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Positional Faithfulness and Vowel Harmony in Lubukusu: An OT Account

Henry Simiyu Nandelenga
Department of English, Literature & Journalism, Kibabii University, PO box 1169-50200, Bungoma, Kenya

Abstract
In a number of languages, vowel harmony is generally initiated in certain positions that are psycholinguistically privileged such as root-initial syllables. Such positions not only trigger vowel harmony but may also block or fail to undergo vowel harmony process initiated elsewhere even when such a process is regular or expected in the phonology of the language. In the rule-based derivational analysis, such phenomenon was explained in serial rules that were often blind to outputs and could produce non-recurrent harmony types. Similarly, the derivational approach often failed to account for the privileged status of harmony triggering vowels. In a Positional Faithfulness (PF) account adopted in this study, it is argued that positional sensitive harmony is due to a high-ranked positional faithfulness constraint; IDENT-IO, (F) in an Optimality Theoretic Grammar. In this paper, based on Lubukusu (a Bantu language of Kenya), it is shown that vowel height harmony that is initiated in the root initial syllable can best be accounted for by recourse to constraint interaction in which positional specific faithfulness constraints dominates general faithfulness and markedness constraints. Vowels in root initial syllables may initiate or block vowel height harmony based on a universal constraint ranking for root-initial faithfulness. The analysis confirms that faithfulness constraints that are positional sensitive may be responsible for root induced vowel height harmony because such positions are psycholinguistically privileged in general language processing.
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1. Introduction

Vowel harmony is a special type of phonological assimilatory process in which vowels share certain phonological features with contrastive vowels elsewhere either in a word or a phrase. It is a kind of long-distance assimilatory process such that the harmonizing vowels tend to be separated by some consonants. Often, it is explained as grammaticalization of the phonetic effect of gestural overlap in speech production or simply as coarticulation effects (Chotoran, Goldstein & Byrd, 2002). Crosslinguistically, vowels at the beginning of a word tend to trigger assimilation of some of their features by the subsequent vowels. The vowels that initiate the assimilation processes are referred to as the triggers while those that harmonize with the trigger (assimilate the feature from the trigger) are targets. However, not all vowels need to participate in the harmonizing process and are therefore referred to as neutral vowels. If they block the harmony process, they are said to be opaque to the harmonizing feature and if they do not affect the process, they are said to be transparent; similar to the intervening consonants (Hulst & Weijer, 1995; Casali, 2008; Archangeli & Pulleyblank, 2007; Rose & Walker, 2011; Walker, 2012).

In majority of languages, vowel harmony triggers are found in the root or stems of a word while the targets are often affixes; typically suffixes and prefixes (Hulst & Weijer, 1995; Casali, 2002, 2008; Hyman, 2002; Krämer, 2003; Archangeli & Pulleyblank, 2007; Gafos & Dye, 2011; Rose & Walker, 2011; van der Hulst, 2012; Walker, 2012). This is a case of root/stem induced or root/stem controlled vowel harmony. The result is that suffixes, for example, may have different allomorphs depending on the vowel in the stem to which they are attached. The harmonizing feature may be based on a number of dimensions such as vowel height, backness, rounding, tongue root position (advancement or retraction) and nasalization (where the nasal stops are invariably the trigger of nasal harmony). Harmony may classify vowels into specific classes or sets such as back or rounded vowels resulting in words that contain only vowels from one of the sets. This is typical of Advanced Tongue Root (ATR) vowel harmony common in many African languages in which words have either the [+ATR] or the [-ATR] vowels only (Casali, 2002, 2008; Noske, 2000; Local & Lodge, 2004; Starwalt, 2008).

In languages such as Finnish and Hungarian that have a front, back and neutral class of vowels, it follows that the initial syllables of a word determine the frontness and backness of the entire word in harmony. The neutral vowels, when non-initial, are transparent to the harmonizing feature, for example, the Hungarian front short [i] and the front long [í] and [é] occur freely with both back and front vowels (Ringen & Vago, 1998; Körkenczy, 2011; van der Hulst, 2012). In Hungarian, the vowels in the dative suffix appear in two forms based on the two harmonizing features in the root vowels [+back] and [-back]. The dative suffix allomorphs are [-nak] and [-nek] each harmonizing for the root vowel features [+back] and [-back] respectively, as illustrated in the examples that follow in (1). Note that there is a contrast between rounded and unrounded front vowels (the given

examples show the rounded vowels).

