ (35).

(34)



(35)



For other theories regarding transparency see, for example, van der Hulst (2016) and Archangeli and Pulleyblank (1994).

2.6 Vowel Harmony Types

Thus far, chapter 2 has outlined some of the basic issues in vowel harmony. This thesis examines how a feature-based interpretation can account for the behavior of /a/ in different types of harmony systems. The types that will be considered are based on the features that may be spread in vowel

harmony. Vowels in vowel harmony languages can harmonize with regard to backness, rounding, tongue root position, and height.

As discussed, vowels in languages with backness harmony agree in terms of the feature [back]. Backness harmony is also referred to as fronting or palatal harmony. Backness harmony commonly occurs in Turkish (see Clements and Sezer 1982), and Finno-Ugric languages such as Finnish (see Kiparsky 1973) and Hungarian (see Vago 1973; 1974; Johanson, 2021b; Rose & Walker, 2011). Tuvan backness harmony will be researched in chapter 3.

Rounding harmony, or labial harmony, is a process in which vowels are rounded under the influence of a nearby rounded vowel (Kaun, 2009). Rounding harmony commonly co-occurs with backness harmony. Like backness harmony, rounding harmony therefore most commonly occurs in languages such as the Mongolic (Svantesson et al., 2005), Turkic (Clements & Sezer, 1982; Harrison, 2000; Johanson & Csato, 2021), and Tungusic (Li, 1996) language groups. Aside from Altaic languages, rounding harmony is also seen in genetically unrelated languages such as Tunica (Louisiana, Gulf) (Odden, 1991), Ewe (Kwa) (Odden, 1991), and several Niger-Congo languages (van der Hulst & van de Weijer, 1995; Krämer, 2003). In these languages, it is suggested that rounding harmony co-occurs with ATR or RTR harmony (which stands for retracted tongue root), though this remains controversial (Krämer, 2003; Rose & Walker, 2011). Chapter 4 will examine Kirghiz (Kyrghyz) rounding harmony.

In height harmony, vowels agree in terms of height. Height harmony is found in metaphony languages, in which vowels are lowered or raised by one step. Metaphony is found in a number of Romance languages. It is unclear whether metaphony languages truly have height harmony, since metaphony processes are conditioned by stress, which is not generally the case for vowel harmony (Linebaugh, 2007). Therefore, metaphony languages will be ignored for the remainder of the thesis.[12]

Height harmony is also found in Bantu languages, but since both height harmony and ATR harmony are cued mainly by differences in F1, these Bantu languages are often analyzed as ATR harmony rather than height harmony (see Casali, 2008; Linebaugh, 2007; van der Hulst & van de

[12] For detailed descriptions of metaphony, see Calabrese (2011), Hualde (1989), Parkinson (1996), and Pulleyblank (2011).

Weijer, 1995). For this reason, C'lela, which is not a metaphony language, nor a Bantu language, will be examined in chapter 5 in order to research height harmony.[13]

In ATR harmony, vowels within a domain must share the feature ATR. For [+ATR] vowels, the tongue root is in a more advanced position in the vocal tract. [−ATR] vowels are pronounced with the tongue root is in a less advanced position. ATR harmony is most commonly found in languages spoken in sub-Saharan Africa, though it does also appear in other parts of the world. Well-known examples include Akan and Maasai. Maasai ATR harmony will be analyzed in chapter 6.

2.7 Predicted behavior of /a/

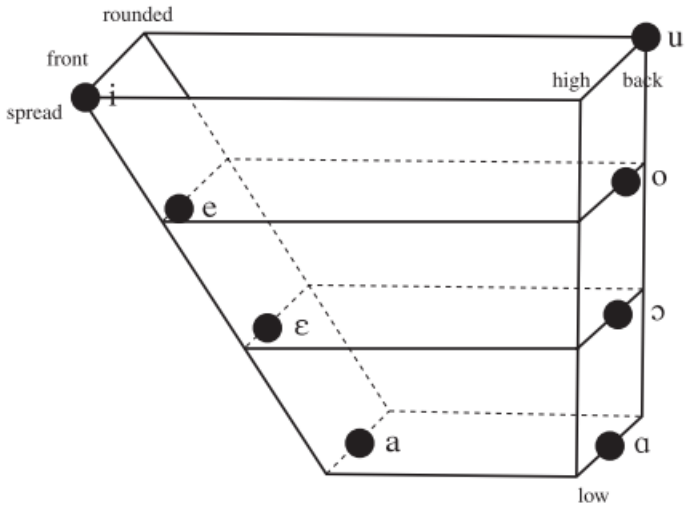
Given the relationships between features as outlined in chapter 1, the following hypotheses regarding how /a/ might behave in vowel harmony languages can be formed.

In backness harmony, /a/ is expected to alternate with a [-back] vowel that is [-high], because it itself is [-high] and [+back]. In order to do so, /a/ might have to move 'up' slightly in the vowel triangle, because it is relatively far removed from possible harmonic counterparts. Some logical [-back] counterparts for /a/ in backness harmony might be /e/ and /ɛ/, depending on the vowels available in the vowel inventory. It is also possible that /a/ fails to harmonize in backness harmony, since vowel harmony requires vowels to be very similar to their harmonic counterparts for all features except for the harmonizing feature. To resolve this, /a/ might harmonize with a front mid vowel through re-pairing, in which case it would need to alter its specification for [+low] to [-low]. This would allow /a/ to harmonize with a /e/ or / ɛ/.

In rounding harmony, /a/, which is [-round], needs to alternate with a [+round] vowel. This may be problematic, since there is a restriction on [-high, +round] vowels. It is more likely for /a/ to find a [+round] counterpart in a back vowel, because rounding favors back vowels as seen in (7). In fact, the further back vowels are, the more strongly rounded they are as well (36) (from Ladefoged & Johnson, 2015: 232).

[13] In C'lela there are both [+ATR] and [-ATR] vowels in the group of [-high] vowels, ruling out the possibility that it is really an ATR harmony language.

(36)



/a/ will thus likely move further back, forcing it to simultaneously move higher, to find its harmonic counterpart. This is likely to be /o/ or /ɔ/. However, it is also possible that /a/ fails to alternate with a [+round] vowel. This would be unsurprising, since there is a restriction on [-high] and [+round]. In this case, /a/ might be opaque or transparent.

At first sight, height harmony appears to be the harmony type in which /a/ has many options. It is indeed not restricted by the 'borders' of the vowel triangle. Instead, it could alternate with a central high vowel such as /ɨ/, or a central mid vowel such as /ə/. One issue might be that many languages do not have central vowels in their inventory. In this case, /a/ could alternate with /e/ or /o/ instead. These vowels are higher than /a/ and possibly still similar enough with regard to the other features, that they form acceptable alternants. However, these vowels are quite likely to prefer harmonizing with the high vowels /i/ and /u/. Other options include the [-ATR] vowels /ɛ/ and /ɔ/, but these vowels are subject to possible restrictions on [ATR] and [high]. This brings us back to the second issue with the high central vowel /ɨ/, which is [+ATR] and [-high]. This combination is an often avoided feature relationship. For height harmony, while /a/ initially appears to have free rein, it might actually fail to harmonize, depending on the vowels available in the particular height harmony language and its inventory.

Finally, in ATR harmony, /a/ might also show interesting behavior, because /a/ is low. Because of the articulatory and acoustic restrictions, a [+ATR] low vowel is uncommon. Casali

(2008) does mention that some African languages do have a relatively low [+ATR] vowel in the form of /æ/. If /a/ has access to this vowel in a language, it might be viable option for a harmonic counterpart. However, this vowel remains uncommon. It is more likely that /a/ fails to harmonize, or that it harmonizes with /o/ or /e/. Then again, these vowels are likely to already harmonize with the [-ATR] vowels /ɛ/ and /ɔ/, if these are available in the inventory.

Based on the phonetic relationships and feature relationships, several hypotheses can be made regarding the behavior of /a/ in vowel harmony languages (see Table 1 for a summary of proposed counterparts mentioned).

Vowel harmony type	Potential harmonic counterparts	Feature relationships	Comments
Backness	/e/ and /ɛ/		If available in the vowel inventory. /a/ moves up and to the front Possibly not similar enough to their harmonic counterparts
	Fails to harmonize		
Rounding	/o/ or /ɔ/.	Restriction on [-high] and [+round].	/a/ moves back and up.
	Fails to harmonize		
Height	/ɨ/ and /ə/,		If available in the inventory.
	/ɨ/	Restriction on [+ATR] and [-high]	
	/e/ or /o/.		Prefer to harmonize with the [+high] vowels /i/ and /u/.
	/ɛ/ and /ɔ/	Restriction on [ATR] and [high].	
	Fails to harmonize		
ATR	/æ/	Restriction on [+ATR][-high]	
	/o/ or /e/.		Prefer to harmonize with the [-ATR] vowels /ɛ/ and /ɔ/
	Fails to harmonize		

Table 1

Overview of the possible behavior of /a/ in four vowel harmony types.

In all vowel harmony types, finding a harmonic counterpart for /a/ may likely not be straightforward. This may be due to restrictions on feature combinations, but also due to unavailability in the inventory, or the vowels differing too much from one another. Overall, the hypotheses suggest that in each vowel harmony type, /a/ will likely have to change an extra feature in order to pair up, or opt for opacity or transparency instead.

2.8 Structure of the Thesis

The following four chapters will provide a typology of each of these vowel harmony systems. Each harmony type will be discussed using a language that demonstrates this harmony type. The languages discussed include Tuvan (backness), Kirghiz (rounding), C'lela (height), and Maasai (ATR). For each language, the vowel inventory and examples of the vowel harmony process will be given, and language-specific properties of the harmony processes will be discussed. This includes direction, restrictions to the harmony process, transparent or opaque vowels, and harmony domain. After this, the behavior of /a/ in this vowel harmony language will be examined.

3. Backness Harmony

The first vowel harmony type that will be examined is backness harmony. As illustrated in section 2.1, vowels in languages with backness harmony agree in terms of the feature [back]. For the purpose of this thesis, the Turkic language Tuvan (or Tyvan) will be examined in order to gain insight into backness harmony. This chapter will be based on Anderson and Harrison (1999), Harrison (1999a, 1999b, 2000), Smolek (2010), and Johanson (2021a) unless otherwise specified. Tuvan has roughly 260,000 speakers, most of whom live in Siberia, Mongolia, and the Xinjiang province of China (Boeschoten, 2021; Smolek, 2010).

3.1 Tuvan Backness Harmony

Tuvan shows rightward backness harmony with a symmetrical vowel inventory. There are no neutral vowels in Tuvan backness harmony. The language also has rounding harmony, resulting in overlapping domains. The domain of its backness harmony is the prosodic word. Tuvan has some disharmony, for example in reduplicants. This section will consider these aspects in more detail.

Like almost all Turkic languages, Tuvan has a symmetrical vowel inventory with eight vowels that is identical to the Turkish inventory in (37) (Harrison, 2000: 10; Ko, 2012: 396).[14]

(37)

	[-back]		[+back]	
	[-round]	[+round]	[-round]	[+round]
[+high]	i	y	ɯ	u
[-high]	e	ø	ɑ	o

These vowels can be either long or short. In addition to vowel quality and length, Tuvan vowels may have tone contrast on the first syllable. Both vowel length and low pitch will be disregarded in this section.

[14] High vowels that follow [y, ø, u] and [o] also harmonize with regard to rounding. Low vowels are opaque for rounding harmony, like in Turkish (Smolek, 2010). This chapter will focus solely on Tuvan backness harmony. Rounding harmony will be discussed in chapter 4.

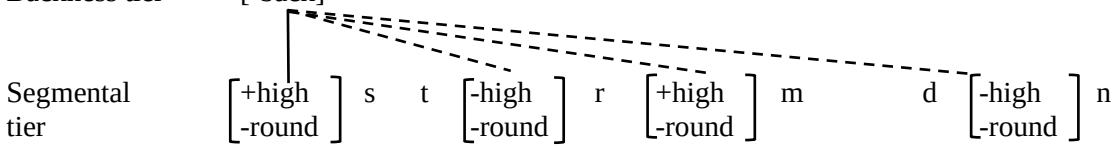
In Tuvan, the roots of words are either [+back] (as in (38a)) or [-back] (as in (38b); Rose & Walker, 2011). Like Turkish, Tuvan is a highly suffixing language. Any suffixes harmonize along with the values of the root (as in (38c); data from Rose & Walker, 2011: 251).

