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# *Kinande vowel harmony: domains, grounded conditions and one-sided alignment**

**Diana Archangeli**
University of Arizona

**Douglas Pulleyblank**
University of British Columbia

The canonical image of vowel harmony is of a particular feature distributed throughout a word, leading to symmetric constraints like AGREE or SPREAD. Examination of the distribution of tongue-root advancement in Kinande demonstrates that harmonic feature distribution is asymmetric. The data argue that a formal (yet asymmetric) constraint (like ALIGN) is exactly half right: such a constraint correctly characterises the left edge of the harmonic domain. By contrast, the right edge is necessarily characterised by phonetically grounded restrictions on feature co-occurrence. Of further interest is the role of morphological domains: the interaction between domain restrictions on specific constraints and unrestricted constraints suggests a formal means of characterising the overwhelming similarity between constraint hierarchies at different morphological levels while at the same time characterising the distinctions between levels.

## 1 Introduction

Canonically, vowel harmony describes a situation where a feature distributes itself throughout some definable domain, for example, the word. This canonical situation can be accounted for within Optimality Theory (McCarthy & Prince 1993a, b, Prince & Smolensky 1993) by positing a pair of constraints on feature alignment. That is, following a proposal by Kirchner (1993) and subsequent work such as Pulleyblank (1993, 1996) and Akinlabi (1994, 1996), vowel harmony can be achieved by aligning

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the harmonic feature with both the left and right edges of a harmonic domain, thereby accomplishing harmony from one edge to the other.[1] Alternatively, harmony might be represented by a symmetric constraint (e.g. AGREE; Pulleyblank 1997, Baković 2000).

Kinande, a Bantu language of the Democratic Republic of the Congo, is particularly illuminating about the role of formal constraints, like alignment, in defining vowel-harmony spans.[2] We argue that, crucially, the formal constraint employed to achieve harmony must be asymmetric, with orientation to the left edge. Thus, only one edge of the harmonic domain is defined in terms of alignment. The other edge is defined in terms of substantively GROUNDED CONDITIONS (Archangeli & Pulleyblank 1994).

The grounding involved here is the inherent desirability of assigning to high vowels the feature for advanced tongue root. That is, a lexical [+ATR] specification gets assigned to a high vowel (if there is one) to produce the more grounded, and hence more optimal, high vowel, the ADVANCED high vowel. This high vowel forms the right edge of the harmonic domain. Leftward alignment then determines the left edge of the domain. Thus we argue that the basic Kinande harmonic pattern results from an interaction between (i) the phonological instantiation of such physically sympathetic relations that define the rightmost extent of harmony and (ii) alignment that defines the leftmost extent of harmony. In short, this analysis construes harmony as the interplay between substantive and formal properties, a central theme of Archangeli & Pulleyblank (1994).

To unravel the various subpatterns of Kinande harmony, we also demonstrate the central role played by determinations of DOMAINS, whether defined morphosyntactically or phonologically (Mutaka 1990). We show that domains such as root, stem and word play a crucial role in delimiting the effects of both the substantive grounded constraints – which determine the right edge of the harmonic domain – and the formal alignment constraints – which determine the left edge. (See also Bickmore 2000 for an analysis of Namwanga tone relying crucially on domain restrictions.)

Finally, we show that the domain results have implications for the representation of the morphology–phonology interface in Optimality Theory (see, for example, Beckman 1998, Borowsky 2000, Grijzenhout 2000, Krämer 2000), arguing for the integration of sets of constraints into a *single* ranked hierarchy rather than into semi-independent mini-grammars (as found in e.g. McCarthy & Prince 1993a, Inkelas 1998, Inkelas & Orgun 1998, Kiparsky 1998).

[1] While we cast our analysis in terms of alignment, it would also be possible to use a harmonic constraint such as SPREAD (Walker 1998) or an anti-disharmony constraint such as *F G (Smolensky 1993, Pulleyblank, in press).

[2] Work on [ATR] harmony in Kinande includes Valinande (1984), Schlindwein (1987), Steriade (1987), Hyman (1989), Mutaka (1990, 1995), Archangeli & Pulleyblank (1994).

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## 2 Background

### 2.1 Kinande morphology

For our analysis of Kinande, we adopt the domain distinctions and terminology of root, stem and macro-stem directly from Mutaka (1990), along with his proposals about the pairings between affixes and domains.

For nouns, Mutaka (1990) argues that the lexically selected class prefixes belong to the macro-stem domain, while the productively attached prefixes, such as the augmentative and diminutive, belong to the word domain.

The augment is shown outside the word domain. The distribution of this prefix is syntactically determined (Seki 1986, Mutaka & Hyman 1990, Mutaka, ms), suggesting an analysis whereby the augment is only attached at the syntactic level, to the phrase rather than to the word. Interestingly, the augment only optionally undergoes harmony. The analysis of the augment as phrasal accounts for its optional harmony since optionality is consistent with the behaviour of other postlexical harmony. (See § 6.3 on phrasal harmony in Kinande.) We consistently show the augment as a retracted vowel throughout this work. Though essentially an arbitrary decision, this serves as an expository reminder that the domain subject to obligatory harmony does not include the augment.

(1) *Morphosyntactic constituents in Kinande*

augment $_{\text{Word}}[$ diminutive/ augmentative prefixes $_{\text{Macro-stem}}[$ class prefixes $_{\text{Stem}}[\ _{\text{Root}}[\ \ldots\ ]\ \ldots\ ]]]$

This same basic structure makes sense for verbs, too. Mutaka (1990) argues that the left-hand root–stem boundary is highly significant for verbs, because that boundary marks a critical edge for several different effects. (Downing 2000 accepts these arguments; see also Myers 1987, 1998 and Mchombo 1999 for arguments in support of the verb root–suffix complex as a constituent in Bantu languages in general.) Mutaka (1990: 36–37) also advances an interesting argument based on 'minimal stem' effects that the object prefix is part of the stem domain, but the subject and tense markers are part of the macro-stem, not part of the stem.[3]

Verbal suffixes fall into two categories, 'extensions' and the 'Final Vowel' (FV). Extensions add a wide range of meanings to the verb root, such as causative, reversive and reciprocal, and multiple extensions may co-occur (e.g. … *imb-ir-an-is-i-bu-a*, parsed as root-APPLIC-RECIPROCAL-CAUS-CAUS-PASS-FV, means 'be caused to sing for each other'; Mutaka & Tamanji 1995).

[3] For general motivation and discussion of the macro-stem, see Bresnan & Mchombo (1987), Goldsmith & Sabimana (1989), Hyman & Ngunga (1994), Black (1995), Mugane (1997), Myers (1998), Mchombo (1999), Bickmore (2000), etc.

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We demonstrate below that ATR harmony functions differently according to the morphological domain. Central to our analysis, a single constraint hierarchy is sufficient for all patterns, with the morphological effects resulting from the assignment to different morphological domains of a single constraint requiring that high vowels be advanced:[4]

(2) … $\text{H}_{\text{I}}/\text{ATR}_{\text{Root}}$ … ≫ … $\text{H}_{\text{I}}/\text{ATR}_{\text{Stem}}$ … ≫ … $\text{H}_{\text{I}}/\text{ATR}_{\text{Macro-stem}}$ …

This is a significant departure from Mutaka (1990), where the phonology–morphology interaction is mediated by assigning a stratal organisation to both affixation and phonological effects. Here, we argue in favour of a single constraint hierarchy, responsive to morphosyntactic constituents (Selkirk 1982, Inkelas 1989, Downing 1999).[5]

## 2.2 Kinande phonology

Of the many issues of interest in Kinande phonology, we touch here on those relating directly to the distribution of vowels in the language. On the surface, there are ten vowels, advanced and retracted versions of a typical five-vowel system.

(3) *advanced* i e ə o u
*retracted* ɪ ɛ a ɔ ʊ

As will be seen in detail below, only the high vowels exhibit a lexical contrast in their tongue-root values; all non-high vowels are retracted except when appearing within an advanced harmonic domain conditioned by the presence of a high vowel.

The inclusion of the advanced low [ə] in this set is somewhat controversial. In Schlindwein (1987), Cole & Kisseberth (1994) and Mutaka (1995), low vowels in an advanced harmonic domain are treated as transparent, an analysis that is reflected in the orthographic representations that recognise a single 'a'. Hyman (1989) and Mutaka (1995) raise questions about low vowel transparency, however, suggesting that low

[4] Beckman (1998) suggests that positional faithfulness can include special faithfulness to a morphological domain such as the root, a proposal taken up in work such as Borowsky (2000), Grijzenhout (2000) and Krämer (2000). The analysis here extends this notion with a richer set of morphological domains, but separates out the assignment of domains from faithfulness. That is, just as faithfulness may hold more stringently of a small domain than a larger domain, so may markedness constraints exhibit such variable strength.

[5] Inkelas (1989) and Downing (1999, 2000) argue that phonological effects are defined in terms of *phonological* constituents that correspond (fully or partially) to morphological structures. Rather than having the phonology directly refer to morphosyntactic constituents, they argue for indirect reference through such phonological constituents. While our analysis could be rephrased in terms of these models, assuming full correspondence between the morphological and phonological structures, we do not have evidence for the sorts of domain mismatches that might motivate such indirect reference.

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vowels surface as perceptually advanced in an environment where they are long, low-toned and followed by an advanced vowel, for example, *o-mu̱-kal-i̱* [ɔ̀múkə̀ːlì] 'woman'.[6] In an examination of low vowels by ultrasound, Gick *et al*. (in preparation) report that low vowels are significantly advanced in an advanced harmonic domain independent of length or tone, even where they are transcribed as retracted in previous work. They conclude that there is no evidence in Kinande for the transparency of low vowels. On the basis of the evidence in Gick *et al*. (in preparation), we transcribe low vowels as advanced in the appropriate harmonic contexts.

The full distribution of tongue-root advancement is dealt with in detail in this article. By way of preliminaries, we mention briefly certain restrictions governing the distribution of these vowels in words, restrictions that have to do with tongue height directly or indirectly. Within stems, mid vowels are restricted to root-initial position and to positions immediately following another mid vowel (Mutaka 1990). Suffixes exhibit a restricted three-way pattern with respect to height (Valinande 1984). A suffix may be low ([a]); if rounded, a suffix will be mid after a mid round vowel ([o]) and high elsewhere ([u]); if non-low unrounded, a suffix will be mid after a mid vowel ([e]) and high elsewhere ([i]). As far as we can determine, these restrictions do not interact in crucial ways with the distribution of [ATR] in Kinande.

Hierarchical and moraic structure play no appreciable role in the harmonic patterns of Kinande. Thus, our representations do not include such prosodic detail. Formally, we assume that the anchors for [+ATR] are moras, and that association between [+ATR] and a mora is mediated by an appropriate hierarchical structure along the lines of the proposals for tongue-root features in Cole (1987), McCarthy (1988), etc.[7]

Finally, we note two phrasal phonological effects. The double acute accent (e.g. on the penultimate vowel of [ɛ̀rìlḯːbà] 'to cover') indicates a phrasal high tone, as opposed to a lexical high tone. Such high tones differ in the way they are assigned, but apparently not in their pitch realisation. Similarly, the length indicated on penultimate vowels is predictable for the penultimate vowel of a phrase. We have included phrasal phenomena such as length throughout, although we do not analyse these phenomena here.

[6] Two types of remarks are helpful for understanding the transcription used here. First, to be consistent with the Kinande literature we adopt an orthographic convention of indicating advanced vowels with a subscripted cedilla, as in *e-ri̱-li̱b-a* 'to cover'; retracted vowels bear no diacritic. We also provide a phonetic transcription, demarcated by square brackets, distinguishing vowels as in (3).

[7] In a full treatment of Kinande phonology, the absence of deletion, epenthesis and so on would result from faithfulness and other constraints governing prosodic organisation. We do not go into this level of detail on Kinande here. See McCarthy & Prince (1993a, b) and Prince & Smolensky (1993) for a general discussion of such constraints.

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### 2.3 Overview: constraint interaction

Kirchner (1993) develops the hypothesis that vowel harmony is accounted for by the imposition of pairs of alignment constraints (McCarthy & Prince 1993a, b, Prince & Smolensky 1993, Pulleyblank 1993, 1996, Akinlabi 1994, 1996, etc.). The central idea is that one alignment constraint requires that the harmonic feature be aligned with the left edge of the harmonic domain, while a second constraint requires alignment with the right edge. The combined result is a domain specified throughout for the harmonic feature.

(4) *Harmony via alignment*

a. ALIGN(F, R; D, R)
The right edge of every harmonic feature F is aligned with the right edge of some harmonic domain D.

b. ALIGN(F, L; D, L)
The left edge of every harmonic feature F is aligned with the left edge of some harmonic domain D.

For Kinande, we argue that this proposal is exactly *half*-adequate. We suggest that left-edge alignment does indeed play a crucial role in the harmonic system, straightforwardly defining the leftmost extent of a harmonic span.[8]

(5) *Kinande* ALIGN-L

ALIGN([+ATR], L; Word, L)
The left edge of every [+ATR] specification is aligned with the left edge of some word.

The right edge, however, is defined by substantive considerations, not by alignment. The central idea revolves around a markedly skewed relation between the features [+high] and [+ATR]. Following Archangeli & Pulleyblank (1994), we assume that the feature values [+high] and [+ATR] are in a SYMPATHETIC or ENHANCEMENT relation (on the relation between [+high] and [+ATR], see Perkell 1971, Ladefoged *et al.* 1972, Jacobson 1980, summarised in Archangeli & Pulleyblank 1994; for enhancement, see Stevens *et al.* 1986, Stevens & Keyser 1989). Articulatorily, raising the tongue body tends to correlate with advancement of the tongue root; acoustically, lowering of F1 is an indicator for both feature values. This leads to a universal constraint preferring [+high] to be advanced.[9] (A corollary is the absence of any universal constraint

[8] This paper assumes a binary feature [± ATR] but an analysis in terms of the presence or absence of a monovalent feature 'ATR' would be essentially equivalent. §6 contains relevant discussion.

[9] We use implicational grounding conditions (HI/ATR and ATR/HI) instead of using 'configurational prohibitions' (e.g. *[+high, −ATR], *[−high, +ATR]; see Baković 2001 for this line of thought). The configurational prohibitions are satisfactory in accounting for the Kinande data, provided that full specification is assumed (every vowel has a value for [ATR] and a value for [high]). Given

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preferring [+high] to be [−ATR], not [+ATR]; see Archangeli & Pulleyblank 1994.)[10]

(6) *Grounded condition*: HI/ATR
If [+high] then [+ATR].

