1. Introduction

(1) Opacity in coronal harmony
- Opacity in coronal harmony is rare. Sanskrit’s Nati is the only previously reported case of which we are aware.
- Our study documents opacity in the coronal harmony of Kinyarwanda, a Bantu language spoken in Rwanda.
- Our research finds that Kinyarwanda’s harmony involves retroflexion, rather than an alveo-palatal articulation as described in previous studies.
- Our investigation also reveals that Kinyarwanda’s coronal harmony is sensitive to morphological conditions.

(2) Kinyarwanda coronal harmony
- Harmony has the potential to operate across intervening Cs and Vs (2a).
- However, certain sounds, such as coronal stops, are opaque to harmony (2b).

a. /sákuz- + i-e/ → [sákuțe] "to shout+ perf."

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b. /zituz- + i-e/ → [zituțe]. "to cause someone to detach + perf."

Note: The perfective suffix /+i-e/ causes a stem-final alveolar fricative to become retroflex (see also below, the agentive suffix /-i/).

(3) Chief points
a. Basic properties of Kinyarwanda retroflex harmony and its analysis.
b. Comparison with Sanskrit’s retroflex harmony (Nati).
c. Patterns of coronal harmony with the long causative suffix -iिः(िः)- in Kinyarwanda, with comparison to Kirundi.
d. Theoretical implications of coronal opacity for the understanding of consonant harmony in general.

2. Kinyarwanda data – basic facts

(5) Coronal and palatal consonants in Kinyarwanda

<table>
<thead>
<tr>
<th></th>
<th>Alveolar</th>
<th>Pre-Palatal</th>
<th>Palatal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stops</td>
<td>t d</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affricates</td>
<td>ts</td>
<td>tʂ</td>
<td></td>
</tr>
<tr>
<td>Fricatives</td>
<td>s z</td>
<td>s ʐ</td>
<td></td>
</tr>
<tr>
<td>Nasals</td>
<td>n</td>
<td>p</td>
<td></td>
</tr>
<tr>
<td>Liquids</td>
<td>ŋ</td>
<td>j</td>
<td></td>
</tr>
</tbody>
</table>

- Prenasalized singleton segments also occur.
- Non-coronal consonants: [B b m f v pf k g w h (p)]

(6) Vowel inventory:
5 phonemes [i e a o u], with length and high / low tone opposition. The high tone is marked with an acute accent; the low tone is not marked.

(7) Canonical structure of inflected words in Bantu

<table>
<thead>
<tr>
<th>CV- prefix</th>
<th>CVC- VC-</th>
<th>V final morph</th>
<th>Inflectional stem</th>
</tr>
</thead>
<tbody>
<tr>
<td>prefix</td>
<td>root suffix</td>
<td>Derivational stem</td>
<td>word</td>
</tr>
</tbody>
</table>

(for detailed analysis, see Downing 1999a and Hyman 2002)
(8) Kinyarwanda coronal harmony:
- Triggers are /s/z,
- Operates regressively,
- (Audible) targets are s/z.
- Interacting fricatives may disagree in voicing.
- Intervening vowels and consonants are perceived as unaffected.

a. -sáaz- + i-e  → [siaže], *[siaže] "become old + perfective"
b. -tūuz- + i-e  → [tūuze], *[tūuze] "fill + perfective"
c. -sas- +i-e  → [saše], *[saše] "make the bed + perfective"
d. -soo’z- +i-e  → [soo’zej], *[soo’zej] "be hungry + perfective"
e. -baaz- +ii-  → [baaziša], *[baaziša] "plane (woodwork) + perfective"

(9) Retroflex harmony, rather than palatal harmony
- Our preliminary investigation shows that triggers of coronal harmony in Kinyarwanda are phonetically characterized by retroflexion (cf. Kimenyi 1979).
- Articulatory observation conducted in two adult native speakers, and preliminary acoustic analysis.
- The spectrograms of the pre-palatal fricatives in (11), based on speech of a male native speaker, display the characteristics of retroflex sounds.

(10) Observations

a. In spectrograms in (11), the second and third formants (F2, F3) for the long V [a] in [gaazè] and [gaasã] show convergence.
- According to Hamann (2003), transitions from vowels into consonants for retroflexes show some distinct lowering of F3, and mid to high F2 depending on vowel context.
- The lowered trajectory of F3 appears as the most distinctive acoustic feature of retroflex articulation (Hamilton 1996 on Australian Aboriginal languages; Ohala & Ohala 2001 on Hindi retroflex stops; see Hamann 2003 for an overview).

b. F3 and F4 for the long V in [gaazè] and [gaasã] appear to be relatively lower than those for [a] in [gaasa] and [gaazã], which show a rising orientation.


