Height-Based Restrictions on Vowel Harmony in Mayak

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1. Introduction

Mayak is a Western Nilotic language of northern Burun that exhibits dominant-recessive ATR harmony where [+ATR] is dominant (Andersen 1999a, 1999b, 2000)[2]. This ATR harmony system is crucially dependent on vowel height in that the direction and acceptance of the spreading of [+ATR] depends on the height of the potential trigger and target for vowel harmony. High vowels are unrestricted, mid vowels are partially restricted and low vowels are the most restricted in that only a small set of low vowels participate in vowel harmony in any form. This is shown in (1) ([+LOW, +ATR] vowels are transcribed as [ʌ]).

(1) Vowel Harmony in Mayak (Andersen 1999a)

(a)	/ʔuŋ-ɪ/	→	[ʔuŋi]	'knee 1S possessed'
(b)	/lɛp-u/	→	[lewu]	'open- Past'
(c)	/ʔʌm-ɪ:/	→	[ʔʌmɪ:]	'he is eating'

The fact that all three vowel heights behave differently with respect to vowel harmony reflects the phonetic naturalness in the dependency of height and ATR: high vowels are more naturally [+ATR]; non-high vowels are not. These facts are handled straightforwardly using Headed Feature Domains Theory (Smolensky 1997, 2005). Headed Feature Domains Theory is a theory of feature representation in which all segments are part of feature domains in which a single segment acts as the head of that domain. A constraint against feature domains (*HD) motivates general vowel harmony by limiting the number of distinct feature domains. Complex vowel harmony systems can

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[1] I am greatly appreciative of all the helpful comments and questions from the following people: Paul Smolensky, Luigi Burzio, Jane Grimshaw, Joe Pater, and all the participants of HUMDRUM. All errors are my own.

[2] Mayak also has optional round harmony, which will not be discussed in this paper.

be derived by conjoining *HD with conventional, phonetically-grounded markedness and faithfulness constraints.

This paper will proceed as follows: I will begin with an overview of Headed Feature Domains Theory, explaining its assumptions, and how basic harmony patterns are derived. I will then give an overview of the Mayak data, detailing the complexities of the height-based restrictions on harmony. This will be followed with an analysis of the data using headed feature domains, including an analysis of morphological variation in low vowels.

2. Headed Feature Domains Theory

The headed feature domains approach to harmony is an attempt to incorporate the strengths of autosegmental phonology into OT by providing a way of representing shared phonological features in a single domain. It combines the strengths of Optimal Domains Theory (Cole and Kisseberth 1994a, b) with the strengths of AGREE constraints (Bakovic 2000).

The main assumption behind Headed Feature Domains Theory is that all phonological features are individually represented as feature domains. For a given phonological domain, if adjacent segments share the same value for a given feature, those segments share the same feature domain. For example, for the word [be:kum], all vowels share a single [+ATR] feature domain, represented as $[\text{be:kum}]_{[+ATR]}$.

Further, all feature domains are required to have one and only one head, marked with º. It is assumed in the present analysis that GEN eliminates all structures that have no head (*$[\text{be:kum}]_{[+ATR]}$), have multiple heads (* $[\text{be:}^{o}\text{ku}^{o}\text{m}]_{[+ATR]}$) or are adjacent domains of the same feature value (*$[\text{be:}^{o}\text{k}][\text{u}^{o}\text{m}]_{[+ATR]}$).[3]

While all feature domains are required to have a head, the existence of a head is marked by the constraint *HD. Because heads are required, each phonological domain will have at least one violation of *HD for any given feature. For example, $[\text{be:}^{o}\text{kum}]_{[+ATR]}$ has one violation of *HD[ATR], and $[\text{bɛ:}^{o}]_{[-ATR]}$ $[\text{ku}^{o}\text{m}]_{[+ATR]}$ incurs two violations of *HD[ATR]. The ranking of *HD above featural identity results in harmony because in order to minimize violations of *HD, one must eliminate feature heads. This is achieved only when adjacent vowels share the same value of a given feature. In this way, *HD is logically equivalent to AGREE; the harmonic candidate will always have the fewest violations of *HD and AGREE.