Within Optimality Theory, this relation is expressed by directly incorporating the HI/ATR condition into the Kinande constraint hierarchy, a ranked scale of violable conditions. As laid out more fully below, the effect of imposing this condition is that a non-advanced high vowel will incur a violation mark, while high advanced vowels will satisfy the condition. No restrictions are placed on non-high vowels by this constraint.

The Kinande harmonic span, we suggest, is determined by the interplay of ALIGN constraints with grounded conditions like HI/ATR. We sketch this analysis schematically here. Consider the effect of imposing both ALIGN-L and HI/ATR in a language. The ALIGN constraint establishes the preference for association of [+ATR] at the left edge of the domain; the optimal configuration, given ALIGN-L and an input with a floating [+ATR], is shown in (7a).[11] The grounded HI/ATR constraint establishes the preference for high vowels to be associated with [+ATR]; the optimal configuration according to HI/ATR is given in (7b), assuming an input with both a high vowel and a floating [+ATR] (and, of course, the appropriate rankings with respect to the relevant faithfulness constraints).

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evidence such as that of Keating (1988) against full specification at the phonetic level and the comparable Kinande evidence presented in §6.3, it appears that full specification is inappropriate. Further, formally, there is no requirement within Optimality Theory that segments be fully specified, and Richness of the Base overtly precludes full specification of all inputs. See §6 also for an exploration of Richness of the Base with respect to the Kinande phenomena.

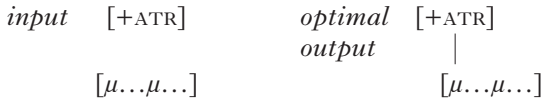
[10] As formulated, HI/ATR forbids an output representation that is specified [+high] and has no specification for [±ATR], as well as a representation that is [+high, −ATR]. We leave open the question of whether a prohibition on the combination of [+high] and [−ATR], *[+high, −ATR], should be conceived of as a separate constraint from HI/ATR or part and parcel of a single implicational requirement. That both 'if [+high] then [+ATR]' and 'if [+high] then not [−ATR]' are needed in languages of the world has been argued in Archangeli & Pulleyblank (1994). Languages which make a three-way distinction in tongue-root values, between [+ATR], [−ATR] and [∅ATR] (see, for example, Archangeli & Pulleyblank 1994, Noske 2000), have the potential for distinguishing between needing the [+ATR] and [−ATR] clauses in independent constraints *vs.* a single unified constraint.

[11] The formal definition of featural alignment is examined in Pulleyblank (1996), along with a demonstration that a floating feature is successfully aligned with both left and right edges of its domain, following the definition of EDGE given in Archangeli & Pulleyblank (1994). As such, the output in (7a) illustrates satisfaction of alignment by a *linked* feature, as guaranteed by other constraints, such as MAX[ATR], LINK[ATR]. Although we assume at this point in the exposition that an input root [+ATR] is floating, this assumption is explored in §6 and shown to be non-crucial. That is, the presence or absence of a [+ATR] value in the input is crucial, but whether it is linked or not, and if linked, where it is linked, is not critical to the output.

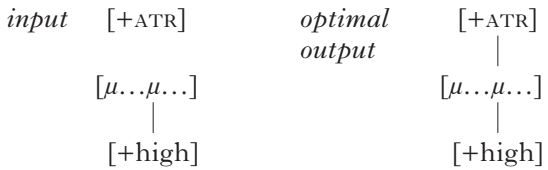
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(7) *Schematics of formal and substantive constraints*

a. ALIGN-L

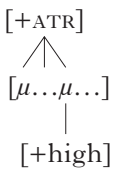



b. HI/ATR



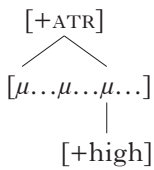

Of special interest with respect to Kinande is the interaction of these two constraints. Consider a representation including both a non-initial high vowel and a [+ATR] specification. Any configuration that links the [+ATR] value to the high vowel will satisfy HI/ATR; any configuration that links the [+ATR] value to the leftmost vowel will satisfy ALIGN-L. The optimal configuration, then, is one that has [+ATR] linked not only to the high vowel but also to the leftmost vowel, schematically illustrated in (8): both constraints are satisfied. The net result of imposing both ALIGN-L and HI/ATR is a harmonic span anchored at the right edge by a [+high] vowel, and extending leftwards to include any and all vowels.

(8) *Schematic harmony span in Kinande*




Before beginning our argument that Kinande exhibits precisely the pattern illustrated schematically in (8), however, we address an imaginable alternative to the configuration in (8), a representation in which [+ATR] is linked only to the leftmost mora and to the [+high] mora, but not to any intervening non-high moras, shown schematically in (9), a 'gapped' representation.

(9) *Illicit gapped configuration*




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Following Archangeli & Pulleyblank (1994), we take such gapped representations to be ill-formed because the anchors for [+ATR] are not adjacent to each other, a violation of locality. In optimality terms, we can similarly interpret locality as a defining property of all phonological representations, as a property of GEN.[12] As a result of assuming the universal inadmissibility of gapped constructions, we do not consider such gapped representations as possible candidate structures anywhere in this article.

We are now in position to explore the Kinande data. We turn first to evidence that high vowels play a crucial role in the Kinande harmony system.

## 3 The harmonic effects of grounding

In this section, we establish the central role of HI/ATR in an account of Kinande vowel harmony. We refine the concept in §4. In §5, we present the argument for Alignment in conjunction with HI/ATR, in order to account for non-high vowels that surface as advanced, provided there is a [+ATR] environment on their right.

### 3.1 The basic Kinande ATR harmony pattern

Kinande roots are of four basic types. The general pattern for roots is that only those with high vowels contrast lexically in terms of tongue-root position, shown in (10a, b). As these forms reveal, the high vowel sequences agree in tongue-root position. In (10), this harmony is revealed in the class prefix *-rI-*, which surfaces as advanced when preceding advanced root vowels, (10a).[13] With a retracted high root, however, the class prefix surfaces as retracted (10b).

Turning now to roots with only non-high vowels, (10c) illustrates the most common case: mid and low voweled roots normally exhibit only retracted vowels and are preceded by retracted vowels ([-rɪ-], not [-ri-]). There is, however, a fairly small class of retracted roots composed entirely of non-high vowels which nonetheless conditions advanced prefixes (10d). Note that with these forms, the root itself remains retracted.

[12] We note in addition that gapped configurations are not required to account for transparency effects. For discussion in a rule-based framework, see Archangeli & Pulleyblank (1994); for various approaches within Optimality Theory, see Pulleyblank (1996), Gafos (1996), Ní Chiosáin & Padgett (1997). Note that if gapped configurations are considered to be formally admissible, then the Kinande effects could be achieved by the high ranking of a NOGAP constraint, as in Itô *et al.* (1995).

[13] As noted in §2.1, the initial vowel is a word-level morpheme called the 'augment', which only optionally harmonises.

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(10) [+ATR] *association restricted to high vowels in Kinande root properties*

| | | | |
|---|---|---|---|
| a. high, [+ATR] | e-rɟ-ljb-a | [èrìlĭ:bà] | 'to cover' |
| | e-rɟ-hu̱k-a | [èríhŭ:kà] | 'to cook' |
| b. high, not [+ATR] | e-ri-lim-a | [èrìlĭ:mà] | 'to cultivate' |
| | e-ri-hum-a | [èrìhŭ:mà] | 'to beat' |
| c. non-high, not [+ATR] | e-ri-hek-a | [èrìhɛ́:kà] | 'to carry' |
| | e-ri-kar-a | [èrìkɑ́:rà] | 'to force' |
| | e-ri-boh-a | [èríbɔ́:hà] | 'to tie' |
| d. non-high, [+ATR] | e-rɟ-hembe | [èríhè:mbè] | 'horn' |
| | e-rɟ-lolo | [èrì:lɔ́:lò] | 'sin' |

With respect to the distribution of [+ATR], there are two classes of cases to consider here, those forms with and those without [+ATR]. We examine the latter group first, then turn to those with an input [+ATR], focusing specifically on how HI/ATR creates a harmonic effect.

### 3.2 Roots without [+ATR]: DEP[ATR]

Roots of the types in (10b, c) do not contain a lexical [+ATR] value. These surface with retracted vowels throughout and establish the basic faithfulness constraints regarding [+ATR]. Our assumption is that any vowel leaving the Kinande phonology without a [+ATR] specification is realised phonetically as retracted (Archangeli & Pulleyblank 1994). Words such as [èrìhŭ:mà] 'to beat' and [èrìhɛ́:kà] 'to carry' are therefore represented as in (11): both in the input and in the output representations, such words are devoid of [+ATR] specifications.[14]

(11) *The representation of retracted vowels*

a. $\varepsilon\text{-}\left[\text{rɪ-hʊ:m-a}\right]_{\text{Wd}}$ [èrìhŭ:mà]

b. $\varepsilon\text{-}\left[\text{rɪ-hɛ:k-a}\right]_{\text{Wd}}$ [èrìhɛ́:kà]

The crucial point about such representations is the absence of any advancement feature. In Optimality Theory terms, these forms demonstrate a pressure against inserting [+ATR], regardless of the other qualities of the vowels in a form: high vowels need not be advanced.

[14] The attested surface forms, with retracted vowels, are obtained regardless of whether the output has [−ATR] specifications (consistent with an analysis employing binary features and requiring fully specified outputs) or whether the retraction of the output is the phonetic interpretation of unspecified vowels (consistent with either monovalent features or binary features plus sparse surface specifications). In the main text of this paper, we assume sparse specification of features, a point we return to in §6. Nothing precludes the postulation of [−ATR] values as overtly present in outputs, however. To obtain fully specified outputs corresponding to the sparse representations presented, one would simply require a high-ranking constraint requiring that all vowels have a [±ATR] specification, with DEP[ATR] (defined in (12)) outranking DEP[RTR] (comparably defined, but with respect to [−ATR]).

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The DEP family of constraints (McCarthy & Prince 1995) provides a means of preventing the insertion of [+ATR]. DEP[ATR] prevents the addition of non-lexical tokens of [+ATR]; this is never violated in Kinande.[15]

(12) DEP[ATR]

An output F-element [+ATR] must have an input correspondent F-element [+ATR].

By contrast, DEPPATH[ATR], which prevents insertion of associations between [+ATR] and its anchors, is roundly violated in this language.

(13) DEPPATH[ATR]

An output path between [+ATR] and an anchor has an input path between a corresponding [+ATR] and a corresponding anchor.

The tableau in (14) for *e-ri-lim-a* [èrìlĩ́mà] 'to cultivate' demonstrates the critical role of DEP[ATR]. Only the optimal (14c) satisfies DEP[ATR]. We cannot appeal to DEPPATH[ATR] to select the winning candidate despite the observation that its violations match DEP[ATR] violations for the other candidates. Anticipating the results of the next subsection, HI/ATR is crucially ranked between DEP[ATR] and DEPPATH[ATR]. (Were HI/ATR to outrank DEP[ATR], there would be no retracted high vowels in the language; such a pattern is found in e.g. Fula (Pulaar) (see Paradis 1986, Archangeli & Pulleyblank 1994).) Because of this ranking, the violations of DEPPATH[ATR] are irrelevant for deciding among these candidates.[16]

(14) *Underlying forms without* [+ATR] *specifications*

| rI-lIm-A | DEP[ATR] | HI/ATR | DEPPATH[ATR] |
|---|---|---|---|
| a. +ATR<br>ri-li:m-a | *! | | *** |
| b. +ATR<br>rɪ-li:m-a | *! | * | ** |
| ☞ c.<br>rɪ-lɪ:m-a | | *** | |

[15] For detailed discussion of the notions F-ELEMENT (informally, featural element) and PATH (association), see Archangeli & Pulleyblank (1994). For discussion of DEPF-ELEMENT and DEPPATH, or comparable constraints under different names, see McCarthy (1993), Pulleyblank (1993, 1996), Itô *et al.* (1995), McCarthy & Prince (1995), Lombardi (1995, 1998), Myers (1997), Pater (1999). With DEP($\alpha$), we are appealing to Correspondence Theory terms (McCarthy & Prince 1995), rather than choosing a name, such as LEX($\alpha$), which better reflects our understanding of this constraint as preferring output components to be morphologically licensed.

[16] Here and throughout, violations of feature co-occurrence constraints are assessed in terms of the number of paths from a mora to the antecedent feature in the co-occurrence constraint. Thus, in (14c) there are three violations of HI/ATR, one assessed for the monomoraic high vowel in the first syllable and two for the bimoraic high vowel in the second syllable.

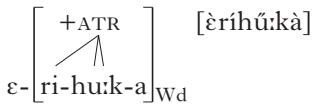
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Because there is no [+ATR] specification, it is impossible for any high vowel to be advanced; HI/ATR is unavoidably violated for every high vowel in such a retracted word. [+ATR] could be inserted onto a high vowel, but this is precisely what is prohibited by DEP[ATR], as shown by (14a, b). Thus, DEP[ATR] crucially outranks HI/ATR.

### 3.3 Roots with [+ATR]: HI/ATR ≫ DEPPATH[ATR]

Consider now the pattern observed where a high vowel root contains a [+ATR] specification (10a). In such forms, all and only the high vowels are advanced, a pattern consistent with the requirement imposed by HI/ATR, but not by the demands imposed by Alignment. The constraint HI/ATR alone, then, is sufficient to define the complete harmonic domain for a word like [ɛ̀ríhṹːkà] 'to cook'.

(15) *Root-induced harmony: root with high vowel*




The tableau in (16) demonstrates the irrelevance of alignment and the necessity of HI/ATR in forms with strings of high vowels. The attested candidate, shown in (16a), fully satisfies HI/ATR. Were HI/ATR not part of the grammar of Kinande, then candidate (16b), with no advanced vowels at all, would be selected as optimal. HI/ATR is the only constraint that makes this distinction: leftward and rightward alignment fail to do so, and the attested form, (16a), maximally violates DEPPATH[ATR]. (DEP[ATR] is omitted and no candidates violating DEP[ATR] are considered.) (Note that forms with only one high advanced vowel fare worse with respect to HI/ATR, and so lose to candidate (16a), the fully harmonic form.)

(16) *Underlying high-vowel roots with* [+ATR] *specifications*

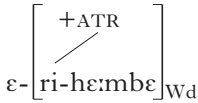
| +ATR<br>rI-hUk-A | HI/ATR | ALIGN-L | ALIGN-R | DEPPATH[ATR] |
|---|---|---|---|---|
| ☞ a. +ATR<br>ɛ-ri-huːk-a Wd | | | * | *** |
| b. +ATR<br>ɛ-rɪ-huːk-a Wd | *!* | | | |

From this demonstration, we conclude that HI/ATR is critical to an account of Kinande harmony, regardless of the role of alignment. (We establish the importance of ALIGN-L in §5.)

