

On Triggers and Opacity in Coronal Harmony*

RACHEL WALKER¹ and FIDÈLE MPIRANYA²

University of Southern California¹ and CNRS Sorbonne Nouvelle/University of Southern California²

0. Introduction

This study documents and analyzes opacity in the coronal harmony of Kinyarwanda. This harmony presents several features of interest. First, the existence of opacity in coronal harmony is rare: to the best of our knowledge it has only previously been reported in Sanskrit's nasal retroflex harmony. In Kinyarwanda the harmony audibly affects only sibilants, and it is blocked by coronal stops, palatals and the alveolar affricate, but not the coronal liquid. Our study also finds that the assimilating property in Kinyarwanda is a retroflexion articulation, rather than an (alveo-)palatal one as described in previous studies. In addition, the harmony is obligatory in adjacent syllables, but it is optional over longer spans.

We argue that Kinyarwanda's harmony involves feature spreading, rather than feature agreement by correspondence. Also, a comparison of retroflex harmony in Kinyarwanda and Sanskrit reveals how Kinyarwanda enlarges the perspective on coronal harmony systems with blocking. The organization of this paper is as follows. §1 describes Kinyarwanda's coronal harmony. In §2 we develop our analysis, and in §3 we compare Sanskrit's retroflex harmony. In §4 we discuss typological and theoretical issues and identify topics for further research.

1. Kinyarwanda Data

1.1. Phoneme Inventory and Word Structure

Kinyarwanda's inventory contains the following sets of coronal / palatal segments: alveolar [t d ts s z n], pre-palatal [tʃ ʃ z ɹ] and palatal [ɲ j]. Additional consonants are [β (b) m f v pf k g w h (p)] ([b, p] are allophones of /β, h/, respectively). Prenasalized singleton segments also occur. Kinyarwanda has five vowel phonemes [i e a o u], with length and high / low tone opposition. The high tone is marked with an acute accent, whereas the low tone is not marked.

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Inflected words in Kinyarwanda generally follow canonical Bantu structure, i.e. CV-CVC-VC-V, mapping to PREFIX+ROOT+SUFFIX+FINAL MORPHEME, with ROOT+SUFFIX corresponding to the derivational stem, and derivational stem+final morpheme corresponding to the inflectional stem (Downing 1999, Hyman 2002).

1.2. Kinyarwanda Coronal Harmony

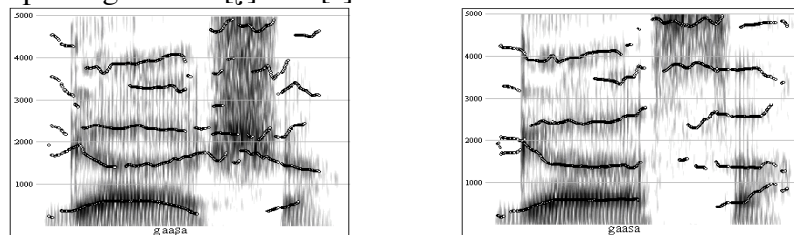
Kinyarwanda's coronal harmony is triggered by pre-palatal sibilants [ʃ z̥] and audibly affects alveolar sibilants [s z] in adjacent syllables or, optionally, in non-adjacent syllables, as shown in (1). Intervening segments are perceived as unaffected. Interacting fricatives may disagree in voicing, as seen in (1a, c). (It may be observed that the perfective suffix [-i-e] causes a stem-final alveolar fricative to become retroflex; note also agentive [-i], below). The harmony is purely regressive, e.g. -ʃit- + i-e → [ʃise], *[ʃiʃe], *[sise] 'penetrated'.

- (1) a. -sáaz- + i-e → [sáaz̥e], *[sáaz̥e] 'become old + perfective'
 b. -úuzuz- + i-e → [úuzuz̥e], *[úuzuz̥e] 'fill + perfective'
 c. -sákuz- + i-e → [sákuz̥e] ~ [ʃákuz̥e] 'shout + perfective'

The data we report present retroflex harmony rather than palatal harmony. Our preliminary investigation shows that triggers of the coronal harmony are phonetically characterized by a retroflex articulation. This is based on our articulatory observation of two adult native speakers and preliminary acoustic analysis.