(1) Backness vowel harmony in Hungarian

(i) /város/	→	[város-nak]	'city'
(ii) /öröm/	→	[öröm-nek]	'joy'
(iii) /bab/	→	[bab-nak]	'bean'
(iv) /érv/	→	[érvnek]	'argument'

Similarly in Turkish, a suffixal language, vowels are divided into back, the so called A-undotted vowels (AIOU; /a/, /ɪ/, /o/, /u/) and front, the E-dotted vowels (EİÖÜ: /e/, /i/, /ö/, /ü/). Due to stem-controlled harmony, the plural suffixes are realized as –lar or –ler for [+back] or [-back] harmony feature respectively (Kirchner, 1993; Levi 2000; van der Hulst, 2012, among others). Backness/rounding harmony in Turkish native words can be exhaustive so that vowels of all qualities can be triggers and all vowels can be targets (Walker, 2012). Generally, harmony in Turkish proceeds rightwards although other harmonies may be left biased or bidirectional.

Languages may exhibit a mixture of harmony systems, for instance, Altaic languages often have rounding harmony superimposed on backness harmony (Vaux, 1996) and palatal and rounding harmony are initiated by root initial syllables. Languages having vowel harmony may nevertheless display lexical disharmony in which there are words with mixed sets of vowels in the absence of opaque or neutral vowels. This is particularly common in loanword phonology in which unassimilated loanwords resist nativisation process determined by the harmonizing feature and this has implications for phonological contrast theory.

The concept of positional privilege has been proposed to account for a number of phenomena among them, root governed vowel harmony. Linguistically privileged positions are those that play a critical role in language processing; they have some psycholinguistic or phonetic prominence. These are root initial syllables, stressed syllables, syllable onsets, roots and long vowels (Kaun, 1995; Beckman, 1999, 2004; McCarthy & Prince, 1995; Krämer, 2003). According to Beckman, these psycholinguistically prominent positions are important in lexical access, storage, retrieval and general language processing hence act as triggers of phonological processes while blocking processes initiated in non-privileged positions. Indeed, one of the key phonological diagnoses of positional privilege is the triggering vowel harmony in which segments in privileged positions act as triggers of not just vowel harmony but also other forms of assimilation and also different types of dissimilatory processes.

In root/stem induced vowel harmony, the vowels of the root/stem determine the vocalism of the affixes. In initial syllable governed harmony, the phonological features of the vowels in the root-initial syllable are shared by the subsequent root vowels and their affixes in progressive assimilation. Among these harmony types are the vowel height and [ATR] harmony prevalent among Bantu languages and the palatal and labial harmony common among the Uralic and Altaic languages of Europe (Hulst & Weijer, 1995; Casali, 2008). In such processes, features of the non-privileged sounds are virtually lost and this phenomenon may be found in place assimilation as well as in gemination (Lombard, 1995, 1996, 2004). Phonological processes triggered exclusively by sounds in non-privileged positions (affix only triggered harmony) are generally unattested unless overridden by some functional motivations (Noske, 2000; Local & Lodge, 2004; Walker, 2005, 2012). In essence, vowels in prosodically prominent positions often exert stronger co-articulatory effects on their neighbours in weaker prosodic positions.

Related to the above observation is the resistance to phonological processes such as assimilation and dissimilation by segments in privileged positions. This is yet another diagnostic of phonological positional privilege. Segments in privileged positions such as onsets or roots may resist an otherwise regular phonological process when initiated elsewhere or in a non-privileged position. For example, in Zulu (Beckman, 1999), labial dissimilation is a regular unbounded process affecting rightmost labials in morpheme concatenation of a labial consonant plus the passive morpheme [w]. However, dissimilation of labials to palatals fails or is blocked if the target labial is in the root-initial syllable. Segments in root initial syllables do not just initiate assimilatory/dissimilatory processes, but they also resist the same process even when they do not act as triggers. Segments in such prominent positions resist alternations for purposes of maintaining phonological contrast in such positions for perceptual distinctiveness and language processing.

In this study, based on Lubukusu language of western Kenya, it is apparent that vowel harmony is initiated by the vowel in the root as a privileged position. In this language, there is vowel height harmony which is normally initiated in the verb-root initial syllable. As explained in the previous paragraphs, root-initial syllables are known to trigger various phonological processes such as vowel harmony or fail to undergo such processes that are otherwise very regular. We adopt a Positional Faithfulness (PF) account of Beckman (1998, 1999, 2004) within Optimality Theory (OT) as expounded in Prince and Smolensky (1993/2004) and McCarthy and Prince (1993b). In this study, we follow Beckman in arguing that positional faithfulness or neutralization, triggered or blocked harmony, is due to a high ranked positional faithfulness constraint (IDENT-IO,[F]) whose universal ranking for root-initial faithfulness sub-hierarchy is as follows;

(2) Universal ranking of root-initial faithfulness.

IDENT- σ1 (F) ≫ IDENT-IO-(F)

Based on this ranking, it will be shown that positional faithfulness account can explain the vowel height harmony system attested in Lubukusu similar to what has been reported in related Bantu languages (Beckman, 1999; Hyman, 2002; Casali, 2008). PF theory is subsumed under OT with the basic argument that harmony is driven by constraints and a number of harmony-driving constraints have been proposed (Kirchner, 1993; Kenstowicz, 2009; Walker, 2012). These constraints fall under: Alignment, Agree, Spreading and Correspondence classes.

