Cumulative Constraint Interactions: Violations and Domains Encompassing Segmental Spans

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1. Introduction

Cumulative interaction among constraints refers to an effect where violations of two or more constraints combine to win out over a constraint that is higher ranked or higher weighted than those constraints individually. Two primary approaches to cumulative constraint interaction have emerged: gang effects in Harmonic Grammar (HG; Legendre et al. 1990, Smolensky & Legendre 2006, Pater 2009a, 2016) and local constraint conjunction (Smolensky 1993, 1997, 2006), the latter usually deployed in Optimality Theory (OT; Prince & Smolensky 2004). The aims of this paper are two-fold. One goal is to show how gang effects in HG provide a new understanding of an apparent local triggering phenomenon in vowel harmony. A second, broader goal is to contribute to understanding how the predictions of gang effects in HG differ from those of local conjunction in OT (henceforth OT-LC). Fundamental to this difference is that gang effects involve an *asymmetric trade-off* in HG (an approach henceforth called HG-ATO), where a violation of one constraint is traded against violations of two or more other constraints (Pater 2009a, b, 2016).

The asymmetric trade-off requirement on gang effects in HG inherently restricts their scope. A benefit of this restriction emphasized in previous research is that it serves to limit cumulative constraint interaction in contrast to a certain degree of overgeneration predicted under OT-LC (Pater 2009b, 2016, Jesney 2016). This paper focuses on differences between these approaches from another angle, namely, how gang effects in HG predict attested patterns that are *not predicted* by OT-LC using the same constraints. This difference can potentially be elicited in a context where a ganging constraint has a locus of violation that encompasses a span of segments (or other material). In this situation, as elsewhere, HG-ATO predicts a gang effect where a single violation of one constraint simultaneously trades for a violation of each constraint in the gang. However, OT-LC does not inherently possess this restrictiveness. In OT-LC, the span-sized locus of violation widens the potential scope of application for evaluation of the conjunction. As will be shown, this predicts that two constraints can interact cumulatively over a span with respect to a conflicting constraint even when violating the conflicting constraint does not simultaneously alleviate violations of each constraint in the gang.

This difference is illustrated with the example of apparent local triggering in round harmony in Yakut. It is shown that using well-motivated markedness constraints on the distribution of round vowels, cumulative constraint interaction in HG obtains the Yakut pattern without a process-specific locality restriction. In contrast, OT-LC is unable to predict the Yakut pattern using the same basic constraints. An OT-LC account is nevertheless possible with different constraints and particular assumptions about the domain of the conjunction, but these modifications complicate the picture.

The organization of this paper is as follows. Section 2 presents the pattern of round harmony in Yakut, illustrating apparent local triggering. Section 3 reviews a previous OT analysis of Yakut round harmony, showing how it succeeds for two-syllable words but makes faulty predictions for apparent local triggering in words of three or more syllables. Section 4 analyzes the apparent local triggering as an epiphenomenon in an HG-ATO account, using constraints from the previous OT analysis that have

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strong typological support. Section 5 considers OT-LC approaches to the pattern, and section 6 discusses an alternative that alters the constraint set so as not to employ cumulative constraint interaction. Finally, section 7 presents the conclusion and outlook.

2. Round harmony in Yakut

Yakut, also known as Sakha or Saxa, is a Turkic language spoken in central and northeastern Siberia. The vowel patterns and data presented here are based on Krueger (1962) and Anderson (1998). Yakut has eight vowel qualities, shown in (1), which are fully crossed for two-way contrasts in height, rounding, and backness. Vowels may be long or short.[1]

(1) Yakut vowels

	Front		Back	
	Unround	Round	Unround	Round
High	i	y	ɯ	u
Nonhigh	e	ø	a	o

Like many other Turkic languages, Yakut exhibits round harmony and backness harmony. The focus here is on round harmony (RH), but the distributions of backness harmony are also present in the data. Vowel harmony in Yakut produces alternations in suffixes. Vowel harmony distributions are usually enforced in roots too, with the vowel of the first syllable determining the backness and rounding of vowels in following syllables; however, recent loanwords may be disharmonic, in which case the last stem vowel determines harmony in a following suffix. As will be shown, RH exhibits restrictions on the height of triggers and targets, where the *trigger* is a vowel from which spreading is initiated and the *target* is a vowel that undergoes spreading. However, backness harmony is enforced without any restrictions on the quality of the trigger or target vowels; that is, it operates without sensitivity to their height, rounding, or length. Therefore, vowels in a word are either all front or all back, excepting disharmonic stems.