In the spectrograms of the voiceless fricatives in (2), based on speech of a male native speaker for the pair [gaaʃa] / [gaasa] (cf. [gaaʃa] 'reprimand', [zaʒaasa] 'agitate s.o.'), the pre-palatal sibilant displays characteristics associated with a retroflex sound. The second and third formants (F2, F3) for [aa] in [gaaʃa] show convergence, whereas F2 and F3 diverge in [gaasa]. Also, F3 and F4 for [aa] in [gaaʃa] appear to be lower overall than in [gaasa], and F3 in [gaasa] shows a rising orientation. We have observed a similar contrast between the voiced pre-palatal sibilant and alveolar sibilant (a spectrogram of [gaaza] is given in (7)).

(2) Spectrograms of [ʃ] and [s]



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. More generally, lowering of F3 appears to be the most stable and distinctive acoustic feature of retroflex articulation, as was shown by Hamilton (1996) for Australian languages and Ohala and Ohala (2001) for Hindi retroflex

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stops (see Hamann 2003 for a review of the related literature).

An important property of Kinyarwanda's coronal harmony is that it displays a proximity effect. In particular, harmony is *obligatory* between sibilants in adjacent syllables (see 3a-b) but *optional* in non-adjacent syllables (see 3c-d).¹

- (3) a. -sooⁿz- + i → [ʃooⁿzi], *[sooⁿzi] 'victim of famine'
 b. -sas- + i → [ʃaʃi], *[saʃi] 'bed maker'
 c. -zimagiz- + i-e → [zimagize] ~ [ziⁿmagize] 'mislead + perf.'
 d. -ásamuz- + i-e → [ásamuze] ~ [áⁿsamuze] 'open mouth + caus. + perf.'

An especially notable characteristic is that coronal stops and palatals are opaque to the coronal harmony, as shown in (4). This property was overlooked by previous descriptions (see, e.g., Kimenyi 1979, Coupez 1980). Nevertheless, it has been confirmed by our direct investigation with native speakers and is supported by data from Kinyarwanda's reference dictionary (Jacob 1983-1986). (In these and later data, it may be observed that in certain contexts the perfective aspect is expressed by the allomorph [-ize] when it occurs with an underlying causative suffix -i-; also /n+i/ → [ɲ]).

- (4) a. -sítaaz- + i-e → [sítaaze], *[síⁿtaaze] 'make stub+ perf.'
 b. -zújaaz- + i-e → [zújaaze], *[zúⁿjaaze] 'become warm (liquid) + perf.'
 c. -sáaⁿdaaz- + i-e → [sáaⁿdaaze], *[sáⁿaⁿdaaze] 'make explode + perf.'
 d. -sódook-i- + ize → [sódookeze], *[sóⁿdookeze] 'make move slowly + perf.'
 e. -súnuuk-i- + ize → [súnuukize], *[súⁿnuukize] 'show furtively + perf.'
 f. -zíg-an-i- + ize → [zígajize], *[zígⁿajize] 'economize + perf.'

In addition, the alveolar affricate [ts] does not undergo harmony, and it is opaque, as in (5). The retroflex affricate [ʈʂ] is infrequent in post-initial position. Its limited occurrences give us no information about whether it triggers harmony.

- (5) a. -tsii^mbaɾaz- + i-e → [tsii^mbaɾaze], *[ʈʂii^mbaɾaze] 'cause to be obstinate + perf.' (cf. -tsii^mbaɾaɾ- + -i- 'caus.')
- b. -setsaguz- + i-e → [setsaguze], *[ʂetsaguze], *[ʂeʈʂaguze] 'cause to carve up + perf.' (cf. -sets- + -ag-uɾ- + -i- 'pierce + freq. + caus.')

In contrast to other non-sibilant coronals, [ɾ] does not block coronal harmony (6a-b). It also does not trigger (6c-d). In other words, it is neutral in the system. Examples in (6a-b) further demonstrate the proximity effect mentioned above.