What makes *HD different from AGREE is that *HD, as part of a theory of feature representation, implicitly forces harmony, while AGREE explicitly requires it. While both AGREE and *HD are by themselves inherently bidirectional, headed-feature domains are

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[3] It is possible that the restrictions on GEN may be derived through harmonic bounding or additional constraints (Jane Grimshaw, personal communication). For this paper, however, I will assume candidate sets that conform to these restrictions.

able to account for non-morphologically motivated directionality effects in harmony (such as those seen in Mayak) through alignment of the feature domain head to the left or right edge of the domain.

In terms of vowel harmony, the head of a feature domain is analogous to the autosegmental harmony trigger, and it is important that the head of the feature domain actually be the harmony trigger. This occurs only when the head of the feature domain for feature α has no changes in feature α from input to output. This is captured by the constraint FAITHHD, which states that the head of the feature domain must be the same from input to output. FAITHHD is a shorthand for the conjunction of ID[α] and *HD[α]. Notice, however, that FAITHHD is a violable constraint. Thus, the trigger of harmony need not be the head of the feature domain, though languages may require it. In Mayak, faithful heads are not required. This is achieved by ranking FAITHHD below *HD.

In addition to FAITHHD, other constraints may be derived through the local conjunction of *HD with traditional OT constraints. These local conjunctions are able to derive complex restrictions on vowel harmony without the postulation of novel, specialized constraints. The domain of the local conjunction may span one segment (e.g. the head of the feature domain) to the entire feature domain, reflecting the fact that the markedness of a feature domain may be dependent on the markedness of its head. Because segments and feature domains may be linked through local conjunction, the markedness of the segment that acts as the domain head affects the markedness of the entire domain. These markedness-based dependencies are reflected in the height-based restrictions in Mayak: non-high [+ATR] vowels are restricted both as harmony triggers and targets.

Headed-feature domains are therefore a powerful method for representing and accounting for the complicated nature of long-distance feature dependencies such as vowel harmony, and provide a the potential for a natural account of phonetically-based restrictions on vowel harmony.

3. Vowel Harmony in Mayak

As mentioned above, Mayak displays dominant-recessive [ATR] harmony with [+ATR] dominant. What makes Mayak an interesting case study is the fact that while the vowel inventory for Mayak is entirely symmetric, the harmony system is asymmetric with respect to which vowels participate in harmony.

(2) Mayak Vowel Inventory (Andersen 1999a)

	[+ATR]		[–ATR]	
High	i	u	ɪ	ʊ
Mid	e	o	ɛ	ɔ
Low	ʌ		a	

These asymmetries are entirely dependent on height. The first idiosyncrasy to note is the fact that [+ATR] mid vowels [e] and [o] are licensed only by vowel harmony, as evidenced by the fact that words like *[lep] are ungrammatical, as shown in (3) a and b. However, (3) c-f show that [+ATR] mid vowels only surface when they are in a harmonic environment, preceding a [+ATR] high vowel.

(3) Mayak Mid Vowels (Andersen 1999a)

(a)	[lɛp] (*[lep])		'tongue'
(b)	[pɔk] (*[pok])		'mouth'
(c)	[be:kum]		'monkey'
(d)	[okur]		'chickens'
(e)	/lɛp-u/ →	[lew-u]	'open- Past'
(f)	/wɔŋ-u/ →	[woŋ-u]	'eye -Pl'

While [+ATR] mid vowels may appear in harmonic environments, these vowels only appear as targets of regressive assimilation, shown in (4).

(4) Right-Left Directionality for Mid-Vowel Targets (Andersen 1999a)

(a) *Left to Right

[ʔib-ɛr] *[ʔib-er] 'shoot, 3S'

(b) ✓ Right to Left

/lɛp-ir/ → [lepir] 'open'

Therefore, Mayak appears to have directionality effects, which violates the general tendency of dominant-recessive harmony systems to be inherently bi-directional (Bakovic 2000; Krämer 2003). However, this directionality effect is selective: it applies only to mid vowels. High vowels spread [+ATR] bi-directionally, shown in (5).

