39th Meeting of the North East Linguistic Society (NELS 39)
Cornell University
November 7, 2008

Retroflex harmony in Kalasha: Agreement or spreading?*

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1. Introduction

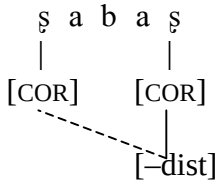
- In this paper we investigate co-occurrence restrictions on coronal consonants in Kalasha (Dardic, Indo-Aryan), evaluating two current theories of consonant harmony: local feature spreading (Gafos 1999) and long-distance agreement by correspondence (Hansson 2001; Rose & Walker 2004).
- Our study reveals that Kalasha roots exhibit a pattern of retroflex consonant harmony (or 'coronal' harmony, more generally) that is sensitive to relative similarity of coronals in terms of their manner of articulation.
- We argue that the data are compatible with the agreement by correspondence approach, which encodes featural similarity, but problematic for the spreading approach.

2. Background: Retroflex consonant harmony

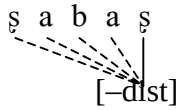
- Retroflex consonant harmony is an assimilatory effect or co-occurrence restriction holding between consonants that are separated by a vowel and/or other segments, resulting in identical retroflex or non-retroflex features/gestures on those consonants.
- Current theories of consonant harmony can be classified into two broad groups: those that analyze harmony as feature *spreading* and those that analyze it as feature *agreement*.
- *Local Feature Spreading*: The harmonic feature spreads locally to segments that are adjacent (in some sense) within a given domain. All segments within the domain that are contrastive for the spreading feature are either triggers, targets or blockers of harmony.
    - Locality can be defined in terms of autosegmental tiers (1a). Intervening segments are transparent due to underspecification of the relevant tier (e.g., Shaw 1991).
    - Locality can be defined in strict segmental terms (1b). Intervening segments are targeted and permeated by the spreading feature with no significant audible effect (e.g., Gafos 1999).

(1) Harmony as local feature spreading

a. Tier-based locality



b. Strict segmental locality



* We would like to thank Ron Trail and Greg Cooper for graciously providing us with an updated copy of the electronic database on which their (1999) Kalasha dictionary is based. Special thanks also to Karen Buseman for technical assistance with the database, and to Jan Heegård Petersen and Ida Elisabeth Mørch for supplying us with materials from their own research on Kalasha.

- *Agreement by Correspondence* (Rose & Walker 2004; Hansson 2001): A correspondence relationship is established between segments in an output string if they are highly similar. Agreement for the harmonic feature is enforced between corresponding segments. Segments that do not enter into the correspondence relationship are transparent (2).

(2) Harmony as feature agreement by correspondence (ABC)

$$\underset{[-\text{dist}]}{\underset{|}{\text{ʂ}_x}}\ \text{a}\ \text{b}\ \text{a}\ \underset{[-\text{dist}]}{\underset{|}{\text{ʂ}_x}}$$

- Previously identified cases of retroflex consonant harmony involve either coronal stops or coronal sibilants (affricates and/or fricatives).
  - Malto (Dravidian): coronal stops within a root must be either retroflex or dental (3).
  - Gimira (Afro-Asiatic): posterior sibilant affricates and/or fricatives within a root must be either retroflex or palato-alveolar (4).

(3) Retroflex harmony in Malto (Mahapatra 1979; Hansson 2001)

a.	ʈuːɖ	‘tiger’
	dudu	‘mother’
	ɖaɳɖa	‘staff’
	toːtotri	‘quickly’
b.	*ʈ...t, *d...ɖ, etc.	

(4) Retroflex harmony in Gimira (tones omitted) (Breeze 1990; Rose & Walker 2004)

a.	ʂaʂ	‘vein’
	ʃatʃ	‘stretcher’
	ʈʂ’uʈʂ’	‘louse’
	ʧ’aʃt	‘be pierced’
b.	*ʂ…ʃ , *ʧ…ʈʂ, *ʂ…ʧ, etc.	

