Tongue-Height Harmony in Kinyarwanda Verbal Morphology*

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Lee, Minkyung. 2015. Tongue-Height Harmony in Kinyarwanda Verbal Morphology. *The Linguistic Association of Korea Journal, 23*(1), 23-42. In autosegmental phonology, vowel harmony (VH) is considered assimilation as feature spreading. However, in Optimality Theory (OT) based upon serialism, this central insight is embodied by local optimality and gradualness via the Gen-Eval loop. Tongue-height harmony found in Kinyarwanda is rightward spreading from a root to suffixes over a morpheme boundary. A mid vowel in a root triggers height harmony, thus suffix vowels are lowered to be mid. Here interestingly, only tongue height feature spreads, thus mid [o] cannot surface in suffixes due to the feature cooccurrence restriction. Furthermore, root high vowels are transparent in VH while root low vowels are neutral in VH. Therefore, height harmony in suffixes is banned due to the demand of markedness constraint and featural identity constraint. In essence, tongue- height harmony in Kinyarwanda verbal morphology is well couched into the major spirits of serial OT paradigm.

Key Words: serial OT, height harmony, high vowel transparency, low vowel neutrality, local optimality, gradualness

I. Introduction

Optimality Theory (McCarthy & Prince, 1995; Prince & Smolensky, 1993/2004)(henceforth OT) on the basis of Harmonic Serialism (McCarthy, 2007,

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2008a,b, 2009)(hereafter serial OT) pursues harmony in gradualness. No maximal harmony can be achieved via a single pass of Gen and Eval. Therefore, from an input to the ultimate output, local optima can be generated through the iterative courses of Gen and Eval. In serialism paradigm, each local optimum is yielded again and stands as a new input for the next local optimality. Due to this locality characteristic of serial OT, harmony improves step-by-step under the key principle of gradualness.

As fully discussed in previous literature (McCarthy, 2007, 2008a,b, 2009; Lee, 2012, 2013), vowel harmony (hereafter VH) in serial OT takes place iteratively from a harmony-inducing trigger to the adjacent targets within or across a morpheme boundary, instead of applying to the input string at a time. Therefore, it affects the next vowel which, in turn, gives input to the next vowel and so on. This is quite far different from the parallel version of OT (McCarthy & Prince, 1995; Prince & Smolensky, 1993/2004). Adopting the serialism-oriented OT model which is equipped with local optimality and gradualness, this paper focuses on the VH phenomena found in Kinyarwanda, an eastern Bantu language spoken in Rwanda and Burundi, in which VH results from the vital role of a harmony-inducing constraint at the expense of an input faithfulness constraint. In addition, the lack of VH in suffixes results from conspiracy of the markedness constraint and featural identity constraint, both top-ranked in hierarchy.

This language involves the tongue-height harmony from left to right, i.e., from a root to suffixes. Of particular interest is that only mid-vowels /e/ and /o/ in verbal root trigger off vowel harmony of a suffix which follows it. Therefore, suffix vowels are lowered from their original height to become mid. However, root high vowels /i/ and /u/ are transparent, thus do not compel VH. More interestingly, low vowels are neutral in VH as well, thus do not demand VH.

To deal with this asymmetric VH behavior in Kinyarwanda, first section 2 briefly sketches the data and their harmonic patterns where mid vowels in verbal root propagate their height to the following vowels in suffixes. Also, it will be shown that both high and low vowels in roots do not induce height agreement over a morpheme boundary. Section 3, under pro-serialism, demonstrates how OT achieves local optimality and gradualness in VH. As

briefly stated above, local optimality results from the iterative courses of Gen and Eval whereby a local optimum is fed back into the next pass up to the point of convergence in which maximal harmony is created. In section 4, the harmony-inducing constraint Share (McCarthy, 2009) plays a vital role in spreading the harmonic feature to the following target vowels across a boundary. In the meanwhile, featural identity constraint and feature cooccurrence restriction in the literature are responsible for the disparity of height harmony in suffixes. Section 5 concludes and summarizes the present paper.

2. Overview of Kinyarwanda Phonology

2.1. Phonemic Inventory of Vowels

As observed in Kimenyi (1979), Kinkyarwanda consists of five vowels, i.e., two front, two back, and a low. The vowel inventory in Kinyarwanda is illustrated in (1).