(5) Bi-Directionality for High-Vowel Targets (Andersen 1999a)

(a) Right to Left Spreading

/ʔit̪- u/ → [ʔit̪u] 'shape with an axe'

(b) Left to Right Spreading

/ʔuŋ-ɪ/ → [ʔuŋi] 'knee 1S possessed'

The most curious aspect of vowel harmony in Mayak is the fact that in general, low vowels are neutral to harmony: [a] is not a target in either direction; [ʌ] is not a trigger in either direction. This is shown in (6) and (7).

(6) /a/ does not assimilate (Andersen 1999a)

(a) No Left-to-Right Assimilation

/kuɖ-ak/ → [kuɖ-ak] 'nest-Plural'

(b) No Right-to-Left Assimilation

/ʔam-u/ → [ʔam-u] 'eat- PST'

(7) /ʌ/ does not trigger harmony (Andersen 1999a)

(a) No Left-To-Right Spreading

/ʔʌm-ɪr/ → [ʔʌm-ɪr] 'he is eating'

(b) No Right-to-Left Spreading

/dɪːm-b-ʌr/ → [dɪːm-b-ʌr] 'spear- 3SG'

Typologically, low vowels generally do not participate in ATR vowel harmony. It is generally assumed that this is a result of the fact that [+ATR] low vowels are marked, and are disallowed in the inventory. However, this explanation clearly cannot hold for Mayak, as both [+ATR] and [–ATR] vowels surface freely.

Andersen assumes that the non-participation of low vowels is the regular state of affairs since the vast majority of vowels behave in this manner. However, Andersen notes that there are a handful of low vowels that do participate in harmony. For example, the singular suffix [-at̪]/[-ʌt̪] is an exceptional target for [+ATR] harmony (8). In addition, a set of high vowel suffixes undergoes harmony in the presence of [+ATR] low vowels (9).

(8) Low vowels as harmony targets (Andersen 1999a)

(a) /kʊm-at̪/ → [kʊmat̪] 'egg- singular'

(b) /ruj-at̪/ → [rujʌt̪] 'worm- singular'

(9) High vowels undergoing harmony from low vowel source (Andersen 1999a)

(a) /gʊj-ʊk/ → [gʊjʊk] 'bowl- PL'

(b) /jʌŋ-ʊk/ → [jʌŋuk] 'crocodile- PL'

The height-dependent asymmetry of participation of vowel harmony mirrors the phonetic naturalness of [+ATR] vowels: high vowels are most naturally [+ATR]; low vowels are most naturally [–ATR]. When thought of in this manner, it is clear why high vowels should be least restricted in vowel harmony; they are bi-directional triggers and targets, but mid vowels are only partially restricted to harmony, and the majority of low vowels play essentially no role.

It is possible to make sense of the unusual nature of low vowels by appealing to the fact that the markedness of [+ATR] low vowels is greater than the markedness of [+ATR] mid vowels. If the markedness of feature domains is dependent on the markedness of the segments that make up the feature domains, then low vowels should be most restricted in [+ATR] domains. This results in restrictions on low vowels both as triggers and targets of vowel harmony.

Headed feature domains theory (Smolensky 2005) provides a clear approach to account for these facts. By using the markedness of [+ATR] at different height levels, it is possible to constrain the type of vowels that may head or be contained within a feature domain. Feature domains penalize disharmony, but can account for both directionality and trigger/target effects through head-alignment and restrictions on feature domain heads. Mayak is an example of the type of language that occurs when these constraints interact.

In the next section, I will show how the Mayak data follows from combining featural markedness and faithfulness with *HD constraints without postulating any new constraints. The phonetic basis for the height-based restrictions follows naturally from the coordination of phonetically-based markedness constraints with *HD and featural identity.