(38)	a.	ivi	‘deer’	
		idegel	‘hope’	
		xylymzyrer	‘smile.FUT’	‘will smile’
		eːren	‘totem’	
		xøːmej	‘throat singing’	
	b.	ɯrɑk	‘far’	
		ulu	‘dragon’	
		ɑjɯːl	‘danger’	
		oruk	‘road’	
	c.	is-ter-im-den	‘footprint.PL.1.ABL’	‘from the footprints’
		ɑt-tɑr-ɯm-dɑn	‘name.PL.1.ABL’	‘from the names’
		esker-be-di-m	‘notice.NEG.PST.II.1’	‘I did not notice’
		udu-vɑ-dɯ-m	‘sleep.NEG.PST.II.1’	‘I did not sleep’

As can be seen in (39) and (40), like in Turkish, Tuvan target vowels are specified for height, but not for backness.[15]

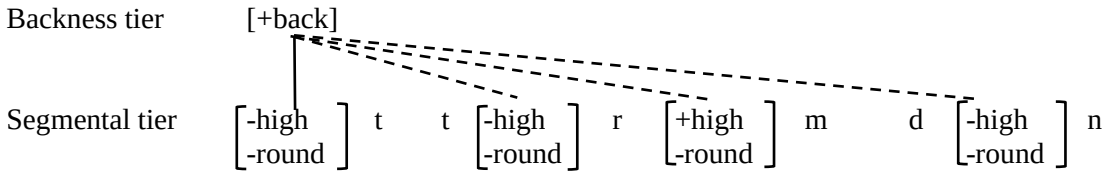
(39)

[is-ter-im-den] ‘footprint.PL.1.ABL’ ‘from the footprints’



(40)

[ɑt-tɑr-ɯm-dɑn] ‘name.PL.1.ABL’ ‘from the names’



[15] As can be seen in (38c), Tuvan consonants also alternate due to consonant harmony. [p] might for example be realized as [p], [b], [v] or [m]. Though interesting, this issue cannot be discussed within the scope of this thesis. For details, see Johanson (2021b).

Every vowel in the Tuvan inventory can be the target and the trigger for backness harmony. The feature [±back] is spread from left to right, filling in the values for the vowels to the right of the leftmost vowel. It is clear that Tuvan has rightward spreading, since it is a suffixing language in which features spread from the root onto the suffix vowels. Further proof for rightward vowel harmony is found in epenthetic vowels in Russian loan words with disharmonic roots (see (41), epenthetic vowels are underlined). In a word like /ɑčɯki/, the epenthetic vowel surfaces as [ɯ] rather than [i], since the leftmost vowel is [-back]. This confirms that the directionality of Tuvan harmony is rightward. If the direction of Tuvan harmony were leftward, the epenthetic vowel would have surfaced as the front vowel /i/ (data from Harrison, 2000: 112).

(41)

Tuvan word		Russian source word	
ɑčɯki	*ɑčiki	ɑč'ki	‘eye-glasses’
texɯnɑɑr	*texunɑɑr	tex'nɑr	‘grain alcohol’
pɑrtɯfel	*pɑrtifel	pɑrt'fʲel	‘wallet’

According to Harrison (2000), the domain of Tuvan backness harmony is the prosodic word, since enclitics fail to harmonize. See, for example the emphatic enclitic in (42). The emphatic form for ‘he’ is /men=da/ rather than */men=dee/. The prosodic word is the domain, since the enclitic does not harmonize for backness, but starts its own domain (data from Harrison, 2000: 116).

(42)

on=dɑɑ	‘i=EMPH’
men=dɑɑ	‘he=EMPH’

While Tuvan has transparency and opacity in its rounding harmony, there are no neutral vowels in Tuvan backness harmony. It is therefore possible for harmony systems with both rounding and fronting, that there are various domains within a word. These domains may overlap, so that part of a word forms the domain for backness harmony, and another part harmonizes for lip-rounding.

Harrison (2000) argues that harmony is gradient. Languages in which vowels on the whole almost always follow the harmony rule are more harmonic than languages in which vowels fail to

harmonize, whether this is due to neutral vowels, disharmonic roots, or other reasons. Smolek (2010) demonstrates that Tuvan is significantly more harmonic than Turkish. Disharmony in Tuvan mostly stems from loan words. There are, on the other hand, loan words on which speakers impose backness harmony, such as the Russian /televisɑr/ 'television set', which is realized as /televiser/ by speakers of Tuvan (data from Anderson & Harrison, 1999: 5).

In addition to disharmony from loan words, an interesting phenomenon is found in reduplicants (see Harrison, 1999b). Reduplicants in Tuvan are used to express vagueness or a humorous tone, and they are made by duplicating the word, as seen in (43) (data from Harrison, 1999b: 76).

(43) syt syt-sɑt 'milk'

The consonants are copied, but the vowel is altered. The result is that the vowels do not harmonize in terms of backness and rounding. Reduplicants will be examined more thoroughly in section 3.2. Other disharmony in Tuvan originates from five non-harmonizing suffixes.

3.2 The Behavior of /ɑ/

The first type of behavior of /ɑ/ in Tuvan backness harmony is that it may function as a trigger for backness harmony. The vowel is specified as [+back]. It therefore spreads [+back] to the vowels to its right. In (40), for example, the first /ɑ/ vowel spreads [+back] to the consecutive vowels, so that the surface representation is /ɑt-tar-ɯm-dɑn/.

In Tuvan backness harmony, /ɑ/ can also be a target. In this case, /ɑ/ alternates with /e/. This is demonstrated in (38c), where the non-high ablative suffix is either [den] or [dɑn]. In a [-back] context, the [-high, -round] vowel surfaces as [den], and in a [+back] context, it surfaces as [dɑn].

A third type of behavior of /ɑ/ in Tuvan backness harmony is seen in reduplication. As demonstrated in section 3.1, these are made by reduplicating the base word. More data is provided in (44) (data from Harrison, 1999b: 75). The reduplicant adds a jocular tone. /is-ɑs/ could for example be translated as 'footprints and stuff', or 'something like a footprint'.

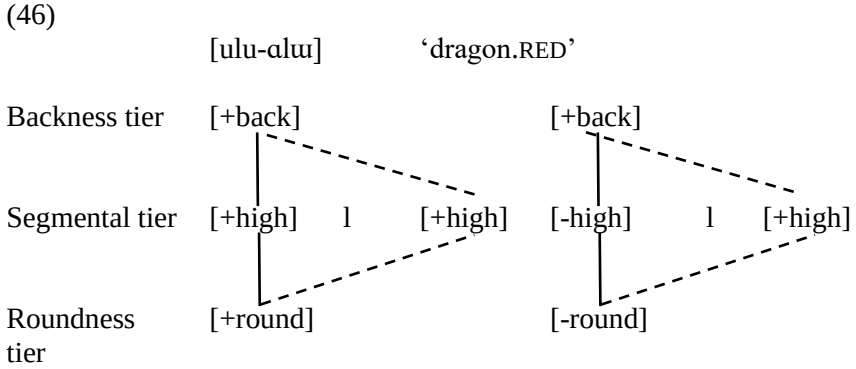
(44)	is	is-ɑs	‘footprint.RED’
	er	er-ɑr	‘male.RED’
	syt	syt-sɑt	‘milk.RED’
	øg	øg-ɑg	‘yurt.RED’
	qɯs	qɯs-qɑs	‘girl.RED’
	ɑt	ɑt-ut	‘name.RED’
	nom	nom-nɑm	‘book.RED’

To form the reduplicant, the consonants of the word are copied, and the vowel of the initial syllable is replaced by a ‘replacement vowel’. This replacement vowel is either /ɑ/ or /u/. As can be seen in (44), all vowels are replaced by /ɑ/, except for /ɑ/, which is replaced by /u/ (data from Harrison, 1999b: 76). Both of the replacement vowels are [+back], suggesting backness is a fixed property of the replacement vowel. The data contained no monosyllabic words with /u/, but as can be seen in (45), /u/ too is replaced by /ɑ/.

(45) ulu ulu-ɑlɯ ‘dragon’

(45) shows that non-initial vowels in polysyllabic words change. See (46) for an autosegmental representation of /ulu-ɑlɯ/. The vowels in the syllables following the replacement vowel harmonize with /ɑ/ or /u/ in terms of backness and rounding. The specification of height is copied from the post-initial base vowels onto the reduplicant vowels. The reduplicant starts its own domain in which harmony is spread. In the case of (46), this means that the non-initial vowel in the reduplicant remains [+high], and takes on [+back] and [-round] from [ɑ].

(46)



The disyllabic words in (47) show that this same principle holds for the other vowels (data from Harrison, 1999b: 76). Because the replacement vowels are both back vowels, the non-initial vowels surface as either [ɑ] or [ɯ] after [ɑ], or as [u] after [u], depending on vowel height.

(47)	idik	idik-adɯk	‘boot(s).RED’
	inek	inek-ɑnɑk	‘cow.RED’
	byry	byry-bɑrɯ	‘wolf.RED’
	ɑrɯ	ɑrɯ-uru	‘bee.RED’
	oktaar	oktaar-ɑktaar	‘throw.FUT.RED’
	ulu	ulu-ɑlɯ	‘dragon.RED’
	kurort	kurort-kɑrɑrt	‘spa.RED’

While [ɑ] is followed by [ɑ] or [ɯ], depending on the vowel height of the original vowel, the [u] in the reduplicant is never followed by [o]. This is because the low round vowels [ø] and [o] are banned from non-initial syllables. Tuvan rounding harmony disallows low vowels to become [+round], just like in Turkish. Because there are no post-initial low round vowels, [o] never appears in the reduplicant.

Since low vowels are never rounded in post-initial position in Tuvan, the word /kurort/ in (47) forms an interesting case. The word is actually a disharmonic loan word from German ‘Kurort’. Its reduplicant shows that the replacement vowel applies harmony to the following vowels. Hence, only the feature [-high] remains, and the harmony thus generates /kɑrɑrt/.

The replacement vowel in Tuvan reduplication is either /ɑ/ or /u/, depending on the first vowel in the original word. Harrison argues that these two vowels are selected because /ɑ/ is the least marked back vowel in Tuvan, followed by /u/. The remaining two back vowels [o] and [ɯ] are more marked, and are therefore less likely to be the replacement vowels.

Returning to Tuvan backness harmony in general, it is clear that /ɑ/ forms a harmonic counterpart with /e/. There are no neutral vowels in Tuvan, and apart from loan words and the abovementioned reduplication, Tuvan is very harmonic compared to other vowel harmony languages like Turkish. In rounding harmony, only the high vowels are targeted, but backness harmony in Tuvan does not have such constraints. Rounding harmony is commonly subject to conditions regarding height and backness (Kaun, 2009). From the data regarding Tuvan it becomes clear that Tuvan

backness harmony is not similarly restricted by rounding harmony. In Tuvan backness harmony, /ɑ/ forms a harmonic counterpart with /e/, without restrictions from other harmony types.

All in all, the low vowel /ɑ/ in Tuvan backness harmony plays several roles. First, it may function as a trigger for backness harmony, since it is itself [+back]. Additionally, /ɑ/ may function as a target, harmonizing with /e/. Finally, /ɑ/ is the replacement vowel for all vowels but /ɑ/ in reduplication. When a word with /ɑ/ in the base is reduplicated, its replacement vowel is /u/.