When a trigger vowel is nonhigh, RH operates to a following vowel of any height. As seen in (2). The examples are organized according to the height of suffix vowels, which show alternations in rounding, as witnessed by comparing the unrounded alternant at the right. Nevertheless, polysyllabic roots also respect the dictates of RH, as expected. ('K #' refers to the page number where an example is found in Krueger 1962.)

(2) a. RH from nonhigh to high

oʁo-nu	'child-ACC' (K 81)	cf. paːrta-nɯ	'desk-ACC' (K 81)[2]
moʁotoj-u	'chipmunk-ACC' (K 81)		
børø-ny	'wolf-ACC' (K 81)	cf. et-i	'meat-ACC' (K 81)
øʁ-y	'arrow-ACC' (K 81)		

b. RH from nonhigh to nonhigh

ohoχ-tor	'stove-PL' (K 74)	cf. aʁa-lar	'father-PL' (K 73)[3]
χopto-lor	'gull-PL' (K 73)		
børø-lør	'wolf-PL' (K 73)	cf. et-ter	'meat-PL' (K 74)
bødøŋ-nør	'strong one-PL' (K 75)		

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[1] Yakut has four diphthongs, which I do not discuss here. Diphthongs pattern with high vowels in round harmony. Further study of their phonological representation is warranted; possibly their nonhigh vocoid is represented as a glide (Walker 2010). See Anderson (1998) on complexities of diphthongs' historical origins and behavior.

[2] The accusative suffix has the form /–nI/, where /I/ represents a high vowel that harmonizes for backness and rounding. The /n/ is deleted after a consonant.

[3] The plural suffix has the form /–lAr/, where /A/ represents a harmonizing nonhigh vowel. The suffix-initial consonant is realized as [t] following a voiceless consonant, as [d] after /j, r/, and [n] after a nasal.

RH from a high vowel is more restricted. It operates to a following high vowel (3a), but not if the following vowel is nonhigh (3b).

(3) a. RH from high to high

murun-u	'nose-ACC' (K 81)	cf. tɯj-ɯ	'foal-ACC' (K 81)
tobug-u	'knee-ACC' (K 81)		
tynnyg-y	'window-ACC' (K 81)	cf. tiːh-i	'tooth-ACC' (K 81)

b. No RH from high to nonhigh

kuːl-lar	'sack-PL' (K 73)	*kuːl-lor
kus-tar	'duck-PL' (K 74)	*kus-tor
tynnyk-ter	'window-PL' (K 74)	*tynnyk-tør

To summarize, RH in Yakut operates among all vowels except when the trigger is high *and* the target is nonhigh. The different triggering capacity of high and nonhigh vowels with respect to a following nonhigh vowel raises a question about distance effects in this pattern: Can a nonhigh vowel trigger RH in a later nonhigh vowel if a high round vowel intervenes? This question arises because nonhigh vowels can trigger harmony in following vowels of any height, and it is conceivable that they could trigger RH in eligible vowels at any distance in the word. However, as shown in (4), a nonhigh vowel is always unround after a high vowel, even when a nonhigh round vowel appears earlier in the word.

(4)

tobuk-tar	'knee-PL' (K 74)	*tobuk-tor
oʁus-tar	'bull-PL' (K 74)	*oʁus-tor
ojuːr-dar	'forest-PL' (K 74)	*ojuːr-dor
ørys-ter	'river-PL' (K 74)	*ørys-tør
bølyːk-ter	'rooster-PL' (K 74)	*bølyːk-tør

This pattern shows *apparent local triggering*: nonhigh round vowels cause RH in an adjacent syllable, but apparently not in a nonadjacent syllable (Sasa 2001, Walker 2010, Kimper 2014). This failure of RH transpires even though the intervening vowel is round, so it cannot be attributed to avoidance of a spreading feature skipping an intervening syllable. The analysis of apparent local triggering in Yakut RH will be a focal issue in the ensuing discussion.