4. Accounting for the Data

This analysis of vowel harmony in Mayak is divided in terms of restrictions on directionality and height, and is organized into three sections. First, I will account for the fact that [+ATR] mid vowels are found only in harmony-induced conditions using markedness restrictions on feature heads. Second, I will account for the fact that mid vowels are leftward targets only using a combination of head alignment and head-markedness. From this analysis, it will follow that high vowels have no restrictions; they are bidirectional triggers and targets. Third, I will account for variation in low vowels, accounting for morphemes that allow for participation, and morphemes that do not allow for participation in harmony by appealing to the markedness of low vowels as [+ATR] heads.

4.1 Accounting for Mid/Low [+ATR] Vowels: Restricting Heads

The fact that [+ATR] mid vowels never surface, except as a target of harmony, can be accounted for if mid vowels are banned from heading a [+ATR] feature domain. If [+ATR] mid vowels may not be the head of a feature domain, then a word like [lep] must be ungrammatical since [lep] has only one vowel [e] which must be the head of the feature domain. However, in a word like [lepir], the high vowel [i] heads the [+ATR] feature domain, therefore licensing the [+ATR] mid vowel.

Constraints governing feature heads are derived by conjoining *HD with featural markedness constraints. This local conjunction has the effect of restricting whether a vowel can be a harmony trigger or a harmony target only. In the case of [e] and [o], which are licensed only by harmony, we can constrain heads of [+ATR] domains to non-high vowels through the local conjunction of *HD[ATR] and *[+ATR, –HIGH] in the domain of the segment. This conjunction makes use of the fact that the markedness of a feature domain is dependent on the markedness of the segments that make it up. In this case, the feature domain head is required to be unmarked. Therefore, marked segments such as non-high [+ATR] vowels are banned as heads.

(10) *HD[ATR] &SEG *[+ATR, –HIGH] (domain = segment): Non-high [+ATR] vowels must not head feature domains.

In (11), below, the hypothetical input /lep/ surfaces with [–ATR] [lɛp]. High-ranked ID[HIGH] blocks vowel raising, and the local conjunction blocks the faithful candidate from surfacing.

(11) Hypothetical input with underlying /e/

/lep/	ID[HIGH]	*HD[ATR] & *[+ATR, –HIGH]	*HD[ATR]	ID[ATR]
a. [le°p]		*!	*	
b.☞ [lɛ°p]			*	*
c. [li°p]	*!		*	

When mid vowels are adjacent to a [+ATR] high vowel, the mid vowel will surface harmonically as [+ATR] because the mid vowel is no longer required to head the feature domain, as shown in (12), in which candidate (b) surfaces because it has the fewest violations of *HD.

(12) Left-ward assimilation of [+ATR] to /ɛ/

/bɛ:k-um/ 'monkey'	ID[HIGH]	*HD[ATR] & *[+ATR, –HIGH]	*HD[ATR]	ID[ATR]
a. [bɛ:°k][u°m]			**!	
b.☞ [be:ku°m]			*	*

The constraint ranking in its present form predicts that both mid and low vowels should be licensed only by harmony, which is a problem, as low vowels surface freely as both [+ATR] and [–ATR]. The 'strong' nature of low vowels can be captured using headed-feature domains, through the local conjunction of FAITHHD[ATR] and *[LOW]. This will force underlyingly [+ATR] low vowels to surface faithfully, as the head of a feature domain, despite the fact that they would violate *HD[ATR] & *[+ATR, –HIGH]. This is shown below, in which the [–ATR] candidate violates FAITHHD, while the [+ATR] candidate does not.

(13) [+ATR] low vowels occur independent of harmony

/pʌ:m/ 'mountain'	ID [HIGH]	FAITHHD[ATR] & *[LOW]	*HD[ATR] & *[+ATR,–HIGH]	*HD [ATR]	ID[ATR]
a. [pa:°m]		*!		*	*
b.☞ [pʌ:°m]			*	*	
c. [pɨ:°m]	*!			*	

The present constraint ranking is also incomplete in that it does not reflect the dominant-recessive nature of vowel harmony in Mayak. In headed feature domains, I propose that dominant-recessive harmony can be accounted for by conjoining *HD and faithfulness constraints. This is similar to Bakovic's (2000) account of dominant-recessive harmony, conjoining *[–ATR] with ID[ATR]. The difference in the approach proposed here is that the harmony-inducing constraint is part of the local conjunction, capturing the fact that the constraint represents a specific characteristic of harmony. The specific case of harmony where [+ATR] is dominant is captured by constraining [–ATR] domains to contain underlyingly [–ATR] vowels. This is done by conjoining *HD[–ATR] with ID[ATR] over the entire feature domain. This has the effect of prohibiting a [–ATR] vowel from spreading its [–ATR] feature.

