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A PfP Approach to Vowel Height Harmony and ATR Harmony

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ABSTRACT. In Standard Element Theory vowel height harmony (HH) and ATR harmony (ATRH) in Bantu languages are treated in contrasting ways: HH operates from left to right and involves spreading of |A|, whereas ATRH operates in both directions is brought about through headedness agreement. To arrive at a unified approach to these two kinds of vowel harmony, this paper employs the Precedence-free Phonology (PfP) model of phonological representation. In this model, the same property |A| is involved in both HH and ATRH. When |A| is specified at an embedded level of structure, it has a greater phonetic prominence and contributes to the manifestation of vowel height. On the other hand, when |A| is specified at the topmost level of a more complex recursive structure—it is shared by a wider domain, its phonetic effects are weaker, and it contributes only ATR-ness (regarded as a variant of height harmony since ATR vowels are slightly higher than non-ATR vowels).*

Keywords: Vowel height harmony, ATR harmony, Precedence-free Phonology, hierarchical structure, elements

1. Introduction

Bantu languages contrast height harmony (HH) and ATR harmony (ATRH), which apply in different domains and differ in directionality. The more prevalent HH (e.g. in 5-vowel systems including Chichewa, Bemba) is more restricted: in most cases it applies from left to right, it is triggered by a verb root and targets following suffixes, and it manipulates height {i→e; u→o}. ATRH (e.g. in Kinande, Budu) applies in a wider domain, affecting both prefixes and suffixes, and can be triggered by a verb root, a prefix or a suffix to affect the whole word, thus involving both anticipatory and preservatory agreement. ATRH manipulates frontness

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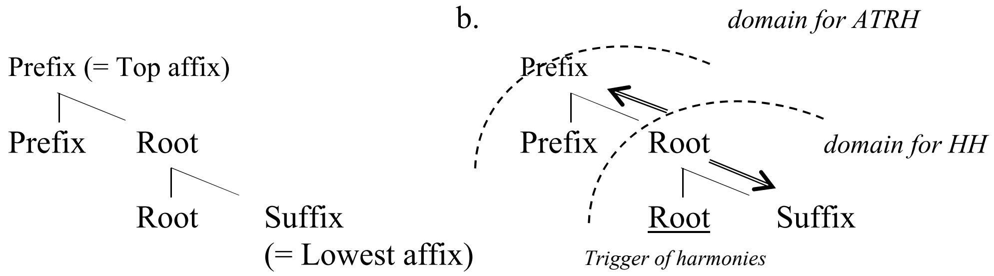
{i→ɪ; u→ʊ}. In addition, there are 7-vowel languages (e.g. Kimatuumbi, Kinyamwezi) where HH is accompanied by a restricted form of ATRH. HH applies in the domain [ROOT-SUFFIXES] while ATRH operates in the domain [PREFIXES-ROOT-SUFFIXES] of the Bantu verb.

To account for this contrast in domain and harmony pattern we adopt a minimalist view of morpho-syntax to derive the structure in (1a). Here the topmost layer is occupied by prefixes rather than by the root, the operation Merge being the sole means of deriving computation.

(1) [PREFIXES [[ROOT] -SUFFIXES]]

a.



Following Precedence Free Phonology (PfP: Nasukawa and Backley 2015, 2017, 2019; Nasukawa 2016, 2017ab, 2020), we assume that the source property for both types of VH is usually present in the root, although exceptions do exist. If a domain is formed at the level containing the root head, its structural dependent, the suffix, receives the source property from its head. On the other hand, if the source of the root must be shared in a wider domain, the property manifests itself not only in the suffix but also in the prefix (the head of the root-headed set). As a result, the former produces rightward harmony while the latter produces both rightward and leftward harmony at the phonetic (surface) level. This matches the minimalist view that no precedence relations between constituents are formally encoded in morpho-syntactic structure.

With respect to vowel height and ATR-ness in the two types of harmony, the difference is attributed to the degree of phonetic modulation of the active source property. In both types, we claim the same property |A| (base element) is involved, and when it is specified in the narrower domain (at an embedded level) it has a greater phonetic salience and contributes to the phonetic manifestation of vowels in terms of height. On the other hand, when |A| is shared by a wider domain—that is, when it is specified at the topmost level of a more complex recursive structure—its phonetic effects are weaker and it contributes only ATR-ness. Expressed in Element Theory terms, the contrast is between |A.I| for [e] below the root and |A.A.I| for [ɪ] above the root.

