Strength in Harmony Systems: Trigger and Directional Asymmetries[*]

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Abstract

This paper proposes an account of harmony systems that have asymmetries in directional spreading, directional blocking, directional bounds, and trigger strength. I show that adopting a derivational version of Optimality Theory with weighted constraints – Serial Harmonic Grammar – as the analytic framework can successfully generate these systems in a general way without relying on problematic Local Constraint Conjunction. Additionally, building on earlier work, the serial nature of the grammar is used in order to prevent predictions of implausible typological pathologies found in existing parallel Optimality Theory and Harmonic Grammar analyses. Small typologies generated by this grammar are presented, and a complex test case from Chilcotin is examined.

Keywords: harmony, directional asymmetries, trigger conditions, blocking, locality, autosegmental, feature spreading, strict domination, Local Constraint Conjunction, weighted constraints, Harmonic Grammar, Harmonic Serialism, parallelism, Optimality Theory, Chilcotin, phonology, typology

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Contents

1 Introduction

This manuscript outlines a general formal account of complex harmony systems that have directions and triggers of different strengths producing asymmetries in the direction of feature spreading, blocking, boundedness, and trigger conditions. Here, *strength* specifically refers to the following:

- the lack of spreading in the *weak* direction but the ability to spread in the *strong* direction
- the ability of blocking segments to block harmony in the *weak* direction but not in the *strong* direction
- bounded spreading in the *weak* direction but unbounded spreading in the *strong* direction
- the lack of spreading from a *weak* featural host but the ability to spread from a *strong* featural host (trigger)
- the ability of blocking segments to block spreading from a *weak* trigger but not a *strong* trigger
- bounded spreading from a *weak* trigger but unbounded spreading from a *strong* trigger

The formal calculus used here is Serial Harmonic Grammar (Pater forthcoming, Pater and Staubs 2010, Elfner 2010, Kimper 2011). Serial Harmonic Grammar is a variant of Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1993, 1995) that has weighted constraints instead of ranked constraints and has serial evaluation rather than parallel evaluation.

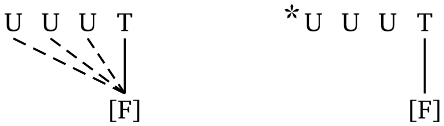
First, several examples of asymmetrical harmony systems are presented (§2) followed by a short background on weighted constraints (§3.1) and the serialist constraint grammar used here (§3.2). Then, I detail assumptions that the analysis presupposes (§3.3–§3.6). After these preliminaries, analyses of each of the asymmetrical types are offered individually (§4–§5). All of the analyses culminate in a challenging test case with multiple asymmetries: Chilcotin vowel flattening (§6). Finally, I briefly argue for this Serial Harmonic Grammar framework over frameworks in standard Optimality Theory with ranked constraints (§7).

2 Asymmetrical Harmony

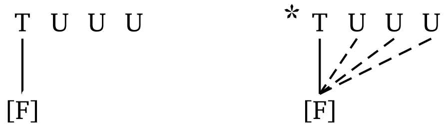
2.1 ASYMMETRY IN SPREADING DIRECTION

A language with an asymmetry in the direction of spreading has unidirectional spreading. For example, a language may regressively spread a feature [F] from a featural trigger *T* to all assimilating undergoer (target) segments *U* in the strong leftward direction (1) while spreading in the opposite weak direction (2) is illicit.

(1) *Spreading feature* [F] *from trigger* T *in strong direction*



(2) *No spreading feature* [F] *from trigger* T *in weak direction*



The rarity of unambiguous directional feature spreading in vowel harmony systems has led previous work to assert the absense of pure directional effects in feature spreading (Baković 2000, 2001, 2003). All feature spreading in these accounts is either bidirectional or stem-controlled in which the feature spreads from an inner root or stem to outer affixes. Any apparent unidirectional spreading is explained as stem-controlled harmony (either stem-to-prefix or stem-to-suffix). However, earlier work, including work in rule-based theories, often assumed directionality. Indeed, unidirectional patterns are attested even in vowel harmony (Hyman forthcoming) although they seem to be more common in other types of feature spreading (Hansson 2001). Below are examples from Warao nasal harmony, Ineseño Chumash coronal sibilant harmony, Assamese Advanced Tongue Root harmony, and Coeur d'Alene faucal harmony.

In Warao, nasal stops and nasalized vowels trigger progressive nasal harmony as evidenced by vowel alternations (Obsorn 1966*a*, 1966*b*, 1967, Peng 2000).[1] Oral stops like [k, p] block harmony. However, the [nasal] spreading is only from left to right: regressive harmony is not attested in Warao. The oral suffix [-a] in (3*a*) occurs in the context of oral segments in (3*b*) and (3*d*). This same suffix has a nasalized variant [-ã] when it is preceded by a nasal suffix [-n] (3*e*) as in (3*f*). Although [-n] triggers progressive assimilation, any vowel preceding [-n] is invariantly oral as demonstrated by the root-final oral [o] in both (3*d*) and (3*f*). The nasal segments trigger progressive harmony from an inner suffix to outer suffixes (3*f*), from an initial stem to a final stem in a stem–stem compound leading to a [waku ∼ w̃ãku] alternation (3*j*), and from a noun to a following verbal particle leading to a [haɛ ∼ h̃ãɛ̃] alternation (3*l*). In all of these examples, progressive harmony is attested while regressive harmony is unattested: hypothetical [*ɛhopõnãɛ̃, *h̃õnĩ, *h̃õnĩw̃ãku, *pãnãpãnãh̃ãɛ̃] are all illicit forms.

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[1] Warao is a language isolate spoken in northeastern Venezuela.

(3) *Warao: Progressive nasal harmony*

a.	-a	(MOMENTANEOUS)
b.	toro-a-ɛ	‘he put in’
c.	ɛhopo-	‘to go out’
d.	ɛhopo-a-ha	‘gone out’
e.	-n	(SG)
f.	ɛhopo-n-ã-ɛ̃	‘he went out’
g.	ho	‘water’
h.	honĩ	‘in the water’
i.	waku	‘terrapin’
j.	honĩ-w̃ãku	‘turtle’
k.	honĩw̃ãku haɛ	‘it’s a turtle’
l.	panãpanã h̃ãɛ̃	‘it’s a porpoise’

This is not stem-controlled harmony since nasal triggers in prefixes like [mã-] (4*a*) cause stems to undergo harmony as in (4*c*). Warao is a fairly clear example of a harmony system that requires the phonological grammar to refer to a directional preference.

(4) *Warao: Progressive harmony is not stem-controlled*

a.	mã-	(1.POSS)	
b.	ha	‘hammock’	
c.	mãh̃ã	‘my hammock’	*mãha

A directional restriction on harmony that cannot be reduced to a stem-control effect is also common in long-distance coronal sibilant harmony. Usually, this type of harmony is feature-changing and strictly regressive. Ineseño Chumash is a typical example (Applegate 1972; Poser 1982, 1993; Steriade 1987; Shaw 1991; Hansson 2001; McCarthy 2007c).[2] Coronal affricates and fricatives assimilate to the point of articulation of the rightmost coronal affricate or fricative: sibilant postalveolars become alveolars when preceding sibilant alveolars and sibilant alveolars become postalveolars when preceding sibilant postalveolars. In (5), an underlying /s/ in a prefix surfaces unchanged in the elsewhere environment but when followed by a suffix containing a postalveolar /ʃ/, the prefix assimilates to the articulation of the suffix. Here, the direction of harmony is regressive: a form with progressive harmony [*hasxintilawas] is not attested. Additionally, the harmony trigger occurs in a suffix showing that the directional process is not stem-controlled.

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[2] Ineseño Chumash is an extinct Chumashan language formerly spoken in southern California.

(5) *Chumash: Regressive coronal sibilant harmony*

a.	s-	(3.POSS)
b.	ha-s-xintila	‘his gentile’
c.	-waʃ	(PST)
d.	ha-ʃ-xintila-waʃ	‘his former gentile’

Assamese Advanced Tongue Root vowel harmony is regressive – and not progressive or stem-controlled (Mahanta 2007).[3] This is found in static phonotactic patterns with monomorphemic words and in vowel alternations. Assamese has [ATR] vowels such as [o, i, e, u] with corresponding non-[ATR] counterparts [ɔ, ɛ, ʊ]. (6*a, b*) show that it is possible that a non-[ATR] vowel may follow an [ATR] vowel: the [ATR] feature does not spread progressively from the preceding vowel to a following vowel. However, the converse is unattested in Assamese: roots cannot have a non-[ATR] followed by an [ATR] vowel. Thus, hypothetical roots like [*ɔbʰinob] or [*xɔrijoh] are ungrammatical. Similarly, underlyingly non-[ATR] roots (7*a, b, c*) alternate with [ATR] forms when followed by an [ATR] vocalic suffix (7*d, e, f*). Again, the converse is not true: non-[ATR] suffixes are invariantly non-[ATR] following an [ATR] root (8).

(6) *Assamese: Non-*[ATR] *vowels can follow* [ATR] *vowels*

a.	obʰinɔb	‘new’
b.	xorijɔh	‘mustard’

(7) *Assamese: Alternations from regressive* [ATR] *harmony*

a.			tɛz	‘strength’	
b.			ʊpɔr	‘above’	
c.			dʰʊl	‘drum’	
d.	/tɛz-i/	→	tezi	‘strong’	*tɛzi
e.	/ʊpɔr-i/	→	upori	‘in addition’	*ʊpɔri
f.	/dʰʊl-ijɑ/	→	dʰulijɑ	‘drummer’	*dʰʊlijɑ

(8) *Assamese: Harmony is not progressive or stem-controlled*

a.			kin	‘buy’	
b.			bʰut	‘ghost’	
c.			pʰur	‘travel’	
d.	/kin-ɛ/	→	kinɛ	‘buy-3.PRES’	*kine
e.	/pʰur-ɛ/	→	pʰurɛ	‘travel-1.PRES’	*pʰure
f.	/bʰut-ʊ/	→	bʰutʊ	‘ghost-ERG’	*bʰutu

Finally, Coeur d’Alene has faucal harmony that is regressive (Doak 1992). Underlying /i, u, ɛ/ are lowered and retracted to [ɛ, ɔ, ɑ] when followed by a uvular, pharyngeal,

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[3] Assamese is an Indo-Aryan language (Indo-European) spoken in Assam, (northeastern) India.

or pharyngealized coronal [q, q’, χ, qʷ, q’ʷ, ʕ, ʕ’, ʕʷ, ʕ’ʷ, rˤ, r’ˤ].[4] This leads to allomorph alternations [tˢiʃ ~ tˢɛʃ] (9*a, b*), [pum ~ pɔm] (9*c, d*), [χɛtˢ ~ χɑtˢ] (9*e, f*), and [ʧɛm ~ ʧɑm, us ~ ɔs] (9*g*).[5] All of these examples show that the pharyngealizing triggers appear in suffixes ([-ɑlqʷ, -ɑlpqʷ]) and target vowels in preceding suffixes and roots.

(9) *Coeur d’Alene: Regressive faucal harmony*

a.	/tˢiʃ-t/	→	tˢíʃt	‘it is long’
b.	/tˢiʃ-ɑlqʷ/	→	tˢɛ́ʃɑlqʷ	‘he is tall’
c.	/s-t-pum-əlxʷ/	→	stpúməlxʷ	‘hide with fur’
d.	/s-pum-ɑlqʷ/	→	spɔ́mɑlqʷ	‘fur coat’
e.	/χɛtˢ-p/	→	χɛ́tˢp	‘he became curious’
f.	/t-χɛtˢ-χətˢ-us/	→	tχɑ́tˢχətˢus	‘he has curious eyes’
g.	/s-n-ʧɛm-us-ɑlpqʷ/	→	snʧɑmɔ́sɑlpqʷ	‘inside mouth’

(10) *Coeur d’Alene: Faucal harmony is not progressive*

a.	χɛtˢ-p	‘he became curious’	*χɑtˢp
b.	s-qʷil-n	‘cheating’	*sqʷɛln
c.	ʕɑtˢ-ʕɑtˢ-qín-ʃin	‘garters’	*ʕɑtˢʕɑtˢqɛ́nʃɛn
d.	t-s-tˢ’ɛ́χʷ-n-tˢut	‘star’	*tstˢ’ɛ́χʷntˢɔt
e.	n-tˢɑq-ítkʷɛʔ	‘he put it in the water’	*ntˢɑqɛ́tkʷɑʔ

Vowels following the faucal triggers are not affected by the harmony process as shown in (10). Thus, progressive harmony is not attested in Coeur d’Alene, and the unidirectionality of regressive feature spreading cannot be explained as root-controlled harmony.

2.2 ASYMMETRY IN BLOCKING DIRECTION

Other directional effects in harmony systems appear as restrictions that are confined to only a single direction. In several harmony systems, feature spreading is blocked by certain segments. For example, in nasal harmony systems, fricatives commonly block nasal harmony. A language with asymmetrical directional blocking allows spreading through otherwise blocking (or opaque) segments *B* in the strong direction (11) while spreading in the weak direction is blocked (12) because the feature [F] cannot be associated with the other features linked to segment *B*. Direction-specific blocking is found in Southern Palestinian Arabic.

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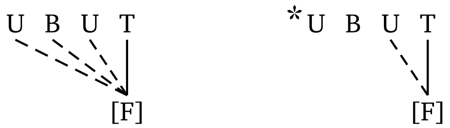
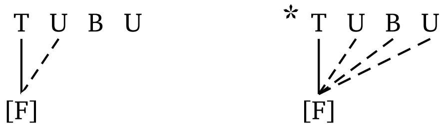
[4] Coeur d’Alene, also known as Snchitsu’umshtsn, is an endangered (Interior) Salishan language spoken in northern Idaho.

[5] The schwa vowels in Coeur d’Alene are due to separate processes of unstressed vowel reduction and epenthesis.

(11) *Segment* B *cannot block spreading in strong direction*



(12) *Segment* B *blocks spreading in weak direction*



Southern Palestinian Arabic has Retracted Tongue Root harmony (*emphasis*) triggered by uvularized coronal segments – [tʶ, ðʶ, sʶ, zʶ] – that are blocked progressively by palatals – [i, j, ʃ, ʤ] – but not regressively by palatals (Davis 1995). The feature spreading is unbounded and bidirectional, retracting both consonants and vowels as shown in (13). In (14), harmony is blocked by palatals since feature spreading is left-to-right (even by an epenthetic vowel (14*d*)). These same palatals do not block right-to-left feature spreading as shown in (15).