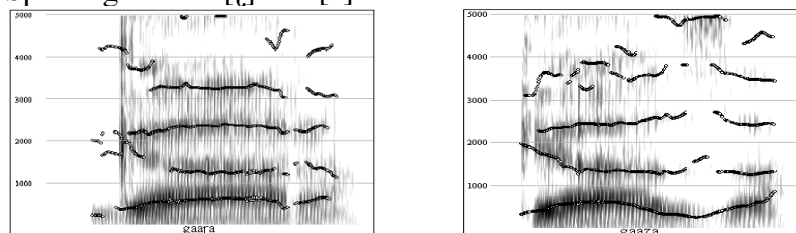
- (6) a. -togoseɾez + i-e → [togoseɾeze] ~ [togoʂeɾeze] 'make boil for / at + perf.'
 b. -seɾuz- + i-e → [seɾuze] ~ [ʂeɾuze] 'provoke, irritate + perf.'
 c. -ziɾ-a → [ziɾa], *[ziⁿɾa] 'be forbidden (taboo)'
 d. -soɾ-a → [soɾa], *[soⁿɾa] 'pay tax'

¹ Harmony initiated by the long causative suffix [-iɪʂ-(i)-] affects preceding sibilants in adjacent syllables only and optionally root-initial sibilants in adjacent syllables (Mpiranya & Walker 2005).

Interestingly, Kinyarwanda’s liquid [ɽ] displays characteristics of retroflexion. This is illustrated by the spectrograms in (7) which exhibit differences between [ɽ] and [z] by presenting the verb, [gaar̥a] ‘widen (intr.)’, alongside its causative form, [gaaza] ‘widen (tr.)’ (compare also the spectrogram of [gaasa] in (2)).

Here we may observe that F3 and F4 in [aa] appear lower overall in [gaar̥a] than in [gaaza] and [gaasa]. Also, they do not show a rising orientation observed with F3 in [gaaza] and [gaasa]. In sum, the acoustics of [aa] before [ɽ] are suggestive that the latter is retroflex (see discussion of acoustics of retroflexion above).

(7) Spectrograms of [ɽ] and [z]



In summary, Kinyarwanda coronal harmony operates regressively among sibilant fricatives, and it propagates the property of retroflexion, rather than (alveo)-palatalization. Harmony is obligatory when sibilants occur in adjacent syllables, but optional when they occur in non-adjacent syllables. Intervening vowels and non-coronal consonants are not perceptibly affected. Among the remaining consonants, coronal stops, palatals, and the alveolar affricate are opaque in the harmony system, whereas the retroflex liquid is neutral.

2. Analysis

We begin our analysis with the assumption that the harmony involves the privative feature [retroflex] (after Ní Chiosáin and Padgett 1997), which is phonetically realized as a tongue tip/blade posture. We assume featural representations here but do not rule out a gestural alternative (Flemming 1995, Gafos 1999).

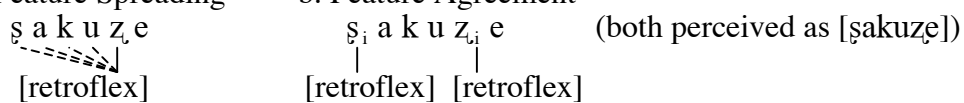
In current theory, two approaches to coronal harmony have come to prominence. One is Feature Spreading, in which the harmony results from feature spreading (or gestural extension) that conducts through articulatorily adjacent segments, as depicted in (8a). In this approach, the spreading feature carries through all segments that intervene between a trigger and target, but it is not perceived on segments characterized as “transparent” (excepting segments which independently present the feature, such as [ɽ]) (Flemming 1995, Ní Chiosáin and Padgett 1997,² Gafos 1999; note Hansson 2001 and Rose and Walker 2004 on Sanskrit; further work suggesting a retroflexion posture is held through intervening segments includes Wiltshire and Goldstein 1998 and Hamann 2003).

The second approach is Feature Agreement, in (8b). Here, harmony is caused by feature matching in segments that stand in a correspondence relation estab-

² Ní Chiosáin and Padgett allow the possibility that although phonological spreading is strictly local, the spreading feature might not be phonetically implemented on transparent segments.

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lished between similar segments (e.g., Hansson 2001, Rose and Walker 2004; note also Clements 2001). In the agreement structure, intervening segments that do not stand in correspondence with those showing harmony are non-participants. Thus, they are structurally unaffected and lack perceptual and articulatory correlates of the harmonizing feature (unless they independently present that feature).