This paper is organized as follows. First, section 2 briefly reviews HH and ATRH in Bantu languages and describes how each has been differently analysed in standard Element Theory. Then section 3 introduces the PfP model and presents a unified approach to the two harmonizing processes. Finally, section 4 provides a short summary.

2. Vowel Height harmony and ATR harmony in Bantu languages

2.1 Vowel Height harmony

This section explains both HH and ATRH. First, an example of HH comes from Bemba, spoken primarily in central and north Zambia, which has the 5-vowel system shown in (2) with element-based representations.

(2) Vowels in Bemba

i |I|		u |U|
e |I A|		o |U A|
	a |A|	

In this language, the verb root does not form an interpretable unit and cannot be employed independently of the final vowel (FV). Bound morphemes attached to the verb root are usually suffixes.

In Bemba, HH is unbounded, and all vowels to the right of the target are affected, except for the Final Vowel (FV). Also, HH is asymmetric, so front mid vowels only target high front vowels and not high back vowels, as shown below.

(3) Bemba asymmetric unbounded HH (Kula 2002)
Suffixes (Kula 2002: 107, van Sambeek 1972)
-uk- SEPARATIVE INTRANS, *-il-* APPLICATIVE, *-a* FINAL VOWEL (FV)

a.	pen-uk-il-a	→	pen-uk-il-a	‘fall back on’
b.	lep-uk-il-a	→	lep-uk-il-a	‘become torn on’
c.	sok-uk-il-a	→	sok-ok-el-a	‘become unstuck on’
d.	kont-uk-il-a	→	kont-ok-el-a	‘become broken on’

Because HH is unbounded, vowel height agreement applies in (3cd) but not in (3ab).

There are several different analyses of the process in question. In a classic analysis in standard Element Theory, for example, the harmonizing property is |A|, which is called the ‘mAss’ element, and the root vowel contains the harmonizing element, which spreads to the target suffix vowels.

(4) A classic Element-based analysis of HH in Bemba

sok-uk-il-a	→	sok-ok-el-a
U U I		U U I
A →		A A A

As depicted above, the source element |A| in the root is assumed to spread to the suffixes except for the FV. That is, the process applies from left to right and is triggered by a verb root.

The second example of HH is from Kinyamwezi (F22, Maganga and Schadeberg 1992), which has a 7-vowel system consisting of tense and lax high vowels, lax mid vowels, and /a/. The system is shown in (5) with classic Element-based representations.

(5) Vowels in Kinyamwezi

Phonetically			Structurally
tense	i $|\underline{\text{I}}|$	u $|\underline{\text{U}}|$	*headed*
lax	ɪ |I|	ʊ |U|	*non-headed*
lax	ɛ |I A|	ɔ |U A|	*non-headed*
tense	a $|\underline{\text{A}}|$		*headed*

The underlined elements are structurally headed and phonetically interpreted as *tense*, while the elements without underlining are non-headed and phonetically interpreted as *lax*. It may be suggested that in this case there could be a reduced ATR system in operation.

With respect to HH in Kinyamwezi, suffixes have lax vowels underlyingly and only show HH with the mid vowels, where -*ɪl*- of the applicative becomes -*ɛl*-. As a result, it can be said that the direction of the process is from left to right.

(6) Kinyamwezi (F22) HH with applicative -*ɪl*- (Odden 2015, Kula in press)

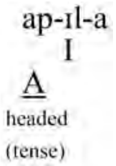
a. ap-íl-a ‘collect money for’
b. ʃik-ɪl-a ‘arrive for’
c. zug-íl-a ‘cook for’
d. βɪt-íl-a ‘pass for’
e. gʊl-ɪl-a ‘buy for’
f. lɛk-ɛl-a ‘let for’
g. βɔn-ɛ́l-a ‘see for’

As shown in (6), only lax vowels are subject to HH triggered by lax mid vowels—compare (6fg) with the other examples. That is, HH agreement must involve both mid and lax vowels targeting and yielding lax vowels. It could be said that −ATR is phonologically active if laxness of the triggering vowels is interpreted as −ATR.