Together, *HD[ATR] & $_{SEG}$ *[+ATR, –HIGH] and *HD[–ATR] & $_{FEAT. DOM}$ ID[ATR] constrain mid vowels to occur only as harmony targets. *HD[ATR] & $_{SEG}$ *[+ATR, –HIGH] must be ranked above *HD[–ATR] & $_{FEAT. DOM}$ ID[ATR] so that underlyingly [+ATR] mid vowels will still surface as [–ATR] if they do not share a [+ATR] domain with a high vowel. This is shown in (14) and (15) below.

(14) Leftward assimilation of [+ATR] to /ɛ/

/bɛ:k-um/ 'monkey'	ID[HIGH]	*HD[ATR] & *[+ATR, –HIGH]	*HD[–ATR] & $_{FEAT. DOM.}$ ID[ATR]	*HD [ATR]	ID [ATR]
a. [bɛ:ºk][uºm]				**!	
b.☞ [be:kuºm]				*	*
c. [bɛkʊºm]			*!	*	*
d. [bɛºkʊm]			*!	*	*

(15) Hypothetical input with underlying /e/

/lep/	ID[HIGH]	*HD[ATR] & *[+ATR, –HIGH]	*HD[–ATR] & FEAT. DOM. ID[ATR]	*HD [ATR]	ID [ATR]
a. [leºp]		*!		*	
b.☞ [lɛºp]			*	*	*
c. [liºp]	*!			*	

Note that the ranking is still incomplete, as [+ATR] mid vowels are predicted to surface as bidirectional targets. In the next section, I will outline how restrictions on directionality are handled using headed-feature domains.

4.2 Directionality

Directionality effects are handled through alignment of feature heads. The directionality effect for mid vowels shows that heads must be aligned to the right edge of the feature domain.

(16) ALIGN HD RIGHT: The head of a feature domain must be at the right edge.

Note that *HD[ATR] & *[+ATR, –HIGH] creates a conflict with ALIGN-HD-RIGHT Because ALIGH-HD-RIGHT outranks *HD[ATR] & *[+ATR, –HIGH], disharmony will be chosen over incorrect alignment or a mid-vowel heading a [+ATR] domain. This is shown in (17) below.

(17) Mid vowels not rightward target

/ʔib-ɛr/ 'shoot- 3S'	ALIGN HD [ATR] RIGHT	*HD[ATR] & *[+ATR, –HIGH]	*HD[–ATR] & ID[ATR]	*HD [ATR]	ID [ATR]
a. [ʔɪbɛ°r]			*!	*	*
b.☞ [ʔi°b][ɛ°r]				**	
c. [ʔibe°r]		*!		*	*
d. [ʔi°ber]	*!			*	*

This conflict does not affect high vowels, as the conflicting constraint *HD[ATR] & *[+ATR, –HIGH] can never apply to high vowels, predicting bi-directionality for high vowels, shown in (18) below. The disharmonic candidate is ruled out by *HD, the [–ATR] candidates are ruled out by the *HD[–ATR] & ID[ATR], and the right-aligned [+ATR] harmonic candidate surfaces.

(18) High vowels bi-directionally triggers and targets

/ʔidɪ/ 'ear- 1S'	ALIGNHD [ATR] RIGHT	*HD[ATR] & *[+ATR, –HIGH]	*HD[–ATR] & ID[ATR]	*HD [ATR]	ID [ATR]
a. [ʔi°][dɪ°]				**!	
b. [ʔɪdɪ°]			*!	*	*
c. [ʔɪ°dɪ]	*!		*	*	*
d. ☞ [ʔidi°]				*	*
e. [ʔi°di]	*!			*	*

In this case, the harmonic candidate has an unfaithful head, violating FAITHHD. In this case FAITHHD, must crucially outrank *HD in order to surface. Mayak therefore makes use of the fact that FAITHHD is a violable constraint.