- (8) a. Feature Spreading b. Feature Agreement

(both perceived as [ʂakuze])

The potential for blocking effects forms a point of departure between these approaches. Feature Spreading predicts the possibility that harmony will be blocked by intervening segments that cannot undergo spreading. This might arise, for instance, because of factors involving contrast or articulatory incompatibility. On the other hand, Feature Agreement predicts that intervening segments will act transparent only, because they do not participate in harmony.³ The data in (4-5) demonstrated that coronal stops, palatals and the alveolar affricate block coronal harmony in Kinyarwanda. We therefore conclude that this harmony arises from Feature Spreading, and we develop an account along these lines in what follows. We return to the issue of diagnostics for Spreading vs. Agreement in §4.

The [retroflex] spreading constraint that we posit is given in (9), modeled loosely after the constraint that Ní Chiosáin and Padgett (1997) frame for analysis of Sanskrit’s retroflex harmony. The constraint operates in a specified domain.

- (9) SPREAD-L-DOMAIN-(retroflex)
 Any [retroflex] feature associated to a [–sonorant, +continuant] segment S_j is also associated to any segment S_i that precedes S_j in a given domain.⁴

The constraint restricts triggers to continuant obstruents, i.e. fricatives. This correlates with an asymmetry that the coronal harmony presents, namely, that

³ In the context of Feature Agreement, we use “intervening segment” to refer to a segment that occurs between a trigger and target of harmony and does not stand in correspondence with them. See Hansson (2005) for discussion of a suggested scenario under which an intervening segment that is in correspondence with the trigger and target could produce blocking effects, given a particular local evaluation of correspondence within sequences of corresponding segments. In response to our BLS presentation, Hansson speculates on the possibility of an Agreement account for Kinyarwanda’s harmony that would rely on blocking consonants standing in correspondence with harmonizing sibilants. The correspondence relation is similarity-governed, such that correspondence between a consonant pair $[\alpha, \beta]$ implies correspondence between any more similar pair $[\alpha, \gamma]$. The scenario thus necessitates widening the set of consonants that stand in correspondence with triggers $[\ʂ z]$ to include not just targets $[s z]$ but also blocking segments. However, as Hansson points out, this approach does not predict the neutrality of retroflex $[\tau]$, which must be excluded from correspondence with $[\ʂ z]$. For instance, it would require that $[\ʂ z]$ be more similar to palatal $[j]$ than $[\tau]$. An Agreement approach to the blocking effect is therefore problematic.

⁴ Alternative formulations of the constraint that drives spreading are conceivable, see, e.g., Kirchner (1993), Bakovic (2000), McCarthy (2004). There might well be reason to choose among them, but this is beyond the scope of our present focus.

fricatives trigger harmony, but not the retroflex liquid. We surmise that this asymmetry exists, because retroflexion is contrastive in fricatives but not the liquid. Kaun (1995) makes a related finding in her study of round harmony. She argues that on the whole such systems serve to improve perceptibility of *distinctive* features. Likewise, certain metaphonic height harmonies have been found to uniquely promote contrastive height specifications (Dyck 1995, Walker in press).

We concentrate first on obligatory harmony in adjacent syllables. The version of the spreading constraint that drives this pattern is given in (10). It requires that [retroflex] spread to any segment in a preceding adjacent syllable in the stem.

(10) SPREAD-L-ADJ σ -(retroflex)

Any [retroflex] feature associated to a [-son, +cont] segment S_j is also associated to any segment S_i that precedes S_j in the stem in an adjacent syllable.

In the statement of this constraint, we posit that adjacent syllables form a cognitively significant window that can delimit phonological processes. Various other research points to a similar conclusion. Phonological phenomena limited to adjacent syllables have been identified elsewhere, and they are abundantly documented within Bantu. One such pattern type is syllable-adjacent nasal agreement, occurring, for example, in Lamba and Ndonga (Odden 1994, Piggott 1996, Hansson 2001, Rose and Walker 2004). Cases of dissimilation or OCP effects in Bantu characterized by Odden (1994) as subject to “syllable adjacency,” include Dahl’s Law (involving voicing) and Meeussen’s Rule (involving tone). Further assimilations that show a restriction to a “two-syllable window” include certain vowel harmony systems in Bantu and other language families (see Piggott 1996). Additional dissimilation / OCP cases characterized as involving consonants separated by up to a mora or separated by up to a vowel are discussed by Suzuki (1998) and Rose (2000), respectively. Whether adjacent syllables constitute a proper “domain” requires further investigation. Nevertheless, a window of adjacent syllables is evidenced in proximity effects in various languages, and it is prominent in patterns across Bantu. We therefore make use of it in (10) but allow that future research on the issue is needed.