(13) *Southern Palestinian Arabic: Bidirectional iterative spreading*

a.	/balːaːsʶ/	→	b̙a̙l̙ːa̙ːsʶ	‘thief’
b.	/sʶabaːħ/	→	sʶa̙b̙a̙ːħ	‘morning’

(14) *Southern Palestinian Arabic: Progressive spreading blocked*

a.	/tʶiːn-ak/	→	tʶiːnak	‘your clay’	*tʶi̙ːn̙a̙k̙
b.	/sʶajːaːd/	→	sʶa̙jːaːd	‘fisher’	*sʶa̙j̙ːa̙ːd̙
c.	/ʕatʶʃaːn/	→	ʕa̙tʶʃaːn	‘thirsty’	*ʕa̙tʶʃ̙a̙ːn̙
d.	/batʶn-ha/	→	b̙a̙tʶinha	‘her stomach’	*b̙a̙tʶi̙n̙h̙a̙
e.	/ðʶaʤːaːt/	→	ðʶa̙ʤːaːt	(type of noise)	*ðʶa̙ʤ̙ːa̙ːt̙
f.	/maʤasʶːasʶiʃ/	→	m̙a̙ʤ̙a̙sʶːa̙sʶiʃ	‘it didn’t solidify’	*m̙a̙ʤ̙a̙sʶːa̙sʶi̙ʃ̙

(15) *Southern Palestinian Arabic: Regressive spreading not blocked*

a.	/tamʃiːtʶa/	→	t̙a̙m̙ʃ̙i̙ːtʶa̙	‘hair styling’	*tamʃiːtʶa̙
b.	/manaːfiðʶ/	→	m̙a̙n̙a̙ːf̙i̙ðʶ	‘ashtrays’	*manaːfiðʶ
c.	/xajːaːtʶ/	→	x̙a̙j̙ːa̙ːtʶ	‘tailor’	*xajːa̙ːtʶ
d.	/naʃaːtʶ/	→	n̙a̙ʃ̙a̙ːtʶ	‘energy’	*naʃa̙ːtʶ
e.	/maʤasʶːasʶiʃ/	→	m̙a̙ʤ̙a̙sʶːa̙sʶiʃ	‘it didn’t solidify’	*maʤasʶːa̙sʶiʃ

A similar case of direction-specific blocking is found in Cairene Arabic although the blocking is optional (Watson 2002: 273–274). Progressive emphasis spread from emphatic coronal triggers is optionally blocked by high front vocoids [i, j]. However, [i, j] never block the feature spreading in the regressive direction. Northern Rural Palestinian Arabic is like its southern counterpart except that the set of opaque blockers consists of all segments except for the low vowel, pharyngeals, and laryngeals (Younes 1993, Davis 1995). Again, harmony is only blocked progressively, not regressively. Another example of directional blocking is found in Dagbani Advanced Tongue Root harmony (Hudu 2010).[6] Progressive harmony triggered by /i/ is blocked by [a, s, l, ɾ], but, regressive harmony is not blocked. Directional blocking in Chilcotin is detailed in §4.2.1.

2.3 ASYMMETRY IN DIRECTION OF BOUNDEDNESS

A language with asymmetrical directional bounds has unbounded spreading in one direction and bounded spreading in the other. For example, a language may spread iteratively in the strong left-to-right direction (16) while in the opposite weak direction, spreading is only local to an adjacent segment (17).

(16) *Unbounded feature spreading in strong direction*

(17) *Bounded feature spreading in weak direction*

Chilcotin has an instance of a directional bound on feature spreading (Krauss 1975; Cook 1976, 1983, 1987, 1989, 1993; Hansson 2001, 2007).[7] In Chilcotin, coronal [RTR] triggers – [ṯˢˤ, ṯˢˤʰ, ṯˢˤ’, s̱ˤ, ẕˤ] – cause assimilation of a following long vowel but no further (18). In contrast, regressive spreading affects all preceding vowels from a stem-final trigger to the left word edge (19).

(18) *Chilcotin: Bound on progressive* [RTR] *harmony*

/s̱ˤæntæn/ → s̱ˤɑntæn ‘son-in-law’ *s̱ˤɑntɑn

(19) *Chilcotin: No bound on regressive* [RTR] *harmony*

/ʔæpɛlɛs̱ˤ/ → ʔɑpələs̱ˤ ‘apples’ *ʔæpɛlɛs̱ˤ, *ʔæpɛləs̱ˤ

Finally, it should be noted that directional effects are found in what may be considered phonetic domains. For example, Zawaydeh (1999) and Jongman *et al.* (2011) found that in Jordanian Arabic regressive [RTR] harmony categorically lowers the second formant of vowels while under progressive harmony F2 is gradiently lowered in which vowels closest to the trigger have lower F2 values compared to vowels further from the trigger.

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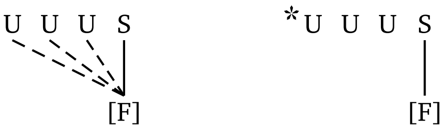
[6] Dagbani is a Gur language (Niger-Congo) spoken in northeastern Ghana.

[7] Chilcotin, also known as Tsilhqot’in, is an endangered (northern) Athabascan language (Dene-Yeniseian) spoken in British Columbia.

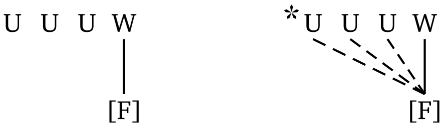
2.4 ASYMMETRY IN TRIGGER CONDITIONS

Other types of asymmetries involve an asymmetry between feature-bearing segments. Although a feature may occur on a particular segment, it may or may not act as a trigger of feature spreading. Both situations can co-exist in a language. One type of strong segment may both bear a feature and trigger feature spreading of that feature (20) while a different type of weak segment bears the feature but fails to act as a trigger of harmony (21).

(20) *Feature spreading from strong host* S



(21) *Lack of feature spreading from weak host W*



This asymmetry is found in Ennemor (Hetzron and Marcos 1966).[8] Both nasal stops and nasalized continuants occur in the language, but only nasalized continuants trigger nasal harmony assimilation on vowels.

(22) *Ennemor: Nasal spreading from strong triggers*

a.	/fʌʔʌβ̃ʌ/	→	fʌ̃ʔʌ̃β̃ʌ̃	'obstruct'	*fʌʔʌβ̃ʌ
b.	/ʌw̃ʌd/	→	ʌ̃w̃ʌ̃d	'gourd'	*ʌw̃ʌd
c.	/dʌʔʌr̃ʌ/	→	dʌ̃ʔʌ̃r̃ʌ̃	'hide'	*dʌʔʌr̃ʌ

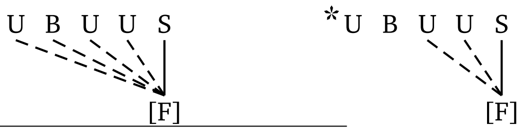
(23) *Ennemor: Nasal spreading from weak hosts is unattested*

a.	/anʌqʌ/	→	anʌqʌ	'strangled'	*ãnʌ̃qʌ̃
b.	/mʌkʌrʌ/	→	mʌkʌrʌ	'advise'	*mʌ̃kʌ̃r̃ʌ̃

2.5 ASYMMETRY IN TRIGGER CONDITIONS ON BLOCKING

The first interaction with a trigger condition and a further restriction is an asymmetry in blocking: harmony instigated by a strong trigger is unblockable (24) while harmony from a weak trigger is blockable (25).

(24) *Segment* B *cannot block spreading from strong trigger* S



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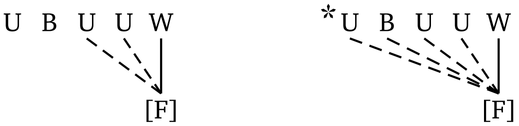
[8] Ennemor, also known as Inor, is a Southern Semitic language (Afroasiatic) spoken in Ethiopia.

(25) *Segment B blocks spreading from weak trigger W*



This pattern is found in Cairene Arabic [RTR] harmony (Watson 2002: 270–276). Cairene Arabic has both strong coronal triggers – [tʶ, dʶ, sʶ, zʶ] – and a weak rhotic trigger – [ɾʶ]. The weak trigger iteratively spreads [RTR] as shown in (26*a*, *b*), but it cannot spread the feature to opaque high front segments [i, j] as in (26*a*–*d*). The strong triggers, however, do spread to these segments (27).

(26) *Cairene Arabic: No spreading to opaque segments from weak trigger*

a.	/bɐʔɐɾʶi/	→	b̙ɑʔ̙ɑɾʶi	'my cows'	*b̙ɑʔ̙ɑɾʶɨ
b.	/diɾʶɐːsɐ/	→	diɾʶɑːs̙ɑ	'learning'	*d̙ɨɾʶɑːs̙ɑ
c.	/infigɐːɾʶ/	→	infig̙ɑːɾʶ	'explosion'	*ɨn̙f̙ɨg̙ɑːɾʶ
d.	/sifɐːɾʶɐ/	→	sif̙ɑːɾʶɑ	'embassy'	*s̙ɨf̙ɑːɾʶɑ

(27) *Cairene Arabic: Spreading to opaque segments from strong triggers is possible*

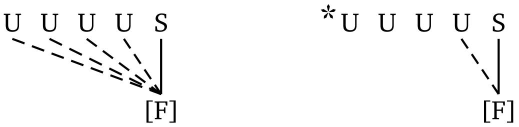
a.	/ʔɐmiːsʶ/	→	ʔ̙ɑm̙ɨːsʶ	'shirt'	*ʔɐmiːsʶ
b.	/wiːsʶil/	→	w̙ɨːsʶɨl̙	'he arrived'	*wiːsʶil
c.	/mɐsʶɐːjib/	→	m̙ɑsʶɑːj̙ɨb̙	'misfortunes'	*m̙ɑsʶɑːjib

Another example of a trigger condition on blocking is found in Chilcotin, which is detailed in §6.

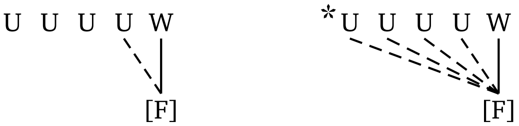
2.6 ASYMMETRY IN TRIGGER CONDITIONS ON BOUNDEDNESS

The last asymmetry involves two classes of triggers and bounded spreading. The strong trigger allows unbounded spreading (28) while the weak trigger only allows bounded spreading (29).

(28) *Spreading from strong trigger* S *is fully iterative*



(29) *Spreading from weak trigger* W *is strictly local*



In Cairene Arabic, weak uvular and pharyngeal triggers spread [RTR] to adjacent vowels but do not iteratively spread the feature to a second syllable (30) while strong coronal triggers spread iteratively to low vowels all the way to word edges (31).

(30) *Cairene Arabic: Bound on spreading from weak trigger*

a.	/qɐtɐl/	→	qɑtɐl	‘he killed’	*qɑtɑl
b.	/ʕɐmɐl/	→	ʕamɐl	‘he did’	*ʕamal

(31) *Cairene Arabic: No bound on spreading from strong trigger*

a.	/tʁɐlɐb/	→	tʁɑl̙ɑb̙	‘he demanded’	*tʁɑl̙ɐb

The uvular and pharyngeal triggers in Cairene Arabic also differ. Pharyngeal triggers only target the first adjacent mora of a long non-low vowel while uvular triggers target the entire adjacent vowel regardless of its length. If analyzed in terms of prosodic structure, the uvular spreads to an adjacent syllable while the pharyngeals spread to an adjacent mora.[9]

3 Harmony in Serial Harmonic Grammar

The current proposal is an implementation of HG with a serial architecture: Serial Harmonic Grammar. Serial Harmonic Grammar has been used in Pater (forthcoming) to account for syllabification in Berber, English, and French, in Elfner (2010) to account for interactions between vowel epenthesis and stress in Selayarese and Levantine Arabic, and in Kimper 2011 to account for opacity, transparency, and locality in feature spreading. Work on probabilistic Serial Harmonic Grammar is in Pater and Staubs (2010). I use Serial HG here to account for the asymmetrical feature spreading discussed in §1. This proposal synthesizes and extends the serial approach taken by McCarthy (2009*a*, forthcoming-*b*) and the weighted constraint approach taken by Potts *et al.* (2010).

A formal grammar utilizing weighted constraints known as Harmonic Grammar can successfully model these types of asymmetrical harmony systems (Smolensky and Legendre 2006, see Pater 2009 for further overview).[10] For instance, concerning the directional blocking case, an additive *gang effect* of the co-occurrence restriction against linking a feature [F] to potentially blocking segment *B* and a (soft) restriction on progressive spreading can incur enough of a penalty so that progressive spreading is blocked by *B* segments. However, if there is comparatively little penalty for regressive spreading, then the co-occurrence restriction is not sufficient to prevent regressive spreading.

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[9] A further difference between the triggers lies in the phonetic realization of the assimilated vowel. Uvulars and coronal triggers retract the targeted low vowels to [ɑ] while pharyngeals retract the vowel to [a]. Additionally, the retraction induced by the pharyngeal is option while uvulars and coronals are obligatory. This also seems to correspond generally to the fact that pharyngeals are the weakest trigger type. However, I have not attempted to formalize the degree of retraction and optionality in the grammar here although this would be an interesting pursuit. It may also be that these are just two different features: one that causes one type of pharyngealization and one that causes uvularization or a different type of pharyngealization.

[10] See Cole (2009) for an alternate exemplar model approach to other kinds of asymmetries in harmony.

‘Classic’ Optimality Theory is not able to model asymmetrical harmony systems using general constraints (Prince and Smolensky 1993). In order to account for asymmetries in harmony, Optimality Theory (OT) must include complex constraints that essentially encode conditioning factors into the constraint definitions. The usual method of building complex constraints is with Local Constraint Conjunction, which allows for general constraints as compositional atoms to be conjoined to form more complex constraints (Smolensky 1993, 2006). However, Local Constraint Conjunction (LCC) suffers from unrestrictive typology prediction and a loss of generality in comparison with Harmonic Grammar (HG) as discussed in §7.

In order for the HG model to generate restrictive language typologies without *pathologies,* HG must be implemented serially. Previous work in Harmonic Serialism, a derivational variant of OT, has demonstrated how a serial architecture can prevent certain pathologies predicted by analyses of harmony systems embedded within a standard OT framework with parallel evaluation. Since Parallel HG suffers from similar problems (although the severity is often greater), the same types of beneficial restrictions imposed by the serial architecture can be imported to Serial HG.

The analysis here combines both weighted constraints and a serial architecture. This Serial Harmonic Grammar framework successfully predicts the attested asymmetrical restrictions of feature spreading as well the more common symmetrical patterns. The analysis has been implemented computationally through OT-Help (Staubs *et al.* 2010).

3.1 OT WITH WEIGHTED CONSTRAINTS

Constraints in HG are weighted (linear numeric ordering) rather than ranked in strict domination (lexicographic ordering) as in standard OT (Legendre, Miyata, and Smolensky 1990*a,* 1990*b;* Smolensky and Legendre 2006; Pater 2009, 2010). Each input–output candidate is assigned a *harmony* penalty ($\mathcal{H}$) that is the sum of the weighted violation scores of the constraint set. This is shown in (32) in which v is the violation score assigned by an individual constraint, w is the weight assigned to a constraint, and **C** is the set of constraints $\{C_k, C_{k+1}, \dots C_K\}$.

(32) *Harmony calculation for input–output candidates*

$$\mathcal{H} = \sum_{k=1}^{K} w_k v_k$$

In order to make HG comparable with OT, violation scores are restricted to negative integers, and constraint weights are greater than zero (Keller 2000, 2006; Legendre, Sorace, and Smolensky 2006; Pater 2009; Potts *et al.* 2010; Prince 2003). In this version of HG, the optimal input–output mapping has the harmony penalty that is the closest to zero. Thus, in the example below, the harmony of *input–output1* is equal to –5.