(1) Vowel phonemes[1)]

i(i)	u(u)
e(e)	o(o)
a(a)	

Kinyarwanda holds five vowel system and each vowel has its long counterpart which is underlyingly phonemic as laid out in (2). Note that all the data are excerpted from Kimenyi (1979).

(2) Long vs. short vowels

i(i)	gusißa[2)]	'to erase'	gusiißa	'to be absent'

1) Following Kimenyi(1979:3), long vowels are represented by the sequence of two identical vowels to differentiate short vs. long in length. Note that Kinyarwanda does not allow any geminated vowels or a sequence of two vowels within a syllable.

2) Note that /ß/ is a voiced bilabial fricative. As described in Kimenyi (1979), consonants in Kinyarwanda occur at the systematic phonemic level. Nasals and affricates are redundantly

	kußika	'to prow'	kußiika	'to put aside'
e(e)	gusega	'to climb a tree'	guseega	'to beg'
	iteke	'cush-cush yam'	iteeke	'to cook yourself'
u(u)	gusura	'to fart'	gusuura	'to visit'
	kuvura	'to foam'	kuvuura	'to cure'
o(o)	kuroga	'to poison'	kuroota	'to dream'
	isoko	'market'	isooko	'source'
a(a)	gutaka	'to scream'	gutaaka	'to ornate'
	inama	'meat'	inaana	'tomatoes'

As witnessed in (2), all vowels are oral and back vowels are round. Also there is no nasal vowel in this language.

2.2. Syllable Structure

Likewise in other Bantu languages, Kinyarwanda has open syllables only, thus all syllables end in a vowel (Kimenyi 1979:7). Since there appear no vowel clusters or geminate vowels, the syllable ends either with a short vowel or a long vowel as illustrated in (3). Note that each parenthesis indicates a syllable boundary.

(3) Syllabification[3)]

umugabo	'man'	(u)(mu)(ga)(bo)
kwaaka	'to ask'	(kwaa)(ka)
imhŋweerumŋe	'male dog'	(i)(mhŋwee)(ru)(mŋe)
ubgaanŋwa	'beard'	(u)(bgaa)(nŋwa)

voiced and voiceless, respectively and further, only affricates and fricatives have the articulatory feature alveopalatal. Also note that the bilabial voiced stop [b] and the velar nasal [ŋ] arise at the phonetic level.

3) Kinyarwanda does not allow geminate consonants but many types of consonant clusters are found, especially mixing with different phonetic features. For instance, most of the consonants can be preceded by nasals or followed by glides. As shown in (3) above, the sequence of [mhŋw] is a labiovelarized aspirated nasal while [mŋ] is a labiovelarized nasal. [bg] is a labiovelarized voiced stop while [nŋw] is a labiovelarized nasal. Refer to Kimenyi(1979:3) for more detailed consonantal phonology in Kinyarwanda.

To confirm this type of syllabification shown in (3), Kimenyi (1979:7) provides clear evidence from the language game as arranged in (4).

(4) Examples of language game

a. igitabo	'book'	ipigipitapabopo
kurgwaara	'to be sick'	kupurgwaparapa
inzu	'house'	ipinzupu
imbogo	'buffalo'	ipimbopogopo
b. iŋhoko	'chicken'	ikoŋho
umuunhu	'person'	unhuumu
umŋaana	'child'	unaamŋa
igi	'egg'	gii

As observed in (4a), language game is realized by either inserting CV-type nonsensical syllable between syllables as underlined, or, as in (4b), by shifting syllables around. Therefore, as clarified, syllables in the language are all open.

2.3. Kinyarwanda VH Patterns

As discussed in Kimenyi (1979:29), VH in synchronic Kinyarwanda is only partial and suffix vowel is a target to harmonize to the height of a root vowel. Interestingly, only mid front vowel /e/ and mid back vowel /o/ trigger height harmony across a morpheme boundary. Consider the data given in (5).[4)][5)]

4) In Kinyarwanda morphology, nouns, adjectives, and verbs are all bound morphemes. A root must be adjoined to other morphemes in order to stand as a full word. Nouns and adjectives must have prefixes but verbs must have both a prefix and a suffix. For instance, in /gu-kor-a/ 'to work', *-kor-* is the root meaning 'work', *gu-* is the infinitive marker and *-a* the imperfective aspect marker.