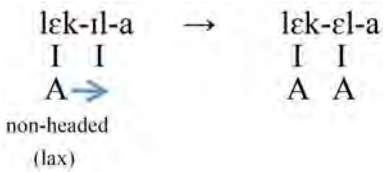
In a standard Element Theory, the analysis, like that of Bemba, involves the spread of |A| from lax mid vowels, as illustrated in (7b).

(7) A classic Element-based analysis of HH in Kinyamwezi

a. No agreement



b. |A|-agreement



What the analysis does not immediately capture is the fact that agreement is restricted to lax vowels. This could be captured with headedness, where headed representations are tense (+ATR) while non-headed ones are lax (−ATR). In this way |A| spreads from a non-headed expression to another non-headed expression (lax). Although there is no overt property such as non-headedness, this analysis (non-headedness agreement) needs to recognize such a property.

2.2 ATR harmony

In this section we turn to ATRH in Kinande (DJ42). This language has the following 10 vowel system (Archangeli and Pulleyblank 2002) presented here with element representations. In element terms, +ATR vowels contain headed elements whereas –ATR vowels do not.

(8) Vowels in Kinande

+ATR vowels		–ATR vowels	
headed		*non-headed*	
i |I|	u |U|	ɪ |I|	ʊ |U|
e |I A|	o |U A|	ɛ |I A|	ɔ |U A|
ə |A|		a |A|	

In this language, the initial prefix vowel /e-/ undergoes ATRH. It is [+ATR] when it occurs with [+ATR] vowels in the root: (9a) *e-ri-yir-a* ‘to dislike’, but is [–ATR] when it occurs with [–ATR] vowels in the root: (9h) ɛ-rɪ-yɪr-a ‘to have’. As will be shown below, this harmony process applies in a wider domain and affects both prefixes and suffixes; also, it can be triggered by a verb root, a prefix or a suffix to affect the whole word and thus involves both anticipatory and preservatory agreement.

(9) ATR harmony in Kinande (Mutaka 1995: 48, Kula in press)

Morphologically, the breakdown of the verb is that *ɛ-* is the augment, *-rɪ-* is the infinitive marker, both with underlying [–ATR] vowels, which are then followed by the verb root and suffixes if present and the default FV *-a*. The causative *-is-i-* is underlyingly [+ATR].

a.	yir-	‘dislike’	e-ri-yi̲r-a	‘to dislike’
b.	yir-	‘dislike’	e-ri-yi̲r-a	‘to dislike’
c.	hum-	‘move’	e-ri-hu̲m-a	‘to move’
d.	hʊm-	‘roar’	e-ri-hum-is-i̲-a	‘to make roar’
e.	sɛk-	‘laugh’	e-ri-sek-i̲-a	‘to make laugh’
f.	sɔk-	‘cross’	e-ri-sok-i̲-a	‘to make cross’
g.	sak-	‘leave’	e-ri-sak-i̲-a	‘to leave out something’
h.	yɪr-	‘have’	ɛ-rɪ-yɪr-a	‘to have’

In an ET-based analysis, ATRH is treated as not involving any spread of elements. In this sense, it is categorically different from HH. Rather, ATRH involves a change in headship: +ATR and –ATR mid vowels have the same elements but one structure contains a head while the other does not, e.g. [+ATR] /e/ = |I̲ A| versus [–ATR] /ɛ/ = |I A|. On this basis, ATRH is regarded as headedness agreement, as illustrated below.

(10) An Element-based analysis of ATRH in Kinande

a. +ATR agreement

e-ri-yir-a
$\boxed{\underline{I}\ \ \underline{I}\ \ \underline{I}}$
A
headed

b. –ATR-agreement

ɛ-rɪ-yɪr-a
$\boxed{I\ \ I\ \ I}$
A
non-headed

2.3 Issues with the standard ET-based analyses

There are at least four issues arising from the ET-based analyses described above. These are listed below.

(11) Issues concerning the ET-based analyses of HH and ATRH in Bantu languages

a. First, we should question why HH and ATRH involve different mechanisms: HH uses the spreading of a phonological element whereas ATRH is based on headedness agreement.

b. Second, in HH it is not clear how a mechanism involving lax vowels can take place if there is no "lax" element.

c. Third, we need to explain how headedness agreement applies, and also at what level in the hierarchy this takes place.

d. Fourth, there is the question of the difference in directionality between HH and ATRH: HH applies only from left to right whereas ATRH applies in both directions.