(11) Spectrograms of sibilants z/z, s/s:

(12) Proximity effects – basic pattern
- Harmony is obligatory in adjacent syllables (see 12a–c).
- Harmony is optional in non-adjacent syllables (see 12d–g).

a. -soo’z- + i  → [soo’zej], *[soo’zej] "victim of famine"
b. -sas- + i  → [saš], *[saš] "bed maker"
c. -siiz- + i-e  → [siiže], *[siiže] "level off + perf."

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d. -zímagiz- +i-e  → [zímagíże] ~ [zímagíže] "mislead + perf"
e. -sákaz- +i-e  → [sákaz], *[sákaz] "make open largely one's mouth + perf."
f. -sákuz- +i-e  → [sákuz], *[sákuz] "shout + perf."
g. -sakaaz- +i-e  → [sakaaze] ~ [sakaaze] "cover (the roof) with + perfective"
- (The special patterning of causative [i-i-g-(i-)] will be addressed in §5).
(13) **Palatals and coronal stops are opaque to coronal harmony**

- A property overlooked by previous descriptions of Kinyarwanda.
- Confirmed by direct investigation with native speakers.
- Also supported by data from the reference dictionary of Kinyarwanda (Jacob 1983-1986).

| a. -síitaaz- +i-e | [sítáaže], *[sítáaže] | "make stub + perf." |
| b. -zíjaaz- +i-e | [zíjaáže], *[zíjaáže] | "bec. warm (liq.) + perf." |
| c. -sáa’dáaz- +i-e | [sáa’dáaže], *[sáa’dáaže] | "make explode + perf." |
| d. -zíg-an+i + iže | [zígáníže], *[zígáníže] (n+i → [n’]) | "economize + perf." |
| e. -súnaak+i + iže | [súnaákikže], *[súnaákikže] | "show furtively + perf." |
| f. -sóoook+i + iže | [sóóookikže], *[sóóookikže] | "make move slowly + perf." |

Note: In some contexts with an underlying suffix /-i/, the perfective aspect is rendered by the allomorph [-iže].

(14) **The liquid /t/ is neutral (neither triggers nor blocks)**

| a. -togošez+ i-e | [togošereže], *[togošereže] | "make boil for / at + perf." |
| b. -seču- i-e | [sečuz], *[sečuz] | "provoke, irritate + perf" |
| c. -zi- | [zi], *[zi] | "be forbidden (taboo)" |
| d. -so- | [so], *[so] | "pay tax" |

(15) **Spectrogram of [t]**

- Kinyarwanda's liquid /t/ displays characteristics of retroflexion:

(16) **Observations**

- F3 and F4 in [aa] appear to be overall lower in [gaaʔa] (in (15)) than in [gaasa] and [gaaza]. Also, they do not show a rising orientation observed with F3 and F4 in [gaasa] and [gaaza].
- The acoustics of [aa] before [t] is suggestive of retroflexion in the latter (see general observations in (10)).

(17) **Affricates do not participate in coronal harmony**

- [ts] does not undergo harmony, i.e. it acts like a stop (17a–b).
- [t] is absent in triggering contexts (it is rare in post-initial position).

| a. -tsii”baqaz- + i-e | [tsii”baqáže], *([tsii”baqáže] | "cause to be obstinate + perf." |
| b. -tsitsimu- + i-e | [tsitsimuže], *([tsitsimuže] | "make drink slowly + perf." |

(18) **Coronal harmony does not affect prefixes**

- Kinyarwanda sibilant harmony applies only within the stem (see word structure in (7)).

| a. zi- + sáaz- + i-e | [zišáaže], *[zišáaže] | prefix cl.10 + "bec. old + perf." |
| b. zi- + z- + i-e | [ziže], *[ziže] | prefix cl.10 + "come + perf." |
(19) Summary
a. Kinyarwanda’s coronal harmony operates regressively among sibilants in the stem.
b. It involves retroflexion, rather than (alveo-)palatalization.
c. Intervening vowels and non-sibilant consonants are not perceptibly affected.
d. Coronal stops and palatals are opaque. The alveolar affricate does not undergo harmony.
e. The retroflex liquid is neutral in the harmony system.
f. Harmony in adjacent syllables is obligatory.
g. Harmony extending to non-adjacent syllables is optional.

3. Analysis – basic pattern
3.1 Diagnosing the assimilation structure
(20) The [retroflex] feature
• Assumption: The assimilation involves the privative feature [retroflex] (after Ní Chiosáin & Padgett 1997; note also Gafos 1998).
• [Retroflex] is phonetically realized as a tongue-tip/blade orientation.
• We assume phonological feature representations here, but do not rule out a gestural alternative (e.g. Flemming 1995a, Gafos 1998).


(21) Feature Spreading
• Coronal harmony results from feature spreading (or gestural extension) that carries through articulatorily adjacent segments (see (22) below).

