Postvelar Harmonies: A Typological Odyssey

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1 Introduction: C-V Interactions

When a segment with an underlying Retracted Tongue Root `[RTR]` feature induces a featural change in the surface form of another segment, *postvelar* harmony occurs. Such harmony can be V$\rightarrow$V,[1] as extensively documented for Wolof and Yoruba by Akinlabi and others, or C$\rightarrow$V, in which case a consonant with a postvelar feature (be it *faucal* (uvular or pharyngeal) or emphatic (a secondary RTR specification) induces a change in the Tongue Root position of a vowel. Though such cases are not extensive in the phonological literature, three compelling cases of C$\rightarrow$V harmony can be understood as involving the RTR feature: Emphasis Harmony in Palestinian Arabic, Faucal Harmony in Interior Salish, and Vowel Flattening in Chilcotin.[2]

Though the precise articulatory basis for these processes has been debated, the emerging consensus is that [RTR] is the active feature;[3] such a claim is crucial to the rest of our discussion. In terms of feature geometry, we adopt the common view that RTR is subordinate to the Tongue Root Node, which is subordinate to the Place Node. One crucial assumption follows from Bert Vaux's dissertation: emphatic consonants are specified for secondary Place features = RTR. In addition, Shahin (1998) analyzes emphatics as secondarily uvularized and secondarily pharyngealized. In discussions of vowel inventories, again, there are many classification issues that have been debated, through articulatory imaging and acoustic data, and a range of transcriptional variants, especially for the vowels; there are a staggering number of papers that reanalyze a particular vowel in a certain language as actually +RTR and not Low or Tense, or something else. However, our primary aim here is to explore a factorial typology derived by Optimality-Theoretic output constraints. As such, this paper focuses more on the general parameters of harmony, such as directionality, locality, transparency, and opacity, as they result from the interaction of input faithfulness and language-specific (though often phonetically "grounded") markedness. After surveying a range of C$\rightarrow$V harmonies, we will zero in on four dialects of Eastern Interior Salish, showing how the dialectal variations shown may spring from re-rankings of OT constraints.

1.1 Consonant-Induced Vowel Harmony

In examining the range of C$\rightarrow$V RTR harmony,[4] there are three asymmetries of interest:

[1] First things first: when we say $\alpha \rightarrow \beta$ harmony, the first element is the trigger, and the second the target, regardless of directionality. So, *both* regressive and progressive assimilation from a consonant to a vowel will be referred to as consonant$\rightarrow$vowel harmony.

[2] As for why we do not treat C$\rightarrow$C harmony directly: it quite rarely attested. Maddieson notes that pharyngeal consonants occur in 14.8% of world's languages, uvulars in 4%; however, retracted vowels are very common. Perhaps faucal features are maximally compatible with vocalic rather than consonantal structure, an issue we will briefly touch at the end of section 5.5.2 on page 20.

[3] If one were so inclined, these processes could make the strong case that [ATR] is not a privative feature. Apparently, Heather Goad (McGill) has done a lot of work on this...

[4] We use the term harmony to avoid terminologicorepresentational issues associated with "spread," "multiple linking," or even "feature attraction," and choose to focus solely on harmony as a case of Input-Output faithfulness violation.

- Leftward Harmony tends to be unbounded/non-local, while Rightward Harmony tends to be bounded/local.
- Rightward Pharyngeal Harmony is local, while Rightward Emphatic Harmony is non-local.
- Certain segments (Non-RTR Consonants and /i/) are opaque (and sometimes transparent) for Rightward Harmony, but not for Leftward Harmony.

As always, the goal of explanation is to understand these asymmetries in terms of grounded phonetic constraints. In fact, such constraints appear formulable:

- Anticipatory coarticulation is more prominent than follow-up coarticulation, and RTR harmony is the result of a phonologization (SPREAD[RTR,LEFT], SPREAD[RTR, RIGHT]) of those processes.
- Spread of *Primary* Place Features is more Local; Spread of *Secondary* Place Features (RTR on Emphatics) is Non-Local.[5]
- Grounded Path Conditions such as *[RTR, HIGH, FRONT] induce opacity (and transparency, if sympathetic faithfulness is involved); in addition, a higher ranking of IDENT[RTR,CONS] relative to IDENT[RTR,VOWEL] could drive opacity of underlyingly [-RTR] consonants.

2 Palestinian Arabic Emphasis Spread

As discussed in Shahin (1998), McCarthy (1997), Davis (1995), and elsewhere, Palestinian Arabic (PA) exhibits two distinct RTR processes: pharyngealization and uvularization harmonies. Before we highlight segmental V→C cases, it is interesting to note a pervasive prosodic constraint: RTR vowels only occur in closed syllables. The data in (1) illustrate the fundamentally positional restriction that short vowels surface as -RTR in open syllables and +RTR in closed syllables:

(1)	/lObIÆ/	[ló.bi.ə]	(a small type of pea)
	/dUUd-Æ/	[dú.də]	“worm”
	/sIId-O/	[sɩ́.do]	“grandpa”
	/mIš/	[mɩš]	“not”
	/zIft/	[zɩft]	“asphalt”
	/cIll/	[cɩll]	“all”

We sidestep the issue of this prosodic restriction at the moment; Shahin proposes a constraint of the form NUC-C$]_\sigma$/RTR, which is basically descriptive: Nuclei in closed syllables are RTR, though it may be the result of phonologization of some sort.[6]

[5] Thanks to Markéta Ceplová, who made this suggestion and put an end to hours of head-scratching.

[6] Michael Wagner (p.c) claims the same process holds for German (tenseness of short vowels in closed syllables); we ought to investigate this further....

2.1 Pharyngealization Harmony

Pharyngeal harmony is triggered by a postvelar consonant or a retracted-tongue-root vowel. The PA postvelars are the gutturals /ʔ h ʕ ħ ʁ χ/ and the emphatics /m̩ b̩ ð̣ ṣ ṭ ṛ ḷ ḳ/. The targets are Short vowels,[7] as shown below:

UR	RTR	-RTR
I	ɩ	i
U	ʊ	u
Æ	ɑ	æ, ə
E	ɛ	e

Both rightward and leftward local pharyngealization harmony are triggered by a postvelar. The targets are only *short vowels*, which surface as RTR if they are *adjacent* to a guttural or an emphatic:

(2)	/sU**ʔ**ÆÆl/	[sʊ.ʔǽæl]	(*[su.ʔǽæl])	"question"
	/**h**IbÆ/	[hɩ́.bə]	(*[hí.bə])	"Hiba" (fem. name)
	/šU**h**UU/	[šʊ.húu]	(*[šu.húu])	"what?!"
	/**ʕ**UlÆ/	[ʕʊ́.lə]	(*[ʕú.lə])	"Ula" (fem. name)