5) Note that the change of /k/→ [g] results from voice dissimilation rule, called Dahl's law whereby voiceless consonants turn into voiced consonants before other voiceless consonants. As argued in Kimenyi (1979:11), this rule applies only across a morpheme boundary, not inside the morpheme in Kinyarwanda. Here I will clarify that any consonantal sound changes found in the data are not included in the current analysis.

(5) Root-controlled left-to-right VH

/ku-kor-ir-a/	[gukorera]	'to work for'
/ku-som-ir-a/	[gusomera]	'to read for'
/ku-ßon-ik-a/	[kußoneka]	'to appear'
/ku-root-ir-a/	[kurootera]	'to dream for/at'
/ku-geend-iish-a/	[kugeendeesha]	'to make go'
/ku-reeß-iish-a/	[kureeßeesha]	'to make see'
/ku-rer-ik-a/	[kurereka]	'to be educatable'

The data in (5) tell us that the harmony-inducing vowel belongs to a verbal root and that its height is mid. If the root vowel is a mid-front /e/ or a mid-back /o/, a suffix high-vowel /i(i)/ becomes lowered to /e(e)/ via assimilating to its root vowel height. Here note that prefixes do not undergo VH, thus stay intact in their original height. Furthermore, the suffix vowel is entirely insensitive to the [round] agreement of the harmony-triggering root vowel.

As discussed in Kimenyi (1979:30), VH is a weakening process likewise in English where unstressed vowels weaken by becoming schwa, as the strength hierarchy (proposed by Hooper, 1976) organized in (6) indicates. The vowel /e/ is the weakest while /a/ is the strongest in hierarchy.

(6) The strength hierarchy of vowels

e <o <i <u <a

As witnessed in (6), target vowels in suffixes, mainly high vowels, turn into a mid vowel, the weakest /e/, via the height agreement to the root mid-vowel.

Another interest in this language is that VH is progressive and affects all high suffix vowels as laid out in (7).

(7) Iterative VH

/ku-kor-iish-ir-iz-a/	[gukoreeshereza]	'to work for with'
/ku-ßon-ik-ir-a/	[kußonekera]	'to appear to'
/ku-geend-ir-ir-a/	[kugeenderera]	'to visit'

VH is cyclically progressed from a root vowel to all the following suffix vowels over a morpheme boundary. From the data shown in (5) and (7), we see that height harmony in Kinyarwanda is left-to-right directionality and a progressive assimilation.[6)]

One step further, the data in (8) tell us that high vowels are transparent in VH, thus there is no height agreement triggered in suffixes. Note that they undergo VH when they occur in a suffix, not in a root.

(8) High vowel (/i/ & /u/) transparency[7)]

/ßa-a-n-tsiik-ye/	[ßaantšiitse]	'they ran away from me'
/ßa-rir-y-ye/	[ßarižiže]	'they just made cry'
/ßa-tuur-ye/	[ßatuuye]	'they live'
/ßa-suur-ye/	[ßasuuye]	'they just visited'

Given the data in (8), root high vowels do not make the target vowels high since they are transparent in VH.

Furthermore, a low vowel in a root is entirely neutral in VH in that it does not trigger VH since its [+high] counterpart does not exist in the language. The relevant data are displayed in (9).[8)]

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6) According to Kimenyi (1979:29), only morphemes holding a high front vowel, namely, i(i) (such as -ik- 'neutral', -ir- 'applicative', -iish-(or -iiš-) 'causative') can undergo VH. Given the rule-based framework, Kimenyi (1979) formulates the rule for the data in (5) and (7) as below:

$$\begin{bmatrix} +\text{high} \\ +\text{front} \end{bmatrix} [\text{V}] \rightarrow \begin{bmatrix} -\text{high} \\ -\text{low} \end{bmatrix} / \cdots \text{VC+} \_\_\_\_ [-\text{high}]$$