4.3 Low Vowels

It is generally true that low vowels are not harmony targets. Rather than treating full-participation as the rule and total non-participation as the exception or vice versa, I will treat the predictions made thus far in this analysis as the regular pattern, and what is not predicted from the analysis so far as the exception. However, there are two cases in which all low vowels behave differently from mid vowels. First, [+ATR] spreads only rightward onto low vowels, never leftwards. This is different from the mid-vowel case in which left-ward spreading always occurs. Second, the present ranking predicts that [+ATR] low vowels should spread harmony in all cases. However, [+ATR] low vowels never spread leftward, but occasionally spread rightwards. Therefore, the 'regular' case for low vowels will be that they always spread rightwards, but are never harmony targets.

The fact that low vowels are never targets of harmony is accounted for by the notion of target-conditioned harmony (Smolensky 2005). Target-conditioned harmony restricts the spreading of a feature when spreading of that feature creates an especially marked segment. The spreading of [+ATR] to low vowels is restricted by the fact that low vowels are the most marked [+ATR] vowels. Target-conditioned harmony is achieved by conjoining featural markedness with faithfulness. When *[+ATR, +LOW] is conjoined with ID[ATR], [+ATR] low vowels will never be created via harmony spreading

(19) Low vowels are not harmony targets

/kij-ak̪/ 'bee-Plural'	FAITHHD [ATR]& *[LOW]	ALIGNHD [ATR] RIGHT	*HD [ATR] & *[+ATR, - –HIGH	*HD [–ATR] & ID [ATR]	*[+ATR, +LOW] &SEG ID[ATR]	*HD [ATR]
a.☞[kiºj][aºk]						**
b. [kiº j ʌk]		*!			*	*
c. [ki j ʌºk]	*!		*		*	*
d. [kɪj aºk]				*!		*
e. [k ɪºj ak]		*!		*		*

In tableau (20), the low stem vowel does not become [+ATR] despite the fact that the suffix vowel is [+ATR]. This is because the target-conditioned harmony constraint prohibits low vowels from participating in harmony.

(20) Low vowels are not harmony targets

/ ʔam-u/ eat-past	FAITHHD [ATR]& *[LOW]	ALIGN HD [ATR] RIGHT	*HD [ATR] & *[+ATR, –HIGH]	*HD [–ATR] & ID [ATR]	*[+ATR, +LOW] &SEG ID[ATR]	*HD [ATR]	ID [ATR]
a. [ʔaºmʊ]		*!		*		*	*
b.☞ [ʔaº][muº]						**	
c. [ʔʌmuº]					*!	*	*
d. [ʔʌºmu]	*!	*	*		*	*	*
e. [ʔamʊº]				*!		*	*

The present analysis predicts that [+ATR] low vowels will spread harmony. This is shown in (21) in which /jʌŋ-ʊk / surfaces as [jʌŋuk]. The disharmonic candidate fatally violates *HD, while the [–ATR] harmonic candidate fatally violates the constraint requiring dominant-recessive harmony.

(21) Low vowels spread harmony

/jʌŋ-ʊk / 'crocodile' Plural	FAITHHD [ATR] & *[LOW]	ALIGN HD [ATR] RIGHT	*HD [ATR] & *[+ATR, –HIGH]	*HD [–ATR] & ID [ATR]	*HD [ATR]	ID [ATR]
a. [jʌºŋ][ʊºk]			*!		**	
b. [jʌºŋuk]		*!	*		*	*
c. ☞[jʌŋuºk]					*	*
d. [jaŋʊºk]				*!	*	*
e. [jaºŋʊk]	*!	*		*	*	*