Although it may be possible to tackle each of these issues individually using various different approaches, it would be preferable to develop an analysis that unifies and shows the relation between the two types of harmony. To achieve this, the following section introduces an analysis of the two harmony patterns within the context of Precedence-free Phonology (PfP). It will be shown that this approach avoids the need to address the issues listed in (11).

3. A unified approach to HH and ATRH without referring to precedence

3.1 Precedence-free Phonology

Precedence-free Phonology (PfP) is a model of representation in which the only melodic units are those with a dual function: they are melodic properties and they also function as organizing units at higher levels. In this approach, a 'nucleus' is represented by one of the three resonance elements |A| ('mAss'), |I| ('dIp') or |U| ('rUmp'); the choice of element is parametric, based on the phonetic quality of a language's baseline resonance. For example, English chooses |A| (phonetically realised as [ə] in its acoustically weak form) as its baseline element, Fijian chooses |I| (realised as [ɨ] in its acoustically weak form) and Japanese chooses |U| (realized as [ɯ] in its acoustically weak form). They function as the foundation of structure-building in each language.

The baseline element may then take one or more dependent elements to construct complex structures which are phonetically realized as full vowels. In PfP, basic vowels are represented as follows.

(12) The PfP representations of basic vowels

a. [ə]
|A|

b. [i]
|A|
|A| |I|

c. [u]
|A|
|A| |U|

d. [ɑ]
|A|
|A| |A|

The representation in (12a) shows a baseline element |A| with no dependent elements (for languages such as English and German). This structure is phonetically realized as the unrounded central vowel [ə], which typically appears in weak and neutralising contexts. However, when the baseline |A| takes |I|, |U| or |A| as a dependent, the acoustic pattern of the baseline is overridden by this dependent element. Therefore, the structures are phonetically realized as [i], [u] and [ɑ] respectively, as illustrated in (12b), (12c) and (12d). What these structures show is that when head-dependent structure is externalised, the relative salience of dependents is reflected directly in the overall phonetic exponence. This is defined by the following principle of phonetic realisation.

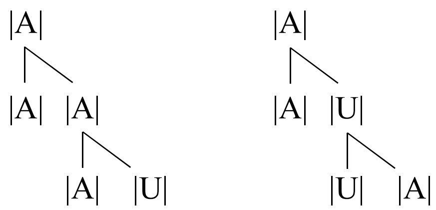
(13) The principle of phonetic realisation of head-dependent structure (Nasukawa 2016, 2017ab; Nasukawa and Backley 2015, 2017)
Dependents, which are not necessary for structural well-formedness, are phonetically more salient in terms of their modulated carrier signal than heads, which are important for building structure.

In this externalising process, the relative salience of (dependent) elements corresponds to their relatively large modulations of the carrier signal when they manifest themselves phonetically. The size of carrier signal modulations then corresponds to the degree of deviation from the carrier signal in terms of acoustic attributes such as periodicity, amplitude, spectral shape, fundamental frequency and duration/timing.

In PfP, more complex vowel structure is expressed by employing further levels of embedded structure. For instance, the mid vowels [o] and [ɒ] in English have compound expressions in which their constituent elements |A| and |U| enter into head-dependent relations. The compound structure of |A|+|U| phonetically manifests itself as [o] when |U| is a dependent (14a) and as a more open [ɒ] when |A| is a dependent (14b).