Alignment constraints, borrowed from McCarthy and Prince (1993a) drive harmony by demanding that features have an association at designated edges (left/right) of some prosodic or morphological category such as a word. This constraint is instantiated in two subclasses of ALIGN-Right ([Back], Word) and IDENT-IO ([Back]) in rounding harmony. In Agreement as a constraint; AGREE (F) demands that adjacent segments have the same value for the feature (F) and neither does it encode any directional asymmetry nor require that a feature be linked across segments. AGREE (F) realized as, say, AGREE ([Back]) invokes locality, it directly picks out adjacent segments only and, consequently, assigns violation marks only to disharmonic junctures (Baković, 2000). Similarly, SPREAD (F) constraint (Kaun, 1995; Padgett, 2002) has similar effects to the two constraints mentioned earlier. This constraint is instantiated, for example, in SPREAD ([Back], word). A violation mark will, therefore, be assigned to every segment in the word to which the feature back is not associated and may lead to bidirectional harmony.

Finally, harmonizing features are said to stand in a relation of correspondence (McCarthy and Prince, 1999). It is assumed that harmony results from the Correspondence family of constraints such as IDENT (F) except that in harmony, correspondence holds between elements within the same output rather than in an input-output (Krämer, 2003). Two classes of Correspondence constraints can be identified both having similar general requirement but minor differences in execution. These are the syntagmatic correspondence (Krämer, 2003) implemented as S-IDENT (F) which requires adjacent elements in an input to have identical values for the feature (F) and the Agreement By Correspondence (ABC) originally by Hansson (2001, 2007). In the ABC, the correspondence relations between elements in the output form is optimized via the work of the constraint hierarchy in which case correspondence is neither restricted to adjacent segments nor is it guaranteed hence more appropriate for parasitic form of harmony (Walker, 2012:579).

In OT, therefore, the key argument is that these constraints, ranked in a language specific hierarchy, should adequately capture vowel harmony across languages without reference to rule derivations or feature underspecification of previous approaches. This paper is organized as follows: Section 2 looks at Lubukusu vowel height harmony, Section 3 examines blocking of height harmony, while Section 4 addresses the interaction of height and rounding harmony. The final Section 5 provides concluding remarks and the way forward based on findings from Lubukusu verbal vowel height harmony.

2 Vowel Height Harmony in Lubukusu

In Lubukusu verbs, whenever initial syllables in the roots begin with mid vowels, only mid vowels can follow. This results in vowel height harmony of the features [-High, -Low] initiated by the root-initial mid vowel. Similarly, when the high vowels [i] and [u] are syllable initial in the roots, there is a [+high] induced form of root-initial vowel harmony that also bans mid vowels from following the root initial high vowels. In the following data, there is vowel height harmony initiated by the root vowels. Note: Bantu verbs end in the canonical verb final [a].

(3) Vowel harmony in polysyllabic verb roots

Root form	height type	Gloss
(i) [xe.nde.xa]	[mid-[e]]	‘feel jealous’
(ii) [te.re.ma]	[mid-[e]]	‘shake’ (from fear)
(iii) [ko.lo.la]	[mid-[o]]	‘straighten’
(iv) [ro.mbo.la]	[mid-[o]]	‘discriminate
(v) [xu.ru.ra]	[high-[u]]	‘drag’
(vi) [ku.lu.la]	[high-[u]]	‘stir’

In the data (3), the initial vowel determines the subsequent vowels in terms of feature values. In (i) and (ii), the syllable initial vowels are the front unrounded mid short vowel [e] having the features; [-High], [-Low] and [-back]. This harmonizes with the following vowel which is realized phonetically as [e]. The same harmony is observed in (iii) and (iv) in which the vowel [o] whose features are [-High], [-Low] and [+Back] are realized in the following vowel which is identical. In (v) and (vi), the root initial vowel [u] whose features are [+Back] [+High] and [+Round] initiates feature harmony in the following vowel which is also realized as [u]. While the data has no harmony involving [i] vowel (this harmony is mainly found in nouns and demonstratives and verbal extensions) the data below shows that the critical harmonizing feature is that of height. This is because there are cases of [i] and [u] having the feature [+High] following each other on one hand and [o] and [e] which are [-High] and [-Low] also following each other in a word.