3.3 A Feature-based Interpretation of the Behavior of /ɑ/

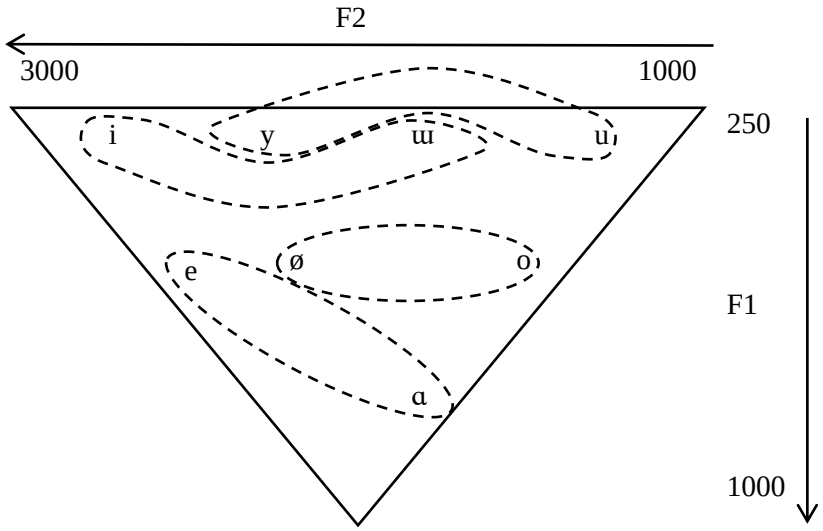
Section 3.2 shows that in Tuvan backness harmony, /ɑ/ triggers backness harmony and harmonizes with /e/, and that there are no neutral vowels in Tuvan backness harmony.

In section 2.7, it was hypothesized that in backness harmony languages, /ɑ/ might have to move 'up' slightly in the vowel triangle, to alternate with /e/ or /ɛ/, depending on whether these vowels are available in the vowel inventory. It was also suggested that /ɑ/ might fail to harmonize in backness harmony, if it is too dissimilar to their harmonic counterparts. To resolve this, /ɑ/ might harmonize with a front mid vowel through re-pairing, in which case it would need to alter its specification for [+low] to [-low]. This would allow /ɑ/ to harmonize with /e/ or / ɛ/. The findings regarding Tuvan backness harmony are in line with the hypotheses regarding backness harmony made based on feature relationships as shown in Grounding Theory. In Tuvan backness harmony, /ɑ/ alternates with /e/, even though the two vowels are not exactly of equal height. To examine how phonetic properties may account for this behavior, see (37) and (48). The inventory is repeated for reference.

(37)

	[-back]		[+back]	
	[-round]	[+round]	[-round]	[+round]
[+high]	i	y	ɯ	u
[-high]	e	ø	ɑ	o

(48)

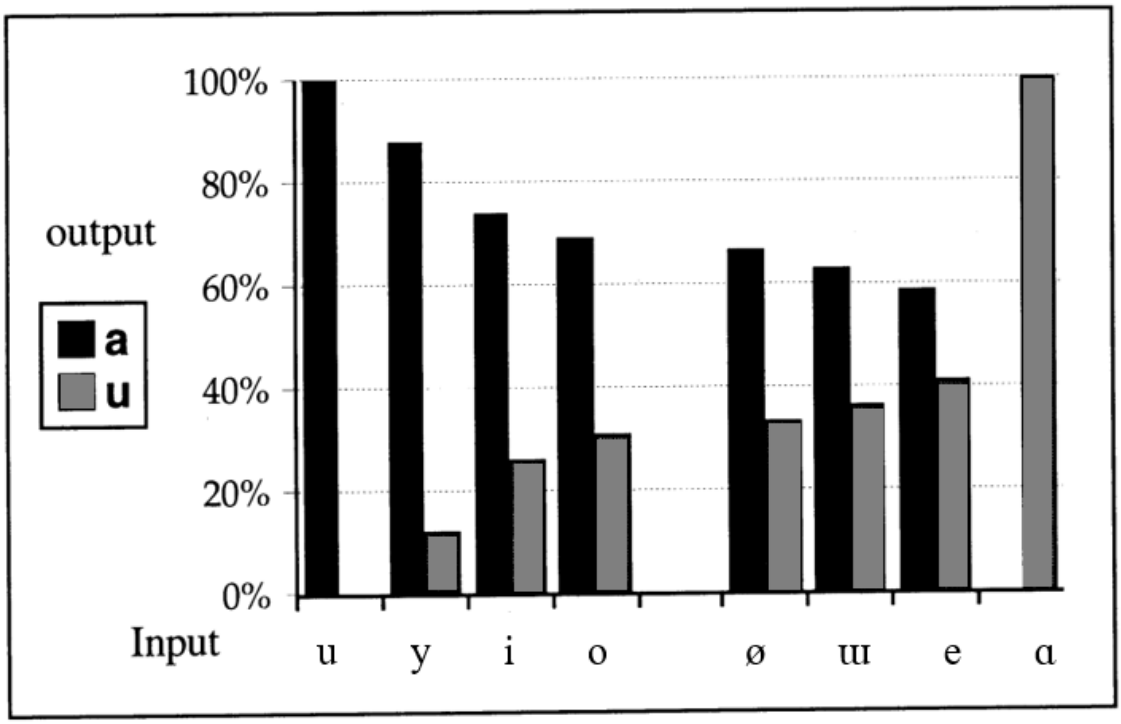


The vowel triangle confirms the findings regarding Tuvan backness harmony. (48) visualizes that in Tuvan backness harmony, vowels alternate in terms of backness. /i/ and / ɯ/, for example, form a harmonic pair. They are very similar in F1, or height, but differ in F2. The difference in F2 here is realized by the variation in backness. The low back vowel /ɑ/ alternates with /e/, which is different in both F1 (height) and F2 (backness). In this regard, /ɑ/ and /e/ are more different to each other than the other alternating vowels in Tuvan backness harmony. In the inventory in (37), [ɑ] has been placed at the same height as [e]. Because these two vowels alternate, adding another height distinction in the form of [±low] appears to be redundant. In the vowel triangle, on the other hand, the difference between /ɑ/ and /e/ and the other harmonic pairs is clearly depicted. In order to alternate, /ɑ/ has to make a larger 'effort' than the other vowels.

With regard to feature relationships as proposed by Archangeli and Pulleyblank, the [-high, -round] vowels [ɑ] and [e] are unhindered, since height and backness do not interfere with one another phonetically. Vowel height mainly influences the F1, while backness is concerned with the F2. An interesting case in the light of a feature-based approach is that of the Tuvan reduplicants. In reduplicants, the initial base vowel is replaced by [ɑ] for all vowels except for [ɑ], which itself becomes [u]. As was noted, Harrison suggests that [ɑ] and [u] are the replacement vowels, because they are least marked amongst the back vowels. The relationships between phonological features support this, because the feature combinations seen in [ɑ] and [u] are [+back, -high] and [+back, +round]. These feature combinations are not antagonistic. This raises the question why [o] is not a

replacement vowel when the base vowel is [ɑ]. The rounded back vowel is also specified as [-high], and thus more similar to [ɑ], yet it is not utilized as the replacement vowel. However, as previously discussed, [o] is restricted in non-initial position. Additionally, [o] is specified as [-high, +round], which is restricted due to opposing acoustic effects, causing the less-similar vowel [u] to be targeted. In fact, it is possible that the intention of the replacement vowel is to be as far removed from the base vowel as possible, especially (but not only) with regard to vowel height. In that case, [ɑ] is a good replacement vowel for the other Tuvan vowels as a whole. It might not be diametrically opposed to the vowels in all features, but it is phonetically more different from the other vowels, than the other vowels are from one another. In fact, this is supported by research carried out by Harrison (1999b: 80), illustrated in (49).

(49)



Harrison shows that in a central dialect of Tuvan, the replacement vowel selected by the more [u]-like vowels is most commonly [ɑ]. The more [ɑ]-like a vowel is, the more likely it is to sometimes also be replaced by [u]. Thus, it might be that in selecting a replacement vowel, a process occurs in which the phonetically least similar back vowel is selected.

In sum, the behavior of /ɑ/ in Tuvan can be accounted for by a feature-based interpretation. /ɑ/ alternates with /e/, even though these two vowels are not identical in height. Here /ɑ/ has to change one extra feature in order to alternate, by moving ‘up’ in the vowel diagram. Feature relationships allow for this combination, because backness and height are a complementary feature combination. Tuvan reduplication suggests a need for dissimilarity rather than harmony. The vowel that is phonetically furthest removed appears to be targeted for the replacement vowel. This replacement vowel starts a new harmony domain.

4. Rounding Harmony

For the purpose of this research, Kirghiz (Kyrghyz) will be examined in order to gain insight into rounding harmony. Kirghiz is a Turkic language with roughly five million speakers, that live in Kirghizstan, Uzbekistan, and Tajikistan as well as in the west of the Xinjiang Uyghur Autonomous Region in China (Boeschoten, 2021; Comrie, 1981). This chapter will be based on Comrie (1981), Hebert and Poppe (1965), Kaun (1995, 2009), Korn (1969), McCollum (2020), Polgárdi (1998), and Washington (2017) unless otherwise specified.

4.1 Kirghiz Rounding Harmony

Kirghiz has backness and rounding harmony, like Turkish. It is generally accepted that Kirghiz has a symmetrical inventory with eight vowels, six of which also appear in a lengthened form (Comrie, 1981; Hebert & Poppe, 1965; Karakoc & Kalieva, 2021; Ko, 2012; McCollum; 2020). There is, however, some discussion in the literature regarding the exact vowels in the inventory, due to the usage of different symbols to represent vowel sounds as well as due to misreporting in early grammars.[16] After newly conducted phonetic research, McCollum (2020: 4) provided the inventory of Kirghiz as printed below in (50).

(50)

	[-round]		[+round]	
	[-back]	[+back]	[-back]	[+back]
[+high]	i	ɯ	y	u
[-high]	e	ɑ	ø	o

While this inventory is the most conclusive, two observations must be made. According to Comrie (1981), it is important to note that /ɑ/ is phonetically a low vowel, while the other non-high vowels are phonetically mid. In addition, Washington (2017) points out that, though the system is symmetrical in the sense that there are eight vowels forming four pairs, /ɯ/ is really a central or mid

[16] Washington (2017) notes that Comrie's (1981) misreporting of the existence of two main dialects in Kirghiz is most likely due to a green pen stripe in the copy of Batmánov (1939: 48) that was being used.

vowel, rather than [high] and [back]. Nevertheless, the vowel inventory in (50) will be used to examine Kirghiz, keeping in mind that such inventories are symmetrical in a theoretical sense only.

In Kirghiz vowel harmony, vowels must share the same feature for round and back. Kirghiz has progressive harmony, meaning that both features are spread from the initial vowel to the right. For an example, see the data in (51) (data from Polgárdi, 1998: 91). For the ordinal numbers, the suffix vowels are specified [+high] (51a), while the ablative suffix in (51b) has vowels that are specified as [-high]. The result is that there are four options for [+high] suffix vowels and four options for [-high] suffix vowels, depending on rounding and backness.

(51)

a.	bir-intʃi	‘first’
	tørt-yntʃy	‘fourth’
	ɑltɯ-ntʃɯ	‘sixth’
	toguz-untʃu	‘ninth’
b.	et-ten	‘meat.ABL’
	yj-døn	‘house.ABL’
	ɑlmɑ-dɑn	‘apple.ABL’
	tokoj-don	‘forest.ABL’

In most Turkic languages, rounding harmony is subject to several restrictions. In Turkish, for example, rounding harmony is more likely to be triggered by front vowels than back vowels, and low vowels are opaque to rounding altogether (Clements & Sezer, 1982; Kaun, 1995). Kirghiz, however, is unusual in the sense that its rounding harmony is very regular. Word-initial vowels spread their value for the feature [round] regardless of trigger and target height (Gordon, 2006).

Exceptions to this regularity include compound words and loan words. Another notable exception is seen in (52) (data from van der Hulst & van de Weijer, 19995: 522). The past participle suffix has a [-high] vowel that is underspecified for [round] and [back]. The vowel therefore alternates between [e], [ø], [ɑ], and [o], harmonizing along with the root vowels. However, the past participle of ‘hold’ in /tutkɑn/ shows that /ɑ/ does not harmonize after the high vowel /u/. The past participle is therefore not [*tutkon], but /tutkɑn/. This issue will be further examined in the next section.