7) As described in Kimenyi(1979), alveolar '*ts*' changes its articulatory place to be alveopalatal *t*š (or č) before front vowels. Also, as in the case of 'they just made cry' in (8), *-iz-* is inserted before the aspect marker *-ye*. The /r/ of the verbal root undergoes consonant mutation, becoming [z] before *-y-*. And the /z/ of the inserted *-iz-* before *-ye* also undergoes mutation and becomes [ž]. Note that the mutated consonant of the verbal root also becomes [ž] due to anticipatory palatalization. In addition, the alveolar liquid /r/ is deleted before the perfective marker *-ye* if it is preceded by a long vowel as shown in [ßatuuye] 'they live'. Here note again that this paper does not delve into any consonantal sound changes and their rule relation, which will be put for further research.

8) From the data in (9), we see that alveolar fricatives /s/ and /z/ tend to be palatalized anticipatorily when the following syllable contains a palatal fricative, i.e., sh(=š) in suffix. As

(9) Low vowel /a/ neutrality

/ku-sas-a/	[gusasa]	'to make bed'
/ku-sas-iish-a/	[gushashiisha]	'to cause to make the bed'
/ba-ra-saaz-ye/	[barashaaže]	'they are old'
/a-samaaz-ye/	[ashamaažiže]	'he just excited'
/ku-uzuz-a/	[kuuzuza]	'to fill'
/ku-uzuz-iish-a/	[kuužužiisha]	'to cause to fill'

The data in (9) indicate that the target vowels in suffixes, -iish- 'causative' and -ye 'perfective aspect', are not harmonized with their root low vowel /a/.

As such, it has been shown that height harmony in Kinyarwanda verbal morphology is characterized by root-dominant/progressive directionality. This means that prefixes do not participate into height harmony. In the meanwhile, root high vowels and low vowels, unlike root mid vowels, show asymmetric behavior in VH in the sense that they do not demand their height spreading to the target vowels.

3. Serial Harmony in OT

To grasp the major premises of serial OT (McCarthy, 2007, 2008a,b, 2009), this section roughly introduces and demonstrates how serialism in OT operates and further, how it is expanded and applied to VH phenomena found in Kinyarwanda.

Harmonic improvement in serial OT is achieved by the iterative passes of Gen and Eval from the input to the ultimate output under the two key principles of local optimism and gradualness. Given these two basic tenets, VH in serialism results from the step-wise processes of assimilation via harmonic feature spreading from a trigger to the target. Unlike parallelism where maximal

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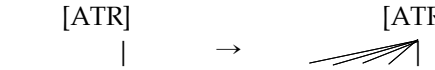
argued in Kimenyi(1979:43), palatal harmony is the type of chain reaction since the alveolar fricatives do not need to immediately precede the palatal consonant. Therefore, palatalization continues applying throughout the same word if there are several more alveolar fricatives as observed in [gu*sh*a*sh*iisha] 'to cause to make the bed' and [kuužužiisha] 'to cause to fill' where the palatalized consonants are italicized.

harmony is obtained at one time, under serialism, starting from an input up to the final destination of convergence there appear multiple local optima through the intermediate stages of Gen and Eval.

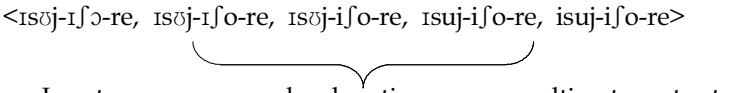
Adopting the case of dominant/recessive [ATR] harmony in Maasai (McCarthy 2009:33) in which an affix vowel affects the root vowel as illustrated in (10), let us take into account how serialism in VH can be realized as schematized in (11).

(10) Dominant/recessive [ATR] harmony in Maasai



'wash-INTRANS-APPL'

(11) Harmony improvement under gradualness



Input local optima ultimate output

From the input, the leftmost candidate, to the ultimate output, the rightmost candidate, the harmonic feature [ATR] spreads step-by-step through the Gen-Eval loop. Here note that, due to gradualness, each local optimum resulting from the preceding pass of Gen and Eval becomes an input for the next Gen-Eval as verified in (11). The exemplary tableau in (12) indicates that the ultimate output can be created via the iterative courses of Gen and Eval.[9)]