In verbal extensions, the suffixes take on the vowel height features of the root-initial syllable vowel; the subsequent vowels that follow in the inflectional suffixes harmonize with the root-initial vowel. This is apparent in the following verbal extensions involving the applicative, causative and the instrumental suffixes all of which harmonize in height with the root initial vowel. Note that the [i] and [u] vowels can follow each other because the harmonizing feature is the [+High], similarly, the [o] and [e] vowels may follow each other because they harmonize for the features [-High] and [-Low] shared by both vowels. However, there are some restrictions on the latter if the initial vowel [-Back] that is the front mid vowel [e]; it cannot be followed by the [+Back] but [-High] [o] due to markedness reasons explained later (see § 3).

(4) Vowel height harmony in verbal extensions

Root+a	Gloss	Applicative-i/ela	Causative-i/esja	Instrumental-ili/elela.
(i) [ke.nd-a]	walk	[ke.nde.la]	[ke.nde.sja]	[ke.nde.sje.la]
(ii) [le.x-a]	abandon	[le.xe.la]	[le.xe.sja]	[le.xe.sje.la]
(iii) [ko.lo.l-a]	straighten	[ko.lo.le.la]	[ko.lo.lo.sja]	[ko.lo.lo.sje.la
(iv) [ko.n-a]	sleep	[ko.ne.la]	[ko.ne.sja]	[ko.ne.se.lja]
(v) [ti.m-a]	run	[ti.mi.la]	[ti.mi.sja]	[ti.mi.si.lja]
(vi) [xi.n-a]	dance	[xi.ni.la]	[xi.ni.sja]	[xi.ni.si.lja]
(vii) [βu.mb-a]	mold	[βu.mbi.la]	[βu.mbi.sja]	[βu.mbi.si.lja
(viii) [xu.l-a]	grow up	[xu.li.la]	[xu.li.sja]	[xu.li.si.lja]

From the data, it can be deduced that the height feature value of the initial vowel of the root determines the subsequent vowel to follow in terms of feature specifications. Ideally, whenever the initial vowel is a mid [-high], [-low] vowel, the following vowels are invariably mid vowels that share these features [-high] and [-low]. Similarly, if the root initial vowel is specified as a [+high] be it a front [i] or a back [u], the following vowels must harmonize for the feature [+high], that is, it must be either [i] or [u]. Mid vowels are not permitted to follow a high vowel in this verbal forms. In both cases, mid and high vowels in the root initial positions are the source of height harmony observed in Lubukusu verbs and verbal inflections.

In an OT grammar, it is assumed that constraints are responsible for the height harmony and the non-harmonic behaviour of some vowel sequences. The fact that the root-initial vowel is both the source and blocker of harmony implies that positional faithfulness constraints may be responsible for the observed behaviour. As already mentioned, vowel in the roots have been known to resist alternations for vowel contrast preservation. There must be some general faithfulness constraints that are dominated to the extent that contrast is neutralized in positions outside the privileged root positions. In the following analysis, we propose these constraints: IDENT-σ1 [high], IDENT-IO [low], *MID, IDENT- [high] and *HIGH.

The constraint that protects the root-initial syllables as the trigger of vowel harmony; IDENT-σ1[high], should be undominated in the constraint hierarchy. This constraint should immediately dominate the markedness constraint against mid vowels: *MID, which in turn dominates the anti-high constraint *HIGH. In mid-vowel height harmony, it is shown that there is restriction in the occurrence of [e]. High vowels are known to supplant mid vowels in phonological process because, from markedness perspectives, a mid vowel is marked compared to a high. In harmony, height specification of the following vowel is routinely changed to accommodate harmony; the identity constraint, IDENT- [high] must be low ranked.

These four constraints should be ranked as follows: IDENT-σ1[high] ≫ *MID ≫ *HIGH ≫ IDENT- [high]. It is noteworth that *HIGH and IDENT- [high] are crucially ranked so that the former dominates the latter. Furthermore, in the representation of harmony, articulatory gestures in harmony are represented as the sharing of aperture nodes (Clements & Hume, 1995) and this is captured in the tableaus as a standard feature (*see* Beckman, 1999). In the analysis, the Bantu verb final (the default stem final) vowel [a] is excluded because it is the expected and often considered as a suffix verb outside the root.

Tableau 1: /kend-el-a/ → [ke.nde.la] 'visit/walk for someone'

/kend-el-a/	IDENT-σ1[high]	*MID	*HIGH	IDENT- [high]
a.☞ [k e. n d e. l a] aperture [-lo] [-hi]		*		
b. [k e. n d e. l a] [-lo] [-hi] [-lo] [-hi]		**!		
c. [k e. n d i. l a] [-lo] [-hi] [-lo]b[+hi]		*	*!	
d. [k i. n d i. l a] aperture [-lo] [+hi]	*!		*	*