From the picture in (2), we quite readily posit the constraints SPREAD[RTR-LEFT] and SPREAD[RTR-RIGHT].[8]

2.2 Uvularization Harmony

Uvularization Harmony is triggered by emphatic consonants, whose Place specification is only secondarily RTR. The targets of 2^0 RTR Harmony are both Long and Short Low Vowels[9] (Æ and ÆÆ) and underlying non-emphatic consonants.[10] The forms in (3) illustrate uvular harmony:

(3)	/nÆÆṛ/	[ṇɑɑr]	(*[næær])	"fire"
	/ṭÆÆb/	[ṭɑɑb]	(*[ṭææb])	"he became well"
	/ṭÆz Æ/	[ṭɑ́.ẓə]	(*[ṭǽ.zə])	"fresh"
	/ṭwÆÆl/	[ṭw̩ɑɑḷ]	(*[ṭwææl])	"rall"
	/ʔÆbÆÆṭ/	[ʔə.ḅɑ́ɑṭ]	(*[ʔə.bǽæṭ])	"hug"
	/mÆṛÆ/	[ṃɑ́.ṛə]	(*[mǽ.ṛə])	"wife"
	/ṣÆħħÆ/	[ṣʌ́ħ.ħə]	(*[ṣǽħ.ħə])	"health"
	/ṭÆIjjÆb-Æt-nI/	[ṭàij̣.j̣ə.ḅ-ʌ́ṭ.-ṇi]	(*[ṭàij.jə.b-ǽt.-ni])	"she made me become well"

[7] Long Vowels are denoted by a sequence of two short vowels.

[8] The precise formulation of such constraints, in terms of SPREAD, ALIGN, or AGREE, is not crucial here; McCarthy (1997) simply uses RTR-LEFT and RTR-RIGHT to illustrate his point.

[9] Stem-final vowels don't pharyngealize..see Shahin (1996) for a complicated explanation.

[10] In this case, /j/ denotes the palatal approximant.

One set of appropriate OT constraints to capture these output patterns would be: SPREAD[2^0-RTR,LEFT] and SPREAD[2^0-RTR,RIGHT].[11]

2.3 Opacity and Bounded Emphatic Harmony

In the Southern dialect of Palestinian Arabic discussed by Davis (1995), the segments /i, y, š, j/ are opaque with respect to rightward harmony but undergo leftward emphatic harmony.[12,13] The data in (5) show unbounded leftward emphatic harmony:

(5)	ḅa̤l̤l̤ɑṣ	"thief"
	ħaḍ̣ḍ̣	"luck"
	ʔaḅṣaṭ	"simpler"
	ḅɑɑṣ	"bus"
	ṃaṇɑɑf̣ɪ̣ḍ̣	"ashtrays"

However, rightward emphatic harmony exhibits the opacity effects:

(6)	ṣaḅɑɑħ	"morning"
	ʔaṭf̣ɑɑḷ	children"
	ṭʊʊḅ-aḳ	"your blocks"
	ṭiin-ak	"your mud"
	ṣɑyyææd	"hunter"
	ʕaṭšææn	"thirsty"
	ḍajjaat	"type of noise"

[11]The reader may question this formalization of a difference in behavior between primary and secondary features. We believe it captures the data not only for PA but Chilcotin; in addition, the only alternative in the OT literature is ALIGN[RTR,L,WD,L] and ALIGN[RTR,R,WD,R] which Shahin calls syntagmatic grounding constraints, "grounded in the slow movement of the tongue root, which is due to its relative large mass. The phonological consequence of this sluggishness is that [RTR] tends to span more than one segment in a word" (p. 155) - so, [lɪ́.bʊ.ʔə] links with both sides. In this case, local pharyngeal harmony comes from ALIGN[RTR,NUC] while non-local emphatic harmony comes from ALIGN[RTR,WD], thus losing any generalizations about the relevant articulatory differences.

[12]Davis's transcription only indicate the underlying emphatic consonants, without reference to the RTR quality of the vowels; we must inherit these deficiencies at present. Hence, in this data, a dot under the segment indicates an underlying emphatic, a capital letter indicates a surface emphatic, and a lower case letter indicates a surface non-emphatic. McCarthy (1997) inherited this convention, but in the interest of consistency through our discussion, we do not use capital letters to indicate surface emphatics; in all of the cases shown, the underlying emphatic is denoted by boldface.

[13]There are plenty of problems in the data, as in (4). For the first two forms, it is unclear what [ỵ] and [j̣] refer to, since emphatic /y,j/ do not exist in the inventory. In the third form, given as an example of leftward harmony, it is clearly not strictly leftward, as the final vowel assimilates.

(4)	x̣ɑỵỵɑɑṭ	"tailor"
	ṃɑj̣ɑṣṣAṣiš	"it didn't become solid"
	ṭɑṃṣ̌ɯṭɑ	"hairstyling"

An OT account for unbounded leftward harmony and opacity in rightward harmony is a simple matter of constraint ranking. To explain the opacity of /i,j,y,š/, Davis assumes a combination of grounded constraints, following Archangeli and Pulleyblank (1994) : RTR/HI and RTR/FR. As McCarthy shows, these can be viewed as a conjoined constraint, *[RTR,HI,FRONT] about which we will have some to say in section 5.1. Assuming this is right (though Davis's glosses make things a trifle uncertain), the opacity of these segments in rightward spreading but not leftward spreading can be captured through a ranking such as

$$\text{RTR-L}\textsc{eft} \gg {}^*[\text{RTR,HI,FRONT}] \gg \text{RTR-R}\textsc{ight}.$$[14]

3 Salish Faucal Harmony

Faucal Harmony also involves RTR spread.[15] But it is only regressive, only targets vowels (unlike PA) and does not have emphatic consonants. The unbounded leftwardness we have seen before. We discuss three dialects of Salish:

- Nxaʔamxcin (hereafter *Nx*), a.k.a Moses-Columbia Salish; spoken in Washington State.
- Snchitsuʔumshtsn (hereafter *Sn*), a.k.a Coeur d'Alene Salish; spoken on Washington-Idaho border.
- Flathead Salish; spoken in Washington State.