(52)	Root	Past participle	
	bil	bilgen	‘know’
	ber	bergen	‘give’
	kyl	kylgøn	‘laugh’
	kør	kørgøn	‘see’
	kɯl	kɯlgɑn	‘do’
	ɑl	ɑlgɑn	‘take’
	tut	tutkɑn	‘hold’
	bol	bolgon	‘be’

The word is the harmony domain in Kirghiz for both rounding and backness. Since Kirghiz has many suffixes, this results in long words that agree both in [round] and [back] throughout the entire word.

4.2 The Behavior of /ɑ/

/ɑ/ behaves in several ways in Kirghiz rounding harmony. Since /ɑ/ is [-round], it spreads [-round] in domains like /ɑltɯ-ntʃɯ/ ‘sixth’ and /alma-dan/ ‘from the apple’ (see (51a)). It may also harmonize with /o/, as seen in (51b) in a domain like /tokoj-don/.

Another role of /ɑ/ in Kirghiz becomes apparent through the data in (53) (data from van der Hulst & van de Weijer, 1995: 522).

(53)	Root	Past definite	Past participle	
	bil	bildi	bilgen	‘know’
	ber	berdi	bergen	‘give’
	kyl	kyldy	kylgøn	‘laugh’
	kør	kørdy	kørgøn	‘see’
	kɯl	kɯldɯ	kɯlgɑn	‘do’
	ɑl	ɑldɯ	ɑlgɑn	‘take’
	tut	tuttu	tutkɑn	‘hold’
	bol	boldu	bolgon	‘be’

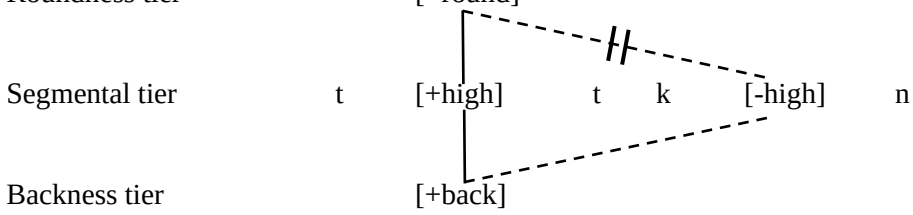
As was introduced in section 4.1, the rounding harmony rule in Kirghiz fails to produce an /o/ in a context where /ɑ/ follows the high vowel /u/. In the data in (53), the suffix vowels are underspecified for [round] and [back]. The suffix vowel for the past definite is realized as [i], [ɯ], [y],

or [u], since it is [+high], and the past participle suffix vowel is realized as [e], [ø], [ɑ], or [o], since it is [-high].

The vowel in the root /tut/ is [+round] and [+back]. These features are successfully spread onto the [+high] suffix vowel for the past definite, resulting in the surface form /tuttu/. For the past participle, however, the features are not spread successfully. The data for the past participle in /tutkɑn/ are illustrated in the autosegmental representation in (54).[17]

(54)

[tut-kɑn] ‘hold.PST.PT’



Since the suffix vowel is specified as [-high], the harmony rule is expected to form the suffix [kon]. Instead, [+round] fails to spread, resulting in the [+back, -high] suffix [kɑn]. The data for ‘be’ (53) shows that other root vowels do not fail to spread [+round] and [+back]. The root /bol/ is [+round] and [+back]. (53) shows that these features are able to spread onto the suffix vowel, resulting in the surface forms /boldu/ and /bolgon/. There is thus no restriction in Kirghiz regarding the spreading of [+round] and [+back] from a low vowel to a high vowel, or from a low vowel to another low vowel.

In addition, the data in (55) demonstrate that the fact that [u] fails to produce a rounded suffix vowel is not restricted to the past participle suffix. In locative suffixes, the same disharmony is found (data from Hebert & Poppe, 1965: 11).

[17] The initial consonant of the past participle suffix devoices to [k] after voiceless sounds. This is not shown in the representation. For more detail, see Hebert and Poppe (1965).

(55)

uč-kɑ	‘to the tip’
uč-tɑ	‘on the tip’
uč-tɑn	‘from the tip’

Since the root /tut/ successfully spread its features onto the [+high] suffix vowel in /tuttu/, but failed to do so for the low suffix vowel in the past participle /tutkɑn/, it is likely that this is due to the difference of height between the root vowel and the suffix vowel. This is referred to as parasitic harmony (Archangeli & Pulleyblank, 1994). Kaun explains that harmony is dependent on (or ‘parasitic on’) the presence of a shared feature specification. Because the root vowel and the past definite suffix vowel are both [+high], the features spread successfully, while those in /tutkɑn/ fail to do so, due to their difference in height.

It is important to note that this restriction in Kirghiz only applies to the high back vowel /u/, as is shown by the existence of forms like /boldu/ in (53). In fact, all of the suffixed forms in (53) have either two identical vowels, or two vowels that differ in height. Of all of the vowels in the Kirghiz inventory, only the root vowel /u/ fails to produce a vowel that is different in height.

Kaun (2009) states that rounding harmony languages are commonly restricted by height. In Turkish, for example, all target vowels must be [+high], making low vowels opaque to rounding harmony (as was demonstrated in chapter 2). In Yokuts, triggers and targets must agree in vowel height (see (56); data from Odden, 1991: 278).

(56)

	Past tense	
pin	pin-ʃi	‘sting’
hut	hut-ʃu	‘know’
tɯʔ	tɯʔ-ɯssɯ	‘make’
tʰan	tʰan-ʃi	‘go’

Because Yokuts, like Kirghiz and Turkish, has rounding and backness harmony, the result is that vowels that agree in height are identical within a domain. Vowels that disagree in height, such as /tʰan-ʃi/, do not harmonize, and therefore also differ in roundness and backness. Yokuts, Turkish, and

Kirghiz all demonstrate that height commonly restricts rounding harmony. In the case of Kirghiz, rounding harmony is restricted only when /ɑ/ follows the high vowel /u/.

In sum, /ɑ/ behaves in several ways in Kirghiz rounding harmony. On the whole, /ɑ/ alternates with /o/ in a [+round] context. /ɑ/ may also trigger harmony with the value [-round] when it is in a word-initial position. However, /ɑ/ fails to alternate with /o/ when it follows the high vowel /u/ in words like /tutkɑn/. Here, rounding harmony is dependent on the presence of a shared feature for height. Since /ɑ/ and /u/ are dissimilar in height, parasitic harmony causes /ɑ/ to fail to harmonize after /u/.

4.3 A Feature-based Interpretation of the Behavior of /ɑ/

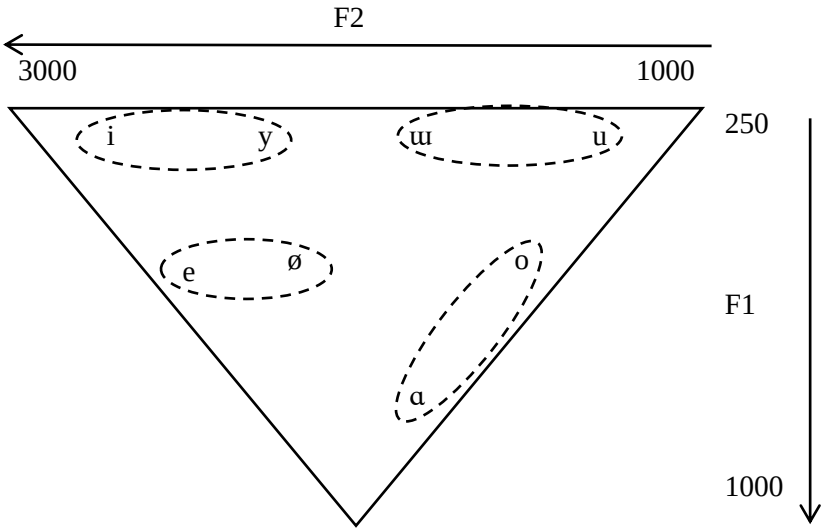
Findings in chapter 4.2 show that /ɑ/ alternates with /o/ in a round context, but fails to harmonize when it precedes /u/. The hypotheses in chapter 1 include that in rounding harmony, it may be problematic for /ɑ/ to alternate with a [+round] vowel, since there is a restriction on [-high, +round] vowels. It was suggested that it is more likely for /ɑ/ to find a [+round] counterpart in a back vowel, because rounding favors back vowels such as /o/ or /ɔ/. Additionally, it was suggested that failure to alternate would be unsurprising for /ɑ/, since Grounding Theory shows that there is a restriction on [-high] and [+round].

Phonetic properties may account for the fact that /ɑ/ alternates with /o/. In rounding harmony, /ɑ/ has to find a [-high, +round] counterpart. Since there are no low round vowels in Kirghiz, /ɑ/ will have to find a counterpart slightly higher in the phonetic triangle (see (50) and (57). As was argued in the introductory chapter, it is more likely to find a harmonic counterpart in a back vowel, since back vowels are more typically rounded than front vowels. /ɑ/ is thus less likely to alternate with /ø/. The features [+back] and [+round] are complementary, since they both result in a lower second formant, making /o/ a good option for a [+round] harmonic counterpart for /ɑ/ in Kirghiz rounding harmony.

(50)

	[-round]		[+round]	
	[-back]	[+back]	[-back]	[+back]
[+high]	i	ɯ	y	u
[-high]	e	ɑ	ø	o

(57)



The vowel triangle in (57) illustrates that there is a lack of similarity in height between /u/ and /ɑ/. Feature relationships can account for the fact that in words like /tutkɑn/, where /ɑ/ follows /u/, /ɑ/ fails to alternate. [+round] and [-high] are antagonistic features, because [+round] lowers F1 and F2, while [-high] raises F1. In other words, rounding adds little to a vowel with an open articulation. In addition, the two gestures are physically antagonistic. This may explain why in rounding harmony languages like Turkish, rounding harmony is restricted to only [+high] vowels. Since Turkish rounding harmony is restricted to high vowels, the height is predictable. Any alternations in F1 are then realized by lip rounding. Kirghiz rounding harmony is not restricted to the high vowels. Instead, there is a restriction on /ɑ/, which fails to alternate with /o/ after the high vowel /u/. As was discussed in sections 4.1 and 4.2, /ɑ/ fails to alternate due to the fact that the harmony is parasitic. Here, the vowels are too different in height, as is confirmed by (57). While each of the vowels alternates with a vowel of the same height, /ɑ/ and /o/ vary in F1, due to the relationship between features [+round] and [-high], accounting for the parasitic harmony in words like /tutkɑn/.

To summarize, in Kirghiz vowel harmony /ɑ/ and /o/ alternate, since back vowels are more round than front vowels. When /ɑ/ fails to harmonize, this is due to parasitic harmony, which reflects the feature relationship between [+round] and [-high]. These two features are opposing, and thus avoided.

5. Height Harmony

Height harmony is vowel harmony with regard to the height of the tongue body (Linebaugh, 2007). The Benue-Congo language C'lela (Dettweiler, 2000) will be examined to gain insight into vowel height harmony. The language is spoken in Nigeria and has approximately 90,000 speakers (Michel, 2009). The following discussion is based on Dettweiler (2000) unless otherwise specified.

5.1 C'lela Height Harmony

The C'lela vowel inventory in (58) consists of three [+high] vowels and five [-high] vowels. Dettweiler does not give any feature specifications other than [±high] in the inventory. A suggestion for a more specific inventory is made in (67). Dettweiler also recognizes a non-phonemic raised schwa which, is represented by the superscript schwa symbol, which he does not include in the vowel inventory.