9) Note that Share(F) (McCarthy, 2009) in serial OT goes along with feature privativity hypothesis in which privative features present contrasts by their presence or absence. As argued in previous literature (Steriade, 1995; Trigo, 1993), no languages spread [-nasal] but [+nasal] frequently spreads. Also, Lombardi (1991) proposes privative laryngeal features and Steriade (1995) extends privativity to the feature [round]. Also notice that, as fully discussed in McCarthy(2009:2), Share(F) replaces the pro-spreading markedness constraint like local Agree or long distance Align which causes various pathological problems (first identified by Wilson, 2003, 2004, 2006). See Lee (2013:299) for the detailed argument for the necessity of Share(F) contrary to Agree or Align adopted in parallel OT.

(12) Iterative [ATR] spreading (McCarthy 2009:34)

/ɪsʊ̈j-ɪʃɔ-re/	Sh[ATR]	Id $(ATR)_{rt}$	Id (ATR)	Init (ATR)	Fin (ATR)
☞a. isuj-iʃo-re		2	4	1	
b. ɪsʊ̈j-ɪʃɔ-re	4 W	L	L	L	

The top-ranked harmony-inducing constraint Share[ATR] motivates [ATR] spreading to the neighboring vowels over a morpheme boundary. Do not be confused with the tableau in (12) where all the intermediate steps in propagating the harmonic feature [ATR] to one vowel at a time are conflated together here, instead of displaying each pass of Gen and Eval as separately arranged in (11). Therefore, under the crucial ranking of Share[ATR] over Id(ATR), the output in (12a) finally becomes the winner with the maximal [ATR] harmony.

Suppose that the winner in (12a) occurs without the processes of local optimality via the iterative pass of Gen-Eval, that is, from the input to the ultimate output at a time. Serial OT is not tolerant with the one-time harmony maximization under the requirement of gradualness. Here note that we necessitate the four steps of Gen-Eval from the input to the convergent point in which all the derivations terminate.

As discussed in Maasai [ATR] harmony, VH in serial OT results from the step-wise feature spreading either leftward or rightward via the intermediate steps of local optimality. Gradualness in harmony improvement is, thus, fully guaranteed.

4. Pro-serial OT Account

This section provides an OT account based upon the premises of local optimality and gradualness. In Kinyarwanda, tongue height of a root vowel determines the presence or absence of VH in suffixes. Only root mid vowels incur VH in suffix vowels. Asymmetrically, high and low vowels in root do not trigger any height change in suffixes. As argued earlier, the constraint Share(F) demands adjacent vowels to share the same [F] autosegment as adopted in (13).

(13) Share(F) (McCarthy 2009:8)
Assign one violation mark for every pair of adjacent segments that are not linked to the same token of [F].

Given the fact that root mid vowels /e/ and /o/ trigger height harmony to the following suffix vowels in Kinyarwanda, Share[High] is responsible for the root-dominant height agreement as posited in (14).

(14) Share(High)(=Sh(Hi))
Assign one violation mark for every pair of adjacent vowels that are not linked to the same token of [high].

The harmony-inducing constraint Sh(Hi) guarantees the feature [high] propagation from a root to the suffixes step-by-step under gradualness, which, in turn, incurs the violation of Id(Hi) posited in (15) since all the suffix high vowels become lowered via height agreement.

(15) Ident(High)(=Id(Hi))
A segment in the input must have the same specification for [high] as its corresponding segment in the output.

With the ranking of Sh(Hi) sitting over Id(Hi), let us first take a look at the data in (5), here simplified, as in (16).

(16) Root-to-suffix height harmony

/ku-kor-ir-a/	[gukorera]	'to work for'
/ku-root-ir-a/	[kurootera]	'to dream for/at'
/ku-geend-iish-a/	[kugeendeesha]	'to make go'
/ku-rer-ik-a/	[kurereka]	'to be educatable'

Given the tableau in (17), Sh(Hi) induces height agreement from a root to the suffixes.[10)]

10) As will be discussed later, Sh(Hi) and Id(Hi) in (17) will be revised into Sh(Hi)-J_{sfx} and Id(Hi)-J_{sfx}, respectively.