3.1 Nxaʔamxcin and Snchitsuʔumshtsn: Action-at-a-Distance

Both Doak (1992) and Bessell (1998) point out that Salish has lots in common with PA. Bessell suggests that coarticulation was at work in regressive consonant→vowel harmony, and subsequent phonologization occurred. In Interior Salish, non-local C-V interaction (faucal harmony, if one groups uvulars and pharyngeals as faucal consonants) can target preceding vowels *up to six segments away* from the faucal. Yep, six - now that's non-local. She even looked at the intervening consonants phonetically - we won't go into the details here - it seems to be the case though, that intervening consonants are unaffected[16] but the vowel quality is determined long-distance by the word-final uvular /q/ in [y'ál-stq] ("summer"). Restricting our attention to C→V harmony, then, we examine the vowel alternations in *Sn* data (from Doak):

(7)	t^{s}ɛ́ʃ-ɑl**q**^{w}	"he is tall"
	t^s-dkɑ́m-ɑl**q**^{w}	"train"
	nɛʔ-sɑ́tt^ʕ-ɛʔ**q**s-n	"crank"
	ʔat-kɔ́s-**q**n	"his hair is curled"

[14] All of these must dominate IDENT-RTR for the assimilation to occur at all, thought the precise nature of RTR-LEFT will be discussed later.

[15] So says Czaykowska-Higgins and many others.

[16] c.f. Padgett/Ni Choisain's strict locality.

Similar regressive harmony holds for *Nx* (data from Bessell):

(8)	non-retracted	non-faucal context example	retracted	faucal context example
	[i]	tʃíĺkʃt, "five"	[ɪ, ɪe, e]	t ʃíqn, "digging"
	[u]	stʃúɬm, "bull"	[o, ɔ]	tʃnúχʷtaʔ, "come!"
	[æ,a]	tʃákaʔ, "older sister of a man"	[a,ɑ]	ɬáqlxtaʔ, "get up!"

The relevant constraint is thus SPREAD[RTR,LEFT]; in this case, as in the others, there is no locality restriction[17] on regressive harmony; the consonant transparency must be due to a higher-ranked IDENT[CONS,RTR] constraint.

3.2 Flathead Salish: Transparency (and Sympathy)

An interesting thing phenomenon arises in Flathead Salish: during regressive faucal harmony, there is /i/ transparency (and not opacity, as we had seen for PA) (data is from Bessell's summary of Flathead Salish):

(9)	Non-faucal context	Faucal Context
	qaʔʃíń, "shoe"	q'aʔʃin-sqá(χeʔ), "horseshoe"
	ʔúpn, "ten"	ʔɔ́-ʔ(u)pn-(e)tʃt-q(i)n, "thousand"

A few comments on (9): in the first form, there is transparency, and harmony across five segments; the second form, the surface form contains only the initial stressed vowel, which is thus affected six segments away form the trigger. An OT analysis of transparency must involve faithfulness to a sympathetic candidate that crucially violates a higher-ranked constraint. That higher-ranked constraint is *[RTR,High], the grounding constraint seen previously; the sympathetic candidate thus satisfies SPREAD/AGREE totally, and the winning candidate maintain ❀-faithfulness to the sympathetic candidate, as shown in the tableau in (10)

(10)

	Input	*[RTR,HIGH]	FAITH-❀O	SPREAD[RTR,L]
☞	q'aʔʃin-sqá(χeʔ)			*
❀	q'aʔʃɪn-sqá(χeʔ)	!*		
	q'æʔʃɪn-sqá(χeʔ)	!*	*	*

Although the ❀-Faithfulness is somewhat specific to this case, the other relevant constraints have held generally throughout our discussion.

4 Chilcotin Flattening

A Northern Athabaskan language spoken in British Columbia, researched by Cook (1993), Chilcotin exhibits "flattening" — RTR harmony by yet another moniker. Underlying flat

[17]As an interesting sidenote, a morphophonological constraint on unbounded regressive harmony: a root of suffix followed by a faucal consonant undergoes faucal harmony, but this *never happens to vowels in the prefix*...cf. Beckman's root faithfulness...

consonants cause pharyngealization/flattening of vowels.[18] The data in (11) illustrate contrasts in the vowel system,[19] with the triggering consonant in boldface; note that the harmony can be leftward and rightward:

	UR Sharp	Non-flattening Context	Surface Flat	Flattening Context
(11)	i	**s**id, "I"	ᵊi/e	**ŝ**ᵊit, "kingfisher"
	ɛ	ʔɛ**k**ɛn, "vagina"	e	ʔe**q**en, "husband"

Cook derives the following generalization: if the word contains no flat consonant, all the vowels are sharp (as underlyingly); if a word contains only flat consonants, all vowels are flat. The "disharmonic" cases are thus the interesting ones.

4.1 Rightward Harmony: 1^0 vs. 2^0 Place

In Chilcotin, a surprising generalization holds for rightward and leftward RTR Harmony:

> Q-triggered flattening is strictly local (affecting the adjacent vowel only), while Ŝ-triggered flattening is non-local.[20]

It's true, though quite puzzling at first blush. Q-forward flattening affects only a following vowel, as in (12), while Ŝ-forward flattening can go one vowel further, shown in (13):

(12) /ɣ̣iti/ [ɣ̣ᵊiti], "I slept"
/ɣ̣ɛlmɛɬ/ [ɣ̣əlmɛɬ], *[ɣ̣əlməɬ], "it's rolling"

(13) /ŝɛɬtin/ [ṣəɬtᵊin], "he's comatose"

In fact, this asymmetry fits well with our previous findings from PA: SPREAD[RTR] and SPREAD[2^0-RTR] deserve different ontological status. Perhaps for phonetic reasons (though this is pure speculation), coarticulation of secondary place is more easily phonologized. Whatever the case, the difference in distance of affected targets must be reflected somehow as an output constraints, and SPREAD[2^0-RTR] seems natural as any.

[18] In addition, harmonization occurs between "flat" and "non-flat" (read: sharp) sibilant consonants; as we focus here mainly on C-V interactions we do not delve into the C-C details of this but the process *is* important in our discussion of opacity (see below).

[19] Cook calls ᵊi "a pseudodiphthong"; though the details of its vowel quality may be fascinating, what interests us here is the environments in which it is targeted. In fact, the flat correspondents of the sharp /i are /ᵊi, which always follows the flat consonant, and /e/, the monopthong, which always precedes the flat consonant:

/niqin/ [neqᵊin]

[20] Q is for the class of flat velars with primary RTR Place; Ŝ for the class of flat sibilants, with secondary place = RTR (primary place = coronal).

4.2 Sharpness Identity: Consonant Faithfulness

Though S-forward flattening may be more unconstrained, an intervening sharp consonant will act as an opaque segment,[21] blocking further assimilation:

(14) /ŝɛgɛn/ [ṣəgɛn], "it is dry"

A natural constraint, alluded to earlier, is a faithfulness condition, namely IDENT[CONS,RTR], which must crucially outrank SPREAD[2^0-RTR,RIGHT].

4.3 Leftward Spreading: Interaction with Sibilant Harmony

Above, we discussed differences between Q-flattening and ŝ-flattening w.r.t. progressive harmony. As for regressive harmony, Q-backward harmony again affects one vowel, as shown in (15), whereas Ŝ-backward harmony is *unbounded*, as in (16).