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The class illustrated in (10d) is comparable despite the root's absence of a high vowel: these forms have a retracted non-high root that conditions advanced prefixes. Assuming that such roots have a [+ATR] specification (Schlindwein 1987, Archangeli & Pulleyblank 1994), HI/ATR correctly defines the extent of the harmonic domain in a case like [èríhɛ̀ːmbɛ̀] 'horn'.

(17) *Root-induced harmony: root with non-high vowels only*




[èríhɛ̀ːmbɛ̀]

Cases like (17) support the conclusion that vowel height is crucial in an account of Kinande ATR harmony. Although the root /hEmbE/ contains a [+ATR] specification, that specification does not link within the root, because the root does not contain a high vowel (*[èríhèːmbè]), even though the language exhibits advanced mid (and low) vowels in other contexts. As will be seen quite categorically below, the right edge of a linked harmonic span *must* be high. Neither mid nor low root vowels can constitute the rightmost extent of a [+ATR] span: [èríhɛ̀ːmbɛ̀] surfaces with retracted root vowels.

Before moving to our next set of arguments, it is important to firmly establish the ranking of the three constraints motivated in this section, DEP[ATR] ≫ HI/ATR ≫ DEPPATH[ATR]. Inputs with a high root vowel but no [+ATR] specification, surfacing as retracted throughout, motivate the ranking DEP[ATR] ≫ HI/ATR, DEPPATH[ATR], as shown in (14). The ranking HI/ATR ≫ DEPPATH[ATR] is motivated by tableau (16), where the input contains both a high root vowel and [+ATR]: the form surfaces with advanced high vowels.

## 4 Domains of constraint applicability

In the discussion of the preceding section, the domain within which harmony takes place has been left deliberately vague. However, as noted in §2.1, Kinande morphology is relatively rich. In this section, we explore the consequences of domain restrictions on HI/ATR. We show that without morphological domain delimitations on the grounded constraints, an account of Kinande harmony fails. Domain-restricted grounded constraints are critical.

### 4.1 A paradox

Hyman (1989) noted the importance of a class of forms involving harmonic high vowel extension suffixes, for example the benefactives (*-ir-*) and reversives (*-ul-*) in (18). Examples such as (18a), which surface as entirely retracted, show that the benefactive and reversive suffixes are not intrinsically specified for [+ATR]. Forms such as (18b), however, show

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that advancement is attested when these suffixes follow an advanced root: the suffixes are subject to harmony.[17] These observations are entirely consistent with the analysis of [+ATR] distribution already established.[18]

(18) *Stem-level harmony in Kinande*

| | | | | |
|---|---|---|---|---|
| a. | e-ri-[lim]-a | [èrìlĭːmà] | e-ri-[lim]-ir-a | [èrìlìmĭːrà] |
| | | | | 'work/work for' |
| | e-ri-[tab]-a | [èrìtáːbà] | e-ri-[tab]-ul-a | [èrìtàbʊ́ːlà] |
| | | | | 'bury/disinter' |
| b. | e-rɨ-[lɨm]-a | [èrílĭːmà] | e-rɨ-[lɨm]-ɨr-a | [èrílìmĭːrà] |
| | | | | 'exterminate/exterminate for' |
| | e-rɨ-[hʊk]-a | [èríhʊ́ːkà] | e-rɨ-[hʊk]-ʊl-a | [èríhùkʊ́ːlà] |
| | | | | 'cook/get food out of cooking pot' |

Of particular interest are forms such as (19), where the root contains a high–low sequence of vowels followed by a high vowel suffix. This class of forms demonstrates that the advancement of a high vowel suffix takes place only when the suffix is immediately adjacent to a high advanced root vowel. The suffix high vowel surfaces as retracted, not advanced, when a retracted low vowel intervenes.

(19) e-rɨ-[lɨban]-a [èrìlìbáːnà] e-rɨ-[lɨban]-ir-a [èrìlìbànĭːrà]
'disappear/disappear for someone'

The partial constraint hierarchy developed thus far predicts that all high vowels will be advanced, suggesting *[èrìlìbànĭːra] instead of the attested [èrìlìbànĭːrà].

(20) *Underlying forms with* [+ATR] *specifications*

| +ATR<br>rI-lIbAn-Ir-A | DEP[ATR] | HI/ATR | DEPPATH[ATR] |
|---|---|---|---|
| ☜ a. [ +ATR<br>ri-liban-ɪːr-a ]Wd | | *!* | ** |
| 🖒 b. [ +ATR<br>ri-libən-iːr-a ]Wd | | | **** |
| c. [ +ATR<br>rɪ-lɪban-ɪːr-a ]Wd | | *!*** | |

[17] While there are verb roots with mid and low vowels, we know of none with a lexical [+ATR]. Thus, roots with only mid and low vowels patterns like the roots in (18a).

[18] Thanks to Ngessimo Mutaka for the data with back vowel suffixes.

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Before exploring an analysis of these disharmonic forms, it is useful to consider fully harmonic forms with the same [… I … A … I …] sequence. Such examples are included in (21) for comparison with the high–low–high vowel sequences in (19). As the forms in (21) illustrate, there is no purely phonological reason preventing the high vowels in a high–low–high [… I … A … I …] sequence from being advanced in a perfectly regular fashion, whether the advancement is a property of the root or of the suffix: after all, they are advanced in (21).[19]

(21) e-kɻ-[kalɻ] [èkíkà:lì] 'woman'
o-mʊ-[kam]-ɻ [ɔ̀múkɑ́:mì] 'brewer'

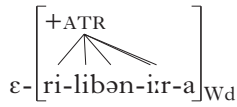
The disharmonic property of the [… I … A … I …] sequence occurs specifically when the rightmost high vowel is suffixal and the [+ATR] specification is a property of the root.[20]

(22) *The high–low–high vowel paradox: if* H1/ATR *is maximally satisfied, some forms are well-formed and others ill-formed*

a. *Well-formed* [èkíkà:lì]




b. *Ill-formed* *[èrìlìbànɪ́:rà] (cf. [èrìlìbànɪ́:rà])




A phonological analysis solely in terms of grounding by definition requires the H1/ATR condition to hold generally in order to account for the [i … ə … i] sequence in forms like [èkíkà:lì] 'woman'.

[19] Such forms also illustrate the independence of ATR harmony in Kinande from the common Bantu process of progressive height harmony (which causes high–mid alternations in forms such as *e-ri-hek-er-a* [èrìhèkɛ́:rà] 'to carry for' (cf. *e-ri-hat-ir-a* [èrìhàtí:rà] 'to peel for', *e-ri-lim-ir-a* [èrìlìmí:rà] 'to work for') and *e-ri-βɔh-ɔl-a* [èríβɔ̀hɔ́:là] 'to untie' (cf. *e-ri-mat-ul-a* [èrímàtʊ́:là] 'to ungrab' and *e-ri-lung-ul-a* [èrìlʊ̀ngʊ́:là] 'to straighten')). Height harmony must be distinguished from ATR harmony in various respects. Height harmony is strictly progressive, unlike ATR harmony, which is dominantly regressive. Low vowels do not trigger height harmony (e.g. [èrìhàtí:rà]), but transmit ATR harmony (e.g. [èkíkà:lì] (21)). Unrounded mid vowels do not cause height harmony in a high rounded vowel (e.g. *e-ri-seng-ul-a* [èrìsèngʊ́:là] 'to unpack') but do transmit ATR harmony to such a vowel (*o-mʊ-hɛ̨k-ɻ* [ɔ̀mùhɛ́:kì] 'porter'). The last example also shows that an exception to height harmony (such as the final [i]) can trigger ATR harmony in unexceptional fashion.

[20] Note that these data present a counterargument to the hypothesis that opacity necessarily involves harmonically unpaired vowels, counter to the assumptions made in e.g. Baković (2001).

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(23) *Domain of* HI/ATR *must be unrestricted*

| +ATR<br>E-kI-kAlI | HI/ATR | DEPPATH[ATR] |
|---|---|---|
| ☞ a. [+ATR ε-[ki-kəːli]Wd | | **** |
| b. [+ATR ε-[ki-kaːlɪ]Wd | *! | * |
| c. [+ATR ε-[kɪ-kaːli]Wd | *! | * |
| d. [+ATR ε-[kɪ-kaːlɪ]Wd | *!* | |

Comparing the following tableau with (23) illustrates the paradox. While in (23), the constraint hierarchy selects the attested form, in (24) the wrong candidate is preferred over the attested (24b).

(24) *Domain of* HI/ATR *must be restricted*

| +ATR<br>rI-lIbAn-Ir-A | HI/ATR | DEPPATH[ATR] |
|---|---|---|
| ☞ a. [+ATR ri-libən-ɪːr-a]Wd | | ***** |
| ☞ b. [+ATR ri-liban-ɪːr-a]Wd | *! | ** |

Importantly, since the input sequence /… I … A … I …/ behaves differently in different morphological structures, no combination of purely phonological factors will suffice to derive both patterns. Consequently, any combination of grounded conditions (with or without alignment) which fails to differentiate morphosyntactic domains will fail to account for these data.

### 4.2 Root *vs*. stem: domain restrictions on HI/ATR

§3 argued for an analysis in terms of grounding, while the discussion above demonstrates that grounding alone leads to a paradox. We are now in position to demonstrate the necessity of incorporating morphosyntactic domains into the grounding analysis. We show here that reference to the morphological constituents root, stem and word is crucial for an understanding of these forms. The morphological structure presented in (1) is repeated here for convenience.

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(25) *Morphosyntactic constituents in Kinande*

augment [Word [diminutive/ augmentative prefixes] [Macro-stem [class prefixes] [Stem [Root [ … ] … ]]]]

Root and suffix vowels behave differently in Kinande. In order to spread [+ATR] from a root vowel to a prefix, it is acceptable to cause a low vowel to advance (26a); in contrast, to spread [+ATR] from a root vowel to a suffix vowel is ill-formed if such harmony would cause a low vowel to become [+ATR] (26b). That is, the elimination of a suffixal violation of HI/ATR does not warrant the advancement of a low vowel.

(26) *Low vowel … high vowel sequences: ill-formed if* HI/ATR *is maximally satisfied*

| | *Maximally obeys* HI/ATR | *Minimally obeys* HI/ATR |
|---|---|---|
| a. | *Well-formed:* [èkíkə́ːlì] | *Ill-formed:* *[èkíkàːlì], *[èkíkàːlì] |
| | ɛ-[[[+ATR ki- kəːli]Rt]St]Wd | ɛ-[[[+ATR ki- kaːlɪ]Rt]St]Wd |
| | | ɛ-[[[kɪ- [+ATR kaːli]Rt]St]Wd |
| b. | *Ill-formed:* *[èrìlìbə̀nḯːrà] | *Well-formed:* [èrìlìbə̀nḯːrà] |
| | ɛ-[[[+ATR ri- libən]Rt -iːr-a]St]Wd | ɛ-[[[+ATR ri- liban]Rt -ɪːr-a]St]Wd |
| | | HI/ATR *violated* |

Two factors become apparent in such forms. First, as already noted, it is essential to encode the different morphosyntactic domains in some way in order to distinguish the two types of structures. Importantly, the domain specification must pertain specifically to the grounded conditions. We turn to this point momentarily.

Second, the single grounded condition, HI/ATR, is inadequate for expressing the Kinande pattern, even when augmented by domain specifications: by itself, this condition is insufficient to differentiate the dual behaviour of high-voweled suffixes – harmonic in (18b), but not harmonic in (19) or (26b). That is, adding a domain specification including the suffix domain to HI/ATR would incorrectly lead to overapplication in the latter class of cases, while excluding the suffix domain would cause underapplication in cases like (18b) (predicting *[èrílìmḯːrà]).

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Of central importance is the observation that advancement takes place only when the suffix high vowel is adjacent to a root advanced high vowel (as in [ɛ̀rílìmĭ́ːrà] 'exterminate for').[21] When the assignment of [+ATR] to a suffix vowel would create a non-high [+ATR] vowel (as in [ɛ̀rìlìbànĭ́ːrà] *[ɛ̀rìlìbɛ̀nĭ́ːrà] 'disappear for someone'), such advancement is blocked. Apparently at play is a condition that is violated if [+ATR] is assigned to non-high vowels: in short, there is a preference for advanced vowels to be high.

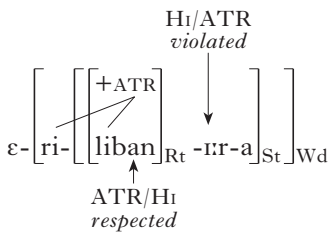
The required condition, ATR/HI, is one of those motivated under Grounding Theory. Just as tongue-body raising tends to induce tongue-root advancement (HI/ATR), so does tongue-root advancement tend to induce tongue-body raising (ATR/HI) (Archangeli & Pulleyblank 1994).[22]

(27) *Grounded condition*: ATR/HI
If [+ATR] then [+high].

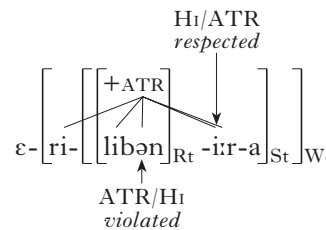
When [+ATR] is assigned to a high vowel, the ATR/HI constraint is respected, but when [+ATR] is assigned to a mid or low vowel, a violation is incurred. This violation is fatal in certain cases, as illustrated in (28b).

(28) ATR/HI ⩺ HI/ATR

a. [ɛ̀rìlìbànĭ́ːrà]




b. *[ɛ̀rìlìbɛ̀nĭ́ːrà]

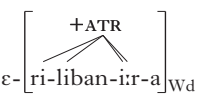



Consider now the cases of harmony affecting non-high vowels such as (21). Here the opposite ranking is crucial, HI/ATR over ATR/HI. Were ATR/HI to take precedence, one of the two unattested representations in (29a, b) would be preferred to the correct [ɛ̀kíkə̀ːlì] (29c).[23]

[21] This observation is made clearly in Hyman (1989).

[22] As with HI/ATR, we leave open the question of whether the condition formally conflates two sub-clauses: 'if [+ATR] then [+high]' and 'if [+ATR] then not [−high]'.

[23] Recall that the prohibition against gapped representations (see note 12) prevents [+ATR] from skipping the low vowel, the type of configuration shown in (i).