- In Malto and Gimira the contrast between retroflex and non-retroflex consonants is limited to one manner class: either to stops or to (a subset of) sibilant affricates and fricatives, as shown in bold in (5) (based on Mahapatra 1979; Breeze 1990).

(5) Inventories of coronal obstruents in Malto (a) and Gimira (b)

a.

ʈ		**ʈ**	c
ɖ		**ɖ**	**ɟ**
	s		
ð			

b.

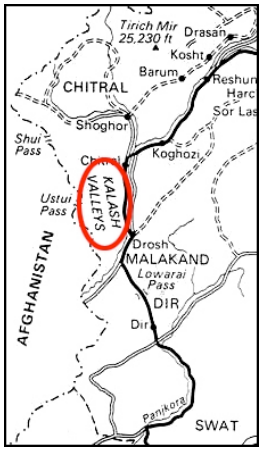
t	t^j			
t’	t'^j			
d	d^j			
ts			**tʃ**	**tʂ**
ts’			**tʃ’**	**tʂ’**
s	s^j	s^w	**ʃ**	**ʂ**
z	z^j		**ʒ**	**ʐ**

- Both models of consonant harmony – local feature spreading and ABC – can account for the patterns of retroflex harmony exhibited in languages like Malto and Gimira, where the harmony holds between all segments that are contrastive for retroflexion.
- However, the two theories make different predictions about harmony in languages where retroflexion is contrastive for both stops *and* sibilant affricates and fricatives.
    - The ABC approach relies crucially on featural similarity of participating segments. Thus, it predicts that consonants sharing the same manner of articulation (e.g., two stops, two fricatives, etc.) are more likely to harmonize than consonants with different manners of articulation (e.g., a stop and a fricative, etc.).
    - The spreading approach does not encode similarity, and, consequently, does not predict similarity effects. Rather, all segments contrastive for retroflexion – regardless of manner – are expected to participate in the harmony.
- Until now, these predictions have not been tested. This is largely due to the fact that languages with contrastive retroflexion in stops, affricates and fricatives are typologically rare (Maddieson 1984) and relatively under-studied.

In this paper we present new data from a language with contrastive retroflexion in stops, affricates and fricatives. The evidence from this language has an important bearing on the theoretical debate concerning the mechanisms of retroflex harmony.

3. Coronal obstruent contrasts in Kalasha

- Kalasha is an Indo-Aryan language of the Dardic sub-group spoken in Southern Chitral District of Pakistan.



- Kalasha has a rich inventory of coronal obstruents (6) (based on Bashir 1988, 2003; Heegård & Mørch 2004; Mørch & Heegård 1997; Petersen 2006; Trail & Cooper 1999).
- Contrasts within the coronal obstruent system include:
    - 'dentals' (dental/alveolar stops, fricatives, and affricates)
    - 'palatals' (alveolopalatal fricatives and affricates)
    - 'retroflexes' (retroflex stops, affricates, and fricatives)
- In addition, the language has a full set of contrastive retroflex vowels, shown in (7).

(6) Kalasha consonant phonemes

Labial	Coronal			Dorsal	Laryngeal
	dental	palatal	retroflex		
p p^h	t t^h		ʈ $ʈ^h$	k k^h	
b ($b^ɦ$)	d ($d^ɦ$)		ɖ ($ɖ^ɦ$)	g ($g^ɦ$)	
	ts ts^h	tɕ $tɕ^h$	ʈʂ $ʈʂ^h$		
	dz	dʑ ($dʑ^ɦ$)	ɖʐ		
	s	ɕ	ʂ		h
	z	ʑ	ʐ		
m	n	(ɲ)	(ɳ)	(ŋ)	
	r		(ɽ)		
	l ɬ				
w		j			

(7) Kalasha vowel phonemes

Front		Back	
non-retroflex	retroflex	non-retroflex	retroflex
i ĩ	iˠ ĩˠ	u ũ	uˠ ũˠ
e ẽ	eˠ ẽˠ	o õ	oˠ õˠ
		a ã	aˠ ãˠ

- Morgenstierne (1973: 201) observed a few cases of "assimilation at a distance" applying diachronically in Kalasha, most of them involving retroflexion (e.g., ʂiʂ 'head' < *ɕiːʂ).