Spreading potentially conflicts with the faithfulness constraint in (11), which prohibits segments that become retroflex. After Pater (1999), we adopt the IDENT-OI(F) formalism, applicable to privative features.

(11) IDENT-OI(retroflex)

Let α be a segment in the input and β be any correspondent segment of α in the output. If β is [retroflex], then α is [retroflex].

The adjacent-syllable spreading constraint dominates IDENT-OI(retroflex) to obtain obligatory harmony in this context, as illustrated in (12). The winning candidate in (a), which spreads [retroflex], obeys the spreading constraint at the cost of IDENT-OI(retro). The alternative in (b), which does not show harmony, is

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ruled out by a violation of spreading. Two violations of the spreading constraint are tallied here, one for each non-retroflex segment to the left of [z] (i.e. [s] and [aa]).⁵ Following Ní Chiosáin and Padgett (2001), we assume strict locality holds of feature linkage, preventing spreading from skipping segments (cf. Gafos 1999).

(12) Obligatory harmony in adjacent syllables:

/sáaz-i-e/	SPREAD-L-ADJσ-(retro)	IDENT-OI(retro)
☞ a. <i>šáazɛ</i>		***
b. <i>sáazɛ</i>	*!*	*

We turn now to optional harmony extending to non-adjacent syllables, e.g., [sákuɛ] ~ [šákuɛ] ‘shout (perf.)’. We posit that harmony over longer distances is driven by the constraint in (13), which requires regressive spreading in a stem.

(13) SPREAD-L-STEM-(retroflex)

Any [retroflex] feature associated to a [-sonorant, +continuant] segment S_j is also associated to any segment S_i that precedes S_j in the stem.

We have just established that a spreading constraint and IDENT-OI(retro) may conflict in words showing harmony. We posit that optional harmony results from their ranking potentially varying from one occasion to another. This can be captured by constraints that are probabilistically ranked according to assigned ranking values (Boersma 1998, Hayes and MacEachern 1998). A constraint with a much higher ranking value than another will effectively always dominate it. That will be the case for SPREAD-L-ADJσ-(retro) vs. IDENT-OI(retro), whose ranking drives obligatory harmony in adjacent syllables. On the other hand, the stem-spreading constraint and IDENT-OI(retro) will have close ranking values, which will produce variation in the constraint that dominates. The tableau in (14) shows the outcome in a case where stem-spreading outranks IDENT-OI(retro). This yields harmony across multiple syllables, as in the winning output, in (a). An occasion where the reverse ranking occurs is shown in (15). The alveolar fricative separated from the retroflex fricative by an intervening syllable is thereby left intact.

(14) Harmony extending to non-adjacent syllables:

/sákuz-i-e/	SPREAD-L-STEM-(retro)	IDENT-OI(retro)
☞ a. <i>šákuɛ</i>		*****
b. <i>sákuɛ</i>	*!*	***

(15) No harmony extending to non-adjacent syllables (but targets adjacent [ku]):

/sákuz-i-e/	IDENT-OI(retro)	SPREAD-L-STEM-(retro)
a. <i>šákuɛ</i>	****!*	
☞ b. <i>sákuɛ</i>	***	**

⁵ We do not analyze here the retroflexion of the stem-final consonant under affixation. For discussion of sibilant alternations in these contexts, see Coupey (1980) and Mpiranya (1998).

We consider next the opacity of coronal stops, palatals and [ts]. We propose opacity is driven by the constraints in (16), which prohibit retroflex counterparts of these segments. On the incompatibility of retroflex and palatal articulations, see Gafos (1999), Clements (2001), and Hamann (2003). The constraints in (16) prevent the harmony from causing retroflexion in the segments in question. They therefore dominate the spreading constraints. These constraints will also play a role in shaping the language’s inventory, preventing or restricting retroflex consonants, but for reasons of space, we do not discuss the applicable rankings.

- (16) a. *[retroflex]/CORSTOP: No retroflex coronal stops.
- b. *[retroflex]/PAL: No retroflex palatals.
- c. *[retroflex]/CORAFFRICATE: No retroflex coronal affricates.