3. Classic OT analysis

In analyzing Yakut RH I first consider an approach framed in classic OT. Kaun (1995, 2004) develops a comprehensive typology and analysis of RH in OT. Kaun proposes a set of constraints that she argues make typological predictions that are a close fit with the observed typology of patterns. Kaun employs four main constraints or constraint families, which are outlined below with some minor modifications and updates in names and definitions.

The harmony-driving constraints that Kaun employs are a family of SPREAD[Round] constraints.[4] A general version of this constraint is defined in (5); it assumes autosegmental representations of features and spreading.

(5) SPREAD[Round]:
For each feature [Round] in a word, assign a violation to every vowel that is not associated with that token of [Round].

[4] In Kaun 1995 this constraint family is labeled EXTEND[RD] and in Kaun 2004 it is ALIGN-L/R([RD], PRWD).

Kaun also proposes versions of SPREAD[Round] that enforce harmony from a weak trigger, that is, spreading from vowels in which the perception of rounding is more perceptually difficult. Kaun argues that rounding contrasts are more perceptually subtle in nonhigh vowels than in high vowels, giving rise to the constraint in (6).

(6) SPREAD[Round]if[-high]:
For each feature [Round] in a word that is associated to a nonhigh vowel, assign a violation to every vowel that is not associated with that token of [Round].

The unbounded formulation of SPREAD[F], which promotes feature spreading to *every* vowel in a word, has a functional motivation. By driving maximal exposure of a feature, harmony enhances the feature's perceptibility, especially aiding in identification of a feature in a weak trigger (Kaun 1995, 2004, Walker 2005, 2011, Jiménez & Lloret 2007).[5]

Kaun proposes additional markedness constraints that govern the association of [Round]. *ROLO, defined in (7), penalizes [ø] and [o].[6] GESTURALUNIFORMITY[Round], in (8), penalizes RH across a sequence of vowels that differ in height, that is, across a high-nonhigh vowel sequence or a nonhigh-high vowel sequence.[7] Noting that the execution of lip rounding differs in high vowels in comparison to nonhigh vowels, which have a more open jaw, Kaun proposes that GESTUNI[Rd] reflects an imperative to avoid nonuniform execution of a lip-rounding gesture corresponding to a single token of [Round].[8]

(7) *ROLO:
Assign a violation to each nonhigh round vowel.

(8) GESTURALUNIFORMITY[Round]: (Henceforth GESTUNI[Rd])
Assign a violation to a pair of vowels that share association with a [Round] feature and are the locus of a transition in vowel height.

Finally, Kaun assumes faithfulness constraints that govern identity for rounding. They are defined here as IDENT constraints (McCarthy & Prince 1995), adapted for a privative [Round] feature (Pater 1999). The constraint in (9) penalizes vowels that acquire rounding in the output. The position-sensitive constraint in (10) preserves rounding in vowels in the initial syllable.[9]

(9) IDENT-O→I([Round])
Assign a violation to a segment specified as [Round] in the output whose input correspondent is not [Round].

(10) IDENT-I→O-σ1([Round])
Assign a violation to a segment not specified as [Round] in the initial syllable in the output whose input correspondent is [Round].

[5] Further motivation for a harmony-driving constraint that promotes spreading beyond adjacent vowels comes from patterns with nonlocal trigger-target relations, as discussed in section 4.
[6] Kaun also proposes constraints reflecting the markedness of front round vowels, namely, *ROFRO and a constraint equivalent to SPREAD[Rd]if[-back]; however, they are not active in shaping the Yakut pattern.
[7] Kaun (1995) calls this constraint UNIFORM[Rd]. Its definition has been adjusted here along lines closer to that of Walker (2011) to make precise the locus of violation.
[8] Rounding can be shared across high and nonhigh elements in a diphthong in Yakut. Possibly one element in a diphthong is represented as a glide in Yakut or GESTUNI[Rd] operates over head nuclear vocalic elements only.
[9] Kaun's counterpart of the constraint in (9) is DEP(LINK) (2004: 104) and of (10) is PARSE[RD]INIT (1995: 149). An additional constraint, IDENT-I→O([Round]), will be relevant for preventing round vowels in contexts where RH has not reached, but it does not figure in the factorial constraint ranking that Kaun examines.