In (21), it was shown that [+ATR] low vowels spread ATR rightwards. However, there are no cases in which a [+ATR] low vowel will spread leftwards. This can be accounted for by appealing to the notion of source-conditioned harmony (Smolensky 2005). Source-conditioned harmony is the idea that marked vowels cannot trigger harmony. This is formalized by conjoining markedness of heads (such as the constraint used in Mayak prohibiting non-high vowels form heading [+ATR] domains: *HD[ATR] & *[+ATR, –HIGH]) with faithfulness constraints. In Mayak *HD[ATR] & *[+ATR, –HIGH] is conjoined with ID[ATR] at the feature domain level. The result of this is shown in (22) below, in which the disharmonic candidate surfaces. The [–ATR] candidates fatally violate the constraint forcing dominant-recessive harmony. The [+ATR] candidate headed by [ʌ] fatally violates the constraint against non-high [+ATR] vowels spreading harmony. The candidate headed by [u] fatally violates right-alignment of feature heads.

(22) Low vowels do not spread leftward harmony, /ʌ/ in suffix

/d̪ɪːm-bʌr/ 'weed- 1S'	FAITH HD [ATR] & *[LOW]	ALIGN HD [ATR] RIGHT	*HD [ATR] & [+ATR, –HIGH]	*HD [–ATR] & ID [ATR]	(*HD [ATR] &$_{SEG}$ [+ATR, –HIGH) &$_{DOM}$ ID[ATR]	*HD [ATR]
a. [diːᵒmbʌr]		*!				*
b.☞[dɪːᵒm][bʌᵒr]			*			**
c. [diː dʌᵒ r]			*		*!	*
d. [dɪːdaᵒ r]	*!			*		*
e. [dɪːᵒda r]		*!		*		*

Source-conditioned harmony will not affect rightward spreading of [+ATR] for low vowels, as the [+HIGH] vowel will take the place of the feature domain head, in order to satisfy right-alignment.

Of course, one must also account for the fact that not all low vowels behave in the manner predicted above. There are cases in which low vowels are rightward targets of harmony, and cases where low vowels fail to spread [+ATR] to the right. I propose to account for this variation using a single morpheme-specific constraint that applies to all morphemes that do not behave as predicted by the current analysis.

This constraint will penalize feature domains that contain a low vowel. This is achieved by conjoining *HD[ATR] with *[LOW] at the feature domain level. This constraint will be tagged as STRONG to signify its high-ranked nature, as well as its morphological tagging.[4] The constraint will apply only to morphemes that are tagged as STRONG, and is violated if the morpheme that triggers this constraint contains a head of an ATR domain, and within that ATR domain is a low vowel.

The STRONG constraint is tagged to the STRONG morpheme, and thus applies only within the feature domain of the suffix. However, the feature domain may span past the morpheme boundary, making it possible for vowels in the root to cause violations of the STRONG affix. Because the domain of the conjunction of *[LOW] and *HD[ATR] spans the entire feature domain, *[LOW] is violated in all cases where a low vowel is present within the feature domain of the STRONG suffix, even if the low vowels is not present in the suffix itself. This is shown in tableau (23) in which the conjunction is violated for all

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[4] Another possibility is to create a constraint *STRONG, and conjoin this to *HD at the segment level (Smolensky, personal communication)

harmonic candidates in which the suffix vowel is a feature domain head. STRONG morphemes are underlined.

(23) Exceptional low vowels do not trigger harmony, /ʌ/ in stem

/d̪ʌ:m-<u>bɪr</u>/ STRONG	*HD [ATR] &DOM *[LOW] STRONG	FAITH HD [ATR] & *[LOW]	ALIGN HD [ATR] RIGHT	*HD [ATR] & *[+ATR, –HIGH]	*HD [ATR]	ID [ATR]
a. [dʌ:ᵒmbir]			*!	*	*	*
b.☞ [dʌ:ᵒm][bɪᵒr]				*	**	
c. [dʌ:mbiᵒr]	*!				*	*
d. [da:mbɪᵒr]	*!				*	*
e. [da:ᵒmbir]		*!	*		*	*

The presense of the STRONG constraints gives evidence for the ranking of FAITHHD[ATR] & *[LOW] above ALIGNHD-RIGHT. In (24) below, both vowels in the input are [–ATR]. The right-aligned harmonic candidates violate the STRONG constraint. The left-aligned [–ATR] harmonic candidate violates ALIGN-HD-RIGHT, but the disharmonic candidate does not. In order for the [–ATR] candidate to surface, FAITH-HD & *[LOW] must outrank ALIGN-HD-RIGHT.