(15) /yunɛqæd/ [yunəqat], "he's slapping him"
/ʔælæx̣/ [ʔelax̣], "I made it"

(16) /ʔæbɛlɛŝ/ [ʔabələs], "apples"
/gʷɛtɛgulyúẑ/ [gʷətəgolyóẓ], "he is rich"

Of note in (16) is the second form, which shows that Ŝ-backward flattening is not blocked by an opaque sharp consonant, as opposed to Ŝ-forward flattening, which is indeed blocked, as we saw in (14). As for whether Q-backwards-flattening is blocked, is remains unclear; Cook discusses extensive variability in "allegro speech."

Some OT hypotheses for the different opacity dependent on direction:

(17) SPREAD-RTR-LEFT ≫ IDENT[CONS,RTR] ≫ SPREAD-S-RIGHT

In fact, this ranking is quite similar to that derived for /i, y, j, g/ opacity in PA, although it is only the velars that seem to block leftwards harmony on the surface. However, we might ask why should sharp velars act as blockers but not sharp sibilants? Cook discusses that Chilcotin has a rule of sibilant harmony, which spreads the sharpness/flatness of a sibilant regressively: *s...š* → *š...š*, etc:

(18) SPREAD-RTR-LEFT ≫ AGREE[SIBILANT,RTR] ≫ IDENT[CONS,RTR] ≫ SPREAD-S-RIGHT

[21] Opacity due to a sharp consonant is never attested with Q-forward flattening, because a flat velar does not occur in prefixes followed by a sharp consonant.

5 Vowel Inventory Effects of RTR

Descriptions of faucal harmony in Salish, as described in section 3 and in Doak (1992) and Bessell (1998), indicate RTR-spreading as the root cause. We would expect, therefore, that a relatively simple typology of RTR interactions with vowels would yield correct the consonant inventories for the various dialects of Salish. In fact, Bessell and Archangeli and Pulleyblank (1994) both point to *[RTR, HIGH, FRONT] (possibly a conjunction of *[RTR, HIGH] and *[RTR, FRONT]) as a motivating constraint.

However, a closer examination shows the explanation is not so simple. We will review the inventory and RTR-harmony processes of the Salish dialects Snchitsuʔumshtsn, Kalispel, Spokane, and Flathead (as reported in Bessell), and then attempt two very different OT analyses of the data. These expose some of Optimality Theory's current deficiencies with respect to transparency effects and "Duke-of-York" derivations. Our responses to these deficiencies follow the proposals by Baković and Wilson (2000), Walker (1999), and McCarthy (1998); but we will see that all of these approaches are inadequate typologically. A third analysis inspired by Turkana data captures the typology of the Salish dialects best.

5.1 Salish Dialect Vowel Inventories

In the eastern Interior Salish languages, phonological vowel retraction occurs in the context of both local and non-local faucals. A portion of the vowel inventory of these languages only appears in non-faucal contexts; the other portion only appears in faucal contexts. The full range of harmony alternations is shown in (19), which is taken from Bessell (1998).

		Non-faucal	*Faucal*
	Snchitsuʔumshtsn	i_1 i_2 ɛ u	ɑ ɛ ɑ ɔ
(19)	Kalispel	i e u	i a o
	Spokane	i e u	i a ɔ
	Flathead	i e u	i ɑ ɔ

Note that in Spokane, Kalispel, and Flathead (the so-called Sp-Ka-Fl dialects), the /i/ segment is transparent, while Snchitsuʔumshtsn has two different underlying segments, /i_1/ and /i_2/, which are both neutralized to [i] in non-faucal contexts. In faucal contexts, /i_1/ surfaces as [ɑ] and /i_2/ surfaces as [ɛ].

Note that retraction is much more consistent in these dialects than in other Salish dialects,[22] where a range of allophones are found for retracted vowels. As Bessell notes (page 6),

> In fact, vowel quality is so consistent that Doak (1992) formulates morpheme structure constraints in the language [*Sn*] which prohibit the occurance of the unretracted vowels /i u/ in the context of faucals.

[22]Such as *Nx*, summarized in (8).

A simple example of Kalispel faucal harmony should clarify any remaining questions about the nature of the harmonic alternations.

		Kalispel faucal harmony: i∼i, e∼a, u∼o			
		Non-faucal context		*Faucal context*	
(20)	a.	i-q^{w}ín	'it is green'	i-q^{w}ín-lqs	'he has a green shirt'
	b.	i-t^{ʃ}n-q^{w}ét^{s}	'I am warm'	q^{w}át^{s}-qn	'hat'
	c.	i-púm	'it is brown'	t^{ʃ}ne-s-n-póm-qn-i	'I am smoking skins'

We will concentrate on the Spokane dialect for analysis, and then determine how easily our Spokane-motivated analysis is extended to the other dialects.

5.2 Deriving the Inventories

In order for a segment to show up in the inventory, we must have some faithfulness constraint on that segment $\mathbb{F}$ dominate any markedness constraint $\mathbb{M}$ on that segment. Likewise, if the segment is absent from the inventory, than $\mathbb{M} \gg \mathbb{F}$ for some $\mathbb{M}$ and any $\mathbb{F}$. For the vowel inventories of Sp-Ka-Fl, the well-motivated markedness constraints *[RTR, FRONT], *[RTR, HI], and *[ATR, LOW] do most of the heavy lifting for us, and are assumed undominated in these languages. These constraints leave both [o] and [ɔ] and both [a] and [ɑ] in the inventory, however; we must introduce ad-hoc constraints *[a], *[ɑ], *[o] and *[ɔ] to narrow down to the correct dialect inventory. The *[a] and *[ɑ] constraints we will ignore, assuming that the difference between a central low vowel and a back low vowel is more a matter of implementation than phonology, and we will accomplish the *[ɔ] constraint using the somewhat-more-palatable constraint *[RTR, −LOW]. We then have the following rankings for our four dialects:

	a. Snchitsuʔumshtsn	*[RTR, high], *[ATR, −high] $\gg \mathbb{F} \gg$ *[RTR, front], *[o]
(21)	b. Spokane/Flathead	*[RTR, high], *[RTR, front], *[o] $\gg \mathbb{F} \gg$ *[ATR, −high]
	c. Kalispel	*[RTR, −low], *[RTR, front] $\gg \mathbb{F} \gg$ *[ATR, −high], *[o]

This is a promising start: by simply re-ranking our five constraints, we can obtain all three Salish vowel inventories.[23] However, we haven't accounted for the harmony process and /i/ transparency yet. The next three sections will attempt to integrate these processes into our analysis in three different ways. We will see that each approach leads to typological problems.