(22) Feature Spreading Approach
\[ \text{Spreading feature carries through all segments intervening between trigger and target, but it is not perceived by speakers on segments characterized as “transparent”.} \]
(23) Feature Agreement
• Coronal harmony results from feature matching in segments that stand in a correspondence relation which is established between similar segments (see (24) below).
• Intervening segments do not participate in the process—they are unaffected in both perceptual and articulatory terms.
• Other consonant harmonies are also posited to arise via feature agreement (e.g. for laryngeal features, [nasal], dorsal harmony, etc.).

(24) Feature Agreement Approach
\[ \text{Feature Agreement} \]

(25) Blocking: A point of departure between the two approaches
a. Feature Spreading
  - Potential for opacity effects. Harmony is blocked by segments that cannot undergo spreading. Factors: articulatory compatibility, contrast.
b. Feature Agreement
   - Intervening segments will not show blocking effects, because they do not participate in harmony.

Kinyarwanda’s coronal harmony shows blocking
• Recall that coronal stops and palatals block harmony.
  [zitusge] ‘to cause someone to detach (perf.)’
  [zijaazge] ‘become warm (liquid) (perf.)’
> Kinyarwanda’s opacity effects therefore diagnose it as a Feature Spreading harmony.

3.2 A Spreading-based Account of Kinyarwanda’s Retroflex Harmony

The spreading constraint
• Operates within specified domains.
• Adapted with some changes from Ní Chiosáin & Padgett (1997) on Sanskrit.

(27) \( \text{SPREAD-L-DOMAIN-(retroflex)} \)
Any [retroflex] feature associated to a [–sonorant, +continuant] segment \( S_j \) is also associated to any [–sonorant, +continuant] segment \( S_i \) that precedes \( S_j \) in a given domain.\(^3\)

Trigger asymmetry:
Retroflex fricatives /\( s \)/ /\( z \)/ trigger harmony but not retroflex /\( t \)/.
> Fricatives alone trigger harmony because retroflexion is contrastive in only these segments: /\( s \)/ /\( s \)/ /\( z \)/.
Related findings:
- Round harmony systems serve to make distinctive feature specifications more easily perceptible (Kaan 1995).

Obligatory harmony in adjacent syllables
• Ex. [\( s\text{-a} \)], * [\( \text{s\text{-a}} \)] ‘bed maker.’
• Two constraints at play.

(29) \( \text{SPREAD-L-ADJ-(retroflex)} \)
Any [retroflex] feature associated to a [–son, +cont] segment \( S_j \) is also associated to any [–son, +cont] segment \( S_i \) in an adjacent syllable that precedes \( S_j \) in the stem.
> Version of \( \text{SPREAD-L} \) requiring that [retroflex] spread to an adjacent syllable.

Processes limited to adjacent syllables or consonants separated by no more than a vowel in other work:
- OCP effects characterized as restricted to segments separated by only a mora (“syllable adjacency”) (e.g. Yimas, Dahl’s Law in Bantu, Meeussen’s rule in Bantu; Odden 1994, Suzuki 1998) or only a vowel (“consonant adjacency”) (Tigre, Tigrinya; Rose 2000). Whether adjacent syllables constitute a “domain” requires further investigation. Nevertheless, a window of adjacent syllables is evidenced in proximity effects in various languages.

(30) \( \text{IDENT-OI(retroflex)} \)
Let \( \alpha \) be a segment in the input and \( \beta \) be any correspondent segment of \( \alpha \) in the output. If \( \beta \) is [retroflex], then \( \alpha \) is [retroflex].
> Prohibits segments that gain a [retroflex] feature. (IDENT-OI(F) after Pater 1999.)

Constraint ranking
(31) \( \text{SPREAD-L-ADJ-(retroflex)} \gg \text{IDENT-OI(retroflex)} \)
• Accomplishes obligatory harmony in adjacent syllables.

(32) Obligatory harmony in adjacent syllables:
\[
\begin{array}{|c|c|c|}
\hline
\text{/s\aaz+i-e/} & \text{SPREAD-L-ADJ-(retro)} & \text{IDENT-OI(retro)} \\
\hline
\text{a. \( \text{s\aaz} \)} & \ast & \ast \ast \ast \\
\text{b. \( \text{s\aaz} \)} & \ast & \ast \\
\hline
\end{array}
\]

\(^{3}\) Alternative formulations using ALIGN (Kirchner 1993), NO-INTERVENING (Zoll 1998), AGREE (Bakovic 2000) or *A-S\text{-SPAN} (McCarthy 2004) are conceivable. There might well be reason to choose among them, but this is beyond the scope of our present focus.
Optional harmony extending to non-adjacent syllables

- Ex. [zímagiže] ~ [dímagiže] ‘mislead + perf.’