(24) Exceptional low vowels do not trigger harmony, /a/ in stem

/d̪a:m-<u>bɪr</u>/ STRONG	*HD [ATR] $\&_{Dom}$ *[LOW] STRONG	FAITH HD [ATR] & *[LOW]	ALIGN HD [ATR] RIGHT	*HD [ATR] & *[+ATR, –HIGH]	*HD [ATR]	ID [ATR]
a. [dʌ:ᵒmbir]		*!	*	*	*	*
b. [dʌ:ᵒm][bɪᵒr]		*!		*	**	
c. [dʌ:mbiᵒr]	*!				*	*
d. [da:mbɪᵒr]	*!				*	*
e. ☞ [da:ᵒmbɪr]			*		*	*

The STRONG constraint can also account for the fact that low vowels can, in some suffixes, be rightward targets of harmony. The local conjunction is violated every time the suffix is the head of a feature domain. Since this is the highest-ranking constraint, only candidates whose feature domain heads are left-aligned will surface. Since the [–ATR] harmonic candidate fatally violates the constraint triggering dominant-recessive harmony, [+ATR] harmony is forced, allowing for rightward spreading of the [+ATR] feature.

(25) Low vowels as rightward targets of harmony

/ru:j-at̪/ 'worm-singular' STRONG	*HD [ATR] &DOM *[LOW] STRONG	ALIGN HD [ATR] RIGHT	*HD [ATR] & *[+ATR, –HIGH]	*HD [–ATR] & ID [ATR]	*[+ATR, +LOW] &SEG ID[ATR]	*HD [ATR]
a. [ru:ºj][aºt̪]	*!					**
b. ☞ [ru:ºjʌt]		*			*	*
c. [ru: j ʌºt̪]	*!		*		*	*
d. [rʊ:j aºt̪]	*!			*		*
e. [rʊ:ºj at̪]		*		*!		*

The account of variation shows that a single morpheme-specific constraint determines whether the harmonic or the disharmonic candidate will surface. What is interesting about this case is that the same constraint can predict harmony in some cases, and disharmony in others. I have assumed that the 'regular' tendency for Mayak low vowels is the same as that predicted to occur with mid vowels. The fact that only low vowels are subject to variation is accounted for by the fact that the morpheme-specific constraint that accounts for the variation refers specifically to low vowels. This prediction cannot be achieved using a pre-specification or underspecification approach (e.g. Andersen 1999a, Inkelas, Orgun, and Zoll 1997), as any vowel could presumably be underspecified.

6. Conclusion

In this paper, I have given an account of vowel harmony in Mayak using headed feature domains. By allowing for more complex representations of features, it is possible to account for a wide variety of restrictions on vowel harmony. By conjoining the general constraint on feature heads (*HD) with traditional markedness and faithfulness constraints, it is possible to make sense of seemingly complicated restrictions without postulating novel constraints.

Previous research on headed-feature domains (Smolensky 1997, 2005) has been with stem-controlled systems only. Mayak, as a case of dominant recessive harmony, shows that headed-feature domains are a viable approach to both classes of harmony.

Vowel harmony in Mayak is interesting because it is a dominant-recessive harmony system that shows clear directionality effects. It also has a systematic set of height-dependent restrictions. Headed-feature domains are able to account for these facts in a way that appeals to the dependency of ATR markedness on height. Thus it is important to derive local conjunctions that are grounded in markedness and phonetic naturalness, which I have been careful to do in this analysis. By appealing to theoretically motivated notions such as source and target-conditioned harmony, the phonetic underpinnings of the height-based restrictions on harmony in Mayak fall-out naturally.

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