(17) Left-to-right VH

Step 1

/ku-kor-ir-a/	Sh(Hi)	Id(Hi)
a. ku-kor-ir-a	1 W	L
☞b. ku-kor-er-a		1

At Step 1, (17b) fares better with height harmony in suffix, which is yielded again and stands as the ultimate output at Step 2, not full-fledged here, since no further [high] propagation is possible.

As argued above, in Kinyarwanda where prefixes are dull in VH, the potential candidate like *[ko.ko.re.ra] is not valid at all. To limit the leftward [high] spreading from a root and to achieve unidirectional feature spreading, Share(Hi) needs to be subdivided into two, that is, Share(Hi)-Juncture suffix and prefix, following Kimper(2011) (also Smolensky, 2006, and others), as adopted in (18).

(18) Share(Hi)-Juncture(root, affix)

a. Share(Hi)-J(root, suffix)(=Sh(Hi)-J_{sfx})
   Assign a violation mark for every pair of segments S_i and S_j that are not linked to the same token of [high], where S_i is [high]'s head and S_j belongs to a suffix.

b. Share(Hi)-J(root, prefix)(=Sh(Hi)-J_{pfx})
   Assign a violation mark for every pair of segments S_i and S_j that are not linked to the same token of [high], where S_i is [high]'s head and S_j belongs to a prefix.

In conformity with the constraints posited in (18), Id(Hi) is demarcated into juncture suffix and prefix as well. Note that (18b) is bottom-ranked in hierarchy, but Id(Hi)-J_{pfx} is undominated, thus blocks the leftward [high] spreading. Therefore, no height harmony is witnessed in prefixes.

One step further, the surface-unattested candidate like *[ku.ku.ri.ra] is filtered out, too due to the undominated positional faithfulness constraint like $Id(Hi)_{root}$ as employed in (19).

(19) Ident(Hi)$_{root}$ (=Id(Hi)$_{rt}$)(McCarthy, 2009)[11]

A root segment in the output and its correspondent in the input must have the same specification for [high].

As stated in (19), given the preferential faithfulness to roots over affixes, no height change in root itself is permitted at all. Here returning to the tableau in (17), we see that featural identity in both prefix and root should be preserved in Kinyarwanda, thus (17b) stands as the ultimate output.

In serial OT, VH is not a one-time process of harmonic-feature spreading from a trigger to the adjacent target over a morpheme boundary. Given the data in (20)(also repeated in (7) above), VH results from the iterative courses of feature spreading until no further segment is left or there appears a segment with an incompatible feature specification.

(20) Iterative height harmony

/ku-geend-ir-ir-a/	[kugeenderera]	'to visit'
/ku-kor-iish-ir-iz-a/	[gukoreeshereza]	'to work for with'
/ku-ßon-ik-ir-a/	[kußonekera]	'to appear to'

To obtain the progressive VH rightward, we still put Sh(Hi)-J$_{sfx}$ ranked over its Ident counterpart as illustrated in (21).[12]

11) Regarding the key role of (19) above, in Shona, as one of the Bantu languages, the change of the root-initial vowel height is intolerant. As argued in Beckman(1997:14), the positional faithfulness constraint like Ident-$\sigma_{1(Hi)}$(=A segment in the root-initial syllable in the output and its correspondent in the input must have identical values for the feature [high].) entirely bars *[pir] from the input /per-/ 'end'.

12) Due to space limit and for neat configuration, all prefixes not participated into VH are omitted from the tableaux. Note again that height harmony in prefixes is surface-unattested in Kinyarwanda since the undominated constraint Id(Hi)-J$_{pfx}$ disfavors any height change in prefixes.

(21) Iterative VH in serial OT

Step 1

/-kor-iish-ir-iz-a/	Sh(Hi)-J_{sfx}	Id(Hi)-J_{sfx}
a. kor-iish-ir-iz-a	1 W	L
☞b. kor-eesh-ir-iz-a		1

Step 2

/-kor-eesh-ir-iz-a/	Sh(Hi)-J_{sfx}	Id(Hi)-J_{sfx}
c. kor-eesh-ir-iz-a	1 W	L
☞d. kor-eesh-er-iz-a		1

Step 3

/-kor-eesh-er-iz-a/	Sh(Hi)-J_{sfx}	Id(Hi)-J_{sfx}
e. kor-eesh-er-iz-a	1 W	L
☞f. kor-eesh-er-ez-a		1

From the exemplary tableaux above, we see that the step-wise harmonic feature propagation causes the suffix vowels to become mid step-by-step via the Gen-Eval loop. Therefore, all the intermediate steps of high vowel lowering characterize local optimality up to the convergent point where the latest input in (21f) is merged into the latest output of Eval at Step 4, not fully displayed here. At this point, all height agreement is complete with no further harmonic improvement.