(33) **SPREAD-L-STEM-(retroflex)**

Any [retroflex] feature associated to a [+son, +cont] segment \( S_j \) is also associated to any [+son, +cont] segment \( S_i \) that precedes \( S_j \) in the stem.

(34) **SPREAD-L-STEM-(retro) and IDENT-OI(retro) are variably ranked**

- Accomplishes optional harmony that extends across multiple syllables.

(35) **Variable ranking**

- A constraint with a much higher ranking value than another will effectively always dominate, e.g. in obligatory harmony in adjacent syllables.
- Two constraints with close ranking values will vary in their ranking. This is the case for **SPREAD-L-STEM-(retro) and IDENT-OI(retro)**.

(36) Harmony extending to non-adjacent syllables:

```
<table>
<thead>
<tr>
<th>/sákuz+i-e/</th>
<th>SPREAD-L-STEM-(retro)</th>
<th>IDENT-OI(retro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. šākužé</td>
<td></td>
<td>****</td>
</tr>
<tr>
<td>b. šākužé</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>
```

(37) Absence of harmony extending to non-adjacent syllables:

```
<table>
<thead>
<tr>
<th>/sákuz+i-e/</th>
<th>IDENT-OI(retro)</th>
<th>SPREAD-L-STEM-(retro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. šākužé</td>
<td>*</td>
<td>***</td>
</tr>
<tr>
<td>b. šākužé</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>
```

**Opacity effects**

- Ex. [šiťaažé], *[šiťaažé] ‘make stub + perf.’

(38) **Markedness constraints**

a. *[retro]/CORSTOP: No retroflex coronal stops.

b. *[retro]/PAL: No retroflex palatals.


**Constraint ranking**

- Coronal stops and palatals never undergo harmony; hence the constraints in (38) dominate [retroflex] spreading constraints, as in (39).

b. The markedness constraints in (38) will also function in the grammar to enforce the lack of contrastive retroflex coronal stops and palatals.

(39) **Retroflex harmony ranking**

```
*{retro}/CORSTOP, *{retro}/PAL

SPREAD-L-STEM-(retro), (SPREAD-L-STEM-(retro))

IDENT-OI(retro)
```

(40) Blocking by a coronal stop

```
<table>
<thead>
<tr>
<th>/šiťaaž+i-e/</th>
<th>*[retro]/CORSTOP</th>
<th>SPREAD-L-STEM-(retro)</th>
<th>IDENT-OI(retro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. šiťaažé</td>
<td></td>
<td>*</td>
<td>****</td>
</tr>
<tr>
<td>b. šiťaažé</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>
```

(41) **Summary – Analysis**

- Harmony is accomplished via feature spreading.
- The spreading [retroflex] feature carries through intervening vowels and consonants but is not perceived on segments described as “transparent”.
- Retroflex fricatives trigger harmony but not the retroflex liquid, because retroflexion is contrastive only in fricatives.
- A regressive spreading constraint requiring harmony in adjacent syllables drives obligatory harmony in this context.
- A spreading constraint operating in the stem domain is variably ranked with IDENT-OI(retro) to produce optional harmony over longer distances.
- Blocking results from markedness constraints that prohibit retroflex coronal stops and palatals.

**Further issues**

Kinyarwanda’s coronal harmony and its analysis clearly provoke a number of issues for further research. See §6 for discussion.
4. Sanskrit: A Second Coronal Harmony System with Blocking

- Sanskrit’s retroflex harmony (Nati) is the only other coronal harmony of which we know that shows blocking.

(42) **Coronal and palatal consonants in Sanskrit** (after Gafos 1998)

<table>
<thead>
<tr>
<th>Dental</th>
<th>/tʰ d dʱ s n l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retroflex</td>
<td>/ʈʰ ɖ ɖʱ ʂ ʐ r t̚</td>
</tr>
<tr>
<td>Palatals</td>
<td>/c cʰ j jʰ j̚ j̚/</td>
</tr>
</tbody>
</table>

(43) **Basic facts – Sanskrit nasal retroflexion harmony**

Retroflexion illustrated in nominal and adjectival suffix –ana, (cf. data in (43b)) (Whitney 1889).

- Triggers are [ʂ r t̚].
- (Perceptible) target is /n/.
- Intervening vowels and consonants are not (perceptibly) affected.
  a. rakṣaṇa ‘protection’
  kṛpana ‘miserable’
  ākramaṇa ‘striding’
  kṣajaṇa ‘habitable’
  b. varthaṇa ‘increase’
  rocana ‘shining’
  vṛjana ‘enclosure’
  cēṣana ‘stirring’

- Opaque segments are all coronal and palatal consonants (except /j/).