(33) *Example* HG *tableau*

	3	*2*	*1*	
/input/	ConA	ConB	ConC	$\mathcal{H}$
☞ a. output1	–1	–1		*–5*
b. output2	–1		–3	*–6*

(34) *Harmony penalty calculation for the first input–output candidate of the tableau in* (33)

$$\begin{aligned}\mathcal{H}(\text{input–output1}) &= w(\textsc{ConA}) * \textsc{ConA}(\text{input–output1}) + \\ &\quad w(\textsc{ConB}) * \textsc{ConB}(\text{input–output1}) + \\ &\quad w(\textsc{ConC}) * \textsc{ConC}(\text{input–output1}) \\ &= (3) * (–1) + (–2) * (1) + (1) * (0) \\ &= –5\end{aligned}$$

Because a candidate's harmony is derived from the sum of the weighted constraint violations, HG allows for additive constraint interaction unlike 'classic' OT (Pater 2009, Potts *et al.* 2010). The additive interaction allows HG to generate certain patterns that OT cannot generate when the constraint set is the same for both HG and OT. These additional patterns found in HG involve asymmetric *trade-offs* between violations from opposing constraints leading to a *gang effect* (also known as *cumulative constraint interaction* or a *worst-of-the-worst effect*). In Pater's succinct characterization, this situation is when a given constraint is satisfied at a harmony score margin of n from other lower weighted constraints but not at a harmony score of $n + 1$.

If we compare tableau (35) to tableau (36), the higher weighted constraint Con1 penalizes *outputB,* and the lower weighted Con2 and Con3 do not assign a great enough penalty to effectively prevent the opposing *outputA* from being evaluated as the optimum. Thus, Con1 is satisfied with a combined penalty of –2 from Con2 and Con3. If Con2 and Con3 assign a combined penalty greater than this threshold of –2, then Con1 is no longer satisfied: a penalty of –2 + –1 would result in tied optima, a penalty of –2 + –2 would result a different optimum as with *outputD* shown in (36).

(35) *Low-weighted* Con2 *and* Con3 *contribute a penalty low enough for* input1–outputA *optimum*

	3	*1*	*1*	
/input1/	Con1	Con2	Con3	$\mathcal{H}$
☞ a. outputA		–1	–1	*–2*
b. outputB	–1			*–3*

(36) *Low-weighted* Con2 *and* Con3 *contribute a penalty high enough to eliminate* input2–outputC

	3	*1*	*1*	
/input2/	Con1	Con2	Con3	$\mathcal{H}$
a. outputC		–1	–3	–4
☞ b. outputD	–1			–3

Classic OT, however, using the same set of constraints above (Con1, Con2, Con3) cannot generate the same optima *outputA* and *outputD* from *input1* and *input2*. Since OT does not allow additive constraint interaction, lower ranked constraints have no effect on a candidate once higher ranked constraints have selected a unique optimum. This is shown below in (37) and (38). Translating the weighting difference between Con2 and Con3 into a constraint ranking relation, the higher ranked Con1 selects *outputA* and *outputC* as optima since the dominated Con2 and Con3 have no power to affect the evaluation's outcome.

(37) OT *tableau comparable to* (35)

/input/	Con1	Con2	Con3
☞ a. outputA		*	*
b. outputB	*		

(38) OT *tableau comparable to* (36)

/input/	Con1	Con2	Con2
☞ a. outputC		*	***
b. outputD	*		

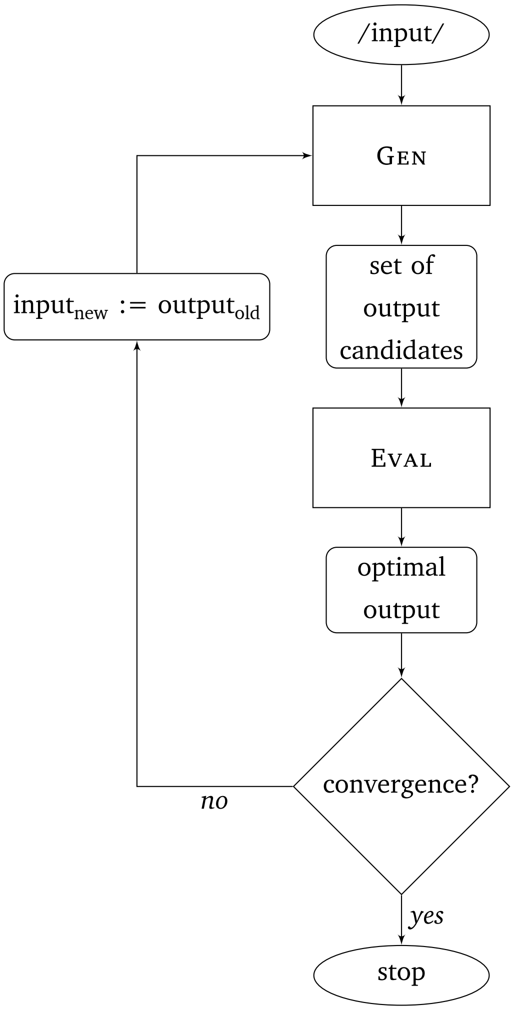
Changing the ranking relations also will not result in the desired optima. If either Con2 or Con3 dominate Con1, then the optima generated would be *outputB* and *outputD*. The only way to generate the *outputA–outputD* pattern in OT is to add further constraints to the grammar. This is arguably an undesired consequence of OT's non-additivity in both conceptual and empirical terms (§7).

3.2 SERIAL FRAMEWORK

Harmonic Serialism (Prince and Smolensky 1993: §2, 79–80; McCarthy 2000, 2002: 159–163, 2006, 2007*a*, 2010*a*, 2010*b*) is a derivational variant of OT, which operates with the two assumptions below. This same serial framework is adapted to the Serial HG proposal presented here.

- A restrictive GEN that generates a finite set of output candidates that differ *minimally* from the input via modifying operations. (Typically, inputs and outputs differ by only a single modification.)
- A derivational loop (39) where candidate generation and evaluation repeats until convergence. The optimal output at each step of the derivation is passed as the input to the next step of the derivation. Derivational *convergence* occurs when an output optimum is identical to its input.

(39) *Derivational loop of Serial* HG



McCarthy (2009*a*, forthcoming-*b*) develops a theory of feature spreading within Harmonic Serialism that lacks implausible typological predictions found in standard Optimality-Theoretic accounts of harmony (McCarthy 2004, 2009*a*, forthcoming-*b*;

Wilson 2003, 2004, 2006).[11] This solution introduces a modified set of harmony constraints, especially the constraint SHARE. This serial implementation of OT with its restricted set of input–output mappings for each step of a derivation allows for feature spreading to occur locally in a step-by-step fashion, preventing the problematic mappings found in parallel OT and more accurately characterizing feature spreading in harmony systems as a *myopic* process (Gafos 1999, Ní Chiosáin and Padgett 2001, Walker 1998).[12]

As for the restrictive GEN, McCarthy proposes a set of minimal modifications that GEN can make with respect to feature spreading. Two operations out of this set are linking a feature to a segment and delinking a feature from a segment. This restrictive generative capacity means that instantaneous total feature spreading across a word is impossible in words that are longer than two segments: feature spreading must instead proceed segment by segment through a series of intermediate stages until it reaches a word boundary or a blocking segment.

If nasal harmony is considered, for instance, (40) is an impossible one-step derivation in Serial HG (although it is possible in a parallel theory). In order for the harmony domain to cover the entire span of a word, the derivation must occur as the series of steps in (41) similar to a serial derivation in rule-based phonology.

(40) *Impossible derivation in Serial* HG

/ãwa/ ↛ [ãw̃ã]

(41) *Derivation in Serial* HG *of total harmony*

/ãwa/ → ãw̃a → ãw̃ã → [ãw̃ã]

This means that at the first step of a derivation of a form with a single linked segment such as /wãya/ there are only three immediately relevant outputs[13]: the faithful output with no spreading (42*a*), feature spreading in either direction (42*b, c*), and feature deletion (or delinking) (42*d*). Under these assumptions about GEN, the serial architecture of the grammar itself demands strictly local myopic spreading at each derivational stage.

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[11] Kimper (2008, 2010*a*, 2010*b*, forthcoming), Mahanta (2007: §5), and McCarthy (2006, 2009*a*, forthcoming-*b*) are previous explorations of issues pertaining to feature spreading utilizing a Harmonic Serialist framework; Kimper (2011) utilizes Serial Harmonic Grammar. Other phonological work within Harmonic Serialism on various topics includes Elfner (2009, 2010); Hyde (2009); Jesney (2009); Kimper (2009); McCarthy (2007*b*, 2008*a*, 2008*b*, 2009*b*, 2009*d*, forthcoming-*a*, forthcoming-*c*); McCarthy, Kimper, and Mullin (submitted); McCarthy, Mullin, and Smith (2010); McCarthy and Pruitt (forthcoming); Pizzo (2010); Pruitt (2008, 2010); and Staubs (forthcoming). See also McCarthy (2009*c*) for a bibliography that includes OT with Candidate Chains. For work in syntax, see Heck and Müller (2006) and the references cited therein.

[12] However, see Walker (2006, 2008, 2009, 2010) for an opposing view that suggests there are attested examples of harmony (metaphony in Romance languages) with a non-myopic lookahead character, which may pose a problem for strictly local spreading.

[13] I put aside other outputs derived from less directly relevant processes such as segmental deletion, building prosodic structure, etc.

(42) *Three possible outputs from input* /wãya/

a. wãya (no spreading/delinking, faithful)
b. w̃ãya (link feature left)
c. wãỹa (link feature right)
d. waya (delink feature)

Given other assumptions about the restrictive power of serial Gen and an appropriate constraint set, the serial architecture of the grammar prevents pathological predictions in harmony systems involving deletion, epenthesis, metathesis, allomorph selection, affix positioning, and stress shift (McCarthy 2008*a*, 2009*a*, forthcoming-*b*).

3.3 PRIVATIVE FEATURES

Features here are assumed to be privative and not equipollent following McCarthy (2009*a*, forthcoming-*b*). This is intended to capture the fact that in many cases of harmony the marked feature value spreads while a corresponding unmarked feature value does not. For example, several languages have nasal harmony, but no language has oral harmony. Having a privative [nasal] feature allows only for the possibility of either spreading [nasal] or not spreading [nasal] (Steriade 1993, 1995). If there were equipollent features [+nasal] and [–nasal], then a third unattested possibility of spreading [–nasal] would be permitted. Similarly, tones are commonly viewed as privative features (Stevick 1969, Odden 1981, Akinlabi 1984, Hyman and Byarushengo 1984, Pulleyblank 1986, Hyman 2001). For example, in many Bantu languages, a high tone contrasts with the absence of tone, which is pronounced phonetically with low pitch, or both high and low tone contrast with the absence of tone, which is pronounced with a mid tone.

Nonetheless, some features seem to allow spreading of two opposing feature values. Rather than assuming that these features are equipollent, two different features are posited. For instance, there are two features [ATR] and [RTR] instead of [+ATR] and [–ATR].[14]

3.4 HEADED FEATURAL DOMAINS

I assume head–dependent relations following previous work (Cassimjee 1998; Cassimjee and Kisseberth 1989, 1998, 1999*a*, 1999*b*, 2001; Cole and Kisseberth 1995*a*, 1995*b*, 1995*c*, 1995*d*; Jurgec 2010; Key 2007; McCarthy 2004; Potts *et al.* 2010; Smolensky 1995, 2006).[15] Featural heads in outputs 'host' or 'sponsor' features. These heads in outputs usually have corresponding segments in the underlying representation that host the same feature

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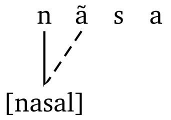
[14] Proposals for *n*-ary features are not considered here but should be investigated in future research.

[15] See also Anderson and Ewen (1987), Harris (1946), Leben (1982), and Zubizarreta (1979).

although this is not necessarily guaranteed. The other segments in the domain lie in a dependent relation with the featural head. For example, a surface form [nãsa] that has a [nasal] domain with [n] acting as the featural head and [ã] as a dependent has the form in (43).

(43) *Two-segment* [*nasal*] *domain with head* n *and dependent* ã



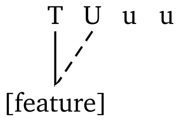
Unlike Potts *et al.* (2010), I assume that headed domains exist even when there are no dependents. In other words, feature spreading is not a prerequisite for headedness. For simplicity, I assume that underlying representations do not contain headed featural domains although the consequences of this should be considered in future work.

3.4.1 Schematic Representation

I use the following conventions in schematic flat representations of harmonic processes.

- Segments that are linked to the feature in consideration are indicated with the capital letters *T, U, S, W, B*.
- Segments that are *not* linked to the feature are indicated with the lowercase letters *t, u, s, w, b*.
- *T* = general trigger, *U/u* = target undergoer (with/without linked feature), *S* = strong trigger, *W* = weak trigger/host, *b* = blocker, *B* = blocker with disfavored linked feature.
- Heads are underlined. Non-heads are unmarked. For instance: ***T*** is a head, *t* is not a head.
- Featural domains are enclosed in parentheses. For example: a word with a four-segment domain: (***T****UUU*); a word with a one-segment domain: (***T***)*uuu*.

(44) *Autosegmental representation of* (**T**U)uu



Thus, the flat representation (***T****U*)*uu* is equivalent to the autosegmental representation in (44).

3.5 OPERATIONS OF RESTRICTIVE GEN

The GEN defined here allows the following operations following McCarthy (2009*a*, forthcoming-*b*):

- Linking a pre-existing feature to a single pre-existing segment
- Delinking a single pre-existing segment from a single pre-existing feature
- Inserting a feature that remains unlinked to any segment
- Inserting a feature and linking it to a single pre-existing segment
- Deleting a pre-existing feature that is not linked to any segment
- Deleting a pre-existing feature that is linked to only a single pre-existing segment

Given this set of operations, an input with single linked segment has the following corresponding outputs (45).

(45) *Eleven possible outputs generated from input* uuTuu

a.	uu(**T**)uu	faithful
b.	u(U**T**)uu	feature linking (leftward)
c.	uu(**T**U)u	feature linking (rightward)
d.	uutuu $^{+\ [F]}$	feature delinking
e.	uu(**T**)uu $^{+\ [F]}$	feature insertion
f.	(**U**)u(**T**)uu	feature insertion–linking
g.	u(**U**)(**T**)uu	feature insertion–linking
h.	uu((**T**))uu	feature insertion–linking
i.	uu(**T**)(**U**)u	feature insertion–linking
j.	uu(**T**)u(**U**)	feature insertion–linking
k.	uutuu	feature deletion–delinking

The second example (46) is an input that lacks the spreading feature. An input with a floating feature is in (47). The final input with a featural domain can lead to the following outputs in (48), putting aside possible feature insertion. In this is case, feature deletion is not possible because the input two segments linked to the feature because Gen can only delete features that are linked to a single segment.

(46) *Seven generated outputs from input* uutuu

a.	uutuu	faithful
b.	uutuu $^{+\ [F]}$	feature insertion
c.	(**U**)utuu	feature insertion–linking
d.	u(**U**)tuu	feature insertion–linking
e.	uu(**T**)uu	feature insertion–linking
f.	uut(**U**)u	feature insertion–linking
g.	uutu(**U**)	feature insertion–linking

(47) *Thirteen generated outputs from input* uutuu $^{+\ [F]}$

a.	uutuu $^{+\ [F]}$	faithful
b.	(**U**)utuu	feature linking
c.	u(**U**)tuu	feature linking
d.	uu(**T**)uu	feature linking
e.	uut(**U**)u	feature linking
f.	uutu(**U**)	feature linking
g.	uutuu $^{+\ [F]\ +\ [F]}$	feature insertion
h.	(**U**)utuu $^{+\ [F]}$	feature insertion–linking
i.	u(**U**)tuu $^{+\ [F]}$	feature insertion–linking
j.	uu(**T**)uu $^{+\ [F]}$	feature insertion–linking
k.	uut(**U**)u $^{+\ [F]}$	feature insertion–linking
l.	uutu(**U**) $^{+\ [F]}$	feature insertion–linking
m.	uutuu	feature deletion

(48) *Five generated outputs from input* u(U**T**)uu *(sans feature insertion)*

a.	u(U**T**)uu	faithful
b.	(UU**T**)uu	feature linking (leftward)
c.	u(U**T**U)u	feature linking (rightward)
d.	uu(**T**)uu	feature delinking (leftward)
e.	u(**U**)tuu	feature delinking (rightward)

In order to keep the presentation simple, I do not fully explore feature delinking, deletion, or insertion and, additionally, floating features are not considered.