(58)

[+high]	i																		u	
								ɨ												
[-high]			e															o		
							ɛ										ɔ			
									a											

C'lela has two vowel height harmony processes. The first operates within the root of the word, and the second across morpheme boundaries. Though Lai (2005) shows that height is only spread from the root of C'lela words onto the suffixes, Dettweiler doesn't state what the direction of C'lela harmony is. Pulleyblank (2002, 2011) states that C'lela vowels are lowered rather than raised. If this is the case, then C'lela might have bidirectional harmony, with [-high] as its dominant harmonic feature. Future research could determine whether C'lela harmony is regressive, progressive, or bidirectional. For the purpose of this research, it will be assumed that C'lela harmony is progressive, since Lai (2005) shows that height is spread from the root to the suffixes.

Root-internally, the vowels agree in terms of height (see (59)). As can be seen in (59a), the high vowels [i ɨ u] co-occur, and in (59b) the low vowels [e ɛ a ɔ o] co-occur. The high vowels [i] and [u] alternate with the low vowels [e] and [o]. Loan words from Hausa form an exception to this pattern.[18] The vowels [ɨ], [a], [ɛ] and [ɔ] have no harmonic counterpart (data from Dettweiler, 2000: 7).

(59) a.

dᵊtɨndi	‘nest’
cᵊrinɨ	‘charcoal’
ɨrmɨ	‘man’
kumu	‘get’
kᵊpɨru	‘flower’
dwiri	‘hyena’

b.

kwesa	‘show’
ᵊddakso	‘palm’
cᵊgɔmbo	‘eyebrows’
soma	‘run’
dᵊvɛso	‘broom’
sᵊʔava	‘tongs’

Across morpheme boundaries, height harmony also occurs. The suffix for the first person singular possessive surfaces either as [me] or as [mi]. For the [+high] root /in/ ‘mother’ in (60), this results in the suffix [mi], while the root /cet/ in (61) spreads [-high] to the suffix, resulting in [me].[19]

(60)

[i in-mi] ‘DEF.mother.1.SG.POSS’ ‘it’s my mother’

Height tier [+high]

Segmental tier i [-back, +ATR] n m [-back, +ATR]

(61)

[i cet-me] ‘DEF.father.1.SG.POSS’ ‘it’s my father’

Height tier [-high]

Segmental tier i c [-back, +ATR] t m [-back, +ATR]

[18] Examples include /kahi/ ‘before’ and /sái/ ‘until’ (data from Dettweiler, 2015: 54).
[19] ATR specifications of the vowels have been added, using the specifications from (67).

Height harmony is also seen in other possessive suffixes. The data in (62) (from Dettweiler, 2000: 8) shows that there are two harmonic pairs, alternating between /i, e/ and /u, o/.

(62)
a.	i in-mi	‘DEF.mother.POSS’
	i cet-me	‘DEF.father.POSS’
b.	i in-vu	‘DEF.mother.POSS’
	i cet-vo	‘DEF.father.POSS’
c.	i hɨn-u	‘DEF.sibling.POSS’
	i waar-o	‘DEF.child.POSS’

However, there are three cases in which height harmony does not spread as expected across boundaries in C’lela. First, while some direct object pronouns alternate as expected (see (63a)), others fail to do so (see the underlined vowels in (63b); data from Dettweiler, 2000: 9).

(63)
a.	buzᵊkᵊ mi	‘chased me’	ɛpkᵊ me	‘bit me’
	buzᵊkᵊ vu	‘chased you’	ɛpkᵊ vo	‘bit you’
	sipkᵊ mi	‘grabbed me’	wegaka me	‘indicated me’
	sipkᵊ vu	‘grabbed you’	wegaka vo	‘indicated you’
b.	buzᵊkᵊ co	‘chased us.EXCL’	batkᵊ co	‘released us.EXCL’
	buzᵊkᵊ no	‘chased you.PL’	batkᵊ no	‘released you.PL’
	sipkᵊ o	‘grabbed him’	wegaka o	‘indicated him’
	sipkᵊ na	‘grabbed us.INCL’	wegaka na	‘indicated us.INCL’

The second case in which height does not spread as expected is when adjectival words have multiple suffixes. Adjectives can be expressed in a short way or in a long way.[20] In both cases, these words contain class-marker affixes, but in the longer phrasing, an adjective marker is added (underlined in (64)). Class-markers signal the noun class or gender of a noun, and appear immediately before and after the noun in C’lela and surface as /i/ or /e/, /u/ or /o/, or as the low vowel /a/. As can be seen in (64a), the vowels agree in height for both the long and the short phrasing, but in (64b) the class-marker suffix vowels appear to be transparent in the long form of the word, even though these

[20] Dettweiler notes that the difference in function of these two forms is not yet clear.

same class-markers were harmonizing in the short phrasing of the word (data from Dettweiler, 2000: 12). The word-medial suffixes do not harmonize, even when the root and the final suffix do.

(64)	a.	i-zis-i	CM.long.CM.ADJM	i-zis-i-ni	CM.long.CM.ADJM
		u-pus-u	CM.white.CM.ADJM	u-pus-u-ni	CM.white.CM.ADJM
	b.	i-rek-e	CM.small.CM.ADJM	i-rek-i-ne	CM.small.CM.ADJM
		u-gʲɔz-o	CM.red.CM.ADJM	u-gʲɔ-zu-ne	CM.red.CM.ADJM

For a more detailed account, see Dettweiler (2000), Linebaugh (2007), Michel (2009), and Pulleyblank (2002). Regarding these two cases, Dettweiler concludes that they are idiosyncratic, referring to van der Hulst (2016: 12), who says idiosyncrasy occurs when "languages with harmony have morphemes containing vowels that do not submit to the harmony regulations even though participation is not in violation of any phonological constraint". Dettweiler continues that these cases are particular to the suffix or class-marker in which the vowel exists. Van der Hulst and Smith (1986) note that in idiosyncratic cases, the vowel is inaccessible. In these cases, the morphology overrules the regular harmonic pattern.

A third case in which C'lela harmony does not function as expected is class-marker /a/, which is opaque (see (65); data from Dettweiler, 2000: 11).

(65)	a.	i kom a-rim-a-ne	'DEF.a hand.CM.black.CM.ADJM'	'it's a black hand'
		i kom a-zis-a-ne	'DEF.a hand.CM.long.CM.ADJM'	'it's a long hand'
	b.	i kom a-rek-a-ne	'DEF.a hand.CM.small.CM.ADJM'	'it's a small hand'
		i kom a-gʲɔ-z-a-ne	'DEF.a hand.CM.red.CM.ADJM'	'it's a red hand'
	c.	i taar dᵊ-pus dᵊ-ni	'DEF.a stone.CM.white.CM.ADJM'	'it's a white stone'
		i taar dᵊ-rim-dᵊ-ni	'DEF.a stone.CM.black.CM.ADJM'	'it's a black stone'

The final suffix, which alternates between [-ne] and [-ni], surfaces as [-high], because it is preceded by the class-marker /a/, which blocks spreading and starts its own [-high] domain. Unlike the two previously mentioned idiosyncratic cases, /a/ is opaque in other situations as well. Dettweiler (2000: 14) states that "the class-marker is opaque in all positions. Moreover, we have no examples in

other morphemes of any /a/ which is non-opaque. So the opacity of /a/ is presumably phonological". This idea is not supported by data in Dettweilers work, and in the data throughout his various descriptions of C'lela (2000, 2015), no evidence for or against the opacity of /a/ in cases other than the class-marker can be found. More data is needed to support this statement. For the purpose of this thesis, it will be assumed that /a/ is opaque in C'lela harmony, since the only present evidence supports this, thus following the example of the existing literature on C'lela. The opacity of /a/ will receive further attention in section 5.2.

To the three cases in which vowels fail to harmonize mentioned in the existing literature (Dettweiler, 2000; Linebaugh, 2007; Michel, 2009; Pulleyblank, 2002), an important fourth case must be added. In discussing C'lela harmony, much attention has been given to the issue of two very specific cases of transparency mentioned above. In these cases, /i, u, o/ behave as transparent when they are part of a particular morpheme (some direct objects and lengthened adjectival suffixes). In any other situation in C'lela, /i, u, o/ do harmonize in roots (as in (59)) as well as in suffixes (as in (62)). Possessive suffix vowels, for example, may alternate between [me] and [mi] 'my', [vo] or [vu] 'your', and [o] or [u] 'his'. So while the cases of transparent /i, u, o/ in (63) and (64) are interesting, a topic that has (to my knowledge) received no attention thus far, is the role of [-high] vowels /ɛ/, /ɔ/, and the [+high] vowel /ɨ/. The opaque vowel /a/ has also received little attention. See (66) for a summary of the behavior of C'lela vowels.

(66)

i	Alternates with /e/in a [-high] context	Spreads [+high]
e	Alternates with /i/ in a [+high] context	Spreads [-high]
u	Alternates with /o/ in a [-high] context	Spreads [+high]
o	Alternates with /u/ in a [+high] context	Spreads [-high]
ɛ	Does not alternate	Spreads [-high]
ɨ	Does not alternate	Spreads [+high]
ɔ	Does not alternate	Spreads [-high]
a	Is opaque (does not alternate and blocks)	Spreads [-high]

Only /i/, /e/, /u/ and /o/ alternate in suffixes depending on the height of the domain. All vowels may be triggers, spreading their value for vowel height, but only [i, e, u, o] are successfully targeted. This leads me to the suggestion that only [+ATR] vowels may be targeted for height

harmony. The vowels that do not alternate are [-ATR]. This specification of [-ATR] is supported by Casali (2008) who specifies /ɛ, ɔ/ as -ATR. /a/ is [-ATR] in Dettweiler, and /ɨ/ is specified [-ATR] in Morton (2012), who describes the eleven-vowel language Anii and in Makeeva (2021), who describes the Togolese language Akebu (Kwa). Of these vowels, /a/ is opaque, and /ɛ/, /ɔ/ and /ɨ/ are neutral. I therefore suggest a more detailed analysis of the C'lela vowel inventory, as seen in (67). In this analysis, the vowels are not specified only for height (as in the inventory in Dettweiler (2000)), but also for [ATR].

(67)

	[+ATR]	[-ATR]	[+ATR]
[+high]	i	ɨ	u
[-high]	e	ɛ ɔ a	o

Since only a particular set of vowels harmonizes, this may point to a condition for height harmony, similar to that seen in Turkish. In Turkish, the low vowels are opaque for rounding, so that /a/ and /e/, which are [-high] and [-round], block spreading of [+round], and continue to spread their own feature [-round], while still continuing to spread the specification for backness. This means that the low round vowels /o/ and /ø/, which do occur in roots in [-high] and [+round] domains, and which may spread their values for roundness and backness, are nevertheless never produced by a rounding harmony rule.

Similarly, the [-ATR] vowels in C'lela follow height harmony in roots by only appearing in the roots of their own height, but they are never the result of a harmony rule. For example, /ɛ/ and /ɔ/ are part of [-high] domains, as seen in the data in (63), and may spread [-high] as seen in /ɛpkᵊ me/, where a root with the low vowel /ɛ/ is suffixed by [me] rather than the high vowel form [mi] (62a). The [+high] vowel /ɨ/ appears in the root in the [+high] domain /dᵊtɨndi/ (see (59), and it spreads its value [+high] in /hɨn-u/ in (62c). These [-ATR] vowels, however, do not alternate, which is especially

remarkable for /ɨ/, which in the inventory as postulated by Dettweiler (2000) does appear to have a low counterpart in /a/ even though both are mid vowels. Instead, these vowels are neutral in C'lela. Unlike the low vowels in Turkish, the [-ATR] vowels in C'lela are not all opaque; only /a/ blocks spreading. The other [-ATR] vowels are not targeted by vowel harmony. This is in line with cross-linguistic research, which shows that [+ATR] low vowels (and [-ATR] high vowels) are commonly avoided (Rose and Walker, 2011).