[23] However, there are 32 different rankings of these constraints with respect to $\mathbb{F}$ (corresponding to 32 subsets of the five constraints which can dominate $\mathbb{F}$), which yield 15 unique vowel inventories: {iɪuʊeɛoɔa}, {iɪuʊeɛɔa}, {iueɛoɔa}, {iueɛɔa}, {iueoa}, {iuea}, {iɪuʊɛɔa}, {iuɛɔa}, {iua}, {iuʊeoɔa}, {iuʊeɔa}, {iueoɔa}, {iueɔa}, {iuʊɔa}, and {iuɔa}. Of these fifteen, only three are in use in eastern Salish, with one more found in the StÕatÕimcets dialect. From inspection, it seems unlikely that all fifteen inventories may be found amongst the world's languages — take, for example {iuʊɔa} — but it would require a much larger cross-linguistic study to tease out the universal rankings or inviolate constraints which further constrain the typology.

5.3 A Sympathetic approach to Spokane Salish

The /i/-transparency of the Sp-Ka-Fl dialects leads to immediate issues in an OT analysis, as /i/'s non-participation in RTR-harmony would be expected to *block* the harmony process, which doesn't happen. Sympathy, as proposed by McCarthy (1998) and refined by Walker (1999), seems to provide an intuitive means for OT to address processes like these.

The most obvious way to obtain the desired effects in analysis is to posit a sympathetic candidate with RTR fully spread on to all vowels. This candidate will contain the segments /ɪ, ʊ, ɛ/ which are not in the inventory. RTR-faithfulness with the sympathetic candidate will ensure that the final OT output contains those segments *in the inventory* which are closest to the RTR-bearing /ɪ, ʊ, ɛ/ segments. In Spokane, we want /ɪ/ to resolve to [i], /ʊ/ to resolve to [ɔ], and /ɛ/ to resolve to [a].

For convenience, we will refer to the inviolate inventory constraints which we derived in section 5.2 as $\mathbb{M}_{\mathrm{INV}}$. Our sympathetic candidate will be derived using the ranking:

(22) RTR-harmony $\gg \mathbb{F} \gg \mathbb{M}_{\mathrm{INV}}$

where $\mathbb{F}$ stands for the relevant IO-faithfulness constraints, as before, and the RTR-harmony constraint is whatever constraint or group of constraints suffice to spread the RTR feature of a faucal onto the vowels. In section 3.2 we claimed that this was Spread[RTR, L], but the exact constraint is not crucial here.

Once we've obtained our sympathetic candidate, we put $\mathbb{M}_{\mathrm{INV}}$ back into the tableau as inviolate constraints and use Ident-❀O[RTR] to coerce the harmony. Highly-ranked Ident[round] will then ensure that /e/ goes to /a/ and not /ɔ/. We still must prevent /i/ from going to /a/. This is very similar to a chain-shift, and we fix the problem using local constraint conjunction following Kirchner (1996). Our final ranking is thus:

(23) Ident[rd], Ident[hi] & Ident[lo] $\gg$ Ident-❀O[RTR] $\gg$ Ident[hi], Ident[lo]

Again, we assume $\mathbb{M}_{\mathrm{INV}}$ is inviolate as so do not show it.

A few examples should show the sufficiency of this analysis. Since $\mathbb{M}_{\mathrm{INV}}$ is considered inviolate, we do not show any candidates with vowels not in the inventory. We use /K/ as a place-holder for any faucal consonant which would trigger RTR-harmony.

The first tableau shows that /i/ goes to /i/ as desired, creating the transparency:

Spokane / . . . i . . . K . . . / ❀ / . . . ɪ . . . K . . . /	Id[rd]	Id[hi] & Id[lo]	Id-❀O[RTR]	Id[hi]
☞ a. . . . i . . . K			*	
b. . . . u . . . K	*!		*	
c. . . . e . . . K			*	*!
d. . . . ɔ . . . K	*!			*
e. . . . a . . . K		*!		*

The next tableau shows that /e/ goes to /a/ in a faucal context.

Spokane / . . . e . . . K . . . / ❀ / . . . ɛ . . . K . . . /	Id[rd]	Id[hi] & Id[lo]	Id-❀O[RTR]	Id[hi]
a. . . . i . . . K			*!	*
b. . . . u . . . K	*!		*	*
c. . . . e . . . K			*!	
d. . . . ɔ . . . K	*!			
☞ e. . . . a . . . K				

And the last tableau shows that /u/ goes to /ɔ/.

Spokane / . . . u . . . K . . . / ❀ / . . . ʊ . . . K . . . /	Id[rd]	Id[hi] & Id[lo]	Id-❀O[RTR]	Id[hi]
a. . . . i . . . K	*!		*	
b. . . . u . . . K			*!	
c. . . . e . . . K	*!		*	*
☞ d. . . . ɔ . . . K				*
e. . . . a . . . K		*!		*

This analysis generates the proper outputs for Spokane, but it is typologically fragile. Although substituting the inventory constraints for Flathead (which merely substitute [ɑ] for [a]) at the top of the ranking yields the correct Flathead behavior, doint the same for Kalispel does not. Recall that Kalispel's inventory is /i, u, e, o, a/, and that /u/ goes to [o] in a faucal context. This subtle inventory change runs directly across our Ident-❀O[RTR] constraint, which attempts to select an RTR output segment in a faucal context. The following tableau shows the trouble we get into: we inadvertently create another transparent vowel![24]

Kalispel / . . . u . . . K . . . / ❀ / . . . ʊ . . . K . . . /	Id[rd]	Id[hi] & Id[lo]	Id-❀O[RTR]	Id[hi]
a. . . . i . . . K	*!		*	
✖ b. . . . u . . . K			*	
c. . . . e . . . K	*!		*	*
d. . . . o . . . K			*	*!
e. . . . a . . . K		*!		*

[24] Note that if we'd used Ident[back] instead of Ident[round] to prevent the /e/∼/ɔ/ alternation, we would have found that /e/ became transparent, too: in Flathead, where the low central vowel /a/ becomes the low *back* vowel /ɑ/.

In section 5.5 we will show how splitting off a lowering process independent from RTR harmony can mitigate this problem.

In summary, sympathy can provide an OT analysis of /i/ transparency in the various dialects of eastern Interior Salish, but the analysis is typologically brittle. Simple constraint reorderings which slightly change the inventory end up having large and undesirable effects on the harmony processes, which do not appear to be amenable to resolution through further reordering. In particular, Kalispel's substitution of the non-RTR segment /o/ for /u/ in a faucal context throws the very basis of the sympathic analysis into question. Clearly, some other analysis more robust to inventory shift is desirable.