Here suppose that both [high] and [round] features propagate from a root vowel /o/ to the target vowels in suffixes. It makes the high front target vowel mid-round [o] but this possibility is entirely banned due to the top-ranked feature cooccurrence constraint, *RoLo, as adopted in (22).[13)]

13) Some might say that Id[Ro] can replace the role of *RoLo. In fact, this is not true. When the root vowel is the mid-back vowel /o/ followed by a suffix starting with the high back vowel /u(u)/ as in the stativizer morphemes, -uk- and -ur- or the reversive morphemes, -uuk- and -uur-, the suffix vowel lowers to be [o(o)] (Kimenyi 1979:30). Id[Ro] is fully satisfied no matter what the suffix vowel /u(u)/ changes to [o(o)] or not. Rather, *Hi along with Sh(Hi)-J_{sfx} motivates the change of /u(u)/→[o(o)]. Therefore, for both cases where the suffix vowel starts with the high front vowel as well as the high back vowel, *RoLo is indispensible. Note that this paper does not touch upon the case where VH is not iterative. In Kinyarwanda, unlike the suffix with /i(i)/, any suffix starting with /u(u)/ is not additionally attached to the root with /o/.

(22) *RoLo (Kaun 1995:144; Beckman 1997:24)
Vowels should not be simultaneously specified [+round] and [-high].

*RoLo sitting over Share constraint militates against the appearance of mid-round [o] in suffixes, thus requiring the mid-front [e], instead as clarified in the data of [kußonekera] from /ku-ßon-ik-ir-a/ 'to appear to'. In this regard, root mid vowels, no matter what they are front or back, spread their height only to the target vowels, leaving behind their roundness. Therefore, with the pivotal role of *RoLo, the invalid candidate like *[kußonokora] is entirely filtered out in Kinyarwanda.

Now let us move onto the case where root high vowels /i/ and /u/ do not trigger VH, thus no height harmony is found in suffixes. The data are repeated, simplified a bit, here in (23).

(23) High vowel (/i/ & /u/) transparency in VH

/ßa-a-n-tsiik-ye/	[ßaantšiitse]	'they ran away from me'
/ßa-tuur-ye/	[ßatuuye]	'they live'

Unlike root mid vowels, as witnessed in (23), the suffix vowels remain intact without their height change. As fully discussed above, if a target vowel changes its height via harmony, thus becomes [i], it goes against the strength hierarchy of vowels. Therefore, there appears no height change in suffixes.

With respect to the lack of height harmony in (23), we see that Share constraint cannot block any height change in suffixes. This means that an independently motivated markedness constraint like *High is essential to prohibit the change of mid to high.

(24) *High(=*Hi):
Avoid [+high, -low].

Since *Hi is ranked over Share, the height change in suffixes is doomed to add more *Hi violation. Therefore, the root-controlled height harmony is not enforced in suffixes. Here note that, though *Hi is ranked high, the positional faithfulness constraint Id(Hi)rt guarantees no height change in root itself under

the crucial ranking of Id(Hi)rt >> *Hi. This is well elaborated from the tableaux in (25).

(25) High vowel transparency in VH

(i) With a high-front root vowel

/-tsiik-ye/	$Id(Hi)_{rt}$	*Hi	*Ro Lo	Sh(Hi)-J_{sfx}	Id(Hi)-J_{sfx}
a. tsiik-yi		2 W		L	1 W
☞b. tsiik-ye		1		1	

(ii) With a high-back root vowel

/-tuur-ye/	$Id(Hi)_{rt}$	*Hi	*Ro Lo	Sh(Hi)-J_{sfx}	Id(Hi)-J_{sfx}
a. tuur-yi		2 W			1 W
☞b. tuur-ye		1		1	
c. tuur-yo		1	1 W	1	
d. tuur-yu		2 W			1 W