Kaun (1995) examines factorial constraint rankings involving the markedness constraints that she uses. She finds that a Yakut-type RH pattern is obtained when SPREAD[Rd]if[-high] dominates GESTUNI[Rd] and *ROLO, and at least one of GESTUNI[Rd] and *ROLO dominates SPREAD[Rd]. One such ranking is given in (11), where the motivation for sub-parts of the ranking are also outlined. ([V•V] represents vowels that belong to adjacent syllables with possible consonants intervening.) For simplicity, only back vowel sequences are used to illustrate RH patterns here and going forward; however, the motivation and analysis are also applicable to counterpart front vowel sequences.

(11) SPREAD[Rd]if[-high] >> GESTUNI[Rd], *ROLO >> SPREAD[Rd]
  a. SPREAD[Rd]if[-high] >> GESTUNI[Rd] generates [o•u] harmonizing sequences
  b. SPREAD[Rd]if[-high] >> *ROLO generates [o•o] harmonizing sequences
  c. GESTUNI[Rd] or *ROLO >> SPREAD[Rd] prevents [u•o] harmonizing sequences

As for faithfulness, IDENT-I→O-σ1([Round]) is ranked above SPREAD[Rd]if[-high], so that vowels in the initial syllable exhibit a rounding contrast, regardless of their height, and they control RH as triggers. IDENT-O→I([Round]) is ranked below SPREAD[Rd] to obtain active RH from vowels of any height (subject to restrictions by higher-ranked markedness constraints). These rankings of the faithfulness constraints will be assumed but not shown in tableaux in order to focus on the interaction of markedness constraints.

Kaun (1995) tested a ranking like that in (11) against schematic two-syllable sequences to verify that they obtain a Yakut-like RH pattern.[10] I will refer to this account as the *classic OT analysis*. The successful predictions are illustrated in (12).

(12) Yakut-like RH pattern: Two-syllable sequences

	SPREAD[Rd]if[-high]	GESTUNI[Rd]	*ROLO	SPREAD[Rd]
a. ☞ o•u		*	*	
b. o•ɯ	*!		*	*
c. ☞ o•o			**	
d. o•a	*!		*	*
e. ☞ u•u				
f. u•ɯ				*!
g. ☞ u•a				*
h. u•o		*(!)	*(!)	

However, when words with three or more syllables are considered, a problem comes to light for contexts where RH from a nonhigh vowel halts at a high vowel and is not transmitted to a later nonhigh vowel, as shown in (13). The winner that is desired but not selected is indicated by '✓' (13a), where RH halts at [u] before [a]. The unwanted selected output, with RH to the final nonhigh vowel is indicated by '☹' (13b), where harmony from [o] propagates across [u] to the final nonhigh vowel. 'W' and 'L' marks are indicated here with respect to the desired winner. They show that in order for (13a) to be favored over (13b) using these constraints, SPREAD[Rd]if[-high] must be ranked below either GESTUNI[Rd] or *ROLO (or both). Yet the opposite ranking is necessary to drive RH from nonhigh vowels to a following vowel of any height (compare (12a-b) and (12c-d)). Indeed, for the example in (13), if GESTUNI[Rd] were ranked over SPREAD[Rd]if[-high], (13c), with no RH, would actually be the winner.

[10] Kaun assumed full ranking. Her tableau with two-vowel sequences ranked GESTUNI[Rd] >> *ROLO (1995: 179).