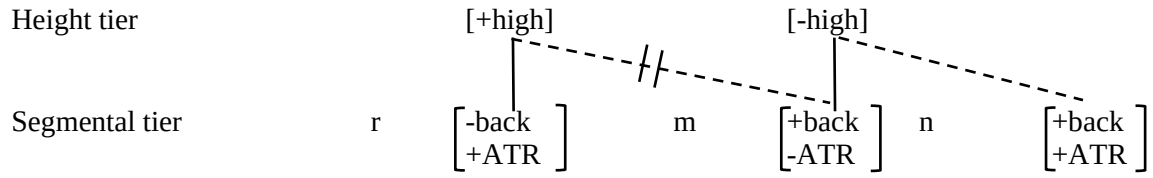
5.2 The Behavior of /a/

C'lela is used to examine the behavior of /a/ in height harmony. As was discussed in section 5.1, /a/ may act as a trigger, and as an opaque vowel that blocks spreading. As a trigger, /a/ spreads [-high] to the vowels that follow, as seen in the roots /ᵊddakso/ and /sᵊʔava/ in (59). In C'lela, /a/ does not form a possible target for height harmony. That is, when [+high] is spread, /a/ does not take on [+high], but rather, it resists the spreading of [+high] and blocks further spreading to vowels to its right (65).

As seen in (65), the class-marker [a] does not alternate, and causes the word-final suffixes to surface as [-high] as well. To illustrate, (68) shows [rim-a-ne], which includes the adjective, the class-marker and the adjective marker.

(68)

[i kom a rim-a-ne] 'DEF.a hand.CM-black-CM-ADJM 'it's a black hand'



(65) shows that the final suffix surfaces as either [ni] or [ne], depending on the height of the preceding vowels. In (65), the prefix is not targeted. The initial vowel [i] is not able to spread [+high] because it is blocked by [a], which in turn spreads its own [-high] specification to the final [e]. The suffix is therefore realized as [ne], and the surface representation is /a rimane/. Dettweiler states that the fact that the class-marker does not alternate is due to the opacity of /a/. Pulleyblank (2002, 2011)

argues that this can be accounted for by referring to the cross-morpheme domain, which allows for high-non-high sequences, but disallows non-high-high sequences of vowels.

Unlike the idiosyncratic cases mentioned in section 5.1, which were transparent, /a/ is opaque. In C'lela, /a/ is not a target, but instead remains [-high] and triggers [-high] harmony, starting a new domain. /a/ does not only block height harmony as a class-marker, but also in other contexts. As will be discussed in section 5.3, a possible explanation for the opacity of /a/ in C'lela might be that cross-linguistically, [+ATR] low vowels and [-ATR] high vowels are avoided (Archangeli & Pulleyblank, 1994; Rose & Walker, 2011).

Even though [a] in C'lela has a possible alternant [ɨ], these two vowels do not alternate. It could be that the vowels do not alternate because [ɨ] is a marked vowel. However, alternation between [a] and [ɨ] is attested in vowel harmony. In Kera, a Chadic language with height harmony and a vowel inventory similar to C'lela, [a] raises to [ɨ] in a [+high] context (see (69); data from Pearce, 2003: 19). Pulleyblank (2011) argues that while Kera does show [a] raising to [ɨ], these two vowels do not alternate because in C'lela height harmony, vowels are lowered rather than raised. [ɨ] is not lowered to [a], and [a] is opaque in C'lela.

(69)

a.	bad	'wash'
	bad-ɛ	'wash.IMPF
	bad-a	'wash.IMP
	bɨd-u	'wash.IMP
b.	kas	'hand'
	kas-a	'hand.POSS
	kɨs-i	'hand.POSS
	kɨs-u	'hand.POSS

All in all, /a/ behaves in two ways in C'lela. First, it acts as a trigger in word-initial position, spreading [-high] to the vowels that follow. Second, /a/ is opaque, and thus blocks the spreading of [+high], continuing to spread [-high].

5.3 A Feature-based Interpretation of the Behavior of /ɑ/

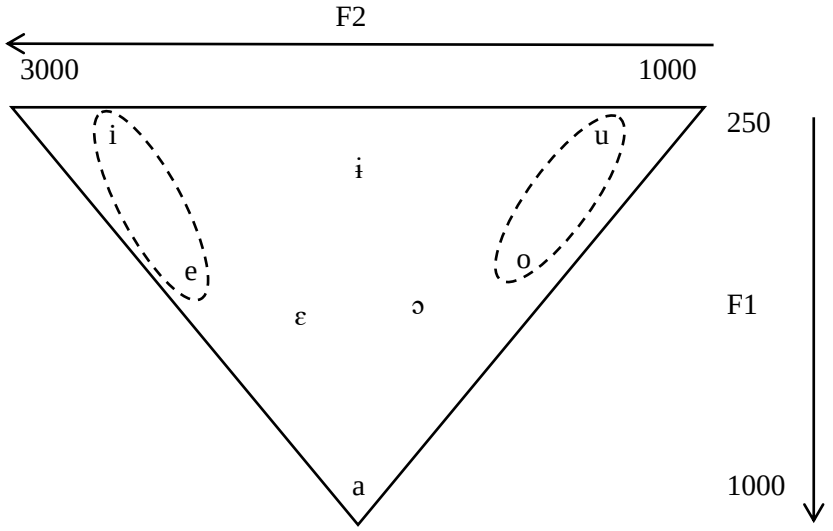
Section 5.2 concludes that /a/ is opaque in C'lela height harmony, so that it blocks [+high] and starts a new [-high] domain. In the hypotheses in chapter 1 it was suggested that /a/ could alternate with a central high vowel such as /ɨ/, or a central-mid vowel such as /ə/, but many languages do not have central vowels in their inventory, and /ɨ/ is [+ATR] and [-high], which is an often-avoided feature combination. Other options for a harmonic counterpart of /a/ included /e/ or /o/ and /ɛ/ or /ɔ/. So while /a/ initially appears to have free reign, it was suggested that /a/ might actually fail to harmonize in height harmony. The findings show that, as predicted, /e/ and /o/ harmonize with /i/ and /u/, but that /a/ is opaque. It is remarkable that /a/ fails to harmonize even though there is a central high vowel available in the C'lela inventory.

To examine how phonetic properties can account for the behavior of /a/, see the vowel triangle in (70). For reference, the vowel inventory is repeated alongside the vowel triangle in (67).

(67)

	[+ATR]	[-ATR]	[+ATR]
[+high]	i	ɨ	u
[-high]	e	ɛ ɔ a	o

(70)



The vowels with a mid-range F2 do not harmonize, though this does appear to be possible when considering the phonetic information. Possibly, the two central vowels differ too much in height to form harmonic counterparts. Looking at the vowel triangle of C'lela, it seems likely that [ɨ] might have historically alternated with a central mid vowel like [ə]. The difference in height between [i] and [e], and [u] and [o] is smaller than that between [ɨ] and [a], and more similar to that between [ɨ] and [ə]. It is possible that [a] does not harmonize in C'lela because the mid vowels harmonize with the high vowels, leaving /a/ without a harmonic counterpart.

Before discussing how feature relationships can account for the behavior of /a/ in C'lela height harmony, it must be discussed how feature relationships can help account for the fact that all [-ATR] vowels (including [a]) fail to harmonize. In C'lela height harmony, there are two harmonic pairs that alternate (see (59)). [+high] /u/ and /i/ alternate with [-high] /o/ and /e/. These features are all [+ATR]. ATR and height have opposite effects on the frequency of F1. [-ATR] raises F1, and [+high] lowers F1, while [+ATR] lowers F1, and [-high] raises F1. Also, Grounding Theory shows that [+ATR] implies [+high], and [-ATR] implies [-high]. As proposed in section 5.1 it appears that the vowel harmony in C'lela only occurs within the [+ATR] vowels, in order to prevent such antagonistic forces. For the harmonizing vowels, the ATR is then predictable, leaving [high] to determine F1 in C'lela harmony.

While all [-ATR] vowels fail to harmonize in C'lela, only the low vowel /a/ is opaque. A combination of the phonetic properties as encoded in features and the relationships between these features may account for this. [a] might fail to harmonize, due to the antagonistic forces of [-ATR] and [+high]. Then, it might fail to form a harmonic pair with [ɨ], because this central high vowel historically harmonized with a central mid vowel like [ə]. By the same token, [a] might have historically alternated with a central mid vowel itself. In that case, the loss of this mid vowel from the inventory may have caused [a] to become opaque in C'lela height harmony.

6. ATR Harmony

In ATR harmony, vowels within a domain must share the feature ATR. For this research, Maasai (Maa) will be analyzed in order to delve into ATR harmony. Maasai is a Nilotic language spoken in Tanzania and Kenya, by over 800,000 people (Guion et al., 2004). Unless otherwise specified, the main sources for Maasai data are Bakovič (2000, 2001), Cole (1987), Guion et al. (2004), Tucker and Mpaayei (1955), Quin-Wriedt (2003), and Rose and Walker (2011).

6.1 Maasai ATR Harmony

Maasai has a bidirectional ATR harmony process, in which [+ATR] is the dominant feature. /a/ behaves as opaque in regressive spreading of ATR, but in progressive harmony, it may surface as /o/. The following section will consider Maasai ATR harmony in more detail.

The vowel inventory of Maasai shows that the language has nine vowels, as illustrated in (71); data from Quin-Wriedt, 2003: 5). Four of the vowels are [+ATR], five are [-ATR].

(71)

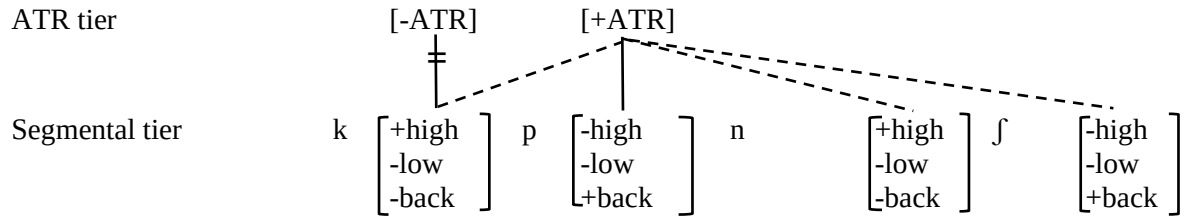
	[+ATR]		[-ATR]	
	[-back]	[+back]	[-back]	[+back]
[+high, -low]	i	u	ɪ	ʊ
[-high, -low]	e	o	ɛ	ɔ
[-high, +low]				a

Casali (2008) states that languages with nine vowels are extremely common among African ATR harmony languages. Symmetrical ATR harmony languages with eight or ten vowels also exist. Here, /a/ often alternates with /ɐ/ or /ə/. Maasai /a/ is represented in the inventory as the low back vowel with no clear harmonic counterpart[21]. As can be seen in (72), Maasai has a dominant harmony pattern, in which [+ATR] is spread regardless of whether the trigger is in the root or in a suffix.

[21] For other interpretations, see Vossen (1982) and Wallace (1980).

(72)

[ki-pon-iʃo] ‘2.PL.PRES.cut the ears of an animal.INTRANS’ ‘you.PL cut the ears of an animal’

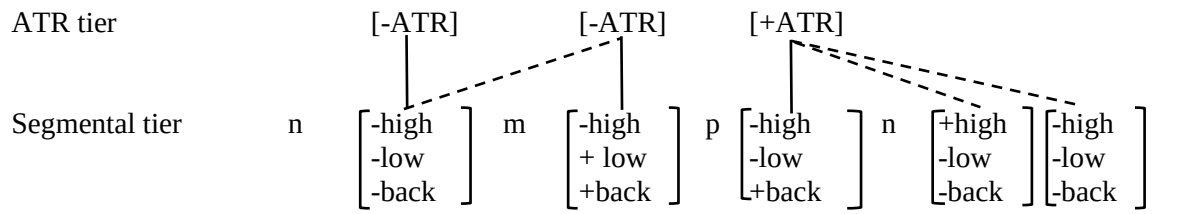


In this case, the root /pon/ has the feature [+ATR], which is spread to the prefix and suffixes. The prefixes in Maasai are underlyingly [-ATR], but may surface as [+ATR] as a result of spreading. Consequently, [+ATR] never spreads from the prefix to the root, but it may be spread from the suffixes to the root, or from the root to the affixes.

The low vowel /a/ is opaque (73). The feature [+ATR] in the root /pon/ can therefore spread to the right, but not to the left, where it is blocked by /a/, causing /ɛ/ to remain [-ATR].