(14) Vowels with compound structures

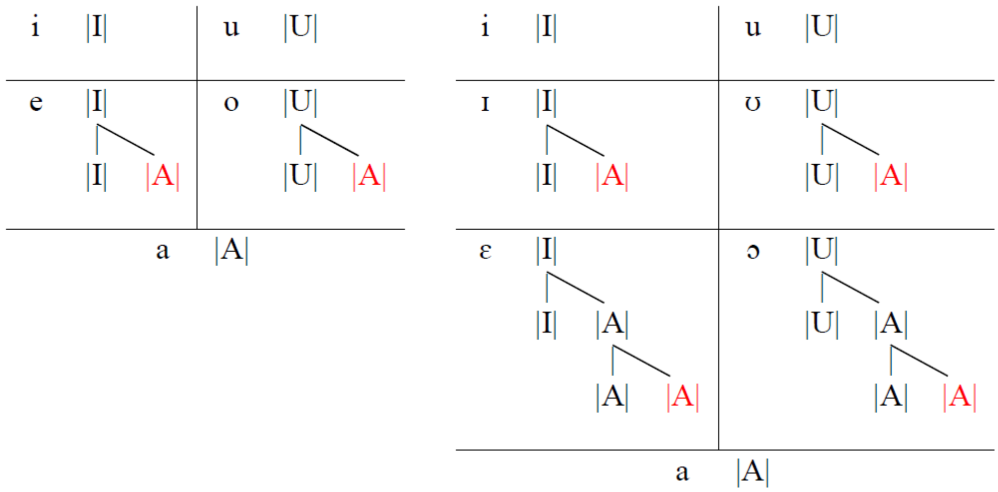
a. [o] b. [ɒ]



Using PfP-based melodic structures of the kind just described, the vowels of Bemba and Kinyamwezi can be represented as follows.

(15) Vowel structures in Bemba and Kinyamwezi

a. Bemba b. Kinyamwezi

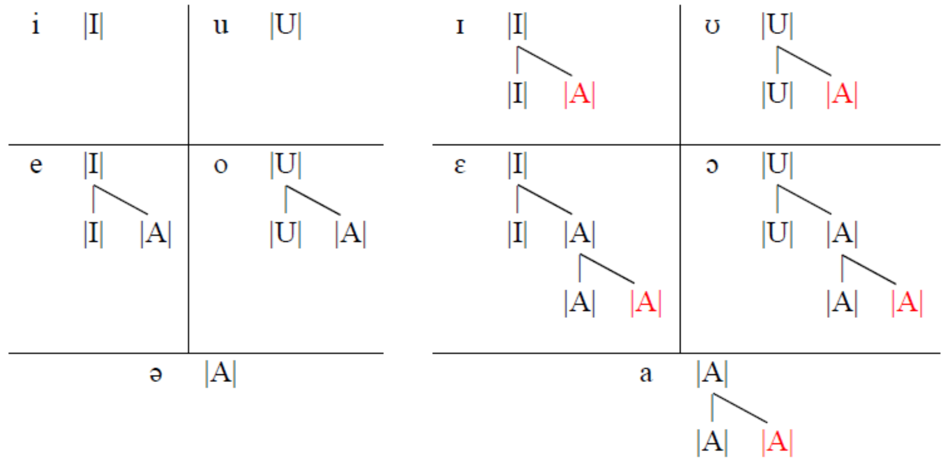


In Bemba's 5-vowel system, there are only two mid vowels /e/ and /o/, both of which contain |A| as a dependent element. On the other hand, Kinyamwezi also has only two mid vowels /ɛ/ and /ɔ/, both of which are lax and contain two |A|s. And unlike Bemba, Kinyamwezi has high vowels which are contrastive in terms of tense versus lax: tense vowels are structurally simplex while lax vowels, which contain |A|, are structurally complex.

Next, in the case of Kinande, as discussed in section 2.2, it shows an ATR distinction in vowels, with +ATR vowels being structurally identical to the 5 vowels in Bemba in (15a), as given below.

(16) Vocalic structures in Kinande

a. +ATR b. −ATR

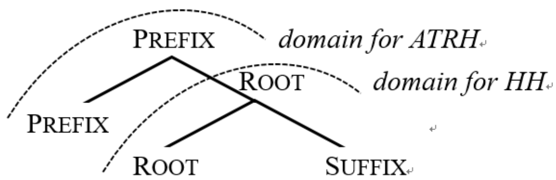


On the other hand, −ATR vowels are more complex than +ATR vowels. As shown in (16b), the structure of a −ATR vowel consists of a +ATR vowel with an additional |A|.

3.2 Analysing HH and ATRH

Before analyzing the two harmony patterns in a unified way, let us first identify the two domains of vowel harmony. To account for the differences in domain and harmony pattern we adopt a minimalist view of morpho-syntax to derive the structure in (17), where the topmost layer is occupied by prefixes rather than by the root (derived from the operation Merge as the sole means of deriving computation).