The tableau in (17) contains a form in which [t] occurs in a blocking context. The ranking here is an instance where the stem-spreading constraint dominates IDENT-OI(retro), yielding the potential for harmony extending to a non-adjacent syllable. *[retro]/CORSTOP prevents the harmony candidate in (b), and the output in (a), with opacity, wins. As our analysis is currently framed, [retroflex] will spread regressively until halted by an opaque segment. Thus, in (17a) [retroflex] spreads to transparent [aa] (a form perceptually identical to one in which [aa] does not undergo harmony). (See Mpiranya and Walker (2005) for an alternative in which spreading occurs only when a preceding fricative is affected.)

(17) Blocking by a coronal stop

/sítaaz+i-e/	*[retro]/CORSTOP	SPREAD-L-STEM-(retro)	IDENT-OI(retro)
a. sítaaze		***	**
b. šítaaze	*!		*****

We summarize the constraint hierarchy in (18). As discussed above, we posit that the ranking values of SPREAD-L-STEM-(retro) and IDENT-OI(retro) are close, resulting in their variable ranking. Differences in ranking values for other interacting constraints are sufficiently large to produce stable ranking relations.

- (18) *[retroflex]/CORSTOP/PAL/CORAFFRICATE >> }

<i>Opacity</i>
<i>Obligatory and optional spreading</i>
- SPREAD-L-ADJσ-(retro), (SPREAD-L-STEM-(retro)) >> }
- IDENT-OI(retro) >> (SPREAD-L-STEM-(retro)) }

To summarize, we have argued that Kinyarwanda’s coronal harmony is produced by feature spreading. The spreading [retroflex] feature carries through segments characterized as transparent, but without perceptibly altering them. A regressive spreading constraint requiring harmony in adjacent syllables drives obligatory harmony in this context, while a constraint that requires spreading in the stem is variably ranked with IDENT-OI(retro) to produce optional harmony over longer distances. [ʂ z] trigger harmony but not [t], because [retroflex] is

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contrastive in the former but not the latter. And finally, blocking results from constraints prohibiting retroflex coronal stops, coronal affricates and palatals.

3. Sanskrit: Another Coronal Harmony with Opacity

For comparison, we turn now to Sanskrit's nasal retroflex harmony, known as "Nati" — the only other coronal harmony reported to show opacity. The coronal and palatal consonants in Sanskrit are /t t^h d d^h s n l ʈ ʈ^h ɖ ɖ^h ʂ ʂ^h r ɽ c c^h ʃ ʃ^h ʒ ʒ^h/. Retroflexion is distinctive in stops, fricatives, nasals, and liquids. The basic harmony pattern is as follows (Whitney 1889; recent analyses include Flemming 1995, Ní Chiosáin and Padgett 1997, Gafos 1999, Hansson 2001, Rose and Walker 2004; previous studies are cited therein). The triggers are [ʂ r ɽ], and the only perceptible target is /n/. Vowel and consonants that intervene between a trigger and affected target are not audibly affected. Dentals, retroflexes and palatals are opaque (except /j/). Nati produces alternations in the nominal and adjectival suffix /-ana/. The harmony applies in forms in (19a) but is blocked by a coronal or palatal in (19b). The harmony is progressive only, e.g. [-niʂt^ha:-] 'eminent', [-nrmɳa-] 'manhood'. The Nati pattern presents further complexities, on which see, e.g., Gafos (1999) and Hansson (2001).

- (19) a. rakṣaṇa 'protection' b. vard^hana 'increase'
 kṛpaṇa 'miserable' rocana 'shining'
 ākramaṇa 'striding' vṛjana 'enclosure'
 kṣajaṇa 'habitable' ceṣṭana 'stirring'

The above-cited recent accounts agree that Sanskrit's retroflex harmony involves feature spreading (or gestural extension). According to these analyses, the spreading feature continues through transparent segments, but its production is not perceived on them. Intervening coronals are opaque because spreading [retroflex] to them would neutralize a contrast (but see Hansson 2001 for discussion of blocking by retroflexes). Palatal obstruents, on the other hand, block because they are incompatible with [retroflex]. Continuant retroflex consonants are proposed to alone trigger harmony because retroflexion is more acoustically salient in these segments vs. stops (Ní Chiosáin and Padgett 1997, Gafos 1999).