5.4 Targeted Constraints and /i/ Transparency

Another treatment of transparency found in the literature relies on targeted constraints (Baković and Wilson 2000). It is not difficult to contruct an analysis of Spokane using the targeted constraint ⊙[RTR, HI, FRONT]. First, we must loosen our inventory constraints to allow the harmonic candidate /ɪ/ for our transparent segment /i/. We will call the new collection of inventory markedness constraints $\mathbb{M}'_{\mathrm{INV}}$. Secondly, we add high-ranking constraints IDENT[HI] & IDENT[LO] and IDENT[ROUND] as before to constrain the possible harmonic pairs: this ensures that neither /i/ nor /u/ will drop to /a/, and that /e/ won't map to /ɔ/. Finally, we sandwich in our targetted constraint ⊙[RTR, HI, FRONT] to eliminate the /ɪ/ candidate while preserving its transparency, and follow that with RTR-HARMONY to coerce the vowels to undergo harmony. Our final ranking looks like this:

(24) $\mathbb{M}'_{\mathrm{INV}} \gg$ ID[RD], ID[HI] & ID[LOW] $\gg$ ⊙[RTR, HI, FRONT] $\gg$ RTR-HARMONY $\gg \mathbb{F}$

We show it in action with tableaus for each case. As before, $\mathbb{M}'_{\mathrm{INV}}$ is inviolable, so we do not show any candidates with segments outside our (expanded) inventory. The first tableau shows the transparency of /i/:

Spokane / . . . i . . . K . . . /	ID[RD]	ID[HI] & ID[LO]	⊙[RTR,HI,FR]	RTR-HARMONY
☞ a. . . . i . . . K				*
b. . . . ɪ . . . K			$a > b$	
c. . . . u . . . K	*!			*
d. . . . e . . . K				*
e. . . . ɔ . . . K	*!			
f. . . . a . . . K		*!		
Cumulative	$\{a, b, d\} > \{c, e, f\}$		$a > b > \{c, e, f\}$ $d > \{c, e, f\}$	$a > b > d > \{e, f\} > c$

As required, /e/ maps to /a/:

Spokane / . . . e . . . K . . . /	Id[rd]	Id[hi] & Id[lo]	⊙[RTR,hi,fr]	RTR-harmony	Id[hi]
a. . . . i . . . K				*	*
b. . . . ɪ . . . K			$a > b$		*
c. . . . u . . . K	*!			*	
d. . . . e . . . K				*	
e. . . . ɔ . . . K	*!				
☞ f. . . . a . . . K					
Cumulative	$\{a,b,d,f\} > \{c,e\}$		$a > b > \{c,e\}$ $\{d,f\} > \{c,e\}$	$a > b > d > e > c$ $f > d > e > c$	$f > a > \ldots$

And /u/ maps to /ɔ/:

Spokane / . . . u . . . K . . . /	Id[rd]	Id[hi] & Id[lo]	⊙[RTR,hi,fr]	RTR-harmony
a. . . . i . . . K	*!			*
b. . . . ɪ . . . K	*!		$a > b$	
c. . . . u . . . K				*
d. . . . e . . . K	*!			*
☞ e. . . . ɔ . . . K				
f. . . . a . . . K		*!		
Cumulative	$\{c,e\} > \{a,b,d,f\}$		$\{c,e\} > \{a,d,f\}$ $a > b$	$e > c > f > a > b > d$

So targetted constraints, too, can give an account of RTR-harmony/transparency in Spokane. And substituting Flathead's inventory constraints will yield the correct behavior for Flathead's minimally different inventory. But let's peer inside our altered inventory constraint bundle $\mathbb{M}'_{\mathrm{INV}}$ for Spokane. This selects an inventory /i, ɪ, u, ɔ, a/ which looks very strange, at least. And, in fact, we must introduce a special *[RTR, high, back] constraint to eliminate the /ʊ/ without eliminating the /ɪ/ or the /ɔ/, and this *[RTR, high, back] constraint also looks very odd. There is phonological basis for the *[RTR, high, front] constraint often used—and which we make targeted—but the RTR feature is supposed to *support* backness and *oppose* frontness, not the other way around. Cross-linguistically, we expect to see /ɪ/ only when /ʊ/ is also in the inventory. What this means is that our analysis *crucially depends* on positing constraints yielding a "cross-linguistically improbable" inventory, in order for the introduction of ⊙[RTR, hi, front] to have the desired effect. Typologically, one would expect that if a ranking such as the posited is proposed, then the ranking without ⊙[RTR, hi, front] in a dominant position would also be possible — but this other ranking would yield an inventory which is not found among the world's languages.[25]

[25] As far as I know, as least!

So despite the initial attractiveness of this approach, we've gotten ourselves into trouble already. Furthermore, this analysis no more explains the Salish dialect variations than the sympathy-based approach did. In particular, by relying on RTR-harmony to select /ɔ/ for /u/, we guarantee that /u/ becomes *opaque* in the Kalispel dialect, when the /ɔ/ is replaced by /o/. In short, we have the same problems with /u/ harmonic process as we did in the sympathy-based approach, except that because of the ⊙[RTR, HI, BK] targeted constraint the segments become erroneously *opaque*, rather than erroneously transparent as before.

Clearly neither sympathy nor targeted constraints have yielded typologically attractive analyses for our vowel transparency.[26]

5.5 Separating Vowel Lowering from RTR Harmony

Another angle into the Salish tangle may be to assume that the "RTR-harmony" process is not (completely) RTR-related at all: instead perhaps there is a vowel *lowering* process instead of, or in addition to, the RTR-harmony. This somewhat contradicts the standard assumptions about Salish: the very first comprehensive grammar published (Reichard 1938) described the faucal-context vowels as produced with the tongue "drawn farther back," and none of the standard analyses disagree with this assessment. However, there is precedent in other languages; in Turkana, for example, Noske (1996) shows evidence that an apparent RTR-harmony process is actually two processes: a raising process *followed by* harmonization. We will take a brief detour to look at her evidence, and then return to see how this may be applied to our Salish dialects.

5.5.1 Analogies from Turkana

Turkana is an Eastern Nilotic language spoken in Kenya. It displays both [ATR] and [RTR] harmony. Suffixes may be specified for either [ATR] or [RTR] or left unspecified; suffixes with an tongue root feature cause regressive assimilation of the root, which unspecified suffixes assimilate to the root. We observe both [ATR] and [RTR] progressive assimilation from the root to an unspecified suffix, and both [ATR] and [RTR] regressive assimilation from a specified suffix onto the root. The following table shows these behaviors (all tables and data are from

[26]Note that, in a controlled acoustic study, Bessell (1998) has clearly shown that *phonological* transparency was involved in Salish, not merely phonetic co-articulation (which would "just happen" in the case of /i/ to yield a sound superficially indistinguishable from the original). So we *must* explain the facts within OT, without relying on an external *phonetic implementation* module to save us. However, another option might be to assume that the problematic Kalish dialect differs *only in phonetic implementation* from the analyzable Spokane and Flathead dialects, so that we can use our working analysis and chalk up any further differences to implementation. This still leaves sympathy as the only reasonable analysis, as we've seen that even when limited to Spokane, the inventory constraints in our targeted-constraint analysis are faulty typologically due to their embedding of an improbable vowel inventory.