To the best of our knowledge Morgenstierne's (1973) passing observation is the only reference to Kalasha consonant harmony in the published literature. The present study is the first attempt to investigate the full extent of consonant harmony in the language.

4. A study of retroflex (coronal) harmony in Kalasha

4.1 Method

- To determine whether Kalasha shows synchronic co-occurrence restrictions on coronal obstruents, we compiled a corpus of roots with relevant consonants, based on an updated copy of the electronic database originally used by Trail and Cooper for their (1999) dictionary of Kalasha.

Included/excluded data

- An initial search of the data revealed 591 instances of word-initial C_1VC_2 sequences, where both C_1 and C_2 are coronal obstruents. For the purpose of statistical analysis, this list was reduced to a more restrictive set of 218 items as follows:
  - Duplicate lexemes were excluded.
  - Morphologically complex words were excluded if C_1 and C_2 belong to separate morphemes.

- Derived forms were excluded if their relationship to another form was morphologically transparent (i.e., multiple instances of a single root).
- Loanwords from non-Indo-Aryan sources such as Arabic, Persian and English were excluded. However, potential loanwords from related Indo-Aryan languages such as Khowar and Urdu were retained on the grounds that these languages share historical roots and developments.

- None of the excluded items were exceptional with respect to the pattern of retroflex (and coronal) harmony that emerged from the study.

Counts and statistical analysis

- All 218 items from the set were classified as belonging to one of 36 logically possible combinations of 8 C_1/C_2 place and manner classes (i.e., dental fricatives, palatal fricatives, retroflex fricatives, dental affricates, etc.), collapsing over laryngeal features and C_1/C_2 order (e.g., ɕat 'oath, claim', ʑadri 'co-wife' and daɕ 'ten' were all classified as representing the combination of palatal fricatives with dental stops).
- 'Observed values' (O): counts of roots for each consonant pair.
- 'Expected values' (E): values that would be statistically expected under random occurrence of the phonemes.
- Observed-to-expected ratios (O/E ratios): were computed for each consonant combination to determine whether some combinations are under- or over-represented in the corpus (cf. Frisch et al. 2004; cf. Kawahara et al. 2006, among others).
  - An O/E ratio of 1.00: no difference between observed and expected frequency (i.e., no co-occurrence effect).
  - A ratio of less than 1.00: the combination is under-represented.
  - A ratio of 0.00: categorical under-representation (complete absence).
  - A ratio of more that 1.00: the combination is over-represented.
  - All under- and over-representations were examined statistically using a chi-square analysis (assuming the significance level of $p < 0.05$, $\chi^2 > 3.84$).

4.2 Results

Table 1. Observed counts of coronals in #CVC sequences (n=218)

C1/C2	s z	ɕ ʑ	ʂ ʐ	ts tsʰ dz	tɕ tɕʰ dʑ dʑʱ	tʂ tʂʰ dʐ	t tʰ d dʱ	ʈ ʈʰ ɖ ɖʱ
s z	6	2	0	1	20	0	22	11
ɕ ʑ		7	0	0	4	0	15	5
ʂ ʐ			9	0	10	3	8	3
ts tsʰ dz				1	1	0	4	1
tɕ tɕʰ dʑ dʑʱ					9	0	17	15
tʂ tʂʰ dʐ						13	7	0
t tʰ d dʱ							9	0
ʈ ʈʰ ɖ ɖʱ								15

Table 2. Expected values, based on a random distribution of consonants

C1/C2	s z	ɕ ʑ	ʂ ʐ	ts tsʰ dz	tɕ tɕʰ dʑ dʑʱ	tʂ tʂʰ dʐ	t tʰ d dʱ	ʈ ʈʰ ɖ ɖʱ
s z	5.30	6.24	6.59	1.39	13.19	5.61	14.24	10.15
ɕ ʑ		1.83	3.85	0.83	7.80	3.30	8.35	5.96
ʂ ʐ			1.95	0.92	8.46	3.50	8.56	6.21
ts tsʰ dz				0.08	1.65	0.73	1.95	1.36
tɕ tɕʰ dʑ dʑʱ					8.03	6.95	18.12	12.78
tʂ tʂʰ dʐ						1.48	7.56	5.38
t tʰ d dʱ							9.36	13.49
ʈ ʈʰ ɖ ɖʱ								4.83