3.6 MOTIVATING FEATURE SPREADING

The present work uses the SHARE constraint to motivate feature spreading (McCarthy 2009*a*, forthcoming-*b*). SHARE lacks the undesired typological issues caused by other constraints – AGREE, ALIGN, and their variants – that have been used in analyses of harmony. The SHARE(feature) constraint motivates bidirectional feature spreading. This markedness constraint prefers for all segments in a word to be linked to the same feature as defined in (49).[16]

(49) SHARE(feature)
Assign a violation for every pair of adjacent segments not linked to the same instance of the feature.

For instance, SHARE is not violated when evaluating a three-segment output with a featural domain encompassing the entire output (50*a*). An output with one segment

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[16] See Kimper (2010*b*, 2011) for a positive formulation of SHARE that rewards feature spreading instead of penalizing spreading failure.

outside of the featural domain (50*b*) violates Share once while an output without a featural domain but with one segment linked (50c) violates Share twice as does an output that completely lacks the feature (50*d*). That Share is directionless is shown in (50*e*).

(50) *Violations assigned by* Share[17]

	Share
a. (UU**T**)	
b. u(U**T**)	–1
c. uu(**T**)	–2
d. uut	–2
e. (**T**U)u	–1

Each step of a derivation in Serial hg (aside from the very last step) is harmonically improving. Given an underlying form with one segment that is linked to the spreading feature /uuT/, Share motivates gradual feature spreading until the featural domain encompasses the entire word. When Share is weighted at a sufficiently high value, the derivation from /uuT/ will always be as in (51) because no other candidate produced by restrictive Gen is more harmonic than the outputs in (51). This is shown in the derivation in (52).

(51) *Harmonic improvement tableau for chain* < uu(**T**), u(U**T**), (UU**T**) >

/uuT/	Share
a. uu(**T**) *is less harmonic than*	–2
b. u(U**T**) *is less harmonic than*	–1
c. (UU**T**)	

(52) *Derivational path of* /uuT/ *under* Share

Step 1: /uuT/ → u(U**T**)

	/uuT/	Share
☞	a. u(U**T**)	–1
	b. uu(**T**)	–2
	c. uut	–2

---

[17] Share also assigns two violations to surface *UU* if both segments are linked to two different instances of the feature as in *(U)(U)*. In this paper, I do not consider this complicating possibility.

Step 2: /uuT/ → u(U$\underline{T}$) → (UU$\underline{T}$)

u(U$\underline{T}$)			Share
☞	d.	(UU$\underline{T}$)	
	e.	u(U$\underline{T}$)	–1
	f.	uu($\underline{T}$)	–2

Step 3: /uuT/ → u(U$\underline{T}$) → (UU$\underline{T}$) → [(UU$\underline{T}$)]

(UU$\underline{T}$)			Share
☞	g.	(UU$\underline{T}$)	
	h.	u(U$\underline{T}$)	–1

At the last step of this derivation, the input to Gen is the same as the output of Eval, and so no further harmonic improvement can be made, leading the derivation to converge.

4 Directional Asymmetries

Languages with harmony may favor spreading in one direction over the opposite direction. In one case, some languages favor one direction to such an extent that the feature spreads in one direction but not the other. Additionally, harmonizing languages may spread in both directions but still favor one direction through interactions with other restrictions. With a blocking restriction, harmony may be blocked in the disfavored *weak* direction but not blocked in the *strong* direction. With a locality restriction, harmony may be bounded in the weak direction but unbounded in the strong direction. These asymmetrical preferences in direction can be modeled in Serial HG. First, I introduce the restrictions on direction (§4.1) and then discuss the interactions with blocking (§4.2) and with locality (§4.3).

4.1 DIRECTIONAL SPREADING AND DEPENDENT CONSTRAINTS

Certain asymmetries are found in harmony systems with respect to direction of feature spreading. A symmetrical system spreads features bidirectionally while an asymmetrical system spreads in only one direction. Since Share is not a directional constraint, directional restrictions on feature spreading require further constraints that penalize spreading in a particular direction. This is formalized in (53) and (54) as constraints against dependents with heads hosting the feature that are relativized by position of head with respect to dependent. Thus, *Dependent-Right penalizes dependents that result from rightward (progressive) spreading while its counterpart penalizes leftward (regressive) spreading. As a feature spreads serially through a derivation, the violations from directional *Dependent-Right/Left constraint linearly increase as the number of dependents increase and the featural domain grows larger.

(53) *Dependent-Right(feature) (*Dp-Right)
Assign a violation for every dependent in a featural domain that lies to the right of its head.

(54) *Dependent-Left(feature) (*Dp-Left)
Assign a violation for every dependent in a featural domain that lies to the left of its head.

The reason for this non-categorical formation is so that at every step of the derivation there is a directional penalty for feature spreading – this allows for the possibility of additive constraint interaction when other constraints are violated. It is this technique which is central to the Serial HG analysis here and will be exploited in following sections.

The directional dependent restrictions interact with pro-spreading Share to produce a small four-language typology (55).

(55) *Four possible languages*

a. /uuTuu/ → [uu(**T**)uu]
b. /uuTuu/ → [(UU**T**UU)]
c. /uuTuu/ → [(UU**T**)uu]
d. /uuTuu/ → [uu(**T**UU)]

One way to generate the language that lacks harmony – without considering any other constraints – is to have the weights of the constraints preventing spreading in each direction outrank the pro-spreading Share as in (56).

(56) *Weighting conditions for lack of harmony*
/uuTuu/ → [uu(**T**)uu]

w(*Dependent-Right) > w(Share)
w(*Dependent-Left) > w(Share)

(57) *Derivation for* /uuTuu/ → [uuTuu]

	2	*2*	*1*	
/uuTuu/	*Dp-Right	*Dp-Left	Share	$\mathcal{H}$
a. u(U**T**)uu		–1	–3	–5
b. uu(**T**U)u	–1		–3	–5
☞ c. uu(**T**)uu			–4	–4

A convenient way to display weighting conditions is through a comparative tableau. Comparative tableaux were developed by Prince (2002*a*, 2002*b*) as a means of showing requisite ranking conditions in OT. The concept can be applied to HG as well as shown by Becker and Pater (2007). The comparative tableau for (57) is shown in (58). A comparative tableau shows comparisons between the optimal or winning candidate (W) and suboptimal or losing candidates (L). In each comparison, every constraint that prefers the optimal form is indicated with a plus (+) while the constraints favoring the suboptimal forms are indicated with a minus (–). The numbers refer to the *margin of separation,* which is the absolute value of the penalty difference between the winner and the loser. As an example, the comparison in (58a) between winner *uuTuu* and loser *uu(TU)u* indicates that *Dependent-Right favors the winner while Share favors the loser. The margin of separation of winner *uuTuu* with its total penalty of –4 and loser *uu(TU)u* with its penalty of –5 is 1. This translates into the following weighting condition necessary for this derivation: one times the weight of *Dependent-Right must be greater than one times the weight of Share. Although the same information is available by comparing (57c) and (57a) above, a comparative tableau display is more succinct. In this paper, I show both derivational violation tableau sets and comparative tableaux for clarity.

(58) *Comparative tableau for* /uuTuu/ → [uuTuu]

	input	*W ∼ L*	Share	*Dp-Right	*Dp-Left
a.	uuTuu	uu(T)uu ∼ uu(TU)u	–1	+1	
b.	uuTuu	uu(T)uu ∼ u(UT)uu	–1		+1

In bidirectional systems, the weights of both *Dependent constraints must be relatively low so that they have no effect on the Share constraint's bidirectional force. Thus, the weight of Share must be greater than the weights both *Dependent-Right and *Dependent-Left as in (59). If this weighting condition is met, then the optimal solution at the first step of the derivation is to spread the feature in either direction. The weights of the *Dependent constraints with respect to each other is irrelevant in this schematic grammar. If their weights are equal as in (60), then there is a derivational choice to first spread leftward /uuTuu/ → *u(UT)uu* or rightward /uuTuu/ → *uu(TU)u.* This choice is not theoretically interesting here since the derivation converges on the same final form no matter in which direction the derivation proceeds. In the derivation (60), I only show one directional choice.

(59) *Weighting conditions for bidirectional harmony*

/uuTuu/ → [(UUTUU)]

w(Share) > w(*Dependent-Right)
w(Share) > w(*Dependent-Left)

(60) *Derivation for* /uuTuu/ → [(UUT̲UU)]

Step 1: /uuTuu/ → u(UT̲)uu

	2	*1*	*1*	
/uuTuu/	Share	*Dp-Right	*Dp-Left	$\mathcal{H}$
☞ a. u(UT̲)uu	–3		–1	*–7*
b. uu(T̲)uu	–4			*–8*

Step 2: /uuTuu/ → u(UT̲)uu → u(UT̲U)u

u(UT̲)uu	Share	*Dp-Right	*Dp-Left	$\mathcal{H}$
☞ c. u(UT̲U)u	–2	–1	–1	*–6*
d. u(UT̲)uu	–3		–1	*–7*
e. uu(T̲)uu	–4			*–8*

Step 3: /uuTuu/ → u(UT̲)uu → u(UT̲U)u → (UUT̲U)u

u(UT̲U)u	Share	*Dp-Right	*Dp-Left	$\mathcal{H}$
☞ f. (UUT̲U)u	–1	–1	–2	*–5*
g. u(UT̲U)u	–2	–1	–1	*–6*
h. uu(T̲U)u	–3	–1		*–7*

Step 4: /uuTuu/ → u(UT̲)uu → … → (UUT̲U)u → (UUT̲UU)

	2	*1*	*1*	
(UUT̲U)u	Share	*Dp-Right	*Dp-Left	$\mathcal{H}$
☞ i. (UUT̲UU)		–2	–2	*–4*
j. (UUT̲U)u	–1	–1	–2	*–5*

Step 5: /uuTuu/ → u(UT̲)uu → … → (UUT̲UU) → [(UUT̲UU)]

(UUT̲UU)	Share	*Dp-Right	*Dp-Left	$\mathcal{H}$
☞ k. (UUT̲UU)		–2	–2	*–4*
l. u(UT̲UU)	–1	–2	–1	*–5*
m. (UUT̲U)u	–1	–1	–2	*–5*

(61) *Comparative tableau for* /uuTuu/ → [(UUT̲UU)]

input	*W ~ L*	Share	*Dp-Right	*Dp-Left
uuTuu	u(UT̲)uu ~ uu(T̲)uu	+1		–1
u(UT̲)uu	u(UT̲U)u ~ u(UT̲)uu	+1	–1	

In unidirectional systems, one directional restriction must be severe enough to prevent the bidirectional impetus of Share while the other directional restriction is lesser and thus unable to overcome Share. Therefore, Share must outweigh one directional *Dependent constraint while the other *Dependent constraint outweighs Share. For instance, in leftward spreading systems (62), spreading the feature regressively at the first derivational step is optimal over spreading progressively since the weight of *Dependent-Right is greater than the weight of *Dependent-Left. And, because the weight of Share is greater than *Dependent-Left, not spreading is suboptimal to spreading regressively. These weighting conditions apply at each derivational step leading to further iterative regressive harmony but no progressive harmony. For the case of unidirectional progressive harmony, the reverse weighting condition is required: the weight of Share must be greater than *Dependent-Right, and the weight of *Dependent-Left must be greater than Share.

(62) *Weighting conditions for unidirectional (regressive) harmony*

/uuTuu/ → [(UUT̲)uu]

w(*Dependent-Right) > w(Share) > w(*Dependent-Left)

(63) *Derivation for* /uuTuu/ → [(UUT̲)uu]

Step 1: /uuTuu/ → u(UT̲)uu

	3	2	1	
/uuTuu/	*Dp-Right	Share	*Dp-Left	$\mathcal{H}$
☞ a. u(UT̲)uu		–3	–1	–7
b. uu(T̲U)u	–1	–3		–9
c. uu(T̲)uu		–4		–8

Step 2: /uuTuu/ → u(UT̲)uu → (UUT̲)uu

u(UT̲)uu	*Dp-Right	Share	*Dp-Left	$\mathcal{H}$
☞ d. (UUT̲)uu		–2	–2	–6
e. u(UT̲U)u	–1	–2	–1	–8
f. u(UT̲)uu		–3	–1	–7
g. uu(T̲)uu		–4		–8

Step 3: /uuTuu/ → u(UT̲)uu → (UUT̲)uu → [(UUT̲)uu]

(UUT̲)uu	*Dp-Right	Share	*Dp-Left	$\mathcal{H}$
h. (UUT̲U)u	–1	–1	–2	–7
☞ i. (UUT̲)uu		–2	–2	–6
j. u(UT̲)uu		–3	–1	–7

(64) *Comparative tableau for* /uuTuu/ → [(UU$\underline{\text{T}}$)uu]

input	*W ~ L*	Share	*Dp-Right	*Dp-Left
(UU$\underline{\text{T}}$)uu	(UU$\underline{\text{T}}$)uu ~ (UU$\underline{\text{TU}}$)u	–1	+1	
uuTuu	u(U$\underline{\text{T}}$)uu ~ uu($\underline{\text{T}}$)uu	+1		–1

Now that an asymmetrical preference for directional feature spreading has been modeled formally, we can see in the following sections how other restrictions interact with this grammatical preference, starting with directional blocking (§4.2).

4.2 DIRECTIONAL BLOCKING

Harmony systems may include blocking (or *opaque*) segments that prevent harmony from iterating throughout a word. In nasal harmony, less sonorous segments like liquids, fricatives, and oral stops often prevent spreading of [nasal]. The feature cannot be linked to these segments, and these segments cannot be skipped over. Arabela has progressive nasal harmony that is triggered by nasal stops and a nasalized laryngeal glide /m, n, ɦ̃/ and targets vowels and glides (65) (Rich 1963).[18] Harmony is blocked by liquids, fricatives, and oral stops (66).

(65) *Arabela: Progressive nasal harmony*

a.	/mjanu/	→	mj̃æ̃nũ	'swallow'
b.	/nuwa/	→	nũw̃ã	'partridge'
c.	/ɦ̃uwa/	→	ɦ̃ũw̃ã	'yellow bird'
d.	/komaɦ̃i/	→	komãɦ̃ĩʔ	'over there'
e.	/ɦ̃ijani/	→	ɦ̃ĩj̃æ̃nĩ	'old woman'

(66) *Arabela: Nasal harmony blocked*

a.	/njaari/	→	nj̃æ̃æ̃riʔ	'he laid it down'	*nj̃æ̃æ̃r̃ĩʔ
b.	/naanri/	→	nããn^{d}riʔ	'type of demon'	*nããnr̃ĩʔ
c.	/ɦ̃juuʃʃano/	→	ɦ̃j̃ũũʃːʃanõ	'where I fished'	*ɦ̃j̃ũũʃ̃ːʃ̃ãnõ
d.	/kanaake/	→	kanããɣɪʔ	'our (EXCL) father'	*kanããɣ̃ĩʔ
e.	/nasekeri (te)/	→	nãsɪxɪri	'did he say it?'	*nãs̃ĩx̃ĩr̃ĩ
f.	/mante/	→	mãntɪʔ	'moth'	*mãnt̃ĩʔ

In the case of bidirectional harmony, blocking segments can block feature spreading from both directions (67). However, there are other languages where one direction appears to be stronger than the other in the sense that feature spreading in the strong direction is undeterred by blocking segments while it is blocked in the weaker direction. Shown in (68) is a schematic case of a blocking segment *b* preventing feature spreading in the dsfavored weak progressive direction and the blocking segment's failure to prevent

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[18] Arabela is an endangered Zaparoan language spoken in northeastern Peru.

spreading in the preferred strong regressive direction. Under leftward spreading, the otherwise blocking segment allows the feature to be associated with it as *B*.

(67) *Segment* b *blocks feature spreading bidirectionally*

(68) *Segment* b *blocks feature spreading unidirectionally*

Of course, the other possible language would lack any apparent blocking restriction, and the segments corresponding to blockers in the first two languages would be identical to undergoers.

(69) *Segment* b *is an undergoer like* U

The problem of direction-specific blocking was first identified in Cook (1987) and Davis (1995). The Harmonic Serialist analysis in McCarthy (2009*a:* 39–43) with its ranked constraints cannot generate directional blocking. Partly motivated by this, cases of directional blocking are questioned. Although there are problems with the data from several of these languages, some of these languages may still turn out to exemplify directional blocking. This aside, Chilcotin has a fairly clear case of direction-specific blocking, which is presented next (§4.2.1).

4.2.1 Chilcotin Vowel Flattening: Direction-specific Blocking

In Chilcotin (Athabascan, British Columbia), pharyngealized coronal consonants trigger long-distance retraction of vowels by iteratively spreading the feature Retracted Tongue Root [RTR] bidirectionally (Krauss 1975; Cook 1976, 1983, 1987, 1989, 1993; Hansson 2001, 2007). The [RTR] triggers can occur in either prefixes or stems. *Flattened* vowels occur in the context of retracting *flat* coronals while *sharp* vowels occur everywhere else. The default forms of underlying vowels and their corresponding retracted forms are abundantly exemplified via vowel alternations. A member of an inflectional paradigm (70) that lacks a retracting coronal shows the default vowel values. (71) shows that underlying /æ, ɛ, i/ surface as flattened [ɑ, ə, ə̯i] (respectively) when retracting /s̠ˤ, t̠s̠ˤʰ/ occurs in the word.

(70) *Elsewhere realization*

a.	[tʰænɛz̪ɛs̪tæn]	‘I’m drunk’
b.	[pɛts̪ʰit]	‘his grandfather’

(71) *Bidirectional* [RTR] *harmony*

a.	/tʰænɛjɛs̱ˤtæn/	→	[tʰɑnəjəs̱ˤtɑn]	‘he’s drunk’
b.	/pɛt̠s̠ˤʰit/	→	[pət̠s̠ˤʰə̯it]	‘his head’

Chilcotin’s [RTR] harmony is blocked under progressive spreading by front velars. However, velars do not block harmony under regressive spreading. In (72), /s̱ˤ, ẕˤ/ trigger the retraction of the preceding vowels /ɛ, i, æ/ to surface as [ə, e, ɑ], but retraction is prevented when the velars /k, k’/ intervene between the vowel and the preceding trigger.[19] Thus, the hypothetical forms [*s̱ˤəkən, *kʷətətʰeẕˤk’ɑn, *nɑtes̱ˤk’ɑn, *kʷətəẕˤəɬk’ɑ̃ç], which would be expected if there were no blocking, are illicit.

(72) *Front velar blocking of progressive* [RTR] *harmony*

a.	/s̱ˤɛ**k**ɛn/	→	s̱ˤə**k**ɛn	‘it’s dry’
b.	/kʷɛtɛtʰiẕˤ**k’**æn/	→	kʷətətʰeẕˤ**k’**æn	‘it’s started to burn’
c.	/nætis̱ˤ(ɛt)**k’**æn/	→	nɑtes̱ˤ**k’**æn	‘it’s burning again’
d.	/(ɬæ) kʷɛtɛẕˤɛɬ**k’**ænʃ/	→	kʷətəẕˤəɬ**k’**æ̃ç	‘don’t make a fire’

Although velars block progressive harmony, they cannot block regressive harmony. In (73), the triggers /ẕˤ, t̠s̠ˤʰ, s̱ˤ/ successfully retract all preceding underlying vowels /æ, i, ɛ, u/ to their flattened counterparts [ɑ, e, ə, o] in spite of the presence of intervening velars /k’, k, kʷ/. Thus, the hypothetical forms [*tʰæniŋk’ɑẕˤ, *kʷɛniŋk’ɑẕˤ, *kʷɛtʰɛkoljóẕˤ, *nækʷənet̠s̠ˤʰə́s̱ˤ] with regressive harmony blocked are illicit.

(73) *No blocking of regressive* [RTR] *harmony*

a.	/tʰænin**k’**æẕˤ/	→	tʰɑneŋ**k’**ɑẕˤ	‘water is getting cold’
b.	/kʷɛnin**k’**æẕˤ/	→	kʷəneŋ**k’**ɑẕˤ	‘water’s cold’
c.	/kʷɛtʰɛ**k**uljúẕˤ/	→	kʷətʰə**k**oljóẕˤ	‘he is rich’
d.	/næ**kʷ**ɛnit̠s̠ˤʰɛ́s̱ˤ/	→	nɑ**kʷ**ənet̠s̠ˤʰə́s̱ˤ	‘fire’s gone out’

4.2.2 Blocking and Direction

In OT grammars, blocking in harmony systems is typically motivated by restrictions on the co-occurrence of a set of features with the spread feature. For instance, since fricatives are commonly blockers of nasal harmony, the explanation is that [nasal, +continuant, –sonorant] is an disfavored feature specification. This is formalized in Serial HG directly

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[19] The retracted form of underlying /i/ is also dependent on directional effects: the vowel surfaces as [e] when followed by a pharyngealizing trigger and surfaces as [ə̯i] when preceded by a pharyngealizing trigger. Interestingly, if /i/ is flanked by triggers on both sides, both surface variants [i ~ ə̯i] are possible in what Cook describes as apparent free variation. I have not attempted to account for this detail here.

as a constraint (as in OT). In a serial derivation, the harmonizing feature iteratively associates to segments when the feature specification is compatible and stops when it reaches a segment in which associating the harmonizing feature would otherwise lead to an incompatible feature specification. I schematize the feature set of these blocking segments as *b*. When the privative spreading feature associates with feature set *b,* it has the disfavored feature specification *B*. Thus, the generic co-occurrence constraint in (74):

(74) *B
Assign a violation for every segment with a feature set of *B*.

Concentrating on just the spreading–blocking interaction, languages with segments that block feature spreading have the weight of the co-occurrence restriction greater than the weight of pro-spreading Share as in (75). Languages with potential blocking segments that act as undergoer segments have the reverse weighting condition as in the derivation in (76).

(75) *A language with blocking:*
w(*B) > w(Share)

Step 1: /bT/ → [bT]

	2	*1*	
/bT/	*B	Share	ℋ
a. (B**T**)	–1		*–2*
☞ b. b(**T**)		–1	*–1*

(76) *A language without blocking:*
w(Share) > w(*B)

Step 1: /bT/ → (B**T**)

	2	*1*	
/bT/	Share	*B	ℋ
☞ a. (B**T**)		–1	*–1*
b. b(**T**)	–1		*–2*

Step 2: /bT/ → (B**T**) → [(B**T**)]

(B**T**)	Share	*B	ℋ
☞ c. (B**T**)		–1	*–1*

The featural co-occurrence constraint interacts with the pro-spreading constraint and the directional anti-spreading constraints to generate nine possible languages (77).

(77) *Set of nine typologically possible languages*

a. /ubuuTuubu/ → [ubuu(**T**)uubu]
b. /ubuuTuubu/ → [ub(UU**T**)uubu]
c. /ubuuTuubu/ → [(UBUU**T**)uubu]
d. /ubuuTuubu/ → [ubuu(**T**UU)bu]
e. /ubuuTuubu/ → [ubuu(**T**UUBU)]
f. /ubuuTuubu/ → [ub(UU**T**UU)bu]
g. /ubuuTuubu/ → [(UBUU**T**UUBU)]
h. /ubuuTuubu/ → [(UBUU**T**UU)bu]
i. /ubuuTuubu/ → [ub(UU**T**UUBU)]

This typology includes languages without harmony (77*a*), languages with bidirectional and unidirectional harmony with and without blocking (77*b*–*g*), and languages with bidirectional harmony with unidirectional blocking (77*h, i*). What is of interest here are the last two languages with asymmetrical direction-specific blocking of bidirectional spreading.

A language like Chilcotin has bidirectional harmony with the progressive harmony blockable and regressive harmony unblockable. Its weighting conditions are in (78).

(78) *Weighting conditions for bidirectional harmony, unidirectional blocking*

/buTub/ → [(BU**T**U)b]

w(*Dp-Right) + w(*B) > *w*(Share) > *w*(*Dp-Right)
w(Share) > *w*(*Dp-Left) + *w*(*B)

Like all languages with bidirectional harmony, the weights of both anti-spreading constraints *Dependent-Right and *Dependent-Left are less than the weight of Share as shown above in (59)–(61). However, in order to generate the directional asymmetry where regressive spreading is stronger than progressive spreading, the constraint penalizing progressive spreading *Dependent-Right must have its weight greater than that of *Dependent-Left. In the initial step of the derivation in (79), this inequality results in spreading regressively being the optimal solution. In the subsequent step, the feature spreads progressively. In the third step, spreading progressively to the disfavored *b* segment is not possible because the gang effect of *Dependent-Right and *B produces a penalty that is greater than the additive penalty assigned by *Dependent-Left and *B. And, since the summed penalty of *Dependent-Left and *B is less than penalty assigned by Share to the faithful candidate, the feature spreads regressively to the disfavored *b* segment. Similarly, the derivation converges in the next step because the sum of the weights of *Dependent-Right and *B is greater than Share. Thus, spreading to favored segments in both directions is possible as is spreading regressively to disfavored segments while spreading to disfavored segments progressively is illicit.

(79) *Derivation for* /buTub/ → [(BUTU)b]

Step 1: /buTub/ → b(UT)ub

	4	3	2	1	
/buTub/	Share	*Dp-Right	*B	*Dp-Left	$\mathcal{H}$
☞ a. b(UT)ub	–3			–1	*–13*
b. bu(TU)b	–3	–1			*–15*
c. bu(T)ub	–4				*–16*

Step 2: /buTub/ → b(UT)ub → b(UTU)b

b(UT)ub	Share	*Dp-Right	*B	*Dp-Left	$\mathcal{H}$
☞ d. b(UTU)b	–2	–1		–1	*–12*
e. b(UT)ub	–3			–1	*–13*

Step 3: /buTub/ → b(UT)ub → b(UTU)b → (BUTU)b

b(UTU)b	Share	*Dp-Right	*B	*Dp-Left	$\mathcal{H}$
☞ f. (BUTU)b	–1	–1	–1	–2	*–11*
g. b(UTUB)	–1	–2	–1	–1	*–13*
h. b(UTU)b	–2	–1		–1	*–12*

Step 4: /buTub/ → b(UT)ub → … → (BUTU)b → [(BUTU)b]

(BUTU)b	Share	*Dp-Right	*B	*Dp-Left	$\mathcal{H}$
i. (BUTUB)		–2	–2	–2	*–12*
☞ j. (BUTU)b	–1	–1	–1	–2	*–11*

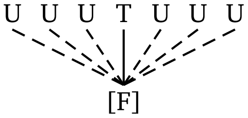
(80) *Comparative tableau for* /buTub/ → [(BUTU)b]

input	*W ~ L*	Share	*Dp-Right	*Dp-Left	*B
buTub	b(UT)ub ~ bu(T)ub	+1		–1	
b(UT)ub	b(UTU)b ~ b(UT)ub	+1	–1		
b(UTU)b	(BUTU)b ~ b(UTU)b	+1		–1	–1
(BUTU)b	(BUTU)b ~ (BUTUB)	–1	+1		+1

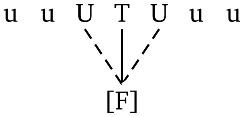
4.3 DIRECTIONAL BOUNDEDNESS

Typically, harmony results in unbounded spreading of the harmonizing feature (81). However, there also seem to be some cases of bounded spreading (82). And, there is at least one language that is an instance of asymmetrical boundedness, in which spreading is unbounded in the strong direction but bounded in the weak direction (83).

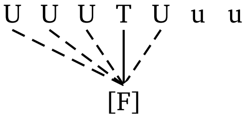
(81) *Feature spreading is (bidirectionally) iterative*



(82) *Feature spreading is bidirectionally bounded*



(83) *Feature spreading is unidirectionally bounded*



However, straightforward examples of bounded spreading of nontonal features are uncommon. This in combination with the fact that formalizing noniterative spreading in parallel OT is problematic has led to a claim that feature spreading is always unbounded (Kaplan 2008*b*). Here, I assume that feature spreading may be bounded and that the boundedness can straightforwardly formalized into constraints that penalize nonlocal spreading. I first present some examples of bounded feature spreading (§4.3.1) before examining the interaction of boundedness and directional restrictions (§4.3.2).

4.3.1 Bounds on Feature Spreading

Some feature spreading systems display boundedness. There are two types of bounds: (i) strictly local noniterative spreading to an adjacent segment or syllable/mora and (ii) semi-iterative metrical spreading where the spreading distance is limited to two moras or syllables. Both of these types exist in both segmental feature spreading and tonal feature spreading although examples from segmental phenomena are rare.

As an example of strictly local spreading, [RTR] spreading (*emphasis*) from uvular and pharyngeal triggers in some Arabic dialects is bounded to an adjacent syllable or mora (Watson 2002). These uvulars and pharyngeals are in contrast with coronal emphatic triggers that spread the feature iteratively. The examples of noniterative spreading from §2.6 are repeated below in (84).

(84) *Cairene Arabic: Bounded spreading from uvulars and pharyngeals*

a. /qɐtɐl/ → (q̠ɑ)tɐl ‘he killed’
b. /ʕɐmɐl/ → (ʕ̠a)mɐl ‘he did’

Tone doubling (85) parallels strictly local spreading of place features. Several instances of high tone spreading in Bantu are also restricted to an adjacent tone-bearing syllable or mora. Such a pattern is found in Ekegusii and Sesotho.

(85) *Bounded tone doubling*

a. /µ́µµµµµ/ → (**µ̲́**µ́)µµµ *(**µ̲́**µ́µ́µ́µ́)
b. /σ́σσσσ/ → (**σ̲́**σ́)σσσ *(**σ̲́**σ́σ́σ́σ́)

In Ekegusii, also Gusii or Kisii (Bantu E.10, southwestern Kenya), underlying high tones are associated with the first mora in a lexical class of verb roots (Bickmore 1997, 1999). This high tone generally spreads to an adjacent mora, which may be in either the same syllable or the following syllable and within the root or in a following suffix (86).

(86) *Ekegusii: Local noniterative high tone spreading*

a. /ko-tám-a/ → ɣo(t**á̲**má) ‘to run away’
b. /ko-símek-a/ → ɣo(s**í̲**mé)ka ‘to plant’
c. /ko-tám-er-a/ → ɣo(t**á̲**mé)ra ‘to run away for’
d. /ko-káan-er-a/ → ɣo(k**á̲**á)nera ‘to deny for’
e. /ko-símek-er-a/ → ɣo(s**í̲**mé)kera ‘to plant for’
f. /ko-bwéekan-a/ → ko(bw**é̲**é)kana ‘to resemble’

Local tone spreading is also found in Sesotho, or Southern Sotho (Bantu S.30; Lesotho, South Africa, Botswana) (Zerbian 2006). Lexical high tones linked to the first syllable of the verbal root spread to an adjacent syllable but no further (87). Unlike Ekegusii, Sesotho high spreading is subject to a further (soft) restriction that disfavors spreading onto a word-final syllable (87*b*). The same bounded spreading also occurs with subject prefixes with high tones (87*f*, *g*).

(87) *Sesotho: Local noniterative high tone spreading*

a. /go ʤá/ → go (ʤ**á̲**) (no translation)
b. /go bína/ → go (b**í̲**)na (no translation)
c. /go bólaja/ → go (b**ó̲**lá)ja (no translation)
d. /go ágisanja/ → go (**á̲**gí)sanja ‘to live in harmony’
e. /go khúrumeletsa/ → go (kh**ú̲**rú)meletsa ‘to cover for’
f. /ó-a-lema/ → (**ó̲**á)lema ‘she is ploughing’
g. /ó-a-lebala/ → (**ó̲**á)lebala ‘she is forgetting’

More interesting are instances of boundedness in which spreading iterates once but no further. The most well-known cases are where a high tone spreads two moras from the tonal head but unbounded spreading is illicit.

(88) *Semi-iterative bounded tone spreading*

a. /μ́μμμμ/ → (**μ̱́**μ́μ́)μμ *(**μ̱́**μ́μ́μ́μ́), *(**μ̱́**μ́)μμμ
b. /σ́σσσσ/ → (**σ̱́**σ́σ́)σσ *(**σ̱́**σ́σ́σ́σ́), *(**σ̱́**σ́)σσσ

For example, Zezura Shona (Bantu S.10, Zimbabwe) has an underlying high tone that is linked to the initial syllable of a verb root (Myers 1987). The high tone can spread rightwards two syllables but no further as in (89). Other tonal languages with this same binary spreading restriction include Sengwaketse Tswana, Venda, Kalanga, Tonga, and Sukuma.

(89) *Zezura Shona: Disyllabic tone spreading*

a. /tóresa/	→	(t**ó̱**résá)	'take (CAUS)'
b. /tóresera/	→	(t**ó̱**résé)ra	'take (CAUS, APPL)'
c. /tóresesera/	→	(t**ó̱**résé)sera	'take (CAUS, INTENS, APPL)'

A similar restriction in place feature spreading occurs in Chilcotin. However, in this language, the bimoraic restriction applies only progressively: regressive [RTR] spreading in Chilcotin is unbounded as shown above in §4.2.1. The vowel system of Chilcotin is shown in (90). I posit that tense (or full) vowels are bimoraic and lax (or reduced) vowels are monomoraic.

(90) *Chilcotin vowel system*

Tense			**Lax**		
i		u	ɪ		ʊ
	æ			ɛ	
Retracted Tense			**Retracted Lax**		
e ~ ə̯i		o	ə̯ɪ		ɔ
	ɑ			ə	

Unlike regressive spreading, the words in (91) appear to restrict spreading of [RTR] from the coronal trigger(s) /s̱ˤ (ẕˤ)/ to an adjacent bimoraic vowel. (Thus, hypothetical [*(s̱ˤə̯itʰɑn), *(s̱ˤə̯itʰə̯in), *(ʔɑnɑtʰəẕˤə̯it'ə̯in), *(nɑtʰəẕˤə̯ipə̯in), *(s̱ˤɑntɑn), *(s̱ˤɑntə̯̃ĩɬ)] are illcit.) However, spreading may iterate once if the adjacent vowel is monomoraic as in (92). Thus, it appears that progressive spreading is bounded bimoraically in parallel with the tonal examples. The boundedness restriction is only applicable when spreading in the weak rightwards direction since leftward spreading has no bound other than a word boundary.

(91) *Chilcotin:* [RTR] *spreading to adjacent bimoraic vowel*[20]

a.	/s̱ˤ(ɛ)itʰæn/	→	(s̱ˤə̯i)tʰæn	‘I placed a long object’
b.	/s̱ˤitʰin/	→	(s̱ˤə̯)itʰin	‘I’m sleeping’
c.	/ʔænætʰɛs̱ˤ(ɛ)i(t)t’in/	→	(ʔɑnɑtʰəẕˤə̯i)t’in	‘we started working’
d.	/nætʰɛs̱ˤ(ɛ)i(t)(t)pin/	→	(nɑtʰəẕˤə̯i)pin	‘we’re swimming away’
e.	/s̱ˤæntæn/	→	(s̱ˤɑn)tæn	‘son-in-law’
f.	/s̱ˤæntinɬ/	→	(s̱ˤɑn)tĩɬ	‘widow’

(92) *Chilcotin:* [RTR] *spreading to adjacent monomoraic vowel and following syllable*

a.	/s̱ˤɛlin/	→	(s̱ˤələ̯in)	‘it’s got bloody’	*(s̱ˤə)lin
b.	/s̱ˤɛɬtʰin/	→	(s̱ˤəɬtʰə̯in)	‘he’s comatose’	*(s̱ˤəɬ)tʰin
c.	/tʰɛs̱ˤɛtʰæn/	→	(tʰəs̱ˤətʰɑn)	‘long object is on surface’	*(tʰəs̱ˤə)tʰæn

A final detail with the Chilcotin data involves the final vowels in (92). I assume that the entire vowel – that is, both moras – are associated with the [RTR] feature because it has the same realization when it is adjacent to the coronal trigger as can be seen in (91).

4.3.2 *Boundedness and Direction*

An asymmetrical direction-specific boundedness restriction can be analyzed in Serial HG much in same way as direction-specific blocking. The boundedness restriction is formalized directly as a markedness constraint that penalizes featural dependents that are outside of the bound. A semi-iterative bimoraic restriction can be expressed as (93) while the strictly local restriction can be expressed as (94). The definition of being *local* may differ depending on the type of spreading involved. For instance, in tone spreading, the locality restriction may require the bound to be not further than one mora or not further than one syllable. In segmental feature spreading, the bound may be not further than one segment.

(93) Dependent-Binarity (Dp-Binarity)
Assign a violation for every dependent of a featural domain that is further than two moras from the featural head.

(94) Dependent-Local (Dp-Local)
Assign a violation for every dependent of a featural domain that is not *local* to the featural head.

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[20] Some of the underlying representations here are fairly abstract morphophonemic representations.

(95) *Set of nine typologically possible languages*

a. /uuuuTuuuu/ → [uuuu($\underline{\mathbf{T}}$)uuuu]
b. /uuuuTuuuu/ → [uuu(U$\underline{\mathrm{T}}$)uuuu]
c. /uuuuTuuuu/ → [(UUUU$\underline{\mathrm{T}}$)uuuu]
d. /uuuuTuuuu/ → [uuuu($\underline{\mathrm{T}}$U)uuu]
e. /uuuuTuuuu/ → [uuuu($\underline{\mathrm{T}}$UUUU)]
f. /uuuuTuuuu/ → [uuu(U$\underline{\mathrm{T}}$U)uuu]
g. /uuuuTuuuu/ → [(UUUU$\underline{\mathrm{T}}$UUUU)]
h. /uuuuTuuuu/ → [(UUUU$\underline{\mathrm{T}}$U)uuu]
i. /uuuuTuuuu/ → [uuu(U$\underline{\mathrm{T}}$UUUU)]

Taking Dependent-Local as the featural bound restriction, this constraint interacts with Share and the directional constraints to generate languages with directional boundedness. The regressive-as-strong-direction version of directional boundedness has the weighting conditions in (96). In the derivation (97), the feature spreads in both directions to an adjacent segment in steps 1 and 2 due to Share's weight being greater than the individual weights of *Dependent-Right and *Dependent-Left. In step 3, the feature spreads iteratively to a nonadjacent segment in the regressive direction rather than remaining faithful because the weight of Share is also greater than the combined weights of *Dependent-Left and the locality constraint. Additionally, since the additive penalty assigned by *Dependent-Right and Dependent-Local (which is –13) is greater than the additive penalty assigned by *Dependent-Left and Dependent-Local (which is –11), spreading regressively is optimal over spreading progressively. In the final step of the derivation, progressive spreading is not possible due to the additive weight of *Dependent-Right and Dependent-Local being greater than the weight of pro-spreading Share, and so the derivation converges on the form with unbounded regressive spreading and bounded progressive spreading.

(96) *Weighting conditions for bidirectional harmony, unidirectional boundedness*

/uuTuu/ → [(UU$\underline{\mathrm{T}}$U)u]

w(*Dp-Right) + w(Dp-Local) > w(Share) > w(*Dp-Right)

w(Share) > w(*Dp-Left) + w(Dp-Local)

(97) *Derivation for* /uuTuu/ → [(UU$\underline{T}$U)u]

Step 1: /uuTuu/ → u(U$\underline{T}$)uu

			4	3	2	1	
		/uuTuu/	Share	*Dp-Right	Dp-Local	*Dp-Left	$\mathcal{H}$
☞	a.	u(U$\underline{T}$)uu	–3			–1	*–13*
	b.	uu($\underline{T}$U)u	–3	–1			*–15*
	c.	uu($\underline{T}$)uu	–4				*–16*

Step 2: /uuTuu/ → u(U$\underline{T}$)uu → u(U$\underline{T}$U)u

		u(U$\underline{T}$)uu					
☞	d.	u(U$\underline{T}$U)u	–2	–1		–1	*–12*
	e.	u(U$\underline{T}$)uu	–3			–1	*–13*

Step 3: /uuTuu/ → u(U$\underline{T}$)uu → u(U$\underline{T}$U)u → (UU$\underline{T}$U)u

		u(U$\underline{T}$U)u					
☞	f.	(UU$\underline{T}$U)u	–1	–1	–1	–2	*–11*
	g.	u(U$\underline{T}$UU)	–1	–2	–1	–1	*–13*
	h.	u(U$\underline{T}$U)u	–2	–1		–1	*–12*

Step 4: /uuTuu/ → u(U$\underline{T}$)uu → … → (UU$\underline{T}$U)u → [(UU$\underline{T}$U)u]

		(UU$\underline{T}$U)u					
	i.	(UU$\underline{T}$UU)		–2	–2	–2	*–12*
☞	j.	(UU$\underline{T}$U)u	–1	–1	–1	–2	*–11*

(98) *Comparative tableau for* /uuTuu/ → [(UU$\underline{T}$U)u]

input	*W ~ L*	Share	*Dp-Right	*Dp-Left	Dp-Local
uuTuu	u(U$\underline{T}$)uu ~ uu($\underline{T}$)uu	+1		–1	
u(U$\underline{T}$)uu	u(U$\underline{T}$U)u ~ u(U$\underline{T}$)uu	+1	–1		
u(U$\underline{T}$U)u	(UU$\underline{T}$U)u ~ u(U$\underline{T}$U)u	+1		–1	–1
(UU$\underline{T}$U)u	(UU$\underline{T}$U)u ~ (UU$\underline{T}$UU)	–1	+1		+1

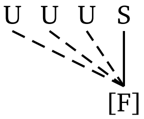
5 Trigger Condition Asymmetries

The other type of asymmetry modeled here is an asymmetry in conditions on trigger types. In languages of these types, one trigger is strong in the sense that a feature associated with it spreads with few or no restrictions compared to another weak trigger. In the simplest case, the weak segment may only host the feature but the feature may not iteratively associate with other segments. In more complex cases, the weak segment may act as a trigger of harmony, but the harmony instigated by the weak trigger is constrained by a bound on its domain or by opaque blocking segments in contrast to the strong trigger, which is unconstrained. First, the interaction of trigger type and boundedness (§5.1) is analyzed followed by the interaction of trigger type and blocking (§5.2).

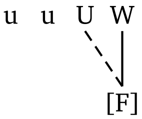
5.1 TRIGGER CONDITIONS AND BOUNDEDNESS

Some harmony systems have two triggers, one of which spreads a feature iteratively (99) while the other spreads the harmony noniteratively (100).

(99) *Iterative spreading from strong trigger* S



(100) *Noniterative spreading from weak trigger* W



For example, in Arabic dialects, coronal triggers of emphasis are strong, spreading the [RTR] iteratively throughout the word. This is in contrast to weak uvular and pharyngeal triggers which spread the feature only to an adjacent syllable or mora.

The differences in trigger strength are formalized here as a difference in penalty assignment. Strong triggers receive no penalty. Weak triggers violate a constraint that penalizes dependents of weak triggers acting as featural heads (101). Ignoring directional and featural co-occurrence restrictions, the small typology in (102) is generated.

(101) *Dependent-Head(W) (*Dp-Head(W))
Assign a violation for every dependent of a featural domain that is headed by a segment with feature set W.

(102) *Set of five typologically possible languages*

a. /uuuuSuuuu/ → [uuu(U**S**U)uuu]
/uuuuWuuuu/ → [uuu(U**W**U)uuu]
b. /uuuuSuuuu/ → [(UUUU**S**UUUU)]
/uuuuWuuuu/ → [(UUUU**W**UUUU)]
c. /uuuuSuuuu/ → [uuu(U**S**U)uuu]
/uuuuWuuuu/ → [uuuu(**W**)uuuu]
d. /uuuuSuuuu/ → [(UUUU**S**UUUU)]
/uuuuWuuuu/ → [uuuu(**W**)uuuu]
e. /uuuuSuuuu/ → [(UUUU**S**UUUU)]
/uuuuWuuuu/ → [uuu(U**W**U)uuu]

The asymmetrical boundedness between strong and weak triggers is achieved via an interaction between Dependent-Local and *Dependent-Head(W) and Share. As with the directional constraints, this constraint assigns violations to dependents so that at each step of the derivation a penalty is incurred by spreading from disfavored triggers. This allows for additive constraint interaction with other constraints at any derivational step as will be seen below. This is the reason why a constraint against featural heads (for example, *Head(W)) is inadequate in Serial HG: satisfaction or violation of a featural head constraint would only be influential on the derivation at a single derivational step. In other words, positing head–dependent relations and constraints on these relations creates a representational solution for tracking where feature spreading originates which the grammar can evaluate for optimality at any distance from the point of origin.

(103) *Weighting conditions for unbounded strong trigger, bounded weak trigger*

/uuS/ → [(UU**S**)]
/uuW/ → [u(U**W**)]

w(Share) > w(Dp-Local)
w(Share) > w(*Dp-Head(W))
w(Dp-Local) + w(*Dp-Head(W)) > w(Share)

(104) *Derivation for* /uuS/ → [(UU**S**)]

Step 1: /uuS/ → u(U**S**)

	3	*2*	*2*	
/uuS/	Share	Dp-Local	*Dp-Head(W)	$\mathcal{H}$
☞ a. u(U**S**)	–1			*–3*
b. uu(**S**)	–2			*–6*

Step 2: /uuS/ → u(US) → (UUS)

		3	2	2	
	u(US)	Share	Dp-Local	*Dp-Head(W)	ℋ
☞	c. (UUS)		–1		–2
	d. u(US)	–1			–3

Step 3: /uuS/ → u(US) → (UUS) → [(UUS)]

	(UUS)	Share	Dp-Local	*Dp-Head(W)	ℋ
☞	e. (UUS)		–1		–2
	f. u(US)	–1			–3

(105) *Derivation for* /uuW/ → [u(UW)]

Step 1: /uuW/ → u(UW)

		3	2	2	
	/uuW/	Share	Dp-Local	*Dp-Head(W)	ℋ
☞	a. u(UW)	–1		–1	–5
	b. uu(W)	–2			–6

Step 2: /uuW/ → u(UW) → [u(UW)]

	u(UW)	Share	Dp-Local	*Dp-Head(W)	ℋ
	c. (UUW)		–1	–2	–6
☞	d. u(UW)	–1		–1	–5

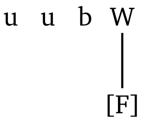
(106) *Comparative tableau for* /uuS/ → [(UUS)], /uuW/ → [u(UW)]

input	*W ∼ L*	Share	Dp-Local	*Dp-Head(W)
u(US)	(UUS) ∼ u(US)	+1	–1	
uuW	u(UW) ∼ uu(W)	+1		–1
u(UW)	u(UW) ∼ (UUW)	–1	+1	+1

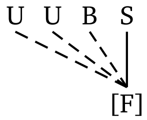
5.2 TRIGGER CONDITIONS AND BLOCKING

Some harmony systems have two triggers, one of which can be blocked (107). The other trigger cannot be blocked (108).

(107) *Weak trigger* W *spreading is blockable*



(108) *Strong trigger* S *spreading is unblockable*



This is the case with Chilcotin. Dorsal triggers are *weak* and are blocked by opaque *sharp* coronal segments under regressive harmony. Coronal triggers are *strong* and cannot be blocked by opaque *sharp* dorsal segments under regressive harmony.

(109) *Set of five typologically possible languages*

a. /ubuuSuubu/ → [ub(UU**S**UU)bu]
/ubuuWuubu/ → [ub(UU**W**UU)bu]
b. /ubuuSuubu/ → [(UBUU**S**UUBU)]
/ubuuWuubu/ → [(UBUU**W**UUBU)]
c. /ubuuSuubu/ → [ub(UU**S**UU)bu]
/ubuuWuubu/ → [ubuuWuubu]
d. /ubuuSuubu/ → [(UBUU**S**UUBU)]
/ubuuWuubu/ → [ubuuWuubu]
e. /ubuuSuubu/ → [(UBUU**S**UUBU)]
/ubuuWuubu/ → [ub(UU**W**UU)bu]

If the weighting conditions in (110) are met, then a language will have a bound on the domain of spreading from a weak featural head but no such bound on spreading from a strong featural head.

(110) *Weighting conditions for unbounded strong trigger, bounded weak trigger*

/ubS/ → [(UB**S**)]
/ubW/ → [ub(**W**)]

w(Share) > *w*(*B)
w(Share) > *w*(*Dependent-Head(W))
w(*B) + *w*(*Dependent-Head(W)) > *w*(Share)

(111) *Derivation for* /ubS/ → [(UBS̲)]

Step 1: /ubS/ → u(BS̲)

	3	2	2	
/ubS/	SHARE	*B	*DEPENDENT-HEAD(W)	$\mathcal{H}$
☞ a. u(BS̲)	–1	–1		–5
b. ub(S̲)	–2			–6

Steps 2–3: /ubS/ → u(BS̲) → [(UBS̲)]

u(US̲)	SHARE	*B	*DEPENDENT-HEAD(W)	$\mathcal{H}$
☞ c. (UBS̲)		–1		–2
d. u(BS̲)	–1	–1		–5

(112) *Derivation for* /ubW/ → [ub(W̲)]

	3	2	2	
/ubW/	SHARE	*B	*DEPENDENT-HEAD(W)	$\mathcal{H}$
☞ a. u(BW̲)	–1	–1	–1	–7
b. ub(W̲)	–2			–6

The derivation for such a language is shown in (111). With all of the mini-grammars of asymmetrical harmony types detailed above, we can proceed to a language that has all of the above asymmetries.

6 Test Case: Chilcotin Vowel Flattening

As seen above, Chilcotin has coronal triggers (113) that iteratively spread an [RTR] feature both leftwards and rightwards. Leftward spreading is unblockable (§4.2.1). However, rightward spreading is both blockable by opaque velar segments (114*b*) and has a bimoraic bound (§4.3.1). The data previously seen is repeated in (115), (116), and (117) below.

(113) *Chilcotin strong coronal triggers*

ṯˢˤ ṯˢˤʰ ṯˢˤ’ s̱ˤ ẕˤ

(114) *Opaque coronal and dorsal segments that block progressive harmony*

a. (t̪ˢ̪ t̪ˢ̪ʰ t̪ˢ̪’) s̪ z̪
b. k kʰ k’ kʷ kʷʰ kʷ’ xʷ w

(115) *Blocking of progressive* [RTR] *harmony by opaque dorsals*

a.	/s̱ˤɛkɛn/	→	s̱ˤəkɛn	‘it’s dry’
b.	/kʷɛtɛtʰiẕˤk’æn/	→	kʷətətʰeẕˤk’æn	‘it’s started to burn’
c.	/nætis̱ˤ(ɛt)**k’**æn/	→	nɑtes̱ˤ**k’**æn	‘it’s burning again’
d.	/kʷɛtɛẕˤɛɬk’ænʃ/	→	kʷətəẕˤəɬk’æ̃ç	‘don’t make (a fire)’

(116) *No blocking of regressive* [RTR] *harmony by opaque dorsals*

a.	/tʰænink’æẕˤ/	→	tʰɑneŋk’ɑẕˤ	‘water is getting cold’
b.	/kʷɛnink’æẕˤ/	→	kʷəneŋk’ɑẕˤ	‘water’s cold’
c.	/kʷɛtʰɛkuljúẕˤ/	→	kʷətʰəkoljóẕˤ	‘he is rich’
d.	/nækʷɛnits̱ʰɛ́s̱ˤ/	→	nɑkʷənets̱ʰə́s̱ˤ	‘fire’s gone out’

(117) *Strong trigger rightward bimoraic boundedness*

a.	/s̱ˤ(ɛ)itʰæn/	→	s̱ˤə̯itʰæn	‘I placed a long object’
b.	/s̱ˤitʰin/	→	s̱ˤə̯itʰin	‘I’m sleeping’
c.	/ʔænætʰɛs̱ˤ(ɛ)i(t)t’in/	→	ʔɑnɑtʰəẕˤə̯it’in	‘we started working’
d.	/nætʰɛs̱ˤ(ɛ)i(t)(t)pin/	→	nɑtʰəẕˤə̯ipin	‘we’re swimming away’
e.	/s̱ˤæntæn/	→	s̱ˤɑntæn	‘son-in-law’
f.	/s̱ˤæntinɬ/	→	s̱ˤɑntĩɬ	‘widow’

In addition to these directional asymmetries, Chilcotin also has asymmetrical trigger conditions like Arabic. While the strong coronal triggers are iterative leftwards and semi-iterative rightwards (due to the bound), the weak uvular triggers (118) are restricted to bidirectionally spreading only to an adjacent vowel, which may be either long or short as shown in (119).[21] Unlike the strong coronal triggers, leftward spreading from weak dorsal triggers is blocked by opaque coronal segments (114*a*) as shown in (120).[22,23]

(118) *Weak dorsal triggers*

q qʰ q’ χ ʁ qʷ qʷʰ qʷ’ χʷ ʁʷ

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[21] Needless to say, the adjacent syllable restriction on weak triggers entails a bimoraic restriction.

[22] There is no evidence that weak dorsal triggers spreading progressively can be blocked by opaque coronal or dorsal segments since the weak dorsal trigger would have to occur in coda position in prefixes or as the first consonant in an onset cluster cluster, which is not attested due to a phonotactic restriction that dorsal segments cannot occur in prefix codas and there are no consonant clusters in onsets. The analysis presented here, of course, predicts that weak dorsal triggers would be blocked in progressive harmony since they are blocked by coronal opaque segments in regressive harmony. There is also no evidence that opaque dorsal segments can block regressive harmony from weak dorsal triggers – again due the same phonotactic restriction: the opaque dorsal segment would have to occur in either a coda or CC onset.

[23] This description is for *elaborate* speech. In *fast* speech, blocking coronal segments do not block regressive harmony from weak triggers.

(119) *Local bounded spreading from weak dorsal trigger*

a.	/ʔælæχ/	→	ʔælɑχ	‘I made it’	*ʔɑlɑχ
b.	/ʁitʰi/	→	ʁə̯itʰi	‘I slept’	*ʁə̯itʰə̯i
c.	/ʁɛlmɛɬ/	→	ʁəlmɛɬ	‘it’s rolling’	*ʁəlməɬ
d.	/junɛqʰæt/	→	junəqʰɑt	‘he’s slapping him’	*jonəqʰɑt
e.	/næʁʷɛs̪pi/	→	nɑʁʷəs̪pi	‘I would like to swim around’	*nɑʁʷəs̠ˤpə̯i

(120) *Regressive spreading from weak dorsal trigger is blocked by* sharp *coronals*

a.	/nɛntʰ**ǽs̪**ʁænɬ/	→	nɛntʰ**ǽs̪**ʁɑ̃ɬ	‘I’ll chase you’	*nɛntʰɑ́s̪ʁɑ̃ɬ
b.	/tʰ**ǽs̪**qʷʰi/	→	tʰ**ǽs̪**qʷʰə̯i	‘I’ll vomit’	*tʰɑ́s̪qʷʰə̯i

This is summarized as restrictions on spreading relativized by trigger and direction in the table in (121).

(121) *Spreading restrictions for Chilcotin*

	Blocked	**Adjacent σ**	**Bimoraic**
S leftward			
S rightward	yes		yes
W leftward	yes	yes	yes
W rightward	(yes?)	yes	yes

Chilcotin requires the weighting conditions in (122). The restrictions on harmony in Chilcotin can easily be read directly off of the inequalities. Share forces feature spreading while the other constraints act as anti-spreading restrictions. If the weight of Share is greater than the combined weights of given set of restrictions, then that combination of restrictions cannot prevent feature spreading. The opposite situation holds if the weight of Share is less than the combination of restrictions. The first inequality line shows that [RTR] can spread leftwards and further than two moras – in other words, unbounded leftward harmony – because Share outweighs the sum of the weights of *Dependent-Left, Dependent-Local, and Dependent-Binarity. However, this is not true of rightward spreading, which is restricted to a two-mora bound since the weighted sum of *Dependent-Right, Dependent-Local, and Dependent-Binarity is greater than Share. These weighting relations account for the direction-specific boundedness of the strong coronal triggers.

(122) *Weighting conditions for Chilcotin vowel flattening*

$$
\begin{array}{lll}
w(\textsc{Share}) & > & w(\textsc{*Dp-Left}) + w(\textsc{Dp-Local}) + w(\textsc{Dp-Binarity}) \\
w(\textsc{Share}) & > & w(\textsc{*Dp-Right}) + w(\textsc{Dp-Local}) + w(\textsc{*Disagree}) \\
w(\textsc{Share}) & > & w(\textsc{*Dp-Right}) + w(\textsc{*Dp-Head}(\mathrm{W})) \\
w(\textsc{Share}) & > & w(\textsc{*Dp-Left}) + w(\textsc{*B})
\end{array}
$$

w(*Dp-Right) + *w*(Dp-Local) + *w*(Dp-Binarity) > *w*(Share)
w(*Dp-Left) + *w*(Dp-Local) + *w*(*Dp-Head(W)) > *w*(Share)
w(*Dp-Right) + *w*(Dp-Local) + *w*(*Dp-Head(W)) > *w*(Share)
w(*Dp-Left) + *w*(*B) + *w*(*Dp-Head(W)) > *w*(Share)
w(*Dp-Right) + *w*(*B) > *w*(Share)
w(Share) + *w*(*Disagree) > *w*(*Dp-Right) + *w*(Dp-Local) + *w*(Dp-Bin)

A complicating factor is that Chilcotin appears to allow spreading rightward past a short vowel and to the vowel of the second syllable – a third mora. The second retracted vowel of the second syllable has the same realization as when adjacent to coronal triggers and, thus, appears to be phonologically a fully retracted vowel. I assume in this case that feature spreading has spread to a third mora in violation of the Dependent-Binarity constraint. In order to motivate this addition iteration, I assume there is a constraint *Disagree that penalizes vowels with an internal disagreement of the [rtr] feature on different moras. For the analysis, then, the sum of weights of Share and *Disagree outweighs *Dependent-Right + Dependent-Local + Dependent-Binarity. The other restrictions' interactions with Share are much the same as the isolated asymmetries examined in §4.2 and §5.

A set of weights meeting the conditions in (122) are used in the derivations (123)–(127). (123) demonstrates the (bidirectional) adjacent syllable bound restriction of the weak trigger, (124) shows blocking of leftward harmony from the weak trigger, (125) and (126) the unidirectional blocking of rightward harmony from the strong trigger, and (127) the unidirectional bound of rightward harmony from the strong trigger.[24]

(123) *Derivation for* /u.u.Wu.u/ → [u.(U.**W**U).u]

Step 1: /u.u.Wu.u/ → u.(U.W)u.u

	10	6	4	3	1	
/u.u.Wu.u/	Share	*Dp-Head(W)	Dp-Local	*Dp-Right	*Dp-Left	ℋ
☞ a. u.(U.W)u.u	–3	–1			–1	–37
b. u.u.(WU).u	–3	–1		–1		–39
c. u.u.(W)u.u	–4					–40

---

[24] Syllable boundaries are indicated with periods, and *.u.* represents a monomoraic syllable while *.uu.* represents a bimoraic syllable.

Step 2: /u.(U.W)u.u/ → u.(U.W)u.u → u.(U.WU).u

	10	*6*	*4*	*3*	*1*	
u.(U.W)u.u	Share	*Dp-Head(W)	Dp-Local	*Dp-Right	*Dp-Left	$\mathcal{H}$
e. (U.U.W)u.u	–2	–2	–1		–2	*–38*
☞ f. u.(U.WU).u	–2	–2		–1	–1	*–36*
g. u.(U.W)u.u	–3	–1			–1	*–37*

Step 3: /u.(U.WU).u/ → u.(U.W)u.u → u.(U.WU).u → [u.(U.WU).u]

u.(U.WU).u						
h. (U.U.WU).u	–1	–3	–1	–1	–2	*–37*
i. u.(U.WU.U)	–1	–3	–1	–2	–1	*–43*
☞ j. u.(U.WU).u	–2	–2		–1	–1	*–36*

(124) *Derivation for* /ub.Wu/ → [ub.(WU)]

Step 1: /ub.Wu/ → ub.(WU)

	10	*8*	*6*	*4*	*3*	*1*	
/ub.Wu/	Share	*B	*Dp-Head(W)	Dp-Local	*Dp-Right	*Dp-Left	$\mathcal{H}$
a. u(B.W)u	–2	–1	–1			–1	*–35*
☞ b. ub.(WU)	–2		–1		–1		*–29*
c. ub.(W)u	–3						*–30*

Step 2: /ub.Wu/ → ub.(WU) → [ub.(WU)]

ub.(WU)							
d. u(B.WU)	–1	–1	–2		–1	–1	*–34*
☞ e. ub.(WU)	–2		–1		–1		*–29*

(125) *Derivation for* /u.bu.Su/ → [(U.BU.**S**U)]

Step 1: /u.bu.Su/ → u.b(U.**S**)u

			10	8	4	3	1	
		/u.bu.Su/	Share	*B	Dp-Local	*Dp-Right	*Dp-Left	$\mathcal{H}$
☞	a.	u.b(U.**S**)u	–3				–1	*–31*
	b.	u.bu.(**S**U)	–3			–1		*–33*
	c.	u.bu.(**S**)u	–4					*–40*

Step 2: /u.bu.Su/ → u.b(U.**S**)u → u.b(U.**S**U)

		u.b(U.**S**)u						
	d.	u.(BU.**S**)u	–2	–1			–2	*–30*
☞	e.	u.b(U.**S**U)	–2			–1	–1	*–24*
	f.	u.b(U.**S**)u	–3				–1	*–31*

Step 3: /u.bu.Su/ → u.b(U.**S**)u → u.b(U.**S**U) → u.(BU.**S**U)

		u.b(U.**S**U)						
☞	g.	u.(BU.**S**U)	–1	–1		–1	–2	*–23*
	h.	u.b(U.**S**U)	–2			–1	–1	*–24*

Steps 4–5: /u.bu.Su/ → u.b(U.**S**)u → u.b(U.**S**U) → u.(BU.**S**U) → [(U.BU.**S**U)]

		u.(BU.**S**U)						
☞	i.	(U.BU.**S**U)		–1	–1	–1	–3	*–18*
	j.	u.(BU.**S**U)	–1	–1		–1	–2	*–23*

(126) *Derivation for* /uS.bu/ → [(U**S**).bu]

Step 1: /uS.bu/ → (U**S**).bu

	10	*8*	*6*	*4*	*3*	*1*	
/uS.bu/	Share	*B	*Dp-Head(W)	Dp-Local	*Dp-Right	*Dp-Left	$\mathcal{H}$
☞ a. (U**S**).bu	–2					–1	*–21*
b. u(**S**.B)u	–2	–1			–1		*–31*
c. u(**S**).bu	–3						*–30*

Step 2: /uS.bu/ → (U**S**).bu → [(U**S**).bu]

(U**S**).bu							
d. (U**S**.B)u	–1	–1			–1	–1	*–22*
☞ e. (U**S**).bu	–2					–1	*–21*

(127) *Derivation for* /u.u.u.Su.uu.u/ → [(U.U.U.**S**U.UU).u]

Step 1: /u.u.u.Su.uu.u/ → u.u.(U.**S**)u.uu.u

	10	*4*	*4*	*3*	*2*	*1*	
/u.u.u.Su.uu.u/	Share	Dp-Binarity	Dp-Local	*Dp-Right	*Disagree	*Dp-Left	$\mathcal{H}$
☞ a. u.u.(U.**S**)u.uu.u	–6					–1	*–61*
b. u.u.u.(**S**U).uu.u	–6			–1			*–63*
c. u.u.u.(**S**)u.uu.u	–7						*–70*

Step 2: /u.u.u.Su.uu.u/ → u.u.(U.**S**)u.uu.u → u.u.(U.**S**U).uu.u

u.u.(U.**S**)u.uu.u							
d. u.(U.U.**S**)u.uu.u	–5		–1			–2	*–57*
☞ e. u.u.(U.**S**U).uu.u	–5			–1		–1	*–54*
f. u.u.(U.**S**)u.uu.u	–6					–1	*–61*

Step 3: /u.u.u.Su.uu.u/ → … → u.u.(U.S̲U).uu.u → u.(U.U.S̲U).uu.u

			10	*4*	*4*	*3*	*2*	*1*	
		u.u.(U.S̲U).uu.u	Share	Dp-Binarity	Dp-Local	*Dp-Right	*Disagree	*Dp-Left	*ℋ*
☞	g.	u.(U.U.S̲U).uu.u	–4		–1	–1		–2	*–49*
	h.	u.u.(U.S̲U.U)u.u	–4		–1	–2	–1	–1	*–53*
	i.	u.u.(U.S̲U).uu.u	–5			–1		–1	*–54*

Step 4: /u.u.u.Su.uu.u/ → … → u.(U.U.S̲U).uu.u → (U.U.U.S̲U).uu.u

		u.(U.U.S̲U).uu.u							
☞	j.	(U.U.U.S̲U).uu.u	–3	–1	–2	–1		–3	*–48*
	k.	u.(U.U.S̲U).uu.u	–4		–1	–1		–2	*–49*

Step 5: /u.u.u.Su.uu.u/ → … → (U.U.U.S̲U).uu.u → (U.U.U.S̲U.U)u.u

		(U.U.U.S̲U).uu.u							
☞	l.	(U.U.U.S̲U.U)u.u	–2	–1	–3	–2	–1	–3	*–47*
	m.	(U.U.U.S̲U).uu.u	–3	–1	–2	–1		–3	*–48*

Step 6: /u.u.u.Su.uu.u/ → … → (U.U.U.S̲U.U)u.u → (U.U.U.S̲U.UU).u

		(U.U.U.S̲U.U)u.u							
☞	n.	(U.U.U.S̲U.UU).u	–1	–2	–4	–3		–3	*–46*
	o.	(U.U.U.S̲U.U)u.u	–2	–2	–3	–2	–1	–3	*–51*

Step 7: /u.u.u.Su.uu.u/ → … → (U.U.U.S̲U.UU).u → [(U.U.U.S̲U.UU).u]

		(U.U.U.S̲U.UU).u							
	p.	(U.U.U.S̲U.UU.U)		–3	–5	–4	–1	–3	*–47*
☞	q.	(U.U.U.S̲U.UU).u	–1	–2	–4	–3	–1	–3	*–46*

(128) *Comparative tableau for*
/u.u.Wu.u/ → [u.(U.WU).u]
/ub.Wu/ → [ub.(WU)]
/u.bu.Su/ → [u.b(U.SU)]
/uS.bu/ → [(US).bu]
/u.u.u.Su.uu.u/ → [(U.U.U.SU.UU).u]

W ~ L	Share	*B	*Dp-Head(W)	Dp-Binarity	Dp-Local	*Dp-Right	*Disagree	*Dp-Left
(U.U.U.SU.UU).u ~ (U.U.U.SU.UU.U)	–1			+1	+1	+1		
(U.U.U.SU).uu.u ~ u.(U.U.SU).uu.u	+1			–1	–1			–1
(U.U.U.SU.UU).u ~ (U.U.U.SU.U)u.u	+1			–1	–1	–1	+1	
u.(U.WU).u ~ (U.U.WU).u	–1		+1		+1			+1
u.(U.WU).u ~ u.(U.WU.U)	–1		+1		+1	+1		
(U.U.U.SU.U)u.u ~ (U.U.U.SU).uu.u	+1				–1	–1	–1	
u.(U.WU).u ~ u.(U.W)u.u	+1		–1			–1		
ub.(WU) ~ u(B.WU)	–1	+1	+1					+1
u.(BU.SU) ~ u.b(U.SU)	+1	–1						–1
(US).bu ~ (US.B)u	–1	+1				+1		

7 Against Classic OT and For HG

7.1 SYMMETRICAL OT: INSUFFICIENT POWER

Using the same set of constraints from the Serial HG analysis detailed above, OT can only generate symmetrical harmony patterns in interaction with the spreading restrictions. In order to demonstrate this, the derivations from the Serial HG analysis exemplifying direction-specific blocking are adapted below into a standard OT grammar with ranked constraints. As can be seen in (129), in order for regressive spreading to be unhindered by any spreading restriction, Share must dominate all other restricting constraints. However, this ranking leads to a ranking paradox in (130). Candidate (130*a*) with progressive harmony blocked is the attested Chilcotin form, but either *B or *Dependent-Right must dominate Share for this candidate to be the optimum in direct contradiction with the ranking argument in (129).

(129) *Generating no blocking under leftward spreading*

Share ≫ *B, Dp-Binarity, Dp-Local, *Dp-Right, *Dp-Left

	/u.bu.Su/	Share	*B	*Dp-Right	*Dp-Left
☞	a. (U.BU.**S**U)		1	1	3
	b. u.b(U.**S**U)	2! W	0 L	1	1 L
	c. u.bu.(**S**)u	4! W	0 L	0 L	0 L

(130) *Ranking paradox: failing to generate progressive blocking*

*B ≫ Share *or* *Dependent-Right ≫ Share

Share ≫ *Left

	/uS.bu/	Share	*B	*Dp-Right	*Dp-Left
☞	a. (U**S**).bu	2!			1
	b. (U**S**.BU)	0 L	1 W	2 W	1
	c. u(**S**).bu	3! W			0 L

7.2 LOCAL CONSTRAINT CONJUNCTION: LESS GENERAL AND PROBLEMATIC

Since OT lacks sufficient power required for asymmetrical patterns, the constraint set utilized in Serial HG analysis presented above must be expanded in order to compensate for OT's shortcomings (Legendre, Sorace, and Smolensky 2006; Pater 2009). A standard analytical technique is to use Local Constraint Conjunction (LCC). Utilizing LCC changes OT into a descriptively adequate grammar that can account for asymmetries as shown in (131) and (132). By conjoining both the co-occurrence restriction *B and the directional constraint *Dependent-Right, blocking that is relativized to only rightward spreading becomes possible.

(131) *No blocking under leftward spreading*

	/u.bu.Su/	*B & *Dp-Right	Share	*B	*Dp-Right	*Dp-Left
☞	a. (U.BU.**S**U)		1	1	3	3
	b. u.b(U.**S**U)		2! W	0 L	1	1 L
	c. u.bu.(**S**)u		4! W	0 L	0 L	0 L

(132) *Blocking rightward blocking by conjoined constraint*

/uS.bu/	*B & *Dp-Right	Share	*B	*Dp-Right	*Dp-Left
☞ a. (U**S̲**).bu		2			1
b. (U**S̲**.BU)	$_{1!}$ W	$_{0}$ L	$_{1}$ W	$_{2}$ W	$_{1}$
c. u(**S̲**).bu		$_{3!}$ W			$_{0}$ L

However, there are at least two arguments against LCC. One is conceptual, the other is empirical.

7.2.1 The Conceptual Argument

LCC is inelegant as it suffers from a loss of generality. Since low-ranked constraints appear to gang up to overcome higher-ranked constraint, it is reasonable to allow for additive asymmetrical trade-offs as in HG. When gang effects are required, LCC simulates gang effects through constraint conjunction on a constraint by constraint basis. In a complex system like Chilcotin, multiple conjunctions are required. Using the same constraints as in the Serial HG analysis presented above, the four necessary conjunctions are the following (133).[25]

(133) *Required constraint conjunctions for Chilcotin*

*B & *DEPENDENT-RIGHT
*B & *DEPENDENT-HEAD(W)
DEPENDENT-BINARITY & *DEPENDENT-RIGHT
DEPENDENT-LOCAL & *DEPENDENT-HEAD(W)

Given the rankings established in tableaux (134)–(138), OT–LCC can generate the Chilcotin pattern. However, the resulting analysis formally misses the more general characterization of regressive spreading being stronger than progressive spreading and the coronal triggers being stronger than the dorsal triggers, which was captured in Serial HG by weighting *DEPENDENT-RIGHT more heavily than *DEPENDENT-LEFT and having the constraint *DEPENDENT-HEAD(W) but no constraint penalizing dependents of strong coronal [RTR] heads. In OT–LCC, this general strength property of Chilcotin harmony must be repeated twice for each interaction with the co-occurrence restriction and the bound on spreading domain. It is the loss of generalization in the OT–LCC analysis that is to its detriment.

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[25] One could get away with using only three conjoined constraints if directional spreading was motivated by featural alignment instead of the interaction of SHARE and *DEPENDENT-RIGHT/LEFT. However, alignment constraints are well-known for their dubious typological predictions.

(134) *No blocking under leftward spreading*

Share ≫ *B, Dp-Local, *Dp-Right, *Dp-Left

/u.bu.Su/	*B & *Dp-Right	Share	*B	Dp-Local	*Dp-Right	*Dp-Left
☞ a. (U.BU.**S**U)			1	1	1	3
b. u.b(U.**S**U)		2! W	0 L	0 L	1	1 L
c. u.bu.(**S**)u		4! W	0 L	0 L	0 L	0 L

(135) *Blocking under rightward spreading*

*B & *Dependent-Right ≫ Share

/uS.bu/	*B & *Dp-Right	Share	*B	*Dp-Right	*Dp-Left
☞ a. (U**S**).bu		2			1
b. (U**S**.BU)	1! W	0 L	1 W	2 W	1
c. u(**S**).bu		3 W			0 L

(136) *Bidirectional blocking under spreading from weak trigger*

*B & *Dependent-Head(W) ≫ Share ≫ *Dependent-Head(W)

/ub.Wu/	*B & *Dp-Head(W)	Share	*B	*Dp-Right	*Dp-Left	*Dp-Head(W)
☞ a. ub.(**W**U)		2		1		1
b. (UB.**W**U)	1! W	0 L	1 W	1	2 W	3 W
c. ub.(**W**)u		3! W		0 L		0 L

(137) *Bimoraic bound under rightward spreading, no bound leftward*

Dp-Binarity & *Dp-Right ≫ Share ≫ Dp-Binarity

		/u.u.u.Suu.uu/	Dp-Binarity & *Dp-Right	Share	Dp-Binarity	Dp-Local	*Dp-Right	*Dp-Left
☞	a.	(U.U.U.SUU).uu		2	1	2	2	3
	b.	(U.U.U.SUU.UU)	2! W	0 L	3 W	4 W	4 W	3
	c.	u.(U.U.SUU).uu		3! W	0 L	1 L	2	2 L
	d.	u.u.u.(S)u.uu.u		7! W	0 L	0 L	0 L	0 L

(138) *Bidirectional bound under spreading from weak trigger*

Dependent-Local & *Dependent-Head(W) ≫ Share

		/u.u.Wu.u/	Dp-Local & *Dp-Head(W)	Share	Dp-Local	*Dp-Right	*Dp-Left
☞	a.	u.(U.WU).u		2		1	1
	b.	(U.U.WU.U)	2! W	0 L	2 W	2 W	2 W
	c.	u.u.(W)u.u		4! W		0 L	0 L

7.2.2 *The Empirical Arguments*

The second argument against OT-LCC lies in its typological predictions. Firstly, OT-LCC is relatively unrestrained in its ability to freely combine several constraints in unnatural ways, a property it shares with earlier rule-based parameter frameworks. This free combination results in OT-LCC lacking the property of the subset criterion for process specificity (McCarthy 1997, Potts *et al.* 2010). In the case of Chilcotin, regressive harmony is strong while progressive harmony is weak. Any limitation on harmony is predicted to fall equally on both directions or only on one direction in OT and HG grammars that lack the superadditive power of constraint conjunction. What is not predicted is one limitation on regressive harmony and a second limitation on progressive harmony. Rather, asymmetrical restrictions apply in the same direction. This is the case with Chilcotin and other asymmetrical harmony systems reported thus far in the literature. This outcome is due to the nature of having ranked/weighted general constraints sans constraint conjunction. If LCC is a permitted grammatical mechanism, then there is no limit on how specific a constraint on a process can be. Other empirical problems exist when an improper domain is specified (McCarthy 1999, 2003).

8 Conclusion

This paper has shown that certain asymmetrical patterns in harmony systems can be modeled using Serial Harmonic Grammar, and a test case of a particularly complex system in Chilcotin was analyzed. Utilizing weighted constraints allows for general explanation and restrictive typologies without resorting to the use of Local Constraint Conjunction, which comparatively suffers from less restrictive typologies and less general explanation. Since the analysis is implemented in a serial framework, several unwanted typological predictions generated by parallel Optimality Theory can be avoided as shown by previous research on feature spreading within Harmonic Serialism. Future work should examine the consequences of feature delinking/deletion, feature epenthesis, transparent segments, and tonal displacement (shift), which were put aside here.

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