(44) **Analytical highlights**

- The spreading feature continues through intervening segments, but its production is not perceived on transparent consonants and vowels.
- Intervening dentals are opaque because spreading [retroflex] to them would neutralize a contrast. Palatals (except /j/) block because they are incompatible with [retroflex]. (E.g. Ní Chiosáin & Padgett 1997, Gafos 1998.)

(45) **Trigger and targets**

- Continuants alone trigger retroflex harmony, because retroflexion is more acoustically salient in them vs. stops (Ní Chiosáin & Padgett 1997, Gafos 1998).
- Nasals alone are targeted, because they are more susceptible to place / retroflexion assimilation (Ní Chiosáin & Padgett 1997, Gafos 1998).

(46) **Why Sanskrit retroflex harmony involves spreading, not agreement**

(Evidence discussed by Hansson 2001; cf. also Rose & Walker)

- Shows opacity. This is not seen in any other pattern of consonant assimilation across an unaffected vowel (or across vowels and consonants).
- Does not show a similarity effect. Patterns of consonant assimilation across an unaffected vowel (at minimum) always target sounds most similar to the triggers. Inclusion of additional targets implies inclusion of any sounds that are more similar to the trigger.
- Shows progressive directionality. Patterns of consonant assimilation across an unaffected vowel (at minimum) show (a strong tendency for) regressive directionality (excluding root-controlled assimilations).
- Potentially applies at the phrasal level, across word boundaries. Patterns of consonant assimilation across an unaffected vowel (at minimum) apply within the word or a smaller morphological domain.

Points of comparison: Sanskrit and Kinyarwanda retroflex harmony

(47) Similarities
a. Assimilating feature. Both involve retroflexion assimilation.
b. Triggers. Retroflex fricatives trigger harmony (but in Sanskrit, /t/ does too).
c. Opacity. Dental/alveolar consonants and (most) palatals block harmony.

(48) Differences
a. Triggers. Triggers in Sanskrit are the continuants [s r], but in Kinyarwanda the triggers are only the fricatives [s z] (/t/ is neutral).
b. Targets. Target of Sanskrit’s harmony is /n/, which is relatively dissimilar from the triggers. Targets in Kinyarwanda’s harmony are fricatives, which are highly similar to the triggers.
c. Opaque segments.
   – Opaque dentals in Sanskrit contrast with a retroflex series. In Kinyarwanda, most blocking alveolars do not contrast with retroflex sounds.
   – The palatal glide /j/ is opaque in Kinyarwanda and transparent in Sanskrit.
d. Direction. Sanskrit’s harmony is progressive, Kinyarwanda’s is regressive.
e. Domain. Sanskrit harmony can operate across words, in Kinyarwanda it is limited to the stem.

(49) Kinyarwanda’s basic coronal harmony: typological / theoretical issues
a. Data. Revised description: retroflexion, optionality at a distance, blocking by coronal stops and palatals.
b. Triggers. Triggers for retroflex harmony may be restricted to those for which the feature is contrastive.
c. Targets. A coronal harmony resulting from feature spreading that shows an apparent “similarity effect”.
d. Opacity.
   – A second case of coronal harmony that shows opacity.
   – Coronal opacity may result from markedness (incompatibility) alone, independent of contrast.
e. Diagnostics. Apart from opacity, Kinyarwanda’s harmony is suggestive that the diagnostics for feature spreading vs. agreement in coronal harmony are not always clear cut.

5. Patterns involving the long causative formative [-iːj-(i)-]

5.1 Data: Coronality in Kinyarwanda causative forms

- The retroflex fricative in the causative suffix [-iːj-(i)-] triggers harmony only in sibilants that occur in a preceding adjacent syllable (see (50) vs. (51)).

(50) Harmony from [s] in the causative affecting an adjacent syllable.

<table>
<thead>
<tr>
<th>Data</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. -mes+iːj-(i)-</td>
<td>[meʃeːsa], *[meʃeːsa] “wash (cloth)” + caus.</td>
</tr>
<tr>
<td>b. -sāːz+iːj-(i)-</td>
<td>[səːzɪʃa], *[səːzɪʃa] “make bec. old” + caus.</td>
</tr>
<tr>
<td>c. -sas+iːj-(i)-</td>
<td>[səʃiʃa], *[səʃiʃa] “make the bed” + caus.</td>
</tr>
<tr>
<td>d. -soo’z+iːj-(i)-</td>
<td>[soo’ʃeːsa], *[soo’ʃeːsa] “be hungry” + caus.</td>
</tr>
</tbody>
</table>

Note: In (50b-d), fricatives affected by sibilant harmony in the syllable preceding [s] in the causative themselves trigger harmony in preceding fricatives.

(51) No harmony from [s] in the causative affecting a non-adjacent syllable.