Table 3. Ratios of Observed/Expected values (bold = significant under-/over-representation)

C1/C2	s z	ɕ ʑ	ʂ ʐ	ts tsʰ dz	tɕ tɕʰ dʑ dʑʱ	tʂ tʂʰ dʐ	t tʰ d dʱ	ʈ ʈʰ ɖ ɖʱ
s z	1.13	0.32	**0.00**	0.55	**1.66**	**0.00**	**1.56**	1.16
ɕ ʑ		**3.82**	**0.00**	0.00	0.48	0.00	**1.81**	0.83
ʂ ʐ			**4.62**	0.00	0.97	0.84	0.92	0.57
ts tsʰ dz				**12.11**	0.73	0.00	**1.98**	0.53
tɕ tɕʰ dʑ dʑʱ					1.12	**0.00**	0.90	1.11
tʂ tʂʰ dʐ						**8.77**	0.93	**0.00**
t tʰ d dʱ							0.96	**0.00**
ʈ ʈʰ ɖ ɖʱ								**3.10**

Key observations

- First, most combinations of two stops, two fricatives, and two affricates that *agree* in retroflexion/non-retroflexion are statistically over-represented.
    - This includes combinations of two retroflexes – fricatives (O/E = 4.62), affricates (O/E = 8.77), and stops (O/E = 3.10), or two non-retroflexes – palatal fricatives (O/E = 3.82) and dental affricates (O/E =12.11).
- Second, combinations of two stops, two fricatives, and two affricates that that *disagree* in retroflexion are categorically absent.
    - There are no instances of retroflex fricatives co-occurring with dental or palatal fricatives (O/E = 0.00), retroflex affricates co-occurring with dental or palatal affricates (O/E = 0.00), or retroflex stops co-occurring with dental stops (O/E = 0.00).
- Third, different-manner combinations – stops with fricatives or affricates, or fricatives wtih affricates – do not show such categorical restrictions and, overall, are not significantly under-represented or over-represented.

(8) Same-manner combinations with retroflexes and non-retroflexes

a. fricative/fricative

s…s	sastirik	‘to roof a house’
s…z	sazu djek	‘to have a cold’
ɕ…ɕ	ɕiɕoa	‘handsome’
ʑ…ɕ	ʑoɕi	‘Spring festival’
ʂ…ʂ	ʂiʂ	‘head, top’

	ʂuʂik	‘to dry in sun and air or smoke’

*s…ʂ, *ɕ…ʂ, *z…ʑ, etc. (no retroflexes with non-retroflexes)

b. affricate/affricate

ts…ts	tsẽtsaw	‘squirrel’
tɕ…tɕ	tɕitɕilak	‘immature corn’
tɕʰ…tɕ	tɕʰatɕi hik	‘to take care of’
dʑ…dʑ	dʑadʑ	‘hair, fur’
tʂ…tʂ	tʂaʈʂukre hik	‘to hold tight to s.o.’
tʂ…tʂʰ	tʂuʈʂʰu	‘dry, dried up’
tʂʰ…tʂ	tʂʰiʈʂik	‘to learn’
tʂ…dʐ	tʂãdʐa	‘pinewood torch’
dʐ…tʂ	dʐaʈʂ	‘male and female spirit beings’
dʐ…tʂʰ	dʐaʈʂʰi hik	‘to bark ferociously’