The case of Sanskrit is discussed in the context of typologies of Long Distance Consonant Agreement or LDCA, where assimilation occurs between consonants separated by at least an intervening segment/vowel. Sanskrit's Nati appeared to stand apart from the other patterns, which are amenable to analysis in terms of Feature Agreement by correspondence (Hansson 2001, Rose and Walker 2004). The following points are raised in support of the claim that Sanskrit's Nati involves Feature Spreading rather than Agreement. First, it shows opacity. This is not seen in any other pattern of LDCA (except now for Kinyarwanda). Second, it does not show a similarity effect. Patterns of LDCA are found to preferentially target sounds similar to the triggers. Inclusion of a given target implies inclusion of any sounds that are more similar to the trigger. In addition, Sanskrit's Nati is

progressive, which Hansson suggests is anomalous in LDCA.

We are now in a position to identify some similarities and differences between the coronal harmonies of Sanskrit and Kinyarwanda. Shared properties include the following: the assimilating property is retroflexion, retroflex fricatives trigger harmony (but in Sanskrit liquids do too), and dental/alveolar consonants block, as do palatals (but not /j/ in Sanskrit). Differences exist along various dimensions, and we highlight only some here. First, the triggers in Sanskrit's harmony are the continuants [ʃ rɽ], but in Kinyarwanda, the triggers are only the retroflex fricatives, /ɽ/ is neutral. The target of Nati is /n/, which is relatively dissimilar from the harmony's triggers, while in Kinyarwanda, the perceptibly affected targets are /s, z/, which are highly similar to the triggers. In the area of opacity, the opaque dental segments in Sanskrit contrast with a retroflex series, but in Kinyarwanda, most blocking alveolars do not contrast with retroflexes. In addition, retroflexes that do not trigger Nati are opaque, but /ɽ/ is transparent in Kinyarwanda. Finally, directionality is opposite: Sanskrit's harmony is progressive, and Kinyarwanda's regressive. We address some implications of these differences in the next section.

4. Conclusion

We turn to some typological and theoretical issues on which this study of Kinyarwanda contributes. We have presented a revised data description: the harmony involves retroflexion, it optionally affects sibilants in non-adjacent syllables, and it shows blocking by coronal stops, palatals and [ts]. As only the second retroflex harmony discovered to show opacity, Kinyarwanda shows properties that contrast with Sanskrit's Nati. Kinyarwanda reveals that the triggers for retroflex harmony may be restricted to those for which the feature is contrastive. It also presents a case where blocking by coronal stops results from feature incompatibility, independent of contrast. In addition, Kinyarwanda indicates that apart from opacity the diagnostics for Feature Spreading vs. Agreement in coronal harmonies are not as clear cut as in Sanskrit. Specifically, the targets of Kinyarwanda's harmony show an apparent "similarity effect" and the harmony is regressive.

On the subject of Kinyarwanda's "similarity effect," the fact that the harmony (audibly) affects only fricatives might at first blush seem suggestive of an Agreement-based coronal harmony system. However, in this case the similarity effect might be incidental, emerging from independent factors interacting with the harmony system, such as the language's contrast system and the particular types of retroflex segments it tolerates. As Rose and Walker (2004) have observed, the potential for diagnostic ambiguities appears true of coronal harmonies in particular, which involve features that are suggested to potentially carry through vowels and certain consonants without audible effect (see §2). Nevertheless, careful examination of the properties of a coronal harmony together with the language's inventory and phonological system can often identify whether it involves Feature Spreading or Agreement (Hansson 2001, Rose and Walker 2004, McCarthy to appear).

We conclude with some issues for further research. The Feature Spreading

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approach provokes the question whether retroflexion is truly produced in transparent segments. We envision investigating this in Kinyarwanda. If it is found that retroflexion is not actually held during 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 (Ní Chiosáin & Padgett 1997). A second issue is that the strict enforcement of harmony in adjacent syllables is reminiscent of proximity effects seen in other phonological phenomena. The special status of adjacent syllables, its formal characterization, and why it cross-cuts Spreading-based and Agreement-based assimilations, as well as OCP effects, merits further research.

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Rachel Walker
Department of Linguistics, GFS 301
University of Southern California
Los Angeles, CA 90089-1693

Fidèle Mpiranya
Laboratoire de Phonétique et Phonologie
19, rue des Bernardins
75005 Paris, France

rwalker@usc.edu

fidele_mpiranya@fulbrightweb.org