<table>
<thead>
<tr>
<th>Data</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. -som+iːj-(i)-</td>
<td>[sʌmeːʃeːz], *[sʌmeʃeːz] “drink” + caus.</td>
</tr>
<tr>
<td>b. -soʃ+iːj-(i)-</td>
<td>[səʃɛʃɛʃɛ], *[səʃɛʃɛʃɛ] “pay tax” + caus.</td>
</tr>
<tr>
<td>c. -āːzi+k+iːj-(i)-</td>
<td>[aʃɛʃɛʃɛ], *[aʃɛʃɛʃɛ] “open one’s mouth” + caus.</td>
</tr>
<tr>
<td>d. -a’zɪk+iːj-(i)-</td>
<td>[a’zɛʃɛʃɛ], *[a’zɛʃɛʃɛ] “make s.o. to begin (grinding)”</td>
</tr>
</tbody>
</table>

In Kinyarwanda, suffix front vowels /i/ are realized as [e] after a root mid vowel /e, o/.

- The long causative [-iːj-(i)-] blocks harmony from a following trigger.

(52) Blocking by causative [-iːj-(i)-].

<table>
<thead>
<tr>
<th>Data</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. -som+iːj-(i)- + iːzɛ</td>
<td>[sʌmeʃɛʃɛ], *[sʌmeʃɛʃɛ] “drink” + caus. + perf.</td>
</tr>
<tr>
<td>b. -soʃ+iːj-(i)- + iːzɛ</td>
<td>[səʃɛʃɛʃɛ], *[səʃɛʃɛʃɛ] “pay tax” + caus. + perf.</td>
</tr>
<tr>
<td>c. -āːzi+k+iːj-(i)- + iːzɛ</td>
<td>[aʃɛʃɛʃɛ], *[aʃɛʃɛʃɛ] “open one’s mouth” + caus. + perf.</td>
</tr>
<tr>
<td>d. -a’zɪk+iːj-(i)-+ iːzɛ</td>
<td>[a’zɛʃɛʃɛ], *[a’zɛʃɛʃɛ] “begin (grinding)” + caus. + perf.</td>
</tr>
</tbody>
</table>

1 Coronal harmony triggered by -iːj-(i)- is optional when the target sibilant occurs in the stem-initial syllable (cf. –se+iːj-(i)- → [ʃɛʃa] ~ [ʃɛʃa], “mould” + caus).
5.2 Analysis

(54) Morphology of causative formation

a. Two formatives: short -i- and long -iïs-(i)-; same meaning.
b. Allomorph choice:
   • Morphophonology: e.g. no -i- with stem-final sibilant or monosyllabic stem.
   • Semantics: e.g. instrumental vs. active: -som+iïs-(i)- [-someesä] ‘drink with (utensil)’; -som+i+ [som³ja] ‘make s.o. drink’ (see Mpiranya 1998).
c. The long causative is morphologically complex.
   • -iïs-(i)- is composed of two morphological segments, i.e. as a discontinuous
     morpheme, because they can be separated in morphological processes. (On
     similar representations in other Bantu languages, see Hyman 1999, 2003; Bastin
   • The long causative is reconstructed in Proto-Bantu as *-iïf- (Guthrie 1967-
d. Evidence for the long causative’s final -i-.
   • Perfective form [-iïg-] follows -iïs-(i)- (see (52)). Perfective allomorph [-iïg-]
     (vs. perf. allomorph -i- e) is realized only after stems ending in underlying /l/
     (compare forms with short causative -i- in (13)).
   • Short -i- and long -iïs-(i)- both trigger spirantization from postposed -i- in
     reduplicative forms, e.g. -og-i- + iïg- → -og-iïg-iï- [õgerþal] ‘cleanse for / at’;
     -og+iïs-(i)- + iïg- → -og-ee-iïg-iï- [õgeesheeža] ‘wash with, for / at’.

(55) Proposal: A strong affix

• The long causative formative in Kinyarwanda involves a category that is
  stronger than other suffixes. For present purposes we call it a “strong-suffix.”
• It has a more robust morphological boundary that inhibits spreading into or
  out of its domain.

(56) Phonological evidence for strength of long causative [-iïs-(i)-]

a. Phonological size:
   • No other suffix in Kinyarwanda has an underlying long vowel. (Other suffixes with
     a long vowel are variants of -VC- forms and generally have emphatic connotation.)
   • Weak/absent participation in phonological processes in the stem
     • Sibilant harmony. (i) -iïs-(i)- triggers harmony only in adjacent syllables, and (ii)
       it blocks harmony from following suffixes. (See discussion above.)
     • Voicing dissimilation. Dahl’s Law in Kinyarwanda causes dissimilation involving
       obstruents: ku-šim- → [ga-šim-a] ‘congratulate’; -sőt-uni- → [sőoůka] ‘move
       slowly.’ But -iïf-(i)- does not participate: -haa-iïs-(i)- → [haahtĩqa] ‘shuck with’.