*ts …tʂ, *tɕ …tʂ, dʐ…dʑ, etc. (no retroflexes with non-retroflexes)

c. stop/stop

t…t	daʷu tatu	‘festival of beans’
t…d	tada	‘close to, near’
tʰ…d	tʰedi	‘now’
d…t	dit	‘half full’
d…d	dodak hik	‘to wait for s.t. expected’
ʈ…ʈ	ʈoʈ	‘apron of a kamiz’
ʈʰ…ʈ	ʈʰeʈ karik	‘to scatter’
ɖ…ɖ	ɖuɖik	‘to sleep’

*t …ʈ, *d…ɖ, ʈ…d, etc. (no retroflexes with non-retroflexes)

(9) Different-manner combinations

a. stop/affricate

t…tɕ	titɕak	‘some, a little amount’
tɕ…t	tɕat	‘argument’
d…tʂ	diʈʂ	‘period of three days of sexual abstinence’
tʂ…t	tʂat	‘moment, an instant’
ts…ʈ	tsaʈẽgik	‘to move, shake’
ʈ…tɕ	ʈõtɕuk	‘active, strong’
tɕ…ʈ	tɕuʈik	‘to touch’

b. stop/fricative

d…ɕ	deɕ	‘district, valley’
ɕ…t	ɕat	‘oath, claim’
t…ʂ	tuʂ	‘straw left after threshing’
ʂ…t	ʂit	‘tight-fitting, well-engineered, closed’
ʈ…s	ʈosu djek	‘to peck’
s…ʈ	saʈuk	‘apple sauce’
ɖʱ…ɕ	ɖʱuɕak	‘medium-fast dance’
ɕ…ʈ	ɕaʈ	‘trouble-making’

c. affricate/fricative

tɕ…s	tɕaspan	‘clever, quick, intelligent’
s…tɕ	sutɕ	‘ritually pure’
tɕ…ʂ	tɕaʂ ~ tɕaʂʈ	‘lunch’
ʂ…tɕ	ʂatɕ	‘temporary shelter’

An additional observation

- Combinations of two non-retroflex fricatives or two non-retroflex affricates that *disagree* in anteriority/posteriority are also absent or very infrequent.
  - There are only 3 exceptions in the entire database with same-manner palatals and dentals, and the status of these exceptions is questionable (10).
  - Exceptions of this kind also occur in morphologically complex forms such as *ɕ-ase* ‘EMPH-that’ (Bashir 2003: 856).

(10)

tɕ…ts	tɕitse maik	‘to talk about this and that’
s…ɕ	suɕ, suʑ	‘needle’ < sūčī- ‘needle’
ʑ…z	ʑazir ~ zazir	‘broken down’

- Thus, restrictions on same-manner combinations may go beyond the retroflex/non-retroflex contrast, affecting coronal obstruents in general (with prohibitions against combinations of retroflexes and non-retroflexes, *s…ʂ, *ɕ…ʂ, etc., and also against combinations of anterior/posterior obstruents, *s…ɕ, *ʑ…z, etc.).

4.3 Discussion

Similarity

- The results show that Kalasha roots exhibit retroflex harmony, or more generally coronal place harmony, but only when participating consonants have the same manner of articulation (both [±continuant, ±strident]).
- Given the important role of similarity in patterns of retroflex (coronal) harmony in Kalasha, the data are more compatible with the agreement-by-correspondence approach.
- While trans-vocalic retroflex harmony can be implemented as featural spreading, there is nothing in the spreading approach that would predict harmony, for example, between two stops but not between a stop and an affricate, when retroflexion is contrastive for both.
- The data are therefore incompatible with the spreading approach, unless it is explicitly modified to incorporate the notion of similarity.

Retroflex vowels

- The existence of contrastive retroflex vowels in the Kalasha sound system adds an interesting dimension to the discussion of agreement versus spreading.
- Some advocates of the spreading account have argued that features pertaining to the orientation of the tongue tip are especially susceptible to long-distance spreading because they are generally irrelevant for vowels and non-coronal consonants. As a result they can spread across intervening vowels and permeate them with little or no audible effect, thus giving the impression of transparency (Gafos 1999).