Noske 1996):

(25)

Turkana			*Suffixes*		
			[ATR]	[RTR]	unspecified
Roots			/-e/	/-rɛ/	/-Un/
[ATR]	/-gol/	'close'	[e-gol-e]	[a-gɔl-ɛ-rɛ]	[a-gol-un]
	/-rem/	'spear'	[e-rem-e]	[a-rɛm-ɛ-rɛ]	[a-rem-un]
	/-buk/	'pour'	[e-buk-e]	[a-buk-ɛ-rɛ][27]	[a-buk-un]
[RTR]	/-dɔk/	'climb'	[e-dok-e]	[a-dɔk-ɛ-rɛ]	[a-dɔk-ʊn]
	/-gyɛl/	'buy'	[e-gyel-e]	[a-gyɛl-ɛ-rɛ]	[a-gyɛl-ʊn]
	/-dʊk/	'hide'	[e-duk-e]	[a-dʊk-ɛ-rɛ]	[a-dʊk-ʊn]

This seems straightforward. However, the underlying low vowel of the elative suffix /-ar/ surfaces as [a] after an [RTR] root, but as the [RTR] vowel [ɔ] after an [ATR] root.[28] That is, the /a/ participates in *raising* motivated by the [ATR] context, but *not* ATR harmony with the root.[29] In fact, the suffix causes the root to become [RTR], which seems to indicate that [ATR]-motivated raising is a separate process from [ATR]/[RTR] spreading.[30]

(26)

a.	/a-dʊk-ar-I/ INF-hide-EL-?	[adʊqar]	'to hide that way'
b.	/a-duŋ-ar-I/ INF-cut-EL-?	[aduŋɔr]	'to cut open'
c.	/a-rɪp-ar-I/ INF-investigate-EL-?	[arɪpar]	'to investigate'
d.	/a-rip-ar-I/ INF-skim-EL-?	[aripɔr]	'to skim off'

If [ATR] can cause raising independent of feature spreading, it seems reasonable to expect that [RTR] might be able to cause lowering in Salish, either in combination with feature spreading or independent of it.

5.5.2 An Analysis of Salish Using Lowering

Let us posit a new constraint Lower, which says, basically, "every vowel should be as low as possible." It is scored gradiently, with low vowels counting no violations, mid vowels scoring

[27]Note that high vowels block the spread of RTR from the suffix, as in this case.
[28]And Noske reports that the a∼ɔ alternation is even more common in the related language Ateso.
[29]The harmonic raised segment would, of course, be [o].
[30]And unfortunately, this process is *opaque*, in that it seems to need rule ordering to allow the raising to occur before the [RTR]-spreading bleeds the necessary [ATR] context. This is known to be problematic in OT; McCarthy originally proposed sympathy in order to deal with opacity (not harmonic transparency).

one, and high vowels scoring two.[31] One could imagine a varient where RTR vowels scored lower than non-RTR vowels, and ATR vowels scored higher than non-ATR vowels, but this simple hi/lo description will work fine for now. A local conjunction of LOWER with *FAUCAL over the harmonic domain (prosodic word?)[32] will ensure that lowering only happens in the appropriate faucal context. If we assume that our markedness constraints $\mathbb{M}_{\text{INV}}$ are inviolate and define the inventory, and LOWER $\&_{HD}$ *FAUCAL cause the lowering, we need only insert some appropriately-ranked faithfulness constraints to ensure that the "correct" lowering happens (and that every vowel doesn't fall to [a] in faucal context). We've seen the requisite faithfulness constraints before: they are IDENT[HI] & IDENT[LO] (to limit the lowering to one "step"), and IDENT[ROUND] (to ensure that /u/ falls to /o/ or /ɔ/ and not /e/ or /ɛ/). In order to ensure that /i/ does not lower, we rank IDENT[HI] & IDENT[FRONT] high.

Our complete ranking looks something like:

(27) $\mathbb{M}_{\text{INV}}$, ID[RD], ID[HI] & ID[LO], ID[HI] & ID[FR] ≫ LOWER $\&_{HD}$ *FAUCAL ≫ $\mathbb{F}$

We present tableaus to illustrate; beginning with the i∼i case. As previously, we assume that the inventory constraints $\mathbb{M}_{\text{INV}}$ are inviolable, and so do not present candidates with vowels not in the inventory.

Spokane / ... i ... K ... /	ID[RD]	ID[HI] & ID[LO]	ID[HI] & ID[FR]	LOWER & *FAUCAL
☞ a. ... i ... K				**
b. ... u ... K	*!		*!	**
c. ... e ... K			*!	*
d. ... ɔ ... K	*!		*!	*
e. ... a ... K		*!	*!	

As you can see, the IDENT[HIGH,FRONT] case single-handedly ensures the invariance of /i/. Now we look at the slightly more interesting e∼a alternation:

Spokane / ... e ... K ... /	ID[RD]	ID[HI] & ID[LO]	ID[HI] & ID[FR]	LOWER & *FAUCAL
a. ... i ... K				*!*
b. ... u ... K	*!			**
c. ... e ... K				*!
d. ... ɔ ... K	*!			*
☞ e. ... a ... K				

[31] The LOWER constraint is thus scored similarly to the HIATUS-RAISING constraint in (Kirchner 1996).

[32] Some prefixes do not participate in harmony, and thus would be excluded from the harmonic domain/prosodic word.

And finally, the u∼ɔ case:

Spokane / ... u ... K ... /	ID[RD]	ID[HI] & ID[LO]	ID[HI] & ID[FR]	LOWER & *FAUCAL
a. ... i ... K	*!			**
b. ... u ... K				*!*
c. ... e ... K	*!			*
☞ d. ... ɔ ... K				*
e. ... a ... K	*!	*!		

Of course, this works with the minor variant Flathead inventory, as well. But unlike the other analyses presented thus far, this same constraint system can be used for Kalispel if we merely substitute the correct inventory constraints for $\mathbb{M}_{\mathrm{INV}}$. We show a tableau for the crucial u∼o alternation in Kalispel:

Kalispel / ... u ... K ... /	ID[RD]	ID[HI] & ID[LO]	ID[HI] & ID[FR]	LOWER & *FAUCAL
a. ... i ... K	*!			**
b. ... u ... K				*!*
c. ... e ... K	*!			*
☞ d. ... o ... K				*
e. ... a ... K	*!	*!		