(57) Further research: Category of long causative

• In containing a long vowel, -iïs- has a prosodic size resembling a root rather
  than an affix. Moreover, its phonological weight is suggestive that it holds
  the status of a head. (For related work, see Deshers & van der Helst 1998, McCarthy
• It is conceivable that -iïs-(i)- belongs to a category-type that stands between
  a suffix and a root. (For a review of work supporting word-formations intermediate
  between derivation and compounding, see Booij 2000. Note also Matthews 1974 on
  the notion of complex roots or stems.)
• Also to explore is whether -iïs-(i)- is a root or stem, and it attaches to form a
  type of compound. The lack of sibilant harmony in other compounds requires
  scrutiny in this regard: -gu- ‘to loan’; -gu-aagu-z-e [guzugeze],
  *[guzaazuge] ‘to loan many times’ (perf.). The presence/absence of stem
  “final vowels” also needs to be considered here. (Related work includes Downing

(58) The effect of boundary strength

• CRISP-EDGE[Cat] prohibits multiple linking of phonological structure across
  the boundary of a given type of linguistic category. (For formal definitions of
(60) **Ranking**

- SPREAD-L-ADJ-(retro) >> CRISP-EDGE[strong-sfx] >> SPREAD-L-STEM- (retro)

  - Accomplishes harmony from that occurs in adjacent syllables only.

**Exemplification**

(61) Obligatory harmony from retroflex in long causative to adjacent syllable:

<table>
<thead>
<tr>
<th>/mes+iis-(i)-a/</th>
<th>SPREAD-L-ADJ-(retro)</th>
<th>CRISP-EDGE[strong-sfx]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a.</strong> meš-eey-a</td>
<td><strong>a</strong></td>
<td></td>
</tr>
<tr>
<td><strong>b.</strong> mes-eey-a</td>
<td><strong>a</strong></td>
<td></td>
</tr>
</tbody>
</table>

(62) No harmony from retroflex in long causative form to non-adjacent syllable:

<table>
<thead>
<tr>
<th>/asam+iis-(i)-a/</th>
<th>CRISP-EDGE[strong-sfx]</th>
<th>SPREAD-L-STEM-(retro)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a.</strong> ásam-iis-a</td>
<td><strong>a</strong></td>
<td></td>
</tr>
<tr>
<td><strong>b.</strong> ágam-iis-a</td>
<td><strong>a</strong></td>
<td></td>
</tr>
</tbody>
</table>

(63) Long causative form blocks harmony from a retroflex which follows it:

<table>
<thead>
<tr>
<th>/asam+iis-(i)-iz/</th>
<th>SPREAD-L-ADJ-(retro)</th>
<th>CRISP-EDGE[strong-sfx]</th>
<th>SPREAD-L-STEM-(retro)</th>
<th>IDENT-OI(retro)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a.</strong> ásam-iis-iz</td>
<td>*(s)</td>
<td>*(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>b.</strong> ágam-iis-iz</td>
<td><strong>a</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(64) **Revised ranking**

- *[retro]/CORSTOP, *[retro]/PAL

  - SPREAD-L-ADJ-(retro)

  - CRISP-EDGE[strong-sfx], (IDENT-OI(retro))

  - SPREAD-L-STEM-(retro)

    - (IDENT-OI(retro))

5.3 Cross-dialectal perspective – Coronal harmony in Kirundi

- Standard Kirundi: sibilant harmony is triggered by /ʃ, ʒ/ and targets /s, z/ in preceding adjacent stem syllables (Meessen 1959; Rodegem 1967,1988; in Nuhokaja 1994).

- In stem-initial position, sibilant harmony targets only /ʃ, z/.

- In post-initial positions, sibilant harmony in Kirundi targets both /s, z/.

(65) Regressive coronal harmony targeting stem-initial /s, z/ in an adjacent syllable

a. -sas+i- → [saše], *[saše] “extend (on flat surface)” + perfective

b. -sees+ i- → [seše], *[seše] “overturn (e.g. liquid)” + perfective
c. -sáaz+ i- → [sáazže], *[sáazže] “become old” + perfective

VERSUS

d. -zooz+ i- → [zoözže], *[zoözže] “incite + perfective

e. -ziz+ i- → [ziiziže], *[ziiziže] “persecute for”+perf. (cf. -zi-i- “avoid”+caus.)
f. -séku-z+ i- → [sékuže], *[sékuže] “make pound” + perfective

(66) Regressive coronal harmony targeting post-initial /s, z/

a. -kíz+ i- → [kížže], *[kížže] “restore to health” (perfective)
b. -úuž+ i- → [úužže], *[úužže] “fill” (perfective)
c. -bíz+ i- → [bížže], *[bížže] “ask” (perfective)
d. -tós+ i- → [tósže], *[tósže] “wat” (perfective) (cf. Nuhirageza 1993)

(67) Preservation of stem-initial /i/: Might be related to free alternation of voiced fricatives with affricates, depending on individual or dialect (Meessen 1959:11). The shift from voiced affricates to fricatives seems a relatively recent innovation in Kirundi, and, as in Kinyarwanda, affricates do not undergo coronal harmony.