(73)

[nɛ-ma-pon-ie] ‘1.SG.NEG.FUT.cut the ears of an animal.CAUS’ ‘I will not cut the ears of an animal’

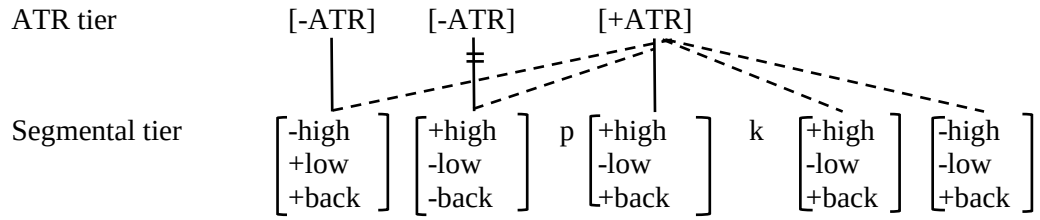


Rose and Walker (2011) refer to such a case in which the dominant feature is able to spread only in one direction, even though the harmony process is bidirectional, as directional asymmetry. In vowel harmony with directional asymmetry, the progressive harmony behaves differently to the regressive harmony. In Maasai, the regressive harmony is blocked by /a/.

There is one condition in which /a/ does alternate. If /a/ is in a suffix, and it follows a [+ATR] vowel, it participates in ATR harmony. In other words, Maasai progressive harmony allows /a/ to alternate. Since there is no [+ATR] low vowel, /a/ alternates with /o/. See for example, (74).

(74)

[aipukuo] ‘1.SG.PST.flee.DIR’ ‘I fled this way’



Casali (2008) points out that alternation of the low vowel with /o/ is not uncommon for East-African languages like Maasai. In West-African languages, /e/ appears to be the harmonic counterpart of /a/.

6.2 The Behavior of /a/

In Maasai, /a/ behaves as opaque in regressive spreading of ATR, but in progressive harmony, it may surface as /o/. The opacity of /a/ can be seen in (75). The dominant [+ATR] suffixes are underlined (data from Bakovič, 2000: 192).

(75)	a.	[kɪ-ŋar-<u>ie]</u>	kɪŋar<u>ie</u>	‘1PL.share.APPL’
		[kɪ-duŋ-<u>ie]</u>	kiduŋ<u>ie</u>	‘1PL.cut.APPL’
	b.	[ɪ-as-ɪšɔ-<u>re]</u>	ɪasišo<u>re</u>	‘2SG.do.INTRANS.APPL’
		[ɪ-duŋ-ɪšɔ-<u>re]</u>	iduŋišo<u>re</u>	‘2SG.cut.INTRANS.APPL’

(75a) and (75b) show that while the prefix harmonizes when the root is [duŋ], it fails to do so when the root contains an /a/ as in [as] and [nar]. As can be seen in (75b), the other vowels are unaffected by the opacity of /a/, and harmonize along with the dominant [+ATR] suffixes. In leftward harmony, the low vowel is opaque, as became clear in the autosegmental representation in (73).

When [+ATR] spreads rightward, /a/ does alternate. If /a/ is in a suffix, and it follows a [+ATR] vowel, it participates in vowel harmony, by alternating with /o/ (see (76); data from Bakovič, 2000: 192).

(76)	a.	[ɔl-mɛn-a]	ɔl-mɛn-a	MASC.SG.VERB.PROD	‘contempt’
		[ɪn-lɪpɔŋ-a]	ɪ-lɪpɔŋ-a	FEM.PL.NOUN.PL	‘full-grown female’
	b.	[ɛŋ-komon-a]	eŋ-komon-**o**	FEM.SG.VERB.PROD	‘prayer’
		[ɪn-mudoŋ-a]	i-mudoŋ-**o**	FEM.PL.NOUN.PL	‘kinship’

In (76a), the word-final /a/ remains unaffected because there is no dominant [+ATR] vowel preceding it. In (76b) it can be observed that the word-final /a/ changes to /o/ as a result of the [+ATR] vowels preceding it. Because of this progressive spreading, /a/ alternates with /o/.

Archangeli and Pulleyblank (1994) and Bakovič (2000) show that the fact that /a/ alternates with /o/ in progressive harmony is due to a process referred to as *re-pairing*. In this process, the vowel that is incompatible with the harmonic feature (in this case /a/) is able to undergo harmony because of a change in an additional feature. For reference, the vowel inventory of Maasai is repeated below in (71).

(71)

	[+ATR]		[-ATR]	
	[-round]	[+round]	[-round]	[+round]
[+high, -low]	i	u	ɪ	ʊ
[-high, -low]	e	o	ɛ	ɔ
[-high, +low]			a	

The feature specifications of /a/ are [-ATR, -high, +low, -round]. There is no [+ATR] counterpart of /a/ available in the inventory that differs from /a/ only with regard to [ATR]. /a/ is thus repaired to /o/ through rounding and raising in progressive harmony, while behaving as opaque in regressive harmony.

Two analyses have been proposed regarding the directional asymmetry of Maasai harmony. Bakovič proposes an Optimality Theory analysis in which the difference in leftward and rightward harmony is due to stem-control. Stem-controlled harmony is a cyclic system, in which segmental and autosegmental rules are applied in an iterative manner. First the stem is derived, after which the phonological rules are applied to it. Then an affix is attached, after which the suffix becomes subject to the vowel harmony rules. This process repeats itself until the entire word or domain is complete.

Within this stem-controlled system in Maasai, Bakovič argues that the constraint SA-IDENT (stem affixed form identity) applies, which dictates that a particular feature in the stem must remain the same in the affixed form and in the unaffixed form. This keeps /a/ in the stem from harmonizing along with any [+ATR] suffix vowels, as seen in (75a). /kɪŋarie/ contains [+ATR] vowels in its suffix, which fail to spread to the stem-controlled /a/. When /a/ occurs in a prefix, it also fails to harmonize. Bakovič assumes that these prefixes are outside of the harmonic domain, or that the prefix vowels are subject to special faithfulness.

Archangeli and Pulleyblank (1994) have a different analysis of the directional asymmetry, which says that re-pairing happens for /a/ in progressive harmony, but that the grounded condition prevents this for regressive harmony, because it disallows ATR and low to be together. In fact, Rose and Walker state that this avoidance of [+ATR] low vowels (and [-ATR] high vowels) is found cross-linguistically. Asymmetrical vowel systems in which /a/ does not have a harmonic counterpart are very common among ATR harmony languages (Casali, 2008; Polgárdi, 1998). In these languages, /a/ can be opaque, transparent, a harmonic counterpart with /o/, or a harmonic counterpart with /e/.

The analyses by Bakovič and by Archangeli and Pulleyblank both account for this directional asymmetry. However, for the purpose of this thesis, which focuses on features, Archangeli and Pulleyblank's Grounding Theory is more relevant.

6.3 A Feature-based Interpretation of the Behavior of /ɑ/

The previous section concluded that in Maasai ATR harmony, /a/ is opaque in regressive harmony, and it alternates with /o/ in progressive harmony, through a process called re-pairing. The introduction showed that because of the articulatory and acoustic restrictions, a [+ATR] low vowel is uncommon. /a/ might alternate with the relatively low [+ATR] vowel /æ/ if it is available in the inventory. It was predicted that it is more likely that /a/ fails to harmonize. /a/ could also harmonize with /o/ or /e/, but these vowels are likely to already harmonize with the [-ATR] vowels /ɛ/ and /ɔ/.

As predicted through considering feature relationships, there is no [+ATR, -high] vowel available in Maasai ATR harmony. Instead, /a/ both harmonizes with /o/, and is opaque. The harmony

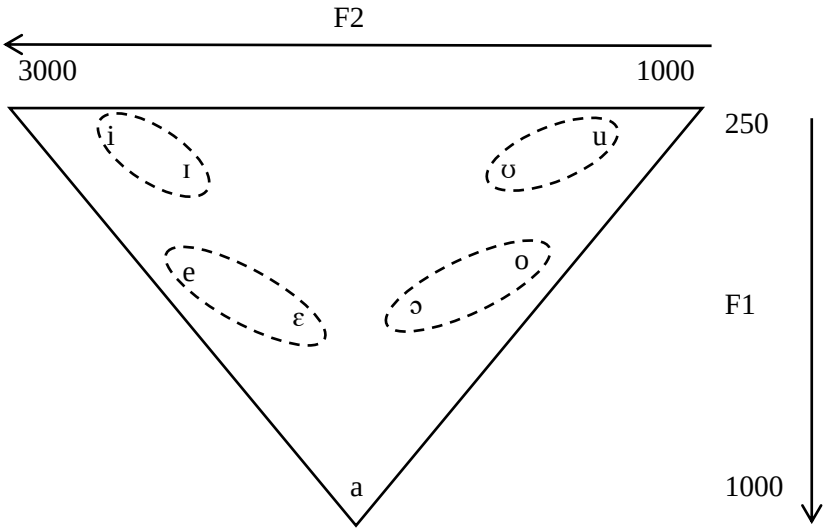
process in Maasai is directionally asymmetrical, since /a/ alternates with /o/ in progressive harmony, but is opaque in regressive harmony.

In Maasai, vowels harmonize in terms of ATR. As shown in (71) and (77), the [+ATR] vowels alternate with vowels with a slightly lower F1, and a F2 that is more towards the center. The low vowel /a/ has no available [-high][+low] [+ATR] partner.

(71)

	[+ATR]		[-ATR]	
	[-back]	[+back]	[-back]	[+back]
[+high, -low]	i	u	ɪ	ʊ
[-high, -low]	e	o	ɛ	ɔ
[-high, +low]				a

(77)



Since [+ATR] lowers F1, and [-high] raises F1, this combination is unlikely to appear in a vowel. Grounding Theory also shows that "if [+ATR], then not [-high]" (Archangeli & Pulleyblank, 1994: 176). In looking for a [+ATR] counterpart, /a/ often alternates with /e/ and /o/ in ATR harmony languages. These are the lowest [+ATR] vowels available in the vowel triangle, and thus make logical options for /a/ in ATR vowel harmony. Thus, the phonetic properties of Maasai vowels account for the fact that /o/ is selected as an alternant for progressive harmony, and the feature relationships are reflected in the fact that /a/ fails to harmonize in regressive harmony.

7. Summary and Discussion

In chapters 3 through 6, four types of vowel harmony were discussed. These results are summarized in Tables 2 through 4. A discussion of these findings can be found in section 7.1. Table 2 is an overview of the four vowel harmony types.

Language	Harmony type	Direction	Neutral vowel(s)	Comments
Tuvan	Backness	→	-	
Kirghiz	Rounding	→	/ɑ/	/ɑ/ is neutral after /u/
C'lela	Height	→	/a, ɨ, ɔ, ɛ/	/a/ is opaque /ɨ, ɔ, ɛ/ are neutral
Maasai	ATR	↔	/a/	/a/ is opaque in prefixes /a/ alternates with /o/ in suffixes after [+ATR] vowels

Table 2

Overview of four vowel harmony types and four corresponding languages, listing the direction, the neutral vowels, and a brief summary of these neutral vowels.

Each of these four languages is used to examine what the behavior of /a/ is in vowel harmony types. A summary of the behavior of /a/ can be seen in Table 3. In all four languages, /a/ plays the role of a trigger, spreading its specification for the harmonizing feature. In Tuvan and Kirghiz harmony, /ɑ/ is also targeted for harmony, but in Kirghiz /ɑ/ fails to harmonize after the high back vowel /u/. In Maasai, /a/ alternates with /o/, but this is restricted to progressive harmony. In C'lela harmony and in Maasai regressive harmony, /a/ is opaque. In Tuvan, /ɑ/ is also the replacement vowel in reduplication.