From the tableau, it is critical that the root-initial height faithfulness constraint is undominated to ensure the initial mid vowel is not changed into the less marked high vowel. The fact that candidate (d) is sub-optimal is significant in this regard. Harmony involving high vowels can only be initiated by root initial high vowel and not a mid vowel. In addition, the optimal candidate (a) agrees with the generalization that only mid vowels can harmonize with root-initial mid vowel. The use of aperture nodes is an important source of differences in assessing optimality. Candidate (a) has the aperture node linking the two mid vowels together, implying a spreading of height features from the root to the subsequent vowels. The concept of feature spreading makes a difference in the evaluation of constraint violation between candidate (a) and (b). The later candidate with separate feature specification incurs one extra violation mark for *MID constraint because it implies there are two separate vowels with the mid feature. Multiple linking of the aperture node implies one mid feature hence less violation of the *MID constraint. Candidate (c) is sub-optimal because it has changed the input [-high] to output [+high]. This is an unmotivated violation of the *HIGH constraint, the only violation that separates candidate (c) from the optimal candidate (a). When features are linked at the aperture node, it minimizes markedness violations because the feature receives one violation mark. Sequences of vowels that are identical but separately linked are phonetically more marked (Kaun, 1995).

Note that the undominated IDENT-σ1 [high] induces the violation of *MID allowing the occurrence of mid vowels in spite of their marked status, but only in the privileged position of root initial syllables. To ensure vowel height harmony, it is vital that the markedness constraint *HIGH dominates IDENT-IO [High]. In addition, IDENT-IO [High] must be dominated by the two markedness constraints to allow for the neutralization of the [+high] feature not found in root-initial vowels. Should IDENT-IO [high] dominate *HIGH, the language would have mid vowels only in the root-initial syllables while banning vowel harmony outside such positions.

In feature driven markedness (Prince & Smolensky, 2004), violations may not be determined by how many mid vowels are present in the candidate but by the number of either single or a combination of auto-segments appearing in the candidate. From the foregoing argument, markedness constraints that evaluate feature combinations such as *[-low], [+high], [-low] or *MID, a violation mark is given for each discrete node (the aperture node) that immediately dominates the relevant feature set (*see* Beckman, 1998, 1999, 2004). In the root-triggered [+high] feature harmony, the candidate with multiple linked features at the aperture node (a) is more harmonic than one with multiple specifications of features as in (b) below.

Tableau 2: /timil-a/ → [ti.mi.la] 'run for'

/timil-a/	IDENT-σ1[high]	*MID	*HIGH	IDENT- [high]
a.☞[t i. m i. l a] aperture [-lo] [+hi]			*	
b. [t i. m i. l a] [-lo] [+hi] [-lo] [+hi]			**!	
c. [t i. m e. l a] [-lo] [+hi] [-lo][-hi]		*!	*	*
d. [t e. m i. l a] [-lo][-high][-lo] [+hi]	*!	*	*	*

The candidate with the multiple-linked aperture node (a) incurs one violation less in terms of the markedness constraint *HIGH while the candidate with separate feature specification (candidate b) incurs two violation marks. Candidate (a) is optimal based entirely on this difference in feature association. The [high] specification of the initial syllable is multiply linked to the following vowels and in so doing, satisfies the requirement that output vowels share height features. In addition, the root-initial specification of [high] must necessarily violate either *HIGH or *MID compelled by the undominated IDENT-σ1[high]. Candidates (c) and (d) have incurred unmotivated violations due to the alteration of the input [+high] feature in both the root-initial vowel and the following syllable vowel.

3 Blocking of Vowel Height Harmony

In the language, low vowels are opaque to vowel harmony; they neither trigger nor facilitate vowel harmony. Instead, they block it if they follow any of the root vowels initiating vowel harmony. No mid vowels can follow each other in harmony after an intervening low vowel [a] even if the trigger mid vowel is in the privileged root–initial position; instead, only the high vowels may follow this low vowel. Basically, low vowels are opaque to vowel harmony.

(5) No harmony after low vowels.

(a) Root-initial [+low]

Root+a	Gloss	applicative	causative	instrumental
	”	(-i/ela)	(-i/esja)	(-ili/elela)
(i) [ka.βu.l-a]	divide	[ka.βu.li.la]	[ka.βu.li.sja]	[ka.βu.li.si.lja]
(ii) [xa.k-a]	try	[xa.ki.la]	[xa.ki.sja]	[xa.ki.si.lja]
(iii) [ka.n-a]	want	[ka.ni.la]	[ka.ni.sja]	[ka.ni.si.lja]
(iv) [xa.la.l-a]	frown	[xa.la.li.la]	[xa.la.li.sja]	[xa.la.li.si.lja]

(b) [+Low] following root-initial vowels

(i) [i.na.m-a]	bend	[i.na.mi.la]	[i.na.mi.sja]	[i.na.mi.si.lja]
(ii) [re.ka.na]	wrestle	[re.ka.ni.la]	[re.ka.ni.sja]	[re.ka.ni.si.lja]
(iii) [lo.ma.na]	quarrel	[lo.ma.ni.la]	[lo.ma.ni.sja]	[lo.ma.ni.si.lja]
(iv) [u.na]	pierce	[u.na.ni.la]	[u.na.ni.sja]	[u.na.ni.si.lja]

In (5a) above, it can be seen that the low vowel does not trigger vowel harmony; no series of low vowels follow the root vowel in the subsequent suffixes. In (5b) above, whenever the low vowels intervene between the root-initial mid vowels, no mid can follow the low vowels. Only the high vowels [i] and [u] can follow the intervening low vowel ([a]) regardless of whether the low vowel is in the root-initial position or not. After the [+Low] vowel, only the [+High] feature vowels are permissible.