The tableaux above are self-explanatory. As fully discussed in the strength hierarchy given in (6) and under the viewpoint that VH is sort of a weakening process, the change of [mid] to [high] is not favored. Rather, preserving original height, i.e., mid /e/, is much preferred to turning into [i]. Therefore, root high vowels do not demand height agreement in suffixes. No matter what the root vowel is high front (as in (25ib)) or high back (as in (25iib)), the suffix vowels reject their height change. Furthermore, the potential candidate like (25iic) is ruled out due to the fatal violation of *RoLo. Here, as clearly evidenced, root vowels propagate their height to the target vowels while their roundness is left behind.

Finally, the data in (26) tell us that target vowels do not experience any height change, either when the root vowel is /a/.

(26) Low vowel /a/ neutrality

/ku-sas-a/	[gusasa]	'to make bed'
/ku-sas-iish-a/	[gushashiisha]	'to cause to make the bed'
/ba-ra-saaz-ye/	[barashaaže]	'they are old'

To include the data in (26) into the current OT analysis, we need one more faithfulness constraint like Ident[Low] ranked over Share, as postulated in (27).

(27) Ident(Low)(=Id(Lo))
A segment in the input must have the same specification for [low] as its corresponding segment in the output.

(28) With the vital role of Id(Lo)
Step 1

/-sas-iish-a/	$Id(Hi)_{rt}$	Id(Lo)	*Hi	*RoLo	$Sh(Hi)\text{-}J_{sfx}$	$Id(Hi)\text{-}J_{sfx}$
☞a. sas-iish-a			1		1	
b. sas-aash-a		1 W	L		L	1 W

As apparently proved in (28), the top-ranked Id(Lo) picks out the ill-formed output in (28b) in which height agreement unnecessarily happens in suffix. Therefore, the winner in (28a) with no height change is yielded again and convergent to the recent most output of Eval at Step 2.

Thus far, it has been highlighted that height harmony in Kinyarwanda verbal morphology is realized in a local and gradual mode. Suffix vowels, thus, agree to the root [high] feature one by one up to the point where harmony improves maximally. In Kinyarwanda, only mid vowels in verbal root trigger VH in suffixes, which means that first, VH is unidirectional since the leftward spreading is not allowed and that, second, compared to root mid vowels, both root high vowels and low vowels show asymmetric behavior in VH. The former is transparent in VH while the latter is neutral in VH, thus height harmony totally lacks in suffixes.

5. Conclusion

Given the viewpoint that VH is an assimilation via feature spreading either leftward or rightward and under the architecture of harmonic serialism, this paper has shown that VH can be accounted for by two major principles of local

optimality and gradualness. A step-wise harmonic feature sharing from a trigger to the target generates each local optimum, which, in turn, is fed back into the next pass of Gen and Eval. This local optimality enables harmony to increase gradually and ends at the convergent point in which the latest input of Gen and the most recent output of Eval are entirely identical.

In Kinyarwanda verbal morphology, a stem consists of a root preceded by prefixes and followed by suffixes to stand as a full word. As witnessed, prefixes do not undergo VH, thus only suffix vowels are the target to VH. Root mid-vowels /e/ and /o/ propagate their height to the target vowels, resulting in height agreement in suffixes. Therefore, suffix high vowels /i/ and /u/ surface as [e] under Sh(Hi)-J_{sfx} >> Id(Hi)-J_{sfx}. However, the feature cooccurrence constraint *RoLo prefers the change of [e] from /u/ to that of [o], which implies that height harmony in Kinyarwanda is not accompanied by roundness.

Furthermore, given the preferential faithfulness to roots over affixes, root vowels are robust in VH, thus not affected but trigger harmony over a boundary since Id(Hi)$_{rt}$ is top-ranked along with Id(Lo) and Id(Hi)-J_{pfx}. In the meanwhile, height harmony in suffixes is entirely banned when a root vowel is high and low. This is attributed to the fact that no height change in suffixes better satisfies the markedness constraint and featural identity constraint. As such, tongue-height harmony in Kinyarwanda verbal morphology is well couched into OT based upon serialism and further, VH is realized locally and gradually via the Gen-Eval loop.

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