Language	Trigger	Target, alternating with	/a/ as a neutral vowel	Other
Tuvan	Spreads [+back]	/e/	-	/ɑ/ and /u/ are replacement vowels The reduplicants start a new domain
Kirghiz	Spreads [-round]	/o/	/ɑ/ fails to harmonize after /u/	
C'lela	Spreads [-high]	-	Opaque	
Maasai	Spreads [-ATR]	/o/ in progressive harmony	Opaque in regressive harmony	

Table 3

Overview of the behavior of /a/ in four vowel harmony languages.

Finally, Table 4 summarizes the feature-based interpretations of the behavior of /a/ in vowel harmony languages.

Language	Behavior of /a/	Feature relationships
Tuvan	Alternates with /e/	No restriction on [-back] [-high]
	Replacement vowels: /ɑ/ and /u/	/o/ is not a replacement vowel /o/ is [+round] [-high]
Kirghiz	Alternates with /o/ /a/ fails to harmonize after /u/	[+round] prefers [+back] restriction on [+round] [-high]
C'lela	Opaque	restriction on [+high] [-ATR]
Maasai	Alternates with /o/ in progressive harmony	restriction on [+ATR] [-high]
	Opaque in regressive harmony	restriction on [+ATR] [-high]

Table 4

Overview of a feature-based interpretation of the behavior of /a/ in four vowel harmony languages.

7.1 Discussion

This thesis set out to examine how a feature-based interpretation can account for the behavior of /a/ in vowel harmony languages. Findings show that the two factors do, at least to some extent, explain the behavior of the low vowel. The phonetic properties point to possible alternants of /a/ in vowel harmony, and feature relationships point to restrictions of feature combinations as well as preferable feature combinations. Findings show that the behavior of /a/ reflects these phonetic possibilities and preferred feature combinations.

Based on the features and feature relationships, the hypothesis regarding the behavior of /a/ in vowel harmony languages was formed. The hypothesis is that it is likely that /a/ 'struggles' to harmonize in all four vowel harmony types. In some languages, /a/ might fail to harmonize, while in others it might opt for alternating with a vowel that differs more from /a/ than other harmonic counterparts in the language differ from one another. The research into four vowel harmony languages confirms this hypothesis. In all four languages, /a/ either has to make a concession by changing an extra feature, or it fails to harmonize. Phonetic properties and feature relationships can account for this behavior. Below, the interpretation, implications, and limitations of these findings will be discussed, after which suggestions for future research will be made.

7.2 Interpretation

The results suggest that behavior of vowels in harmony is (at least to some extent) predictable, and that phonetic properties of features and feature relationships are good indicators for vowel behavior. Restrictions on combinations of [+round] and [-high], [+high] and [-ATR], and [+ATR] and [-high] can account for the behavior of /a/ in all four languages. In the case of regressive Maasai harmony, for example, /a/ fails to harmonize, because a [+ATR, -high] option is a made up of features that are antagonistic, and therefore avoided. The phonetic properties, which are encoded in these features, also account for the behavior of /a/ in all four languages. In Tuvan, for example, the low back vowel alternates with front vowel /e/, which is acoustically and articulatorily higher than /ɑ/. In order to alternate, /ɑ/ has to seek its counterpart slightly higher in the vowel triangle.

On the whole, the findings reflect the existing literature on which the hypotheses were based. In backness harmony, there is no restriction that disallows the low back vowel /ɑ/ to alternate with the front vowel /e/. This is in line with Archangeli and Pulleyblank (1994) and Kaun (2009), who say backness and rounding form a preferred feature combination. Kirghiz rounding harmony reflects the fact that rounding prefers backness as shown in (36), taken from Ladefoged and Johnson (2015). In Kirghiz, /ɑ/ alternates with the [+back] round vowel /o/, rather than the [-back] round vowel /ø/. A surprising case was found in C'lela. The hypothesis for C'lela suggested that /a/ might harmonize with /ɨ/ in height harmony, if such a high central vowel is available in the inventory. This idea is based on Ani (Morton, 2012) and Akebu (Makeeva, 2021), in which this is the case. While /ɨ/ is available in the C'lela harmony, /a/ fails to harmonize with it. This is consistent with the claim made by Archangeli and Pulleyblank (1994), who state that [+high, -ATR] vowels are avoided. Finally, in ATR harmony languages, Casali (2008) shows that if /æ/ is available in the inventory, it may act as the [+ATR] counterpart of /a/. In Maasai, /æ/ is not part of the inventory. Casali also suggests that /a/ might harmonize with /o/ or /e/, or fail to harmonize. Here, findings support the literature, since in Maasai, /a/ harmonizes with /o/ in progressive harmony, and fails to harmonize in regressive harmony.

The findings also suggest that failing to harmonize appears to only happen after other options for vowel harmony have failed. In Tuvan and Kirghiz, /ɑ/ is able to harmonize with a slightly higher counterpart. In C'lela, however, the possible [+high] counterpart appears to be too different from /a/ to form a viable harmonic counterpart.

7.3 Implications

There are several implications for these findings. First, findings show that the behavior of vowels is (at least to some extent) predictable by considering features and feature relationships. This knowledge expands the general understanding of vowel harmony. Additionally, these findings give more insight into the behavior of /a/ in vowel harmony languages. There is, to my knowledge, no work regarding the behavior of /a/ across various vowel harmony types.

The findings show that a feature-based interpretation can account for the behavior of /a/. This suggests that these factors may be good predictors to inform knowledge of the behavior of other vowels in vowel harmony languages as well. An antagonistic feature combination that has received little attention in this thesis is that of [-back] and [+round] vowels. This relationship might predict restrictions in rounding and backness harmony languages.

Another implication of these findings is that it supports Grounding Theory by Archangeli and Pulleyblank (1994), which suggests that certain features correspond to implications of specifications for other features (e.g. [+ATR] implies [+high], etc.). These feature relationships account for the behavior of /a/ in the findings of this research.

Furthermore, this thesis has expanded on the analyses made thus far regarding C'lela height harmony. The failure of the vowels /ɨ, ɛ, ɔ/ to harmonize had thus far received very little attention. This thesis suggests that these vowels, as well as the low vowel /a/, are specified as [-ATR]. It proposes that C'lela height harmony has a restriction on [-ATR] vowels, causing only the [+ATR] vowels /i, e, u, o/ to harmonize. This analysis, and the more detailed vowel inventory in (67) add to the existing literature and might aid future research into C'lela harmony and height harmony more broadly.

A final implication of this thesis is that the findings might support field linguists, as it underpins the predictability of the behavior of vowels in a vowel harmony language. The research shows that the existing literature regarding feature relationships can help predict options for the behavior of particular vowels in vowel harmony languages.

7.4 Suggestions for Future Research

The findings of this thesis are subject to several limitations, which may serve as implications for further research. First of all, cross-linguistic studies have been written regarding all vowel harmony

types except for regarding backness harmony.[22] While there is considerable overlap between rounding and backness harmony languages, a work with backness harmony as its primary focus might provide interesting insights. Similarly, research could examine whether the behavior of /a/ is different to the behavior of other vowels. In order for the vowel harmony process to be upheld, at least a noticeable number of vowels has to harmonize successfully. Therefore, my impression is that while /a/ is mostly restricted by feature relationships and phonetic properties, other vowels might actually be supported by these two factors. Thus, further research could strengthen the claim that these two factors are good predictors for vowel behavior in vowel harmony languages.

This thesis has not addressed several aspects in much detail. For one, locality and rule ordering (Bakovič; see sections 2.5 and 6.2) may help explain why certain sounds are not targeted. Additionally, future research could adopt a monovalent approach, rather than a binary approach. In Element Theory (Backley, 2011), for example, the element |A| appears on its own tier, separately from |I| and |U|. This might lead to interesting new insights regarding the behavior of /a/ in vowel harmony.[23] Also, a more holistic overview of how Grounding Theory (Archangeli & Pulleyblank, 1994) might help gain better insight into the behavior of /a/, and it could further affirm the theory.

The findings show that /a/ is to some extent dependent on which vowels are available in the vowel inventory. This raises the question whether there are (feature-based) patterns that might explain why certain vowels are (not) available in a language inventory. Additionally, unlike the vowel triangles used in this thesis, less than ten percent of all languages' vowels are to be represented on a vowel trapezoid. These languages have significantly more space in the [-high] (or [+low]) regions. Future research might show whether there are languages with a language trapezoid that have vowel harmony, and whether this impacts the behavior of /a/.

[22] Cross-linguistic studies regarding vowel harmony have been written by Kaun (2009) (rounding harmony), Casali (2008) and Archangeli and Pulleyblank (1994) (ATR harmony), and Pulleyblank (2011) (height harmony).

[23] See Polgárdi (1998) for a description of vowel harmony using Element Theory.

Finally, researching the four vowel harmony types and their corresponding languages has raised several questions that might be relevant to future research.

Tuvan backness harmony shows an interesting reduplication process. In the Tuvan data, there was no monosyllabic base word with /u/. Patterns shown by Harrison (1999b) suggest that this monosyllabic /u/ would be replaced with /ɑ/, but there is no data to support this, as can be seen in (44). Future research could provide data to support this. Future research could also provide more data of the behavior of reduplicants and disharmonic loan words. In the word [kurort], it was seen that the disharmony of this loan resulted in [kɑrɑrt], but this is only an example of disharmony with regards to rounding. Data of words that are disharmonic with regard to backness (words that start with a back vowel, followed by a front vowel) could also provide interesting insights into backness harmony, feature relationships, and Tuvan reduplication. In this thesis it was suggested that the replacement vowel is intended to be the vowel most divergent from the other vowels as a group. Future research could compare this reduplication process to that in other languages, to see if there is cross-linguistic evidence for this proposal.

Kirghiz rounding harmony is referred to by Smolek (2010) as a relatively 'more' harmonic language. This raises the question to what extent the level of harmony is linked to the behavior of /ɑ/.

Future research concerning C'lela height harmony could examine several issues. As argued in section 5.1, future research can examine whether C'lela harmony is progressive, regressive, or bidirectional. Also, more data is needed to confirm that /a/ is opaque in C'lela (see section 5.2). The improved inventory of C'lela in (67) as well as the analysis of a restriction on [-ATR] in C'lela might inform future research. Finally, future research might compare several height harmony languages in which /ɨ/ and /a/ are present, in order to determine if alternation between these vowels is attested.

In ATR harmony, a statistical approach might show if there are cross-linguistic patterns that could suggest why /a/ is not transparent instead of opaque, or an alternant of /e/ instead of /o/. The asymmetrical behavior of Maasai could also be researched more broadly by considering the theories by Baković (2000) and Archangeli and Pulleyblank (1994) across a number of asymmetrical (ATR) harmony languages.

7.5 Conclusion

This research set out to examine how a feature-based interpretation can account for the behavior of /a/ in vowel harmony languages. Findings show that a feature-based interpretation can account for the behavior of /a/ in vowel harmony languages. In order to examine this research question, the behavior of /a/ was researched in four vowel harmony languages. Findings show that /a/ alternates in some languages, and fails to harmonize in others. When /a/ participates in vowel harmony, it has to make a concession by seeking its counterpart slightly higher in the vowel triangle, as predicted by looking at phonetic properties. Feature relationships show that some combinations of features are preferable, and thus result in successful harmony, while others are avoided. These 'poor' combinations of features often result in failure to harmonize. All in all, a feature-based interpretation can account for the behavior of /a/ in vowel harmony languages. These findings suggest that the behavior of /a/ is predictable by a feature-based interpretation. Future research could determine if these factors are indicators for the behavior of all vowels in vowel harmony.

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Appendix

Appendix A: Abbreviations

1	First person
2	Second person
3	Third person
ABL	Ablative
ABS	Absolutive
ADJM	Adjective marker
APPL	Applicative
CM	Class-marker
DEF	Definite
DIR	Direction
EMPH	Emphatic
FEM	Feminine
FUT	Future
GEN	Genitive
PAST.II	Definite past
ILL	Illative
INTRANS	Intransitive
MASC	Masculine
NEG	Negative
NOM	Nominative
PL	Plural
POSS	Possessive
PROD	Product verbalizer
PST	Past tense
PST.PT	Past participle
RED	Reduplicant
SG	Singular