Furthermore, a simple re-ranking will give us a correct analysis for Snchitsuʔumshtsn! Recall that the Snchitsuʔumshtsn inventory is /i, u, ɛ, ɔ, ɑ/ and that *two* /i/ alternations are seen: i_1 ∼ ɑ and i_2 ∼ ɛ. We re-order $\mathbb{M}_{\mathrm{INV}}$ appropriately for Snchitsuʔumshtsn (the constraints are listed in (21) on page 11, if you need to flip back there), and need only demote ID[HI] & ID[FR] below LOWER & *FAUCAL to obtain a correct ranking. The next tableau shows how /i_2/ now goes to /ɛ/:

Snchitsuʔumshtsn / ... i_2 ... K ... /	ID[RD]	ID[HI] & ID[LO]	LOWER & *FAUCAL
a. ... i ... K			*!*
b. ... u ... K	*!		**
☞ c. ... ɛ ... K			*
d. ... ɔ ... K	*!		*
e. ... ɑ ... K		*!	

But how do we get /i_1/ to go to /ɑ/?

Here's one simple solution: let's suppose that /i_1/ is *unspecified for* [LO]. It has it's [HI] feature, and [LOW] is non-contrastive on high vowels anyway. Then the constraint ID[HI] & ID[LO] never kicks in to rule out /ɑ/, and we get the desired tableau:

Snchitsuʔumshtsn / ... i_1 ... K ... /	ID[RD]	ID[HI] & ID[LO]	LOWER & *FAUCAL
a. ... i ... K			*!*
b. ... u ... K	*!		**
c. ... ɛ ... K			*!
d. ... ɔ ... K	*!		*
☞ e. ... ɑ ... K			

With a little underspecification, Snchitsuʔumshtsn now works perfectly in the analysis.

Before we pat ourselves too firmly on the back for obtaining a typologically-reasonable analysis, let's stare a little harder at this analysis. The prime advantage is that it works. But there are several disadvantages:

- The RTR feature presumed to be assimilated from the faucal consonant trigger is never explicitly mentioned in the analysis. And if we posit that faucal consonants possess some vocalic feature such as [LOW], we must come up with a rational reason why other apparently "low" consonants don't also have this feature. Faucal consonants, in fact, are not obviously *low*; their salient quality is rather their *backness*: but not only do we not mention backness in our constraints, as footnote 24 mentions the dialects with /ɑ/ instead of /a/[33] stop working if we replace IDENT[ROUND] with IDENT[BACK]. Furthermore, there is a long-established tradition identifying [RTR] with the vowel quality in Salish VC harmony — and analogous processes in languages such as Palestinian Arabic where the feature in question *is* more obviously [RTR].
- The use of conjunction in our LOWER & *FAUCAL constraint is not very clean. It works in our examples because we posit that the conjunctive domain is *exactly equal to* the harmonic domain—but the harmonic domain only extends *leftward* from a faucal consonant and excludes some (not all) prefixes. The constraints ought to be factored in such a way that a non-trivial domain is not required. Sans some particular feature to be spread, it is hard to see how this constraint could be cleaned up.
- The LOWER & *FAUCAL constraint also seems to violate locality, but presumably in no more crucial manner than the ALIGN constraint and constraints governing other non-local spreading processes do.

5.6 Unresolved questions

It is clear that the exact features involved in the Salish harmony process badly need to be discovered, and/or a more productive manner of relating tongue root position to vowel height explored. Intuitively, the downward vowel height pressure from RTR is simple enough to

[33]Snchitsuʔumshtsn and Flathead.

explain, but it is rather difficult to clearly translate this intuition to feature geometry and autosegmental spreading. Clements' aperature theory 1991 was an attempt to do just that, but even a cursory examination will convince the reader that aperature theory does not illuminate the Salish harmony processes.

Further, even seemingly straightfoward cases like Turkana (discussed in section 5.5.1) lead to problematic featural issues. Noske (1996) notes that /k/ is often pharyngealized to [$k^{ʕ}$] in the coda if preceded by the vowels /a/ and /ɔ/. This seems to be a straight-forward RTR-spreading process. But in addition, /k/ is realized at a uvular place of articulation ([q]) if it is followed or preceded in the same syllable by the vowels /a/, /ɔ/, *or /o/!* In exactly the same manner as with Kalispel, we must ask, "what's so RTR about /o/?" In Turkana as in Kalish, /u/ is not "RTR enough," so it is obvious we are not necessarily talking about mere backness.

It seems that a further close *phonetic* examination is necessary to tease out the relevant features in both the Salish and Turkana processes.

6 Conclusion

We have examined closely a range of related C→V harmony processes in Palestinian Arabic, Interior Salish, and Chilcotin, and have seen how the directionality and segmental transparency/opacity parameters differentiating these processes may be expressed via reranking of some basic constraints. We then studied the dialectal differences among four different Interior Salish languages, and showed how the vowel inventories of these four dialects could emerge from re-rankings of a set of five constraints. We considered the behavior of the vowels in faucal harmony contexts, and formulated analyses using sympathy and targeted constraints to obtain the observed /i/-transparency. Neither of these analyses, however, generalized well across the four dialects; the slight re-rankings necessary to obtain the proper output inventories caused the behavior of /u/ to shift in ways entirely unlike those found in the actual dialects. Worse, it was not obvious how further small-scale re-rankings might rectify the situation. Our conclusion was that the OT analyses produced by Sympathy and Targeted Constraints were *typologically fragile*, and did not satisfactorily explain the minor variations in our dialect group.

We then took a step back to look at a vowel-harmony process in Turkana, and saw evidence that [ATR] can induce vowel *raising* independent of the spread of the [ATR] feature. Inspired, we re-analyzed our Salish data under the assumption that the [RTR] quality of the faucal consonants was inducing vowel height lowering, but *not* by direct spreading of the [RTR] feature. This analysis showed much better typological properties, describing all four of our dialects with only a single re-ranking apart from those needed to effect the vowel inventory change. This approach was deemed a much more promising in-road into the behavior of post-velar harmony, but it leaves unresolved feature-theory issues on the exact RTR-lowering mechanism.

Returning to Turkana, we saw how C→V interactions there (in particular, the behavior of /k/ near /o/) showed "RTR harmony" occuring without RTR actually being present on the triggering vowel. This mirrored the anomalous presence of /o/ in the faucal-context vowel set in the Salish data. Further work ought to be done to isolate the mechanism of [RTR]'s interaction with vowel lowering, and determine the other segment features (possessed by /o/ in particular) which are relevant in post-velar harmonic processes.

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