- However, unlike most other languages, tongue tip orientation *is* relevant and potentially contrastive for the vowels of Kalasha.
    - There is independent evidence to support the claim that the feature responsible for retroflexion on vowels is the same feature responsible for retroflexion on consonants. Retroflex vowels derive historically from the coalescence of vowels with intervocalic retroflex consonants (e.g., kuɻaːk 'little child' < *kuḍa-, pɛ̃ː 'palm of hand' < pāṇi̯- (Heegård & Mørch 2004)).
- Significantly, the vowels that occur between retroflex consonants in harmony domains are not phonemically retroflex in any of our sources.
- It is possible that such vowels are phonetically retroflex to some degree, but no instrumental study has yet been carried out to resolve this question.
- All things considered, the similarity effect and the phonemic status of vowels in harmony domains are more compatible with feature agreement than feature spreading.

5. Historical sources of harmony

- Consonant harmony in Kalasha is manifested as a static morpheme structure constraint. We have found no evidence of active alternations in the synchronic grammar.
- Limited diachronic evidence concerning the source of harmony is listed in (11).

(11) Evidence of diachronic harmony in fricatives (based on Trail and Cooper 1999)

a.	s → s			
	sastirik	'to roof a house'	< sāstara-	'layer of grass/leaves'
b.	s → ɕ			
	ɕiɕoa	'handsome'	< *suśōbha-	'splendid'
c.	s, ɕ(ś) → ʂ			
	ʂuʂut, ʂuʂutr	'ornate headband'	< *suṣūtra-	'having fine thread'
	ʂiʂ	'head, top'	< śīrṣá-	'head, skull'
	ʂuʂik	'to dry'	< śúṣyati	'becomes dry'
	ʂuʂʈa	'dry, dried'	< *śuṣṭa-	'dried'

- The evidence in (11) is compatible with either (i) "anticipatory" right-to-left harmony and/or (ii) dominance relationships among coronals in which retroflexes are dominant, dentals are recessive, and palatals are intermediate.
- We tentatively adopt the dominant-recessive interpretation for the following reasons:
    - Similar dominant-recessive relations occur in patterns of local coronal assimilation in Old Indo-Aryan (e.g., Sanskrit). In those cases, direction is not a factor (Whitney 1967 [1889]: 68).
    - The apparent directionality in (11) might be a by-product of the fact that word-initial retroflexes were rare at one time in Old-Indo-Aryan (Masica 1991: 157).

6. An account of Kalasha coronal harmony

- The ABC approach (Walker 2000; Rose & Walker 2004; Hansson 2001; Hansson 2007) captures properties of consonant harmony systems using a set of Correspondence C↔C constraints, CC Faithfulness constraints, and the traditional I/O Faithfulness constraints.

- Correspondence C↔C constraints impose a correspondence relation on two featurally similar segments co-occurring in an output string.

  (12) Corr-T↔Ṭ: any two coronal obstruents ([cor, ±son]) that have the same specifications for [±strid, ±cont] (regardless of differences in [±voi, ±ant, ±dist]) are correspondents of one another.

- Correspondence C↔C constraints that involve less similar segments are ranked below Corr-T↔Ṭ.

  (13) a. Corr-Č↔Ṣ: any two coronal obstruents ([cor, ±son]) that have the same specifications for [±strid] (regardless of differences in [±cont, ±voi, ±ant, ±dist]) are correspondents of one another.
  b. Corr-T↔ Ḍ: any two coronal obstruents ([cor, ±son]) that have the same specifications for [±cont] (regardless of differences in [±strid, ±voi, ±ant, ±dist]) are correspondents of one another.
  c. Corr-T↔Ṣ: any two coronal obstruents ([cor, ±son]) (regardless of differences in [±cont, ±strid, ±voi, ±ant, ±dist]) are correspondents of one another.

  (14) Similarity-based correspondence hierarchy for [±distributed] in coronal obstruents
  Corr-T↔Ṭ » Corr-Č↔Ṣ, Corr-T↔ Ḍ » Corr-T↔Ṣ
  same manner *same stridency* *same continuancy* *same soronancy*

- CC Faithfulness constraints require structural identity of the segments in a correspondence relation. Together with IO Faithfulness constraints, they are part of the consonantal correspondence model (15).