From the harmony data, it is shown that the low vowel [a] is opaque to vowel harmony, thus restricting vowel height in roots and stems that contain the low vowel. This restriction has a bearing on the constraint proposed because there is need for a constraint that takes care of faithfulness to low vowels. The relevant constraint is IDENT-IO[low], a constraint that must dominate *HIGH so that we can derive [CaCiC] given an input of the form [CaCeC] instead of the expected but non-occurring [*CaCaC]. The ranking of IDENT-IO [LOW] ≫ *HIGH, together with the sub-hierarchy established from the previous analysis; *MID ≫ *HIGH, ensures that a [+high] is preferred after the [+Low] vowel and not the [-low, -high] vowel in non-initial positions.

The non-initial vowel must be specified positively for height [+high] in which IDENT-IO [low] is undominated as follows; IDENT-σ1[high], IDENT-IO [low] ≫ *MID ≫ *HIGH ≫ IDENT-IO[high]. In tableau (3), the optimal candidate is (a) in spite of multiple feature linkage.

. Tableau 3: /kaβil-a/ → [ka.βi.la] 'distribute for'

/kaβil-a/	IDENTσ1[high]	IDENT[low]	*MID	*HIGH	IDENT-[high]
a. ☞[k a. β i. l a] [+lo] [-hi][-lo] [+hi]				*	
b. [k a. β e. l a] [+lo] [-hi][-lo] [-hi]			*!		*
c. [k a. β a. l a] aperture [+lo] [-hi]		*!			
d. [k a. β e. l a] aperture aperture [+lo][-hi] [-lo]			*!		*

Candidate (a) violates just one low-ranked constraint *HIGH. This is because linking to the aperture nodes has limitations; so long as vowels have different feature specifications, linking them to a single aperture node does not reduce the violations assessed for the candidate. This is apparent in comparing candidates (b) and (d), the latter does not improve on markedness in spite of multiple linkage. A mid vowel following a low vowel would require having its own aperture node. This renders the multiple linking of the [-hi] feature of no value in terms of violations.

Based on the ranking in (3), any non-low vowel that follows the low [a] would ultimately emerge as a high vowel thus ruling out a mid vowel after the [+low] vowel [a]. On the other hand, because the low vowel [a] is opaque to vowel harmony, so long as it intervenes, the height feature harmony will be blocked after this low vowel. In the context of the tableau (3), the constraints as ranked yield some positive result. However, it is necessary to evaluate outputs whose second vowel is the opaque low [a] to determine whether the predicted blocking of harmony after an [a] is a reality based on constraint interaction. In the following data (6), the intervening [a] is indeed a blocker of height harmony; the input stem /lomak-a/ is realized as [lo.ma.ki.la] when it inflects for the applicative and [lo.ma.ki.li.sja] for the causative.

(6)	Root-stem	Gloss	Applicative	Causative
(i)	/lomak-a/	speak fast	[lo.ma.ki.la]	[lo.ma.ki.li.sja]
(ii)	/jolak-a/	scoup fast	[jo.la.ki.la]	[jo.la.ki.li.sja]
(iii)	/remak-a/	cut fast	[re. ma.ki.la]	[re.ma.ki.li.sja]

From the data, it is observed that only vowels with the [+high] vowel feature [i] and [u] follow in both the applicative and causative after the intervening opaque low vowel but not the [e] or [o] that are expected if there is root initiated vowel height harmony. This is what is depicted in tableau (4) that follows.

Tableau 4: /lomakil-a/ → [lo.ma.ki.la] 'speak fast for (somebody)'

/l o m a k i l-a/	IDENTσ1hi	IDENT-lo]	*MID	*HIGH	IDENT-[h]
a.☞[l o. m a. k i. l a] [-lo][-hi [+lo] [-hi][-lo][+hi]			*	*	
b. [l o. m a. k o. l a] [-lo] [-hi] [+lo][-hi][-lo] [-hi]			**!		
c. [l o. m e. k e. l a] aperture [-lo][-hi]		*!	***		*
d. [l o. m a. k a. l a] aperture aperture [-lo] [-hi] [+lo] [-hi]		*!	*		*

From the tableau, candidate (a) is optimal because no mid vowel follows an intervening low [a]. Secondly, the crucial ranking between *MID and *HIGH is responsible for the sub-optimal status of candidate (b). If the two were not crucially ranked to the contrary, they would tie on violations, a similar situation to the one observed with respect to candidate (d). Finally, IDENT-IO [low] is important in ensuring that low vowels are not supplanted by mid vowels to create height harmony similar to the root-initial vowel height specification. Candidate (c) is a classic example of such cases which is, fortunately, handled by the high ranked faithfulness constraint IDENT-IO [low] without which unattested harmony would result.