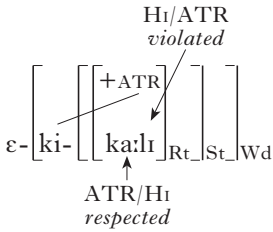
(i) 


The assignment of [+ATR] would only be to high vowels in such a form, satisfying both ATR/HI and HI/ATR. Because general constraints on representations rule out gapped configurations, GEN does not even produce such a form as a potential candidate.

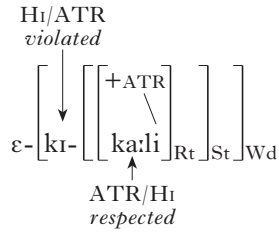
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(29) HI/ATR ⩾ ATR/HI

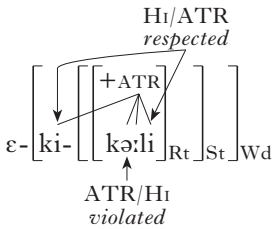
a. *[èkíkà:lì]




b. *[èkíkà:lì]




c. [èkíkə:lì]




This situation is of a canonical optimality type, a case where it is impossible for all relevant constraints to be satisfied. For the sequence I … A … I in a form that contains a [+ATR] specification, constraint satisfaction cannot be perfect. In Kinande, this conflict is resolved in opposite ways in the root and stem domains. Within the root, advancement of high vowels wins ([I] is not tolerated if avoidable): HI/ATR ⩾ ATR/HI. Outside of the root but within the stem, advancement only of high vowels wins ([ə] is not tolerated if avoidable): ATR/HI ⩾ HI/ATR. We propose delimiting the HI/ATR constraint by morphosyntactic domains.

(30) $\text{HI/ATR}_{\text{Root}}$
For specifications morphologically affiliated with a root, if [+high] then [+ATR].

Anticipating our discussion slightly, we also include the same constraint with a stem domain restriction.

(31) $\text{HI/ATR}_{\text{Stem}}$
For specifications morphologically affiliated with a stem, if [+high] then [+ATR].

Before continuing, we make clear precisely what is meant by placing a morphosyntactic domain restriction on a grounded condition like HI/ATR. Our assumption is that a domain restriction limits the applicability of a constraint to the elements included within the appropriate domain. Thus, for $\text{HI/ATR}_{\text{Root}}$, the condition is satisfied if each [+high]

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specification within the root domain is on a path to a [+ATR] value within the root. Hence the constraint would be vacuously satisfied if a root contained no [+high] values, and it would be satisfied if each [+high] was also [+ATR]. The constraint would be violated, however, if a root specification of [+high] was not on a path to [+ATR], or if a root [+high] was on a path to a [+ATR] not itself contained within the root. Note that a condition restricted to a morphological domain would have no effect on an inserted F-element (which has *no* morphological affiliation). (See Pulleyblank 1996 for motivation of a comparable interpretation of domains as applied to particular alignment constraints involved in defining the harmony systems of Yoruba and Wolof.)[24]

Together with ATR/HI, the domain-restricted constraints define the ranking in (32).[25]

(32) $\text{HI/ATR}_{\text{Root}} \gg \text{ATR/HI} \gg \text{HI/ATR}_{\text{stem}}$

[24] We differ from Bickmore (2000) in our understanding of how domain restrictions work. Under our proposal, a violation is incurred if the constraint is not satisfied within the domain identified in the constraint itself. A stem restriction applies to anything within the stem, regardless of whether it is in the root or not. Under Bickmore (2000), a violation is incurred if the constraint is not satisfied by elements occurring within the identified domain but not within any smaller domain. Thus, for Bickmore, a stem restriction applies to anything within the stem, except for any material that is contained within the root. Because of this difference, Bickmore's model is incompatible with the Domain Ranking Hypothesis (75), addressed in §7.

[25] Note that a comparable effect could *not* be achieved by limiting the domain of ATR/HI but not limiting the domain of HI/ATR. Such an analysis might invoke a hierarchy such as the following:

(i) $\text{ATR/HI}_{\text{Stem}} \gg \text{HI/ATR} \gg \text{ATR/HI}_{\text{Root}}$

Under such a ranking, at the stem level, ATR/HI takes precedence over HI/ATR, while at the root level, the reverse is true. In stems, then, a vowel like [ə] would be ruled out. Within roots, since HI/ATR dominates $\text{ATR/HI}_{\text{Root}}$, one might think that in order to satisfy the higher-ranking HI/ATR, non-high vowels would also be [+ATR], deriving a sequence [ə … i]. Universally, however, the morphology is organised such that stems *include* roots (Selkirk 1982) – any element in a root is also in a stem: $_{\text{Stem}}[\text{X}\ _{\text{Root}}[\text{Y}]\text{Z}]$. Consequently, any non-high [+ATR] root vowel (allowed in order to satisfy the dominant HI/ATR) would automatically constitute a violation of $\text{ATR/HI}_{\text{Stem}}$. Hence if [ə] is ruled out in stems, then [ə] is also ruled out in roots. In short, this ranking would be equivalent to ranking both $\text{ATR/HI}_{\text{Stem}}$ and $\text{ATR/HI}_{\text{Root}}$ (or, equivalently, an unrestricted ATR/HI) above HI/ATR, incorrectly ruling out all harmonic effects on non-high vowels. Reversing the positions of $\text{ATR/HI}_{\text{Stem}}$ and $\text{ATR/HI}_{\text{Root}}$ (giving $\text{ATR/HI}_{\text{Root}} \gg \text{HI/ATR} \gg \text{ATR/HI}_{\text{Stem}}$) would also have undesirable effects. The dominance of $\text{ATR/HI}_{\text{Root}}$ would prohibit any non-high root vowel from being [+ATR], again incorrectly eliminating harmonic effects on non-high vowels (as in [ɛ̀kíkə́:lì]). Note also that the analysis presented here predicts that a root-internal … I … A … I … sequence in an advanced morpheme would surface with all three vowels advanced. We know of no relevant roots on which to test this prediction.

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This hierarchy accounts for the harmony pattern in forms such as [èrilibànĩ́ːrà], where the rightmost high vowel is part of the stem domain, but not part of the root.

(33) *Stem violations of* HI/ATR *tolerated in order to avoid* ATR/HI *violations*

| [rI-[[+ATR lIbAn]Rt Ir-A]St]Wd | HI/ATR$_{Rt}$ | ATR/HI | HI/ATR$_{St}$ | DEPPATH[ATR] |
|---|---|---|---|---|
| ☞ a. [ri-[[+ATR liban]Rt iːr-a]St]Wd | | | ** | ** |
| b. [ri-[[+ATR libən]Rt iːr-a]St]Wd | | *! | | ***** |
| c. [rɪ-[[+ATR lɪban]Rt iːr-a]St]Wd | *! | | * | ** |

Here, the root contains both a high vowel and a [+ATR] specification: HI/ATR must be satisfied within the root domain, thereby ruling out (33c). ATR/HI, however, prevents the low root vowel and hence the suffix high vowel from being advanced, ruling out rightward harmony in (33b). The disharmonic candidate (33a) is correctly selected as optimal.

Note that harmony is still possible onto suffixes, provided that there are no intervening non-high vowels. This can be seen with a word such as [èrílìmĩ́ːrà] 'exterminate for'. Only candidates satisfying HI/ATR$_{Root}$ are considered; the absence of suffix harmony in (34b) fatally violates HI/ATR$_{Stem}$; ATR/HI would be violated only if the final low vowel were advanced.

(34) *Harmony within the stem, including stem-level suffixes*

| [rI-[[+ATR lIm]Rt Ir-A]St]Wd | HI/ATR$_{Rt}$ | ATR/HI | HI/ATR$_{St}$ | DEPPATH[ATR] |
|---|---|---|---|---|
| ☞ a. [ri-[[+ATR lim]Rt iːr-a]St]Wd | | | | **** |
| b. [ri-[[+ATR lim]Rt iːr-a]St]Wd | | | *!* | ** |

The Kinande data provide evidence that it is important to interleave morphologically restricted grounding with unrestricted grounding. Such an analysis provides an account of the data considered thus far. The question we address now is whether the introduction of morphosyntactic domains on grounded conditions creates a need for alignment. The following discussion demonstrates that such is the case: leftward alignment is necessary.

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## 5 The distinct roles of ALIGN-L and ALIGN-R

Imposing a domain restriction on HI/ATR has a dramatic effect on a case where the low–high [… A I …] sequence of [… I … A … I …] is within a root, that is, a case such as [ɛ̀kíkə́:lì] 'woman'. Because the righthand high vowel is part of the root domain, the exigencies of $\text{HI/ATR}_{\text{Root}}$ require the vowel to be advanced. The prefix [-kI-], by contrast, is outside of the root domain, and so is not subject to $\text{HI/ATR}_{\text{Root}}$. Consequently, with no changes to the constraint hierarchy, we wrongly predict the absence of leftward harmony, ungrammatical (35b) over grammatical (35c).

(35) *Root violations of* HI/ATR *not tolerated*

| [kI-[[+ATR kAlI]Rt]St]Wd | $\text{HI/ATR}_{\text{Rt}}$ | ATR/HI | $\text{HI/ATR}_{\text{St}}$ | DEPPATH[ATR] |
|---|---|---|---|---|
| a. [ki-[[+ATR ka:lɪ]Rt]St]Wd | *! | | * | * |
| ☞ b. [kɪ-[[+ATR ka:li]Rt]St]Wd | | | | * |
| ☜ c. [ki-[[+ATR kə:li]Rt]St]Wd | | *!* | | **** |

These facts argue in favour of including a purely formal phonological requirement, leftward alignment of [+ATR], in the Kinande grammar, repeated here from (5):

(36) ALIGN([+ATR], L; Word, L)

The left edge of every [+ATR] specification is aligned with the left edge of some word.

Compare (37) with (35): in (37b) *[kɪka:li] is immediately eliminated by ALIGN-L, the sole difference between this constraint hierarchy and that in (35). (We find no motivation in Kinande for crucial ranking of ALIGN-L with respect to $\text{HI/ATR}_{\text{Root}}$.)

(37) *Effect of* ALIGN-L

| [kI-[[+ATR kAlI]Rt]St]Wd | ALIGN-L | $\text{HI/ATR}_{\text{Rt}}$ | ATR/HI | $\text{HI/ATR}_{\text{St}}$ | DEPPATH[ATR] |
|---|---|---|---|---|---|
| a. [ki-[[+ATR ka:lɪ]Rt]St]Wd | | *! | | * | * |
| b. [kɪ-[[+ATR ka:li]Rt]St]Wd | *!** | | | | * |
| ☞ c. [ki-[[+ATR kə:li]Rt]St]Wd | | | ** | | **** |

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Note that ALIGN-L will have no effect on the cases considered above where the non-high vowels are to the right of the high root vowel, not to its left. ATR/HI still prohibits suffix harmony, illustrated in (38b), because suffix harmony would require an advanced low root vowel. HI/$ATR_{Root}$ requires that the root high vowel be advanced, eliminating (38c, d).

(38) *Stem violations of* HI/ATR *tolerated in order to avoid* ATR/HI *violations*

| [rI-[[+ATR lIbAn]Rt Ir-A]St]Wd | ALIGN-L | HI/ $ATR_{Rt}$ | ATR/HI | HI/ $ATR_{St}$ | DEPPATH [ATR] |
|---|---|---|---|---|---|
| ☞ a. [ri-[[+ATR liban]Rt ɪːr-a]St]Wd | | | | ** | ** |
| b. [ri-[[+ATR libən]Rt ɪːr-a]St]Wd | | | *! | | ***** |
| c. [rɪ-[[+ATR lɪban]Rt ɪːr-a]St]Wd | *!** | *! | | * | ** |
| d. [rɪ-[[+ATR lɪban]Rt ɪːr-a]St]Wd | | *! | | *** | |

This completes the essence of our analysis: Kinande vowel harmony relies on the interaction of grounded constraints with alignment. The grounded constraints themselves are divided into two classes, those that are restricted to hold of particular morphological domains and those which have 'free rein' in the language.

However, the same effects are obtained by an analysis replacing HI/$ATR_{Stem}$ by ALIGN-R (rightward alignment of [+ATR], comparable to ALIGN-L). This observation challenges the strength of our argument for restricting phonological constraints by morphological domains. As the next section shows, further details of the Kinande system reveal both that HI/ATR is also limited by the macro-stem, and that ALIGN-R fails to account for the additional data. HI/$ATR_{Macro\text{-}stem}$ is subordinate to both the other HI/ATR constraints and to a constraint restricting tongue-root advancement to front vowels, producing effects beyond the powers of ALIGN-R. We turn to the argument now.

## 5.1 Non-high advanced roots

To set up the argument against ALIGN-R, it is important to understand properties of roots without high vowels. The roots of this phonological class exhibit two distinct patterns of harmonic behaviour, as pointed out in (10). First, there is a class where all vowels are retracted, the non-high root vowels and any prefixal vowels, illustrated in (39a–c). This pattern is

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precisely what is expected for the class of roots devoid of any [+ATR] specification, illustrated in (39d–e).

(39) *Retracted prefixes with* (*retracted*) *non-high vowel roots*

| | | |
|---|---|---|
| a. e-ri-se | [èrí:sɛ̂] | 'rat's dung' |
| b. e-ri-ses-a | [èrìsɛ́:sâ] | 'arrange (a bed)' |
| c. e-ri-sak-a | [èrísɑ́:kà] | 'incise' |
| d. e-ri-tsuku | [èrìtsʊ́:kʊ̀] | 'coldness' |
| e. e-ri-bumba | [èríbʊ̀:mbà] | 'clay' |

Of great interest is the contrast introduced by forms such as those in (40). With the same prefixes seen in (39), this class of roots conditions *advanced* prefixes in spite of the fact that the vowels of the roots concerned are neither high nor advanced.

(40) *Advanced prefixes with* (*retracted*) *non-high vowel roots*

| | | |
|---|---|---|
| a. e-rɟ-hembe | [èríhɛ̀:mbɛ̀] | 'horn' |
| b. e-rɟ-bere | [èríbɛ́:rɛ̀] | 'breast' |
| c. e-rɟ-tako | [èrítɑ́:kɔ̀] | 'buttock' |
| d. e-rɟ-samba | [èrìsà:mbà] | 'eagle' |
| e. e-rɟ-lolo | [èrìlɔ́:lɔ̀] | 'sin' |
| f. e-rɟ-tema | [èrítɛ́:mà] | 'cheek' |
| g. e-rɟ-kala | [èríkɑ́:là] | 'ember' |
| h. e-rɟ-sesa | [èrísɛ́:sà] | 'kind of grass' |
| i. e-rɟ-saka | [èrìsɑ́:kà] | 'kind of rat' |

Just as the forms with suffixes demonstrated the crucial role of $\text{H}_\text{I}/\text{ATR}_{\text{Stem}}$, so do these prefixal forms show the crucial need for $\text{H}_\text{I}/\text{ATR}_{\text{Macro-stem}}$.

(41) $\text{H}_\text{I}/\text{ATR}_{\text{Macro-stem}}$

For specifications morphologically affiliated with a macro-stem, if [+high] then [+ATR], not [−ATR].

Compare a non-high root that conditions retracted prefixes (42) with one that appears with an advanced prefix (43).

(42) *Non-high retracted roots*

| [[[rI-[[sEsA]Rt]St]MSt]Wd | Dep [ATR] | Align-L | $\text{H}_\text{I}/\text{ATR}_{\text{Rt}}$ | ATR/$\text{H}_\text{I}$ | $\text{H}_\text{I}/\text{ATR}_{\text{MSt}}$ | Dep Path [ATR] |
|---|---|---|---|---|---|---|
| a. [[[+ATR ri-[[sɛ:sa]Rt]St]MSt]Wd | *! | | | | | * |
| ☞ b. [[[rI-[[sɛ:sa]Rt]St]MSt]Wd | | | | | * | |

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(43) *Non-high advanced roots*

| | DEP [ATR] | ALIGN-L | HI/ $ATR_{Rt}$ | ATR/HI | HI/ $ATR_{MSt}$ | DEP PATH [ATR] |
|---|---|---|---|---|---|---|
| a. [[[rɪ- [[+ATR lOlO]Rt]St]MSt]Wd | | | | | *! | |
| ☞ b. [[[ri- [[+ATR lɔ:lɔ]Rt]St]MSt]Wd | | | | | | * |
| c. [[[ri- [[+ATR lo:lo]Rt]St]MSt]Wd | | | | *!** | | **** |

Both types of examples have a high vowel in the macro-stem domain that results from prefixation. In the case without a lexical [+ATR] value (42), DEP[ATR] prevents the appearance of an ATR value not lexically present; in the case where the morpheme contains a lexical [+ATR] (43), HI/ $ATR_{Macro\text{-}stem}$ forces the retention and association of the [+ATR] value.

Solely based on examples such as (39) and (40), there would be no need to distinguish the domains of 'stem' and 'macro-stem'. With the data so far considered, what is crucial is that both HI/$ATR_{Stem}$ and HI/ $ATR_{Macro\text{-}stem}$ both be ranked below ATR/HI and above DEPPATH[ATR]. As we will see shortly, however, the two domain-delimited constraints must be distinguished, because there is an additional constraint that must be ranked between the two.

Before turning to such examples, however, there are further facts of interest. The data in (40) establish that the morphemes /hEmbE/ (40a) and /bErE/ (40b) contain [+ATR] specifications lexically. The prediction of our analysis is that [+ATR] will fail to surface unless there is a high vowel present to anchor it. As is expected, when a prefix with a non-high vowel is added, so that there are no high vowels anywhere in a derived form, the lexical [+ATR] values do not surface, as illustrated in (44).[26]

(44) *Non-high prefixes with non-high vowel roots with floating* [+ATR] *specifications*

| | | | |
|---|---|---|---|
| a. a-ma-hembe | [àmáhɛ̀:mbɛ̀] | 'horns' | *[àmáhɛ̀:mbɛ̀], etc. |
| b. a-ma-bere | [àmábɛ́:rɛ̀] | 'breasts' | |

The retraction throughout the cases just considered is consistent with two observations about the surface distributions of [+ATR]

[26] We have been able to investigate the harmonic properties of prefixes exhibiting low vowels and high vowels, but not mid vowels. Unfortunately, all simple class prefixes involve either low or high vowels, never mid vowels (Valinande 1984, Mutaka 1990).

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vowels: (i) advanced non-high vowels are possible only when there is an advanced vowel on the right, and (ii) the rightmost vowel in an advanced sequence is [+high]. This is explained formally because association of [+ATR] to a non-high vowel takes place only when necessary to satisfy both of the highly ranked constraints ALIGN-L and HI/$ATR_{Root}$. Compare (45a, b) below, where [+ATR] is either unlinked or deleted, to representations such as (45c, d), in which the right edge is incorrectly defined by a specification that is not high, in violation of ATR/HI.

(45) *Linking possibilities in words without high vowels*

a. +ATR
a-[ma-hɛːmbɛ]$_{Wd}$

b. a-[ma-hɛːmbɛ]$_{Wd}$

c. * +ATR
a-[mə-hɛːmbɛ]$_{Wd}$

d. * +ATR
a-[mə-heːmbe]$_{Wd}$

[àmáhɛ̀ːmbɛ̀] 'horns'

The constraints HI/$ATR_{Root}$ and HI/$ATR_{Stem}$ are vacuously satisfied by all four representations since there are no high vowels. Of apparent relevance, therefore, are only ALIGN-L and ATR/HI. ATR/HI has the immediate effect of eliminating (45d) since the difference between (45c) and (45d) is simply the degree to which each violates ATR/HI ((45d) has maximal violation since all advanced vowels are non-high; see (47d)). The interesting comparison is therefore between (45a, b), which have the same empirical effect, and (45c). All three representations satisfy ALIGN-L: (45a) satisfies left-edge alignment by leaving the [+ATR] value floating, (45b) satisfies left-edge alignment vacuously since there is no [+ATR] specification and (45c) satisfies left-edge alignment by associating [+ATR] to the leftmost vowel of the word. The choice between (45a, b) and (45c) therefore falls to ATR/HI. Since ATR/HI is violated by (45c) and satisfied by both (45a, b), and since (45c) is unattested, we conclude that ATR/HI must outrank at least one of the constraints that require an input ATR specification to survive (MAX[ATR]) and that require ATR specifications to be associated to prosodic structure (LINK[ATR]).

(46) *Faithfulness and association constraints*

a. MAX[ATR]
An input F-element [+ATR] must have an output correspondent F-element [+ATR].

b. LINK[ATR]
An F-element [+ATR] must be on a path to prosodic structure.

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(47) [+ATR] *words without high vowels*

| A-[+ATR mA-hEmbE]Wd | … | ATR/HI | … | MAX[ATR] | LINK[ATR] |
|---|---|---|---|---|---|
| ☞ a. a-[+ATR ma-hɛːmbɛ]Wd | | | | | * |
| ☞ b. a-[ ma-hɛːmbɛ]Wd | | | | * | |
| c. a-[+ATR mə-hɛːmbɛ]Wd | | *! | | | |
| d. a-[+ATR mə-heːmbe]Wd | | *!*** | | | |

Two points are critical here: (i) the presence of a lexical [+ATR] specification is not sufficient in and of itself to guarantee the surface presence of advancement, and (ii) a lexical [+ATR] specification surfaces on the rightmost [+high] vowel in its domain, even when that vowel is quite far to the left in the word.

Of interest now are additional cases which show that more than simply vowel height is involved in defining the right edge for harmony.

## 5.2 ATR/FR and the macro-stem

Consider the data in (48), consisting of plural/singular pairs involving non-high roots containing [+ATR] specifications. The plural forms in (48a) establish that the relevant roots contain [+ATR] specifications. This can be seen from the fact that the class 10 prefix surfaces as advanced, [si-]. At issue, therefore, is the behaviour of the singular class 11 prefix /lU-/ in (48b). Given that the vowel of /lU-/ is high and that the roots in (48) contain a [+ATR] value, the expectation would be that the /U/ of /lU-/ should surface as advanced, not retracted, in such forms. However, this prefix surfaces as retracted (48b).

(48) *Front and back prefixes in roots with floating specifications*

| | | | |
|---|---|---|---|
| a. e-sɨ-seke | [ɛ̀sísɛ̀ːkɛ̀] | 'reeds' | |
| e-sɨ-sako | [ɛ̀sísɑ́ːkɔ̀] | 'tattoos' | |
| b. o-lu-seke | [ɔ̀lúsɛ̀ːkɛ̀] | 'reed' | *[ɔ́lúsɛ̀ːkɛ̀] |
| o-lu-sako | [ɔ̀lúsɑ́ːkɔ̀] | 'tattoo' | *[ɔ́lúsɑ́ːkɔ̀] |

The analysis presented thus far defines the right edge of harmony through the constraint HI/ATR, and the left edge through leftward alignment. Phrased in these terms, since the high vowels of (48a) establish right edges for legitimate harmonic domains, one would expect

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that the high vowels of (48b) would also establish right domain edges. Surprisingly, they do not. There is a significant phonological distinction between these prefixes: the high vowels of (48b) are back vowels while those of (48a) are front vowels.

We propose that these cases, like the [… I … A … I …] paradox cases, involve the interaction of an additional grounded condition with the basic harmonic interaction of alignment and HI/ATR. Specifically, we propose the inclusion of the grounded condition ATR/FR (Archangeli & Pulleyblank 1994, Davis 1995), preferring that advanced vowels be [−back], not [+back].[27]

(49) *Grounded condition*: ATR/FR
If [+ATR] then [−back].

The phonetic motivation for this constraint lies in the tendency for advanced vowels to involve tongue-body fronting, not tongue-body backing. The phonological motivation in Kinande derives from the stronger tendency to assign [+ATR] to front vowels than to back vowels. (For further phonological motivation, see, for example, the discussion of Lango in Archangeli & Pulleyblank 1994.) We propose that the assignment of [+ATR] to a vowel outside of the stem constituent is governed by ATR/FR.

(50) … $\text{HI/ATR}_{\text{Stem}} \gg \text{ATR/FR} \gg \text{HI/ATR}_{\text{Macro-stem}}$ …

That is, within a stem (root plus suffixes), high vowels are under pressure to be advanced whether they are front or back; outside of the stem but within the macro-stem, high vowels can be advanced only if they satisfy the additional requirement of being front.

We note as well that the macro-stem is the maximal domain within which HI/ATR plays a role in Kinande. Within the macro-stem, HI/ATR exerts pressure to have all high vowels advanced; outside of the macro-stem, other constraints will militate against such an effect.[28]

To see the effect of interleaving ATR/FR between two domain-restricted HI/ATR constraints, $\text{HI/ATR}_{\text{Stem}}$ and $\text{HI/ATR}_{\text{Macro-stem}}$, compare plural and singular forms for a root like /sAkO [+ATR]/ ‘tattoo’, where the high front vowel of the plural class prefix is advanced, [èsísá:kɔ̀] ‘tattoos’, while the high back vowel of the singular class prefix is retracted, [ɔ̀lósá:kɔ̀] ‘tattoo’.

[27] We leave open the question of whether this constraint should also encompass the restriction ‘if [+ATR] then not [+back]’. See note 10 for discussion of this point.

[28] We discuss this further in §5.4. Note that the precise constraint structure preventing any effect of HI/ATR outside the macro-stem domain is not crucial. A straightforward approach is to rank a constraint against the appearance of [+ATR] below the domain-restricted HI/ATR constraint but above the general HI/ATR constraint: $\text{HI/ATR}_{\text{Macro-stem}} \gg \text{*[+ATR]} \gg \text{HI/ATR}$.

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(51) *Advancement of high front vowels within the macro-stem domain*

| [[[sI-[[+ATR sAkO]Rt]St]MSt]Wd | HI/ATR$_{Rt}$ | ATR/HI | HI/ATR$_{St}$ | ATR/FR | HI/ATR$_{MSt}$ |
|---|---|---|---|---|---|
| ☞ a. [[[si-[[+ATR sa:kɔ]Rt]St]MSt]Wd | | | | | |
| b. [[[sɪ-[[+ATR sa:kɔ]Rt]St]MSt]Wd | | | | | *! |

(52) *Failure to advance high back vowels within the macro-stem domain*

| [[[lU-[[+ATR sAkO]Rt]St]MSt]Wd | HI/ATR$_{Rt}$ | ATR/HI | HI/ATR$_{St}$ | ATR/FR | HI/ATR$_{MSt}$ |
|---|---|---|---|---|---|
| a. [[[lu-[[+ATR sa:kɔ]Rt]St]MSt]Wd | | | | *! | |
| ☞ b. [[[lʊ-[[+ATR sa:kɔ]Rt]St]MSt]Wd | | | | | * |

As can be seen with a back vowel prefix, ATR/FR prevents the assignment of [+ATR] to the prefix since such assignment would result in the advancement of a back vowel. (Note that this distinction will be irrelevant in the event that the root contains a high vowel: HI/ATR$_{Root}$ coupled with ALIGN-L will ensure an advanced vowel span, terminating in the high root vowel.)

### 5.3 Why not ALIGN-R?

Consider now the possibility of replacing HI/ATR$_{Stem}$ by ALIGN-R, entertained in our discussion of (37) and (38). As illustrated in (53), this change erroneously selects candidate (53b), whose floating [+ATR] is better aligned to the right than is the linked [+ATR] in the attested (53a). Examples of this sort demonstrate the inadequacy for Kinande of an analysis based solely on alignment.

(53) *Advancement of high front vowels within the macro-stem domain*

| [[[sI-[[+ATR sAkO]Rt]St]MSt]Wd | HI/ATR$_{Rt}$ | ATR/HI | ALIGN-R | ATR/FR | HI/ATR$_{MSt}$ |
|---|---|---|---|---|---|
| ☜ a. [[[si-[[+ATR sa:kɔ]Rt]St]MSt]Wd | | | *!** | | |
| ☞ b. [[[sɪ-[[+ATR sa:kɔ]Rt]St]MSt]Wd | | | | | * |

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We conclude that, while ALIGN-L is critical in Kinande, ALIGN-R plays no significant role in the distribution of [ATR] features. Rather, the interplay of ALIGN-L with grounding, both with and without morphological restrictions, is crucial in defining the surface harmony patterns.

This result is significant: in large part, the harmonic effect in Kinande is the result of preferred combinations of features, characterised by the grounded constraint HI/ATR. Optimality Theory forces a different understanding of the driving forces behind phonological alternations.[29]

## 5.4 Macro-stem or word?

We have claimed that, for Kinande, the macro-stem is the maximal domain within which HI/ATR plays a role. This claim entails that word-level affixes, i.e. those outside of the macro-stem, are exempt from the effects of HI/ATR. In this section, we justify that claim, in an examination of the diminutive and augmentative prefixes.

We first establish that these prefixes do undergo harmony. As illustrated in (54), when followed by an advanced vowel, advancement is possible: (54a) illustrates the prefixation of /hI-/ to retracted roots; (54b) illustrates the prefixation of /hI-/ to advanced roots with high vowels.

(54) *Macro-stem prefixes with advanced and retracted roots*

| | | |
|---|---|---|
| a. e-hi-rere | [ɛ̀hìrɛ́ːrɛ̀] | 'young ones' |
| e-hi-ti | [ɛ̀híːtì] | 'small trees' |
| b. e-hị-rịkụhụ | [ɛ́hìríkùːkù] | 'wood pigeons/doves' |
| e-hị-rẹrụ | [ɛ̀hìrɛ́ːrù] | 'beard' |

Consider now the forms in (55), all of which involve the diminutive prefix /hI-/. The roots in (55) are chosen from the non-high root class that was shown to condition advanced prefixes (see (40)). As shown in (55), however, all instances of the diminutive prefix are retracted, not advanced.

(55) *Diminutive prefixes with roots with floating specifications*

| | | |
|---|---|---|
| a. e-hi-hembe | [ɛ̀híhɛ̀ːmbɛ̀] | 'small horns' |
| b. e-hi-bere | [ɛ̀híbɛ́ːrɛ̀] | 'small breasts' |
| c. e-hi-tako | [ɛ̀hítǎːkɔ̀] | 'small buttocks' |
| d. e-hi-samba | [ɛ̀hìsàːmbà] | 'small eagles' |
| e. e-hi-lolo | [ɛ̀hìlɔ́ːlɔ̀] | 'small sins' |
| f. e-hi-tema | [ɛ̀hìtɛ́ːmà] | 'small cheeks' |

Note that augmentative/diminutive prefixes with back vowels are also immune to advancement. Given the fact that back vowels do not advance even within the macro-stem domain (see (48b)), this is entirely expected, due to the interaction with ATR/FR.

[29] The same point is equally valid if the driving force behind harmony is a different type of constraint (SPREAD, etc.). See note 1.

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(56) *Back vowels in the macro-stem*

| | | |
|---|---|---|
| a. o-tu-sesa | [ɔ̀tʊ́sɛ́ːsà] | 'small thatch' |
| | | cf. e-rɪ̨-sesa [èrísɛ́ːsà] 'kind of grass' |
| b. o-tu-samba | [ɔ̀tʊ̀sàːmbà] | 'small eagles' |
| | | cf. e-rɪ̨-samba [èrìsàːmbà] 'eagle' |
| c. o-lu-bere | [ɔ̀lʊ́bɛ́ːrɛ̀] | 'big breast' |
| | | cf. e-rɪ̨-bere [èríbɛ́ːrɛ̀] 'breast' |
| d. o-lu-tema | [ɔ̀lʊ́tɛ́ːmà] | 'big cheek' |
| | | cf. e-rɪ̨-tema [èrítɛ́ːmà] 'cheek' |

There are two observations to be made about the diminutive prefix. First, this class of prefixal vowels is subject to harmony provided there is an advanced vowel to the right, i.e. it is subject to harmony due to satisfying ALIGN-L. Second, while these prefixes do harmonise, they cannot constitute the right edge of a harmonic domain by themselves. Formally, they are inside the domain of ALIGN-L but outside the domain of HI/ATR.

The proposed analysis of these facts depends crucially on two proposals made above: (i) the adoption of a macro-stem domain as distinct from a word domain, and (ii) the imposition of the macro-stem domain on the grounded condition HI/ATR. Given these proposals, we analyse the pre-stem prefixes that undergo [+ATR] linking as part of the 'macro-stem' domain. The macro-stem includes the stem plus all lexically selected class prefixes, but excludes diminutive and augmentative prefixes, as well as the Augment (see note 13 and §2.1).

Thus, outside of the macro-stem domain, neither high front vowels nor high back vowels exhibit advancement except as a result of ALIGN-L. A root such as /tEmA [+ATR]/ can be seen to be lexically advanced in a simple singular form such as [èrítɛ́ːmà] 'cheek'. With the augmentative and diminutive prefixes, however, there is no advancement – whether the prefix is front ([èhítɛ́ːmà] 'small cheeks') or back ([ɔ̀lʊ́tɛ́ːmà] 'big cheek').

(57) *Failure of association to high vowels outside the macro-stem: high front vowels*

| [hI-[[[[+ATR tEmA]Rt St]MSt Wd] | HI/ATR$_{Rt}$ | ATR/HI | HI/ATR$_{St}$ | ATR/FR | HI/ATR$_{MSt}$ | DEP PATH [ATR] |
|---|---|---|---|---|---|---|
| a. [hi-[[[[+ATR tɛːma]Rt St]MSt Wd] | | | | | | *! |
| ☞ b. [hɪ-[[[[+ATR tɛːma]Rt St]MSt Wd] | | | | | | |
| c. [hɪ-[[[[+ATR teːma]Rt St]MSt Wd] | | *!* | | | | ** |

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As (58) illustrates, if we were to eliminate the macro-stem restriction on the lowest-ranked instance of HI/ATR, this would have the erroneous effect of selecting a candidate where the lexical [+ATR] is associated. We conclude that the macro-stem restriction is crucial in such cases.

(58) *Wrong result without restricting* HI/ATR *to the macro-stem domain*

| [hI-[[[+ATR tEmA]Rt]St]MSt]Wd | HI/ ATR$_{Rt}$ | ATR/ HI | HI/ ATR$_{St}$ | ATR/ FR | HI/ ATR | DEP PATH [ATR] |
|---|---|---|---|---|---|---|
| ☞ a. [hi-[[[+ATR tɛ:ma]Rt]St]MSt]Wd | | | | | | * |
| ☜ b. [hI-[[[+ATR tɛ:ma]Rt]St]MSt]Wd | | | | | *! | |
| c. [hI-[[[+ATR te:ma]Rt]St]MSt]Wd | | *!* | | | * | ** |

Two points are worthy of note regarding the non-association of the lexical [+ATR] in cases such as these. First, LINK[ATR], a constraint that ensures association of [ATR] to higher structure (see note 11) plays no discernible role in ensuring association in Kinande, or else it would cause linking in such cases. Formally, this can be attributed to ranking of LINK[ATR] below a constraint such as DEPPATH[ATR]. Second, the Kinande patterns of non-association constitute one of the arguments in Archangeli & Pulleyblank (1994) and in Hyman & Ngunga (1994) against viewing 'automatic' association as a universal convention. Within Optimality Theory, LINK[ATR] can be interpreted as constituting universal pressure to associate (Goldsmith 1976, 1990), but its precise effect in a given language will depend on its ranking with respect to other constraints.

## 5.5 Summary

To summarise the main results so far, we have argued that both alignment and grounding are necessary to derive Kinande harmony. In addition, we have demonstrated the role of ATR/HI in Kinande, and we have shown that it is necessary to impose morphological domain restrictions on HI/ATR, distinguishing between root, stem and macro-stem domains, with the general ranking noted below.

(59) ALIGN-L, HI/ATR$_{Root}$ … ≫ … HI/ATR$_{Stem}$ … ≫
… HI/ATR$_{Macro\text{-}stem}$

We have shown here that it is impossible to derive the surface patterns of Kinande [ATR] harmony by left and right alignment without reference

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to grounded constraints on feature co-occurrence. Harmony affects non-high vowels only when they occur *to the left of a high advanced vowel*, that is, only when the simultaneous satisfaction of ALIGN-L and HI/ATR forces the harmonic domain to include instances of non-high vowels. Further, harmony affects high vowels outside of the root domain when they occur (i) *within the same domain as a* [+ATR] *feature* (through the satisfaction of the domain-restricted HI/ATR) or (ii) *to the left of an advanced vowel* (once again, through the simultaneous satisfaction of ALIGN-L and HI-ATR).

## 6 Degree of specification

Up to this point, we have assumed sparse specification of [ATR], both in the input and in the candidate set. In this section, we address whether this assumption is necessary with regards to both the input and the output, at the heart of the issue of Richness of the Base.

Central to Optimality Theory as a theory of constraint interaction is that all constraints in a grammar reside in the constraint hierarchy; there are no independent constraints imposed on the inputs. Thus, it is not possible to require that input specification be linked or free, or even that specifications be present. The language-particular requirements are found in the constraint hierarchy, and simply define the best output to pair with whatever input might be proposed. The theory of representations that we assume allows all of the following combinations, and so inputs might contain any of the following representations as part of their make-up.

(60) *Representational possibilities*

| a. | b. +ATR | c. +ATR | d. −ATR | e. −ATR |
|---|---|---|---|---|
| V | V | V | V | V |

Our analysis thus far has assumed that input [+ATR] specifications are free, as in (60b); it has also assumed no tokens of [−ATR] in the input, as in (60a). However, neither of these assumptions are possible requirements under Optimality Theory. In this section, we demonstrate that these assumptions are, in fact, irrelevant to the formal results demonstrated here. For each class of morphemes, roots and affixes, the effects of various inputs fall into exactly two classes, one of which surfaces invariably as advanced, the other of which may be retracted. Not surprisingly, roots and affixes behave differently, due to the interleaving of ATR/HI between $\text{HI/ATR}_{\text{Root}}$ and $\text{HI/ATR}_{\text{Stem}}$.

Before turning to a consideration of different morphological classes, however, it is important to note a substantive point that distinguishes between various possible inputs. Cross-cutting the representational

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possibilities of (60) is the possibility that any given vowel be either high or non-high (mid/low).

As will be seen below, the class of inputs involving vowels that are both [+high] and [+ATR] play a special role in that these vowels are rigorously retained whether in a root or an affix. We suggest that this class of inputs is maintained by the local conjunction of two constraints, as indicated in (61).

(61) MaxPath[Hi/ATR]
The local conjunction of MaxPath[ATR] and Hi/ATR.
a. MaxPath[ATR]
Input anchor-path-[+ATR] representations have output anchor-path-[+ATR] correspondents.
b. Hi/ATR
If [+high] then [+ATR].

MaxPath[Hi/ATR] guarantees that the best possible class of high vowel inputs is maintained, that is, high vowels that are [+ATR]. The effect of the constraint is seen when an input contains a path between [+ATR] and [+high], and in such cases it eliminates candidates that violate both conjuncts. That is, (61) serves to ensure that input [+ATR, +high] vowels are realised as such in the output.

With this background, we return to the discussion of Richness of the Base, and consider types of inputs for roots and affixes that are different than those assumed thus far (i.e. different than (60a, b)). We explore the implications of a linked [+ATR] in roots, representation (60c), as well as representations with [−ATR], linked or free, (60d, e). We then examine the same range of possibilities for affixes.

## 6.1 Two classes of roots: [+ATR] and 'other'

For roots, the critical aspect of feature specification is whether or not [+ATR] is present, regardless of its linked status. All other representations function identically. When a [+ATR] specification is linked, (60c), the crucial point to note is that ATR/Hi, Hi/ATR and Align-L outrank MaxPath[ATR], the constraint preserving input paths to [+ATR]. As a result, an underlying association will be maintained only if it is to a high vowel, or to a non-high vowel if necessary to achieve the advancement of a high vowel and left-edge alignment. That is, the effects are the same regardless of whether an input [+ATR] is linked or free. This point is illustrated by comparing the tableaux in (38) above, with a free [+ATR], and (62), where [+ATR] is linked to both root vowels in the input. The only differences between the tableaux are the violations of MaxPath[ATR], but these are irrelevant violations (indicated by the shading).

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(62) *Stem violations of* HI/ATR *tolerated in order to avoid* ATR/HI *violations*

| rI-libən Ir-A | MAX PATH [HI/ATR] | ALIGN-L | HI/ATR$_{Rt}$ | ATR/HI | HI/ATR$_{St}$ | DEP PATH [ATR] | MAX PATH [ATR] |
|---|---|---|---|---|---|---|---|
| ☞ a. ri-liban ɪ:r-a | | | | | ** | * | * |
| b. ri-libən i:r-a | | | | *! | | *** | |
| c. rɪ-lɪban i:r-a | *! | *!** | *! | | * | ** | ** |

This point holds even were we to propose that only one of the root vowels be linked to [+ATR] in the input. The low vowel would not retain its input association because ATR/HI outranks MAXPATH[ATR], while the high vowel would retain its association to [+ATR] due to both MAXPATH[HI/ATR] and HI/ATR$_{Root}$.

This result can readily be extended to advanced roots with exclusively non-high vowels. Suppose a root contained only advanced mid vowels. MAXPATH[HI/ATR] is irrelevant since there is no path with [+high, +ATR] in the input. And again, since MAXPATH[ATR] is low-ranking, there is no effect on the selection of candidates.

Given the proposed grammar, what is critical is simply that [+ATR] appears in a root's input, regardless of its association status and regardless of vowel height.

But what of a representation with [−ATR], either free or linked? – that is, (60d, e) respectively. Examination of the constraint hierarchy reveals that all constraints refer to [+ATR]. These critical constraints dominate every constraint referring to [−ATR], including the faithfulness constraints. Should an input happen to include [−ATR], linked or free, the result is identical to that obtained with an input devoid of tongue-root features. Compare the tableau seen in (37) for [ɛ́kíkə́:lì] 'woman' with that in (63).

(63) *Tableau showing input with* [−ATR]

| kI-kali | DEP [ATR] | HI/ATR$_{Rt}$ | ALIGN-L | MAX PATH [HI/ATR] | ATR /HI | HI/ATR$_{St}$ | DEP PATH [ATR] | MAX PATH [ATR] |
|---|---|---|---|---|---|---|---|---|
| a. kɪ-ka:lɪ | | *! | | *! | | * | | * |
| b. kɪ-ka:li | | | *!** | | | | | |
| ☞ c. ki-kə:li | | | | | ** | | *** | |

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The addition of a lexically linked [−ATR] specification has no impact on the outcome.

In roots, then, one effect is gained from an input [+ATR], regardless of its linking status. A distinct effect is obtained when there is no [+ATR] present, regardless of whether or not [−ATR] is present, linked or not. In short, there are simply two classes of roots, those with [+ATR] and those without.

(64) *Root types*

| | a. Roots with one or more of | b. Roots with only |
|---|---|---|
| *input:* | +ATR +ATR<br>{ V , V } | −ATR −ATR<br>{ V , V , V } |
| *output:* | Advanced vowels in the surface form if stem contains a [+high] vowel | Retracted vowels |

## 6.2 Two classes of affixes: linked [+ATR] and 'other'

With affixes, the tendency is to *not* have a lexical [+ATR] value. The basic reason for this tendency is that ATR/HI constitutes pressure to avoid advancement (on non-high vowels). The higher-ranked constraint $\text{HI/ATR}_{\text{Root}}$ constitutes pressure to retain advancement – but for root values, not affix values. As we will see in this section, the one configuration where affixes are seen to introduce advancement is when the vowel is lexically [+high, +ATR]. As seen at the beginning of §6, this is precisely the type of representation which is maximally good according to the constraints HI/ATR and ATR/HI, protected by the conjoined constraint MAXPATH[HI/ATR].

To illustrate affix-induced advancement, consider the following agentive forms. The examples in the infinitive column, repeated from (10), show that the roots in (65a, b) are advanced, while the remaining roots (65c–g) are retracted. In the agentive column, it can be seen that all (non-augment) vowels are advanced when the agentive suffix is present. The agentive suffix consists phonologically of a high advanced front vowel.

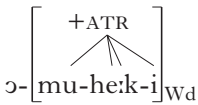
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(65) *High and non-high harmonic targets*

| | *infinitive* | | *agentive* | |
|---|---|---|---|---|
| a. | e-rɨ-lɨb-a ‘to cover’ | [èrìlíːbà] | o-mʊ-lɨb-ɨ ‘coverer’ | [ɔ̀mùlíːbì] |
| b. | e-rɨ-hʊk-a ‘to cook’ | [èríhʊ́ːkà] | o-mʊ-hʊk-ɨ ‘cook’ | [ɔ̀múhʊ́ːkì] |
| c. | e-ri-lim-a ‘to cultivate’ | [èrìlíːmà] | o-mʊ-lɨm-ɨ ‘farmer’ | [ɔ̀mùlíːmì] |
| d. | e-ri-hum-a ‘to beat’ | [èrìhʊ́ːmà] | o-mʊ-hʊm-ɨ ‘beater’ | [ɔ̀mùhʊ́ːmì] |
| e. | e-ri-hek-a ‘to carry’ | [èrìhɛ́ːkà] | o-mʊ-hɐk-ɨ ‘porter’ | [ɔ̀mùhɛ́ːkì] |
| f. | e-ri-kar-a ‘to force’ | [èrìkɑ́ːrà] | o-mʊ-kɑr-ɨ ‘forcer’ | [ɔ̀mùkɑ́ːrì] |
| g. | e-ri-boh-a ‘to tie’ | [èrìbɔ́ːhà] | o-mʊ-bɒh-ɨ ‘tier’ | [ɔ̀múbɔ́ːhì] |

These cases, with violations of ATR/Hɪ in (65e–g), motivate the conjunctive constraint MaxPath[Hɪ/ATR] (61). MaxPath[Hɪ/ATR] requires that the optimal input vowel – high advanced – surface as such in the output, and Align-L outranks ATR/Hɪ, forcing the advancement of non-high vowels. The configuration is illustrated in (66) for [ɔ̀mùhɛ́ːkì] ‘porter’.

(66) *Harmonic effect on non-high vowels of* Align-L *and* Hɪ/ATR




[ɔ̀mùhɛ́ːkì]

The high vowel of the agentive suffix defines the right edge of the harmonic domain, while Align-L forces associations to the left.[30]

(67) *Affix-induced harmony*

| | MaxPath [Hɪ/ATR] | Align-L | Hɪ/ATR Rt | ATR/Hɪ | Hɪ/ATR St | ATR/Fr | Hɪ/ATR MSt |
|---|---|---|---|---|---|---|---|
| a. [[[mU-[[hEk]Rt -i +ATR]St]MSt]Wd | | *!** | | | | | * |
| ☞ b. [[[mu-[[heːk]Rt -i +ATR]St]MSt]Wd | | | | * | | * | |
| c. [[[mʊ-[[hɛːk]Rt -ɪ +ATR]St]MSt]Wd | *! | | | | * | | ** |

[30] One reviewer raised the concern that an advanced affix combined with an advanced root will create an Obligatory Contour Principle (OCP) violation. We adopt Suzuki’s (1998) model, in which the OCP is a family of constraints, ranked with respect to other constraints. For purposes of discussion, we simply assume this constraint is ranked low enough to not affect our analysis, but are not committed to this position.

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The floating feature of (67c) is well aligned to both word edges (see note 11), and so satisfies ALIGN-L. Since there are no high vowels in the root, HI/ATR$_{\text{Root}}$ is irrelevant. In the absence of MAXPATH[HI/ATR], ATR/HI would decide among candidates, for the root advanced vowel in (67b) violates this constraint. The elimination of (67c) is due to MAXPATH[HI/ATR]. This constraint requires the preservation of the association between [+ATR] and the suffix vowel.[31]

By contrast, were the input to contain a floating [+ATR], a retracted form would be predicted. Given a floating affixal [+ATR], MAXPATH [HI/ATR] is irrelevant. The decision then is made by the lower-ranked constraints. Thus, with affixes, a floating [+ATR] typically produces a retracted form, thereby patterning with the absence of any [±ATR] value and with [−ATR] (whether linked or free). Furthermore, a non-high advanced affix vowel is also exempt from MAXPATH[HI/ATR], and so classes with the retracted and unspecified affixes.

One class of morphemes is interesting in that it is underlyingly high and advanced, but can lose its [+high] specification under certain circumstances. While both roots and suffixes exhibit such behaviour, we focus on suffixes here. Consider the past tense marker *-ɟr-e* in the following examples (roots from (10) and (18)) (Hyman 1989).[32]

(68) *Past tense morphology*

| | | | |
|---|---|---|---|
| a. | mǫ-tw-ą-kɟ-liɱ-ɟr-e | [mɔ́twą́kílímí:rɛ̀] | 'we exterminated it' |
| b. | mǫ-tw-ą-kɟ-huʉk-ɟr-e | [mɔ́twą́kíhúkí:rɛ̀] | 'we cooked it' |
| c. | mǫ-tw-ą-kɟ-liɱ-ɟr-e | [mɔ́twə̀kílímì:rɛ̀] | 'we cultivated it' |
| d. | mǫ-tw-ą-kɟ-huɱ-ɟr-e | [mɔ́twə̀kíhúmì:rɛ̀] | 'we beat him/her' |
| e. | mǫ-tw-ą-kɟ-hɛ̨k-ɟr-e | [mɔ́twə̀kíhékì:rɛ̀] | 'we carried it' |
| f. | mǫ-tw-ą-kɟ-kąr-ɟr-e | [mɔ́twə̀kíkə́rì:rɛ̀] | 'we forced him/her' |
| g. | mǫ-tw-ą-kɟ-bǫh-ɟr-e | [mɔ́twą́kíbóhí:rɛ̀] | 'we tied it' |

These examples demonstrate the inherently advanced nature of the past tense suffix, straightforwardly analysed as involving a high vowel underlyingly specified as [+ATR].

Interestingly, the [i] of the tense suffix coalesces with a preceding vowel when it is either adjacent to such a vowel as a result of the morphology (a, b) or as a result of consonant deletion (c–f) (Mutaka 1995):

(69) *Vowel coalescence*

| | | | |
|---|---|---|---|
| a. | mo-tw-a-so-ɟr-e | [mɔ́twáswɛ̀:rɛ̀] | 'we ground' |
| b. | mo-tw-a-ha-ɟr-e | [mɔ́twàhɛ́:rɛ̀] | 'we gave' |
| c. | mo-tw-a-tsakur-ɟr-e | [mɔ́twətsəkwí:rɛ] | 'we voted' |
| d. | mo-tw-a-kohol-ɟr-e | [mɔ́twàkɔ̀hwɛ́:rɛ̀] | 'we coughed' |
| e. | mo-tw-a-senzer-ɟr-e | [mɔ́twásɛ́nzɛ̀:rɛ̀] | 'we slipped' |
| f. | mo-tw-a-suβal-ɟr-e | [mɔ́twásʊ́ßɛ̀:rɛ̀] | 'we urinated' |

[31] Thanks to an anonymous reviewer for bringing the problem to our attention.

[32] Thanks to Ngessimo Mutaka for helping us with the tones in these examples.

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As discussed in Mutaka (1995), a round vowel is retained as a glide (69a, c, d); a sequence of high vowels surfaces as a high vowel (with a round glide in appropriate cases – ʊ+i→wi (69c)); a sequence of non-high–high surfaces as a mid vowel (again, with a round vowel surviving as a glide where appropriate – ɛ+i→ɛ (69e); a+i→ɛ (69b, f); ɔ+i→wɛ (69a, d)). The crucial point to note with respect to tongue-root harmony is that the feature [+ATR] is retained if the output of coalescence is high (69c), but lost if the output of coalescence is non-high (69a–b, d–f).

This dependency on height is predicted by the analysis developed here. When the output of coalescence is high, MAXPATH[HI/ATR] forces the retention of the suffixal [+ATR] specification in a manner entirely comparable to the case of the agentive – see tableau (67). Of particular interest, when coalescence results in the lowering of a high vowel suffix, the ability to induce advancement is lost. Consider a tableau for [mɔ́twásʊ́βɛ̀ːrɛ̀] 'we urinated'. (We do not address the analysis of how to derive consonant deletion and vowel coalescence here, simply stipulating in the tableau that these results must hold, by the leftmost column.)

(70) *Coalescence producing non-high vowels*

| | DEL (C)/ COAL | MAX PATH [HI/ATR] | HI/ ATR Rt | ATR /HI | HI/ ATR St | ATR /FR | HI/ ATR MSt |
|---|---|---|---|---|---|---|---|
| [tU-A[[[sUβAl]$_{Rt}$ +ATR / ir-E]$_{St}$]$_{MSt}$]$_{Wd}$ | | | | | | | |
| a. [twə[[[suβəl]$_{Rt}$ +ATR iːrɛ]$_{St}$]$_{MSt}$]$_{Wd}$ | *! | | * | ** | | *** | |
| b. [twə[[[suβə]$_{Rt}$ +ATR iːrɛ]$_{St}$]$_{MSt}$]$_{Wd}$ | *! | | * | ** | | *** | |
| c. [twə[[[suβ]$_{Rt}$ +ATR eːrɛ]$_{St}$]$_{MSt}$]$_{Wd}$ | | | * | *!** | | ** | |
| d. [twə[[[suβ]$_{Rt}$ +ATR ɛːrɛ]$_{St}$]$_{MSt}$]$_{Wd}$ | | | * | *! | | ** | |
| ☞ e. [twa[[[sʊβ]$_{Rt}$ +ATR ɛːrɛ]$_{St}$]$_{MSt}$]$_{Wd}$ | | | * | | * | | * |

The first two candidates (70) are excluded because they have not undergone consonant deletion and vowel coalescence. Understanding the three remaining candidates depends crucially on two things. First MAXPATH [HI/ATR] is only violated if both conjuncts are violated. Since the result of coalescence is a non-high vowel, the second conjunct (HI/ATR) is vacuously satisfied, resulting in the conjunctive constraint being similarly satisfied for all of (70c–e). Second, $\text{HI/ATR}_{\text{Root}}$ is violated in all candidates because there is no root value of [+ATR] that can link to the root high vowel. That is, whether the suffix [+ATR] value is linked to the root high vowel or not, there is a violation of $\text{HI/ATR}_{\text{Root}}$. Because neither

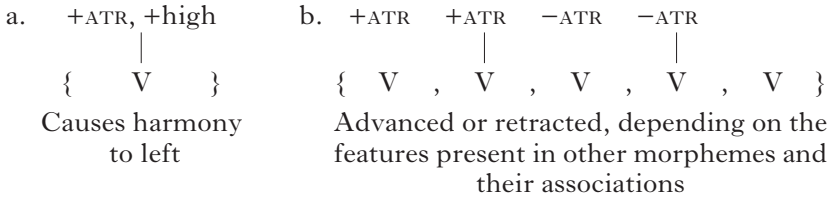
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MAXPATH[HI/ATR] nor HI/ATR$_{Root}$ serves any selective role, determination of the winner falls to ATR/HI – which selects the fully retracted candidate as optimal. (Linking of the suffixal value determines whether or not HI/ATR$_{Stem}$ is violated, but this plays no role in the selection of the optimal candidate.)

The type of case just examined underscores the fact that advancement in Kinande is integrally connected with the presence or absence of high vowels. To appear as advanced on the surface, it is not enough for a morpheme to be lexically specified as [+ATR]. It must also contain at least one high vowel, and for suffixes, that high vowel must be linked to the lexical [+ATR] specification.

The range of inputs and the output effects for suffixes is summarised below.

(71) *Affix types*




There are certain advantages to the representation-and-constraint analysis of affixes like the agentive and the past tense. First, no constraints refer to specific morphemes. That is, there is nothing morpheme-particular in the analysis beyond the standard encoding of a morpheme's individual phonological representation. Second, since this analysis involves a purely phonological constraint, there are no issues of affix faithfulness outranking root faithfulness. Third, the constraint MAXPATH[HI/ATR] emphasises the optimal nature of the enhancement relation between [high] and [ATR]. Fourth, the strategy of employing a faithfulness constraint locally conjoined with a grounded constraint restricts the types of required affix representations that we might expect to the least marked ones, since grounded constraints define unmarked configurations. Finally, as demonstrated above, the analysis satisfies the Richness of the Base requirement: given any imaginable input for root or affix (with respect to [ATR]), an attested output is selected.[33]

There are alternatives that we might consider to this analysis. However, they miss these important points. For example, we might propose a constraint that requires the agentive to be [+ATR]. Such a constraint is parochial, and so can enter the grammar only at significant cost. It also

[33] One imaginable affix type has not been observed. If a suffix had a floating [+ATR] then MAXPATH[HI/ATR] and HI/ATR$_{Root}$ would be irrelevant. The first relevant 'retention' constraint would be HI/ATR$_{Stem}$, but as it is dominated by ATR/HI the floating [+ATR] would be retained only if the suffix or root had a high vowel and there were no non-high vowels to the left of the high vowel.

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fails to draw any phonological connections between the [+ATR] assigned to the affix and the height of the affix vowel. Thus, the grammar would be equally valued should the agentive vowel be mid or low instead of high.

Another possibility would be to impose a high-ranked path-faithfulness constraint on affixes. (We have already demonstrated that MaxPath[atr] is in general a low-ranking constraint because of the behaviour of ATR introduced by root vowels.) However, such a constraint would predict the possibility of non-high affixes which also introduce [+ATR] harmony, but there are no such affixes. It would also run counter to the standard ranking of root faithfulness over affix faithfulness, for we do not want to predict the possibility of lexically advanced roots with non-high vowels.

The proposed Kinande [ATR] hierarchy is given in (72). As this section has demonstrated, the constraint hierarchy in (72) selects all and only the attested candidates regardless of the ATR specification – or non-specification – proposed for the input.

(72) *The Kinande* [ATR] *hierarchy*

Dep[atr]
≫ **Hi/ATR$_{Rt}$**, MaxPath[hi/atr], Align-L
≫ ATR/Hi
≫ **Hi/ATR$_{St}$**
≫ ATR/Fr
≫ **Hi/ATR$_{MSt}$**
≫ MaxPath[atr], DepPath[atr]
≫ **Hi/ATR**, Faith[atr], Link[atr]

## 6.3 Phrase-level harmony and [−ATR]

Before concluding our discussion of the degree of specification necessary in Kinande representations, a final phenomenon must be considered: there is a type of harmonic behaviour that affects a limited class of phrasal constituents. A word that is retracted in isolation surfaces as advanced when preceding an advanced word in a particular phrasal and phonological context.

The generalisations to be captured in these data can be summarised as follows. At the phrasal level, ATR harmony applies in a strictly right-to-left fashion, affecting both high and non-high vowels. For example, all vowels of [èmí:tì] 'trees' are retracted in isolation, but to the left of an advanced adjective, all vowels may surface as advanced, whether high or non-high: [èmítí míkù:hì] 'short trees' (73). This is not the complete picture, however. Phrase-level harmony is subject to a bridge condition: it applies only if the rightmost vowel of the targeted word is high (Schlindwein 1987). As a result of this condition, harmony is observed in [èmítí míkù:hì] 'short trees' since the noun ends in a high vowel, but

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does not appear in a form such as [èmìhámbá míkù:hì] 'short knives', where the noun ends in a non-high vowel. Finally, this harmony does not apply from left to right: the advanced vowels of [èkíkà:lì] 'woman' have no effect on the retracted vowels of [kí:rì] 'tall': [èkíkàlì kí:rì] 'tall woman'.

This phrasal harmony has been treated as phonological in earlier analyses (Schlindwein 1987, Mutaka 1995, Archangeli & Pulleyblank 1994). However, recent discussion of such phrase-level harmony by Ngessimo Mutaka (personal communication) suggests that this harmony is phonetic, not phonological. Two properties of phrasal harmony lead to this conclusion. First phrasal harmony affects the same string in different ways. Mutaka (1995) observes that the extent of harmony in cases like (73) is variable – it optionally affects any contiguous string of vowels adjacent to the harmonic source.

(73) *Variability in phrase-level harmony*

| | | |
|---|---|---|
| a. emiti mɟkʊhɟ | [èmítí míkù:hì] | 'short trees' |
| b. emitɟ mɟkʊhɟ | [èmítí míkù:hì] | |
| c. emɟtɟ mɟkʊhɟ | [èmítí míkù:hì] | |
| d. ɕmɟtɟ mɟkʊhɟ | [èmítí míkù:hì] | |

Second, Mutaka (1995, personal communication) observes that gradience is found in the degree to which a vowel is advanced: 'if only *ti* of *emiti mɟ-kʊhɟ* becomes [+ATR], its ATR is not very prominent. When the *mi* of *emiti* is [+ATR], the ATRness of *ti* becomes as clear as the one of *mɟ-kʊhɟ*. Similarly, if the initial vowel of *emiti* is [+ATR], the ATRness of *miti* is similar to the one in *mɟ-kʊhɟ*'. The impressionistic evidence is that phrasal ATR harmony is gradient both in how far it goes in a word and in how strongly each vowel is affected. Since gradient effects are generally interpreted as a diagnostic for a phonetic property, while categorical effects indicate phonological status, we tentatively conclude that phrasal harmony falls into the realm of phonetic analysis, and do not attempt to extend the constraint-based phonological account to such cases.

Keating (1988) argues that such gradience is the result of the phonetic interpretation of interpolating phonological specifications over strings that lack specifications. Vowels unspecified for tongue-root position are generally realised as retracted. However, anticipatory tongue-root advancement is possible under certain conditions (both phonological and syntactic in this case). See also Pierrehumbert & Beckman (1988) and Archangeli & Pulleyblank (1994). The facts presented in this section, then, support our decision to represent the surface retracted vowels as phonologically unspecified for tongue-root position.

Under the assumption that the constraint hierarchy selects an optimal phonological form that serves as input to phonetic interpretation, Kinande phrasal harmony would not constitute part of the formal constraint system. However, if the Keating/Pierrehumbert & Beckman approach to an account of gradience is assumed, then at some point any

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potential instances of [−ATR] must be eliminated from the representation. Formally, the absence of [−ATR] in outputs can be accomplished by a high-ranked constraint forbidding [−ATR]. This would outrank faithfulness to [−ATR], effectively eliminating candidates that include a [−ATR] specification regardless of the nature of the input.

### 6.4 Summary

To conclude this section, we have argued that the full range of word-level harmonic effects involve the interaction of a condition favouring the left-edge alignment of [+ATR] (ALIGN-L) with pressure to advance high vowels (HI/ATR). The strength of the tendency for high vowels to be advanced, where such advancement is not required by alignment, varies according to the morphological domain:

(i) within the root, the tendency to advance high vowels overrides all other considerations ($\text{HI/ATR}_{\text{Root}}$);

(ii) within the stem, the advancement of high vowels takes place to the extent that non-high advanced vowels are not created ($\text{ATR/HI} \gg \text{HI/ATR}_{\text{Stem}}$);

(iii) within the macro-stem, the advancement of high vowels takes place provided that the vowels affected are neither non-high nor back ($\text{ATR/HI} \gg \text{ATR/FR} \gg \text{HI/ATR}_{\text{Macro-stem}}$).

Harmony results from the formal imposition of alignment and the substantive imposition of grounded featural relations, in part restricted by morphosyntactic domains.

## 7 Conclusion and implications

The optimality-theoretic analysis of Kinande vowel harmony proposed here argues that harmony systems are driven not only by alignment or some other harmony driver, but also by grounded conditions, in particular the preference to formally combine features that are phonetically sympathetic and enhancing. The Kinande data are rich enough that we also find evidence that one of the grounded constraints, HI/ATR, is restricted to specific morphosyntactic domains; other, unrestricted, grounded constraints intervene between the domain-restricted instances of HI/ATR. The implications of these domain restrictions are both empirical and theoretical. Empirically, we see that smaller domains impose domain-differentiated conditions more stringently (Mohanan 1993). Positional faithfulness to morphological categories (Beckman 1998) is one subcase of this general type. Theoretically, the domain restrictions provide a means of characterising the astounding similarity among the phonological systems holding at different morphosyntactic domains, as well as allowing expression of the relatively minor – yet far-reaching – differences among the phonologies of those domains.

Exploring these implications illuminates a broad issue that emerges from the account of Kinande just presented, that of formally encoding

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the interplay of phonology and morphology in grammar. Our understanding of this interplay can be expressed in (74), the Domain Qualification Hypothesis.

(74) *The Domain Qualification Hypothesis*

The role of morphology in phonology is to qualify the domain of relevance for specific constraints.

Under this view, the extent of the interplay between morphology and phonology is the assignment of morphological domains to elements in constraints to determine the range of the constraints' applicability.

At first reading, the Domain Qualification Hypothesis (74) might appear to be a throw-back to derivational models. After all, derivational theories tend to make few claims about the manner in which rules and rule components may interact, and the claims made tend to be entirely extrinsic. For example, within a derivational theory, there is no particular reason why cross-linguistically valid phonological generalisations should tend to hold more strongly of smaller domains than of larger domains, yet they do (Mohanan 1993). Consider a rule of spreading. The rule could in principle be assigned to the root domain, the stem domain, the macro-stem domain – there is no particular reason for assigning it preferentially to one domain or the other.[34]

However, this is not the case with Optimality Theory. Optimality Theory explicitly adopts the hypothesis that families of related constraints will be consistently ranked in particular ways with respect to each other. The member constraints of such families will be HARMONICALLY ORDERED (Prince & Smolensky 1993). For example, Prince & Smolensky show that sonority effects observed in syllabification, etc., can be achieved through the grammaticisation of a harmonic sonority scale. Sonority effects then derive from the ranking of a family of constraints that together govern sonority. Returning to Mohanan's observation concerning domain size, for a set of domain-restricted constraints to be harmonically ordered, a constraint restricted to a smaller domain should be ranked above a constraint restricted to a larger domain.[35]

(75) *Harmonic Domain Ranking*

Sets of constraints differentiated solely by domain are harmonically ranked from smaller to larger domain, smaller domains ranked higher than larger domains.

Of particular interest in this regard are the morphosyntactic restrictions of root, stem and macro-stem as applied to constraints in Kinande.

[34] Note, however, the discussion of this issue within the framework of Lexical Phonology, for example, Kiparsky (1982, 1985) and Mohanan (1986).

[35] As pointed out in note 24, the significance of the Domain Ranking Hypothesis for the model presented here does not extend to the model of morphological domain restrictions advanced in Bickmore (2000), precisely because the Bickmore (2000) model does not treat smaller domains as truly included in larger domains.

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Extracting the constraints that are restricted to these domains from the Kinande grammar given in (72), the following ranking is obtained for the HI/ATR family.

(76) $\text{HI/ATR}_{\text{Root}} \ldots \gg \ldots \text{HI/ATR}_{\text{Stem}} \ldots \gg \ldots \text{HI/ATR}_{\text{Macro-stem}}$

This is exactly the type of ranking expected by the incorporation of domain restrictions into a harmonic scale: HI/ATR holds most strongly of the smallest domain (root) and least strongly of the largest domain (macro-stem).

An important result of attaching domain restrictions to grounded conditions is that the ranking provided by Harmonic Domain Ranking (75) is, in fact, the only ranking with an empirical effect (Pāṇini's Theorem; Prince & Smolensky 1993). With morphology organised such that smaller domains are contained within larger domains, a condition holding over a larger domain, $C_{\text{LargeDomain}}$, also holds of the smaller domain. Thus, a condition holding of the smaller domain, $C_{\text{SmallDomain}}$, has an empirical effect only when it outranks $C_{\text{LargeDomain}}$. Where $C_{\text{LargeDomain}}$ dominates or $C_{\text{LargeDomain}}$ and $C_{\text{SmallDomain}}$ are unranked with respect to each other, the effect of $C_{\text{SmallDomain}}$ is obscured.

To summarise, we propose that constraints actually constitute families of domain-restricted constraints, by the Domain Qualification Hypothesis (74). Pāṇini's Theorem, in conjunction with the Domain Qualification Hypothesis, predicts Harmonic Domain Ranking, that these families will be ranked with the smaller domains outranking the larger domains. Interestingly, this derives Mohanan's (1993) observation, without overtly stipulating that such sets of constraints are harmonically ordered from smaller to larger.

Let us now turn to consider an alternative model of morphophonological interaction under Optimality Theory, wherein different constraint rankings hold over different morphological domains, 'mini-grammars'.

Prominent in the set of proposals for mini-grammars are Lexical Phonology (Kiparsky 1982, 1985, Mohanan 1986, etc.) and co-phonologies (Inkelas 1998, Inkelas & Orgun 1998). In McCarthy & Prince (1993a), an analysis of Axininca Campa is presented where it is suggested that Optimality Theory can be built into a theory of Lexical Phonology. Sets of ranked constraints can be established for different lexical or postlexical strata; the relative rankings of constraints can differ from stratum to stratum (see also Kiparsky 1998). Within such a theory, rather than assign domains such as 'root', 'stem', 'macro-stem' and 'word' to the alignment and grounding of [+ATR], one would (or at least, could) posit multiple strata each with its unique ranking of the alignment and grounding conditions. The co-phonology approach differs primarily in the approach to morphology. While canonical Lexical Phonology assumes that morphemes are organised in ordered blocks, co-phonologies are not structured in such ordered sets. Morphemes are indexed for a particular co-phonology, each co-phonology defining a distinct constraint ranking.

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| *domain* | *ranking* |
|---|---|
| *Root* | DEP [ATR] ⩾ HI/ ATR ⩾ ATR/ HI ⩾ ATR/ FR ⩾ DEPPATH [ATR] |
| *Stem* | DEP [ATR] ⩾ ATR/ HI ⩾ HI/ ATR ⩾ ATR/ FR ⩾ DEPPATH [ATR] |
| *Macro -stem* | DEP [ATR] ⩾ ATR/ HI ⩾ ATR/ FR ⩾ HI/ ATR ⩾ DEPPATH [ATR] |
| *Word* | DEP [ATR] ⩾ ATR/ HI ⩾ ATR/ FR ⩾ DEPPATH [ATR] ⩾ HI/ ATR |

*Table I*
Overlap in constraint rankings across domains.

We reject such approaches to Kinande on several grounds. First, were each lexical domain represented phonologically with a separate constraint hierarchy rather than placing domain restrictions on specific conditions, the considerable overlap in constraint ranking among these hierarchies would be unexplained.[36]

The rampant similarity among levels cannot be explained by insisting that conditions remain in the same relative order within all hierarchies of a language: in Kinande, the relative ranking of HI/ATR depends on the morphological domain, and so does not remain constant across domains.

The overlap in Table I also bears on the proposal in Itô & Mester (1995, 1999) that lexicon stratification results from interspersing indexed faithfulness constraints among a fixed set of markedness constraints. Counter to such a proposal, in Kinande it is a markedness constraint that must vary in its ranking.

Under the mini-grammars view, morphological domains play two completely distinct roles in the phonology: (i) defining each mini-grammar and (ii) in alignment constraints, defining morphological edges for alignment purposes. By contrast, under the Domain Qualification Hypothesis, morphological domains play a single role in the phonology. Morphological domains may restrict the effective range of relevance for specific constraints; they may determine the range of prosodic constituents. In both types of cases, morphological domains are referenced by certain phonological constraints, and this is their sole role in the phonology.

[36] Not all of the rankings shown here are crucial. For example, at the word level, since ALIGN-L dominates both ATR/HI and ATR/FR, the relative ranking of ATR/HI and ATR/FR is not crucial. The point being illustrated in Table I is that there are no crucial differences in ranking except those involving HI/ATR.

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As a final point, the mini-grammars approach fails to capture the generalisation expressed by Harmonic Domain Ranking (75), namely that phonological generalisations tend to hold more strongly of smaller domains. Under the mini-grammars view, this would simply be a stipulation imposed on the multiple grammars of one language.

Our conclusion is that the morphology–phonology interface is better expressed by the Domain Qualification Hypothesis (74), the qualification of otherwise primitive constraints by morphological domain specifications, rather than by mini-grammars, relying on multiple rankings of the same set of constraints within a single grammar.

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