- The causative suffix -ii-(i)- in Kirundi does not trigger harmony (see Meessen 1959; Nuhirageza 1993; Nuhokaja 1994).

(68) No harmony triggered by the causative suffix [-ii-(i)-]

a. -ses-iis-(i)- → [šešeša], *[šešeša] “check” + causative

b. -sáaz-iis-(i)- → [šáaziša], *[šáaziša] “become old” + causative
c. -rás-iis-(i)- → [rásšiša], *[rásšiša] “shoot” + causative
d. -sa-iis-(i)- → [šeša], *[šeša] “resemble” + causative

* According to Nuhirageza (1993: personal communication), in some varieties of Kirundi, sibilant harmony applies also in non-adjacent syllables, varying by individual and occasion.

* According to Meessen (1959), coronal harmony targeting a stem-initial fricative may apply optionally, depending on lexical items and individual speech (see also Rodegem 1967; 1988).

4
Implications for analysis – comparison with Kinyarwanda

a. Harmony distance
   - Operates only between adjacent syllables in standard Kirundi, optionally at greater distances in Kinyarwanda.
   - In Kirundi, $\text{SPREAD-L-STEM}$-(retro) has a comparatively lower ranking value such that it is regularly ranked below $\text{IDENT-OI}$-(retro).

b. Long causative -ii-(i)-
   - Does not trigger harmony in Kirundi, triggers harmony in adjacent syllables in Kinyarwanda.
   - In Kirundi, $\text{SPREAD-L-ADJ}$-(retro) has a comparatively lower ranking value such that it is regularly ranked below $\text{CRISP-EDGE}$[strong-suffix].

6. Conclusion and further issues

Summary — Some key points

a. Kinyarwanda sibilant harmony
   - Optionally extends over multiple syllables.
   - Palatal and coronal consonants are opaque.
   - It is a feature spreading harmony.

b. Distance of harmony
   - Evidence for harmony restricted to adjacent syllables.
   - Kinyarwanda’s harmony optionally operates over longer distances.

c. Morphological effects
   - Long causative form shows effects that impede harmony.
   - Phonological size of the long causative resembles that of a root.
   - Analyzed as a “strong-suffix” with morphological boundary strength that inhibits spreading across it. Further research on category-type needed.

d. Cross-linguistic comparison
   - Only other coronal harmony reported to show opacity is found in Sanskrit.
   - Kinyarwanda is the first living language with coronal harmony in which opacity has been found.
   - Kirundi sibilant harmony is weaker than Kinyarwanda’s. It operates in adjacent syllables only, and the long causative does not trigger harmony.

Further issues: Feature Spreading vs. Feature Agreement

Kinyarwanda’s coronal harmony shows some properties consistent with both the feature spreading approach and feature agreement approach, which point to directions for further research.

Nevertheless, the existence of blocking in Kinyarwanda’s harmony system remains diagnostic of feature spreading.

a. Articulation in transparent segments
   - The feature spreading analysis provokes the question whether retroflexion is truly produced in intervening segments.
   - A study underway at USC is investigating this using magnetometry (EMMA) (in collaboration with D. Byrd & S. Lee). (cf. Gafos & Benus 2003 on Hungarian).
   - If it is found that retroflexion is not held through transparent segments, there will be implications for the theory of strict locality. In that event, a possible solution would be to allow that a harmonizing feature might not be phonetically implemented on transparent segments (Ni Chiosáin & Padgett 1997).

b. An apparent similarity effect
   - Kinyarwanda’s coronal harmony shows an apparent “similarity effect” in the sense that it is (audibly) restricted to only fricatives.
   - At first blush, this suggests diagnostics of agreement-based coronal harmony vs. spreading-based are not as straightforward as previously conceived.
   - However, unlike feature agreement harmonies, Kinyarwanda’s similarity effect might result from a confluence of factors in the language including its contrast system, markedness constraints, and its harmony system.

c. Assimilation within adjacent syllables
   - The adjacent syllable domain that restricts spreading is reminiscent of proximity effects in agreement-based consonant assimilation (Hansson 2001, Rose & Walker 2004).
   - The special status of neighboring syllables, its formal characterization, and why it cross-cuts spreading-based and agreement-based assimilations, as well as OCP effects, merits further investigation.
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