It is possible to account for the failure of mid vowels to follow an intervening low by formally having an input that has a mid vowel after a root initial low. In an OT grammar, only constraint interaction should provide any justification as to why such a harmony type is unattested in the language under investigation. There is no verb stem of the vowel sequence [CeCaCeC-a] → *[re.ma.ke.la] having a mid vowel after a low. Such an input is inevitably realized in the output as [re.ma.ki.la]. The same ranking as (4) is adopted and the hierarchy is able to generate the correct output candidate. As in tableau (5), the ranking of *MID over *HIGH proves decisive in identifying a unique optimal candidate (a).

Tableau 5: */remakel-a/ → [re.ma.ki.la] 'cut fast for…'

/remakel-a/	IDENTσ1[hi]	IDENT-[lo]	*MID	*HIGH	IDENT-[hi]
a.☞[r e. m a. k i. l a] [-lo] [-hi] [+lo] [-hi] [-lo][+hi]			*	*	*
b. [r e. m a. k e. l a] aperture aperture [-lo] [-hi] [+lo] [-hi]			**!		

Candidate (b) loses although it is the replica of the input and, therefore, more faithful. However, because none of the undominated faithfulness constraints play any part in selecting an optimal candidate, it is the low-ranking markedness constraints that are decisive. It is also worth noting that multiple linking of the mid vowel does not rescue it from violating *MID. It in fact violates a universal constraint against crossing association lines between features and segments per wellformedness constraint (Goldsmith, 1999).

4 Interaction of Height and Rounding Harmony.

Generally, the language does not allow a mid vowel to follow any root initial [e] is a root word. Only the back rounded high vowel may follow the initial [e] as the data in (7a) exemplify. However, if the initial vowel is the mid back rounded vowel [o], then the mid vowel harmony is a possibility. In the previous section (see § 3), the presence of a low [a] prevented any of the mid vowels from following it in verbal stems. This restriction is due to the markedness of mid vowels crosslinguistically to the extent that their distribution is severely restricted.

However, the fact that the back high rounded vowel may follow the mid [e] and not the preferred [o] point to the interaction of the height features and rounding. Note that the unmarked rounded vowels are also [+High]

and not [-High]. This also accounts for the ranking established up to this point in which *MID constraints outranks *HIGH in the constraint hierarchy to show the preference of [+High] over [-High] vowels in the inventory and the presence of the [+High] feature harmony after [+Low].

(7a) Only [u] may follow mid [e]: No height harmony.

Attested (occurring)	Gloss	Expected /non-occurring	
[ke.lu.la]	turn over	*[ke.le.la]	*[ke.lo.la]
[xe.βu.li.la]	remember	*[xe.βe.le.la]	*[xe.βo.lo.la]
[le.xu.la]	let go	*[le.xe.la]	*[le.xo.la]
[sje.βu.la]	dance	*[sje.βe.la]	*[sje.βo.la]

(7b) Mid vowels [e] and [o] can follow initial [o]: Height harmony (mid).

[ko.lo.la]	straighten
[ro.βo.la]	choose/elect
[βo.ne.la]	see with
[lo.me.la]	speak for

In (7a), only the high back [u] can follow the initial [e], in (7b), any mid vowel can follow the initial [o]. The difference between the data in (7a) and (7b) is that in the former, height harmony is blocked when the root-initial vowel is non-round and [+High]. The mid unrounded vowel [e] cannot be followed by the mid counterpart vowel [o] because it is not [+High]. In (7b), the height harmony is maintained because the vowel in the initial position is the rounded [o]. In this data both mid vowels [o] and [e] can follow the initial mid thus vowel height harmony is achieved. However, we need an account as to why the back high vowel [u] is preferred over the back non-high [o].

Based on feature specification we have adopted so far, there is no objective reason for the restriction of [o]. Specifically, there seems to be some interaction between height specification of the vowels and their rounding features in allowing or blocking harmony. The [low] and [round] that restrict harmony are due to faithfulness constraints interacting with markedness constraints against mid vowels following the low or high. There are certain restrictions on what to harmonize depending on the height and rounding features of the relevant vowels.