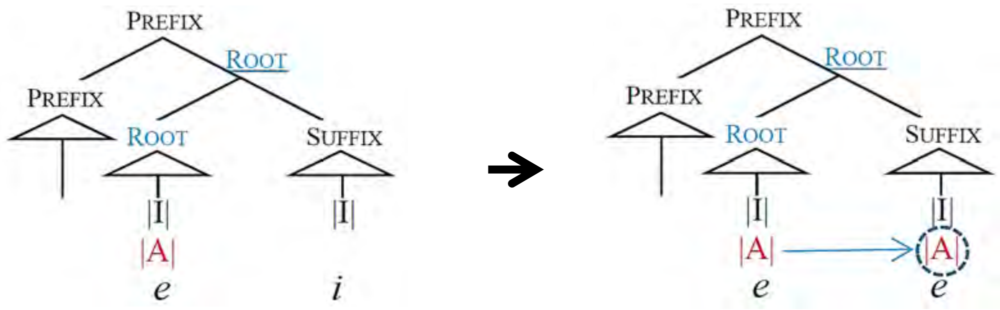
(17) A minimalist view of morpho-syntax



We now start to analyse the harmony processes. First, in the case of HH the source property |A| for HH is usually present in the root, although exceptions do exist. If a domain is formed at the level containing the root head, the suffix (its structural dependent) receives the source property from its head. This is depicted below.

(18) HH in PfP

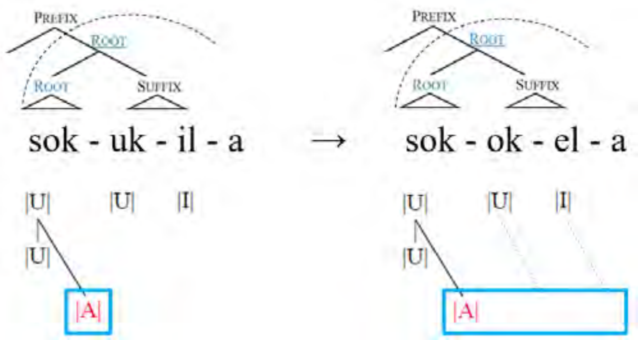
a. Lexical b. Derived



Actual examples from Bemba are given below.

(19) HH in Bemba

a. Lexical form b. Derived form

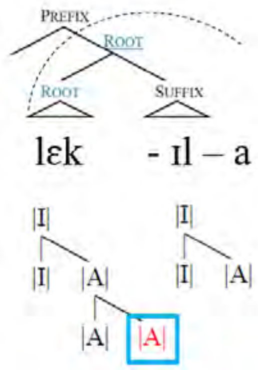


Dependent |A|, the source property, is present in the root. Since a domain is formed at the level containing the root head, its structural dependent, the suffix, receives the source property from its head. This produces (what appears as) rightward harmony.

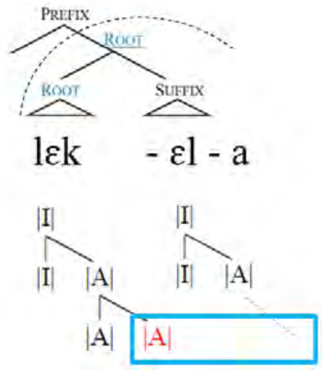
Although the number and type of vowels and the condition triggering the process are different, Kinyamwezi is similar to Bemba in that it also displays a HH effect. This is shown in (20), where dependent |A| must be phonetically interpreted in affixes which have another dependent |A| within the ROOT.

(20) HH in Kinyamwezi

a. +ATR



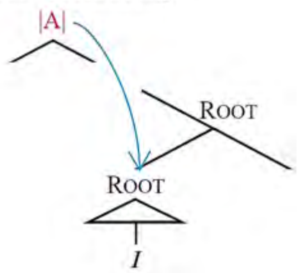
b. –ATR



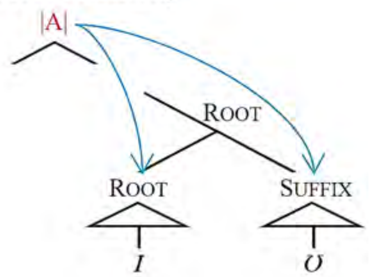
On the other hand, if the harmonizing source is shared in a wider domain, the property manifests itself not only in the suffix but also in the prefix (the head of the root-headed set). As a result, this produces both rightward and leftward harmony at the phonetic (surface) level although no precedence relations between constituents are formally encoded.