  (15) Input / t a ṭ /
  ⇳ IO Faithfulness
  Output [t a ṭ]
  ⇘ ⇙
  CC Faithfulness

- The ranking of CC Faithfulness over IO Faithfulness (and Correspondence C↔C) insures the application of harmony. The ranking of Ident-IO[-dist] over Ident-IO[+dist] insures that retroflexes are triggers of harmony, while non-retroflexes are targets.

  (16) a. Ident-CC [±dist]: segments within a string that are correspondents of one another must have the same value for [±distributed].
  b. Ident-IO [-dist]: segments specified for [-dist] in the input must have the same feature value in the output.
  c. Ident-IO [+dist]: segments specified for [+dist] in the input have to have the same feature value in the output.

(17) Retroflex harmony applies in same-manner combinations: two stops

	/taʈ/	Id-CC [±dist]	Corr-T↔Ṭ	Id-IO [–dist]	Id-IO [+dist]	Corr-Č↔Ṣ	Corr-T↔Č	Corr-T↔Ṣ
a.	$t_x a t_y$		*!			*	*	*
b.	$t_x a t_x$	*!						
c. ☞	$\underset{\frown}{t_x a t_x}$				*			
d.	$t_x a t_x$			*!				

(18) Retroflex harmony applies in same-manner combinations: two fricatives

	/ʂaɕ/	Id-CC [±dist]	Corr-T↔Ṭ	Id-IO [–dist]	Id-IO [+dist]	Corr-Č↔Ṣ	Corr-T↔Č	Corr-T↔Ṣ
a.	$\underset{\cdot}{s}_x a \underset{\cdot}{c}_y$		*!			*	*	*
b.	$\underset{\cdot}{s}_x a \underset{\cdot}{c}_x$	*!						
c. ☞	$\underset{\frown}{\underset{\cdot}{s}_x a \underset{\cdot}{s}_x}$				*			
d.	$\underset{\cdot}{c}_x a \underset{\cdot}{c}_x$			*!				

(19) Retroflex harmony does not apply in different-manner combinations (e.g. stop/affricate)

	/tsaʈ/	Id-CC [±dist]	Corr-T↔Ṭ	Id-IO [–dist]	Id-IO [+dist]	Corr-Č↔Ṣ	Corr-T↔Č	Corr-T↔Ṣ
a. ☞	$ts_x a t_y$						*	*
b.	$ts_x a t_x$	*!						
c.	$\underset{\frown}{t\underset{\cdot}{s}_x a t_x}$				*			
d.	$ts_x a t_x$			*!				

- The addition of posteriority harmony can be formally implemented by adding relevant CC Faithfulness and IO Faithfulness constraints on features [+ant] and [-ant]:

(20) Posteriority harmony in same-manner combinations (e.g. fricative/fricative)

	/saɕ/	Id-CC [±dist]	Id-CC ([±ant])	Corr-T↔Ṭ	Id-IO [–dist]	Id-IO [–ant]	Id-IO [+dist]	Id-IO [+ant]	Corr-Č↔Ṣ
a.	$s_x a \underset{\cdot}{c}_y$			*!					*
b.	$s_x a \underset{\cdot}{c}_x$		*!						
c. ☞	$\underset{\cdot}{c}_x a \underset{\cdot}{c}_x$							*	
d.	$s_x a s_x$					*!			

- In sum, the proposed ABC analysis successfully accounts for the key facts of coronal harmony in Kalasha roots, a pattern that is sensitive to relative similarity of participating segments.

5. Conclusion

- In this paper we examined co-occurrence restrictions on coronal consonants in Kalasha.
- The findings reveal a robust pattern of retroflex harmony, or coronal harmony more generally, in combinations of coronal consonants with the same manner of articulation, and a lack of harmony in different-manner combinations.

- The evidence from Kalasha has an important bearing on current theories of consonant harmony that model the process as either feature spreading or feature agreement.
- Specifically, we argue that the data are more consistent with the agreement approach because it encodes featural similarity.

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