In a nutshell, there is interaction of rounding and harmony in either blocking or facilitating harmony. Note that no verb allows the expected mid vowels ([e] or [o] if the root initial vowel is the unrounded [e]. It is proposed that unless the root-initial mid vowel is [+round], the subsequent vowel cannot be a mid, thus blocking mid-height harmony. This is clear when the root-initial vowel is the mid and [+round] (the [o]), there is vowel height harmony. It is further proposed that a faithfulness constraint IDENT-IO [round] is responsible in ensuring this position cannot have an unrounded vowel. This constraint is undominated too but based on the hierarchy in (tableau 6a), the supposed optimal candidate (d) is not the actual form attested in the language but instead it is candidate (a).

Tableau 6a: /kelul-a/ → [ke.lu.la] 'turn over'

/kelul-a/	IDENTσ1[high]	IDENT-[rd]	*MID	*HIGH	IDENT-[hi]
a. ☹ [k e. l u. l a] [-lo][-hi] [-lo] [+hi]			*	*!	
b.[k e. l i. l a] [-lo][-hi] [-lo][+hi]		*!	*	*	
c .[k e. l e. l a] aperture [-lo] [-hi]		*!	*		*
d. ☜[k e. l o. l a] aperture [-lo] [-hi]			*		*
e. [k i. l u. l a] aperture [-lo] [+hi]	*!				

Apparently, there is a restriction on mid vowel height harmony if the root-initial vowel is non-round. Consequently, there can be no [–high] round vowel following a non-round root initial vowel. This restriction was first reported by Kaun (1995) who proposed a markedness constraint against low and round vowels in the form of *ROLO. This constraint demands that vowels should not be simultaneously specified [+round] and [-high]. The markedness constraint *ROLO prefers the presence of the [+round] and [+high] vowel [u] after the root initial unrounded [e]. In so doing, the mid vowel [o] is formally prohibited from following the [e] that is root initial. This may explain the lack of the form [CeCo] in Lubukusu verbs that we have observed. Note that the language has [CeCe] sequences because this markedness constraint does not ban non-rounded and non-high vowels following root initial [-round] and [-high]. The markedness constraint *ROLO cannot be undominated because there are mid [o] following other root initial vowels. However, it should dominate other markedness constraints hence the ranking proposed would be; IDENT-σ1[high], IDENT-IO[rd] ≫ *ROLO ≫ *MID ≫ *HIGH ≫ IDENT-IO[high] which results in the true form in tableau (6b).

Tableau 6b: /kelul-a/ → [ke.lu.la] 'turn over'

/kelul-a/	IDENTσ1[hi]	IDENT-[rd]	*ROLO	*MID	*HIGH	IDENT-[hi]
a.☞k e. l u. l a] [-lo] [-hi] [-lo][+hi] [rd]				*	*	
b.[k e. l i. l a] [-lo][-hi][-lo] [+hi]		*!		*	*	
c. [k e. l e. l a] aperture [-lo] [-hi]		*!		*		*
d. [k e. l o. l a] aperture [rd] [-lo] [-hi]			*!	*		*
e. [k i. l u. l a] aperture [rd] [-lo] [+hi]	*!					

In the tableau (6b), we have used the same input as in the previous tableau (6a), but with the introduction of the markedness constraint *ROLO. This constraint plays an important role of ensuring that candidate (d) does not emerge the winner. In OT, it is also assumed that certain expected harmony may fail because of positional faithfulness meant to maintain phonological contrast. The form infelicitously declared as the optimal candidate in (6a), would never be optimal because the constraint CONTRAST, which is an undominated in the language's constraint hierarchy, would rule it out.

4 Summary and Conclusion

The constraints proposed for the analysis of positional faithfulness in vowel harmony have yielded the outputs attested in the language. Vowel harmony, in particular vowel height harmony, is initiated and blocked in the word initial syllables. The fact that the same constraints and ranking handle the various aspects of height harmony is a testimony of the economy of the evaluation available by simple recourse to constraint interaction. In essence, faithfulness to the syllable initial position has been observed to both initiate and block harmony and, this in turn, determines vowel harmony in Lubukusu verbal stems. This is only possible if some positional faithfulness constraints are undominated in the hierarchy over the general faithfulness and markedness constraints. This study has shown that there is no need for positing derivational rules that require the 'Elsewhere Conditions' on disjunctive ordering to apply to abstract vowels or other ad hoc rules of absolute neutralization to account for exceptions to the harmonizing rule. Neither nonautomatic phonological rule application nor feature Underspecification approach is required in explaining both the harmonizing and blocking of the features. There is no justification for the feature spreading notions prevalent in the Autosegmental treatment of vowel harmony (Hulst & Weijer, 1995). In a nutshell, vowel height harmony can be fruitfully explained via simple recourse to

positional sensitive faithfulness constraint interacting with general faithfulness and markedness constraints in a language's constraint hierarchy.

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