(13) Unwanted triggering at a distance

/tobɯk-tar/	SPREAD[Rd]if[-high]	GESTUNI[Rd]	*ROLO	SPREAD[Rd]
a. ✓ tobuktar	*!	*	*	*
b. ☹ tobuktor	L	**W	**W	L
c. tobɯktar	*!*W	L	*	**W

Apparent local triggering, of the kind in (13a), thus presents a problem for the classic OT analysis, despite the strong support for its constraints from factorial ranking tests against two-syllable sequences. In the next section, I propose that [Round] spreading from a high vowel to a nonhigh vowel is inhibited by the activity of general markedness constraints. Specifically, apparent local triggering in Yakut RH is analyzed as an epiphenomenon of a gang effect in HG using the very constraints that Kaun motivates for RH. This account avoids any need to invoke a restriction on trigger-target locality.

4. Apparent local triggering as an asymmetric trade-off

The idea pursued here is that a sequence like [(…•)u•o], where a nonhigh round vowel follows a high round vowel, is avoided because a harmonizing nonhigh vowel in this context causes violations of *both* *ROLO and GESTUNI[Rd]. The avoidance of a harmonizing vowel that simultaneously causes violations of these constraints is analyzed as a gang effect in HG that inhibits satisfaction of SPREAD[Rd]if[-high]. I will assume familiarity with the basics of HG. For an overview, see Pater (2009a). As mentioned in section 1, a gang effect in HG involves two or more constraints combining to win out over a constraint whose weighting is greater than each of those constraints on their own. It requires the conditions for an asymmetric trade-off, where violations of the ganging constraints are traded for a violation of a conflicting constraint.

As established in the classic OT analysis, the harmony-driving constraint, SPREAD[Rd]if[-high], has higher priority than *ROLO and GESTUNI[Rd] individually (see (11)). In HG, this results from the weight of constraints that promote harmony from nonhigh vowels being greater than the weight of each of *ROLO and GESTUNI[Rd]. The gang effect comes about by the combined weight of *ROLO and GESTUNI[Rd] exceeding that of the constraints that drive RH. To illustrate the gang effect account, I will roughly mirror the classic OT analysis of Yakut RH, with a few adaptations necessary for implementation in HG.

To begin, constraint weightings that reproduce the basics of the classic OT account are considered. First, to prevent RH from a high vowel to a nonhigh vowel, Kaun observed that at least one of GESTUNI[Rd] and *ROLO dominates SPREAD[Rd]. In HG, this can be reproduced by assigning a higher weight to GESTUNI[Rd] or *ROLO than the weight of SPREAD[Rd]. More specifically, since a harmonizing sequence like [u•o] incurs violations of both GESTUNI[Rd] and *ROLO, the required weighting is that the sum of the weights of GESTUNI[Rd] and *ROLO is greater than that of SPREAD[Rd] (14a).

Second, RH from a nonhigh vowel spreads to a vowel of any height. In the classic OT analysis, this results from SPREAD[Rd]if[-high] dominating GESTUNI[Rd] and *ROLO. SPREAD[Rd]if[-high] and SPREAD[Rd] stand in a special-to-general relationship, meaning that every time SPREAD[Rd]if[-high] is violated, SPREAD[Rd] is too, but not the reverse. In HG, this relationship results in the force of SPREAD[Rd]if[-high] being represented by the sum of the weights of SPREAD[Rd]if[-high] and SPREAD[Rd]. This summing arises because because failing to spread from a nonhigh vowel incurs violations of both spreading constraints, so the weight of the general constraint (SPREAD[Rd]) boosts the effect of the special constraint (SPREAD[Rd]if[-high]) in calculation of a candidate's Harmony (*H*) score in HG. For RH from a nonhigh vowel, the sum of weights of the spreading constraints thus exceeds that of each of GESTUNI[Rd] and *ROLO (14b).

(14) a. $w(\text{GESTUNI[Rd]}) + w(\text{*ROLO}) > w(\text{SPREAD[Rd]})$
Motivation: No RH from a high vowel to a nonhigh vowel

b. *w*(SPREAD[Rd]if[-hi]) + *w*(SPREAD[Rd]) > *w*(GESTUNI[Rd]), *w*(*ROLO)
Motivation: RH from a nonhigh vowel spreads to a vowel of any height

Before addressing apparent local triggering in words of three syllables or more, the effect of these constraint weighting relationships in schematic two-syllable words is exhibited in (15). Constraints have been assigned weighting values consistent with the weighting relationships outlined in (14). For two-syllable words, these weightings are successful in generating the Yakut pattern. Note that in order to simplify the comparison with the classic OT analysis, SPREAD[F] constraints are evaluated negatively. Nonetheless, the negative evaluation is not crucial to the account and does not represent evidence for this particular formulation. A positively evaluated version of SPREAD[F] (i.e. one that earns positive rewards for spreading) implemented in Serial HG could offer benefits (Kimper 2011), but they are orthogonal to the main issues under focus here.[11] As in (12), attention remains on the interaction of the markedness constraints in the Yakut RH pattern, so faithfulness constraints are not shown in (15). Parallel to the OT account, the weight of SPREAD[Rd] will be greater than that of IDENT-O→I([Round]),[12] and the force of faithfulness to rounding in vowels in the initial syllable will exceed that of constraints that drive [Round] spreading.[13]

(15) Yakut-like RH pattern in HG: Two-syllable sequences

	SPREAD[Rd]if[-high] $w = 5$	GESTUNI[Rd] $w = 4$	*ROLO $w = 4$	SPREAD[Rd] $w = 1$	*H*
a. ☞ o•u		–1	–1		–8
b. o•ɯ	–1		–1	–1	–10
c. ☞ o•o			–2		–8
d. o•a	–1		–1	–1	–10
e. ☞ u•u					0
f. u•ɯ				–1	–1
g. ☞ u•a				–1	–1
h. u•o		–1	–1		–8

A problem with the classic OT analysis is its unwanted prediction that RH will operate from a nonhigh vowel to a later nonhigh vowel when a high vowel intervenes. For instance, it predicts unwanted [tobukt<u>o</u>r] rather than desired [tobukt<u>a</u>r] (13). Here a gang effect in HG makes an essential contribution. Spreading [Round] to a nonhigh vowel in a sequence like [(…•)u•o] adds a violation for each of *ROLO and GESTUNI[Rd]. The weighting in (14a) (*w*(GESTUNI[Rd]) + *w*(*ROLO) > *w*(SPREAD[Rd])) ensures that RH will not operate from a high vowel to a nonhigh vowel. When *ROLO and GESTUNI[Rd] gang against the constraints that drive RH from a nonhigh vowel, they will also prevent a nonhigh vowel from enforcing a high-nonhigh round vowel sequence later in the word. This relationship is characterized in (16). As above, the weight of constraints driving harmony from a

[11] Kimper argues that formulating the driver for unbounded harmony as a positive SPREAD[F] constraint in Serial HG (Pater 2012) avoids certain typological pathologies predicted by a negatively evaluated spreading constraint. The proposed HG-ATO analysis of apparent local triggering does not hinge on negative evaluation of SPREAD[F]; it also carries through for positively evaluated SPREAD[F] in Serial HG. Other work contributing to the debate on harmony-drivers in (Serial) HG includes Mullin (2011), Mullin & Pater (2015) and O'Hara (to appear).
[12] On potential problems of count effects involving the harmony-driver and faithfulness in HG and a possible solution, see O'Hara (to appear).
[13] Faithfulness for rounding in vowels of the initial syllable is represented by *w*(IDENT-I→O-σ1([Round])) + *w*(IDENT-I→O([Round])), because these constraints stand in a special-to-general relationship. Whether positional faithfulness is the best way to analyze positional trigger control of harmony in HG remains an open question, but it is not essential to matters under focus. Positional faithfulness is assumed here for purposes of comparison with the classic OT account. For discussion of surrounding issues, see Jesney (2011, 2012, 2016) and McCarvel & Kaplan (2014).

nonhigh vowel are computed as the sum of the weights of SPREAD[Rd]if[-high] and SPREAD[Rd] (see (14b)).

(16) *w*(GESTUNI[Rd]) + *w*(*ROLO) > *w*(SPREAD[Rd]if[-high]) + *w*(SPREAD[Rd])
Motivation: RH from a nonhigh vowel does not cause a high-nonhigh round vowel sequence

The weighting relationship in (16) is already consistent with the particular weights assigned in (15). These same weights are applied in (17) to a word with an apparent local triggering effect in RH.

(17) Yakut RH in HG: Apparent local triggering

/tobɯk-tar/	SPREAD[Rd]if[-high] *w* = 5	GESTUNI[Rd] *w* = 4	*ROLO *w* = 4	SPREAD[Rd] *w* = 1	*H*
a. ☞ tobuktar	–1	–1	–1	–1	–14
b. tobuktor		–2	–2		–16
c. tobɯktar	–2		–1	–2	–16

The winning candidate, in (17a), spreads from [o] to the following high vowel, but not the nonhigh vowel in the third syllable. The [o•u] sequence, which shares [Round] but differs in height, incurs a violation of GESTUNI[Rd]. This violation is enforced by the combined weight of SPREAD[Rd]if[-high] and SPREAD[Rd] exceeding that of GESTUNI[Rd], as seen by comparing (17c), where harmony does not spread to the high vowel. The nonhigh vowel in the initial syllable of each candidate in (17) incurs a violation of *ROLO. Retention of rounding in this vowel will be enforced by faithfulness pertaining to the first syllable. The unround final vowel in (17a) incurs a violation of SPREAD[Rd]if[-high] and its general counterpart, SPREAD[Rd], because a [Round] feature associated with a nonhigh vowel (in the first syllable) does not spread to the last vowel. The competing candidate in (17b), where RH propagates to the final vowel, satisfies both spreading constraints, but in doing so it incurs an extra violation of both GESTUNI[Rd] and *ROLO in comparison to the winner. The second violation of GESTUNI[Rd] is incurred by harmony across the sequence [u•o], and the second violation of *ROLO is incurred by the second [o] in this candidate. Spreading from a high vowel to a nonhigh vowel thus simultaneously violates GESTUNI[Rd] and *ROLO, whose combined weighting of 8 exceeds that of the constraints driving harmony from a nonhigh vowel, whose combined weighting amounts to 6. This prevents RH from propagating from a high vowel to a nonhigh vowel, even when a nonhigh round vowel occurs earlier in the word. The asymmetric trade-off is witnessed in the blocking of RH to the final vowel. The weight of constraints driving harmony from a nonhigh vowel, at 6, exceeds that of GESTUNI[Rd] and *ROLO individually, each weighted at 4, causing RH from a nonhigh vowel to target a vowel of any height. However, these two lower-weighted constraints gang up to block RH spanning a high-nonhigh sequence irrespective of the height of any preceding vowel associated with [Round].

It is noteworthy that even though this account of apparent local triggering involves a gang effect of GESTUNI[Rd] and *ROLO, RH across a nonhigh-high vowel sequence is still predicted, as shown by the selection of (17a), with a round-harmonizing [o•u] sequence, over (17c), with disharmonic [o•ɯ]. An [o•u] sequence incurs a violation of *ROLO for the first vowel and a violation of GESTUNI[Rd] for the two-vowel span. However, the operation of RH from [o] to a following high vowel adds only a violation of GESTUNI[Rd] in comparison to [o•ɯ], as confirmed by the tie of (17a) and (17c) on violations of *ROLO. Therefore, the setting for an asymmetric trade-off of GESTUNI[Rd] and *ROLO against violation of the spreading constraints does not arise in this context, and RH appropriately is not inhibited. The accuracy of the predictions of HG-ATO account – both for where RH is blocked and where it is not blocked – will form an important basis for comparison with an OT-LC analysis in section 5.1.

Several properties of the proposed HG-ATO analysis of apparent local triggering in Yakut warrant highlighting. First, the absence of RH that propagates across high-nonhigh vowel sequences is explained as a cumulative interaction of GESTUNI[Rd] and *ROLO, a type of constraint interaction that is inherent to HG. The interaction of these two constraints inhibits RH whenever a high round vowel immediately precedes a nonhigh vowel, even when a nonhigh round vowel, with privileged triggering strength, occurs earlier in the word. This outcome solves a problem for the classic OT analysis of