(21) |A|: a prosodic property of a given domain

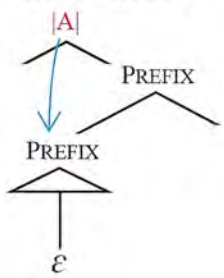
a. –ATR Harmony



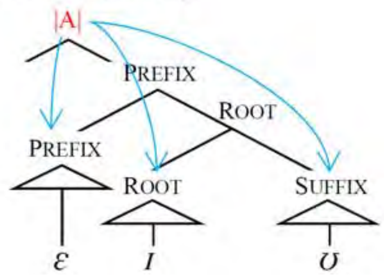
b. –ATR Harmony



c. –ATR Harmony



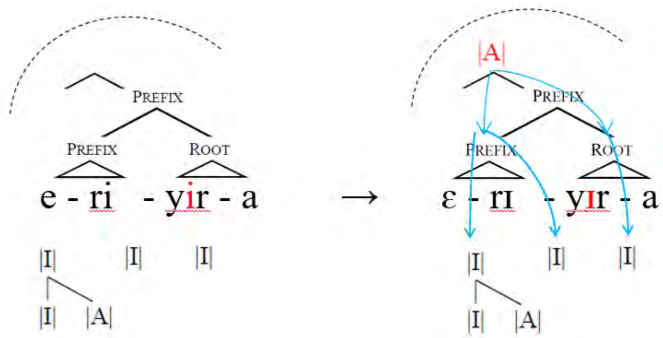
d. –ATR Harmony



As all of these examples indicate, whether it is a stem or an affix, a morpheme which contains ATR vowels is considered to have (the 'mAss' element) |A| at the topmost structural level in Bantu languages such as Kinande. In this configuration, |A|, which is the source of [−ATR], might be recognized as a morphome by itself. Actual examples from Kinande are now given in (22), where the topmost property in the domain is phonetically interpreted simultaneously with the elements present at the segmental level.

(22) |A|: a prosodic property of a given domain

a. +ATR b. −ATR



This could be regarded as a percolation-like process of phonetic externalization.

Thus, HH once again produces (what appears phonetically as) rightward harmony while ATRH produces both rightward and leftward agreement. As we have demonstrated, in both harmony types the same property |A| is involved.

We now turn to the question of how |A| ('mAss' element) can be interpreted on the one hand as openness, and on the other hand as [−ATR]ness. We attribute the difference to the degree of phonetic modulation of the active source property in each harmonic process. According to the principle of phonetic realisation of head-dependency in (13), dependents, which are not necessary for structural well-formedness, are phonetically more salient in terms of their modulated carrier signal than heads, which are important for building structure (Nasukawa 2017b, 2020).

Given this, when |A| is specified in the narrower domain (at an embedded level), it has a greater phonetic salience and contributes to the phonetic manifestation of vowels in terms of height. On the other hand, when |A| is shared by a wider domain—that is, when it is specified at the topmost level of a more complex recursive structure—its phonetic effects are weaker and it contributes only ATR-ness, which is considered here to be a variant of height harmony: vowels with ATR-ness are slightly higher than vowels with no ATR-ness.

4. Summary

This paper has used the PfP model to provide a unified approach to the two opposing vowel harmonies in Bantu languages—HH and ATRH. The former operates predominantly from left to right, is triggered by a verb root, and targets suffixes. On the other hand, the latter operates in a wider domain to affect both prefixes and suffixes; it can be triggered by a verb root, a prefix or a suffix to affect the whole word and thus involves both anticipatory and preservatory agreement. Under the PfP approach, both HH and ATRH are considered to be the same process triggered by the 'mAss' element |A|, which avoids the need to address any of the problems described in section 2.3. The difference between the two harmonies refers to the point in the hierarchical structure where it operates: when |A| is specified at an embedded level, it has a greater phonetic salience and contributes to the realisation of vowel in terms of height. On the other hand, when the same element is specified at the topmost level of a more hierarchically-complex structure, its phonetic effects are less prominent and it contributes only ATR-ness, which may be regarded as a variant of height harmony.

To judge whether the proposed analysis of these two types of harmony is descriptively and theoretically valid, further investigation will be needed in conjunction with cross-linguistic research into not only Bantu languages but also other language types and other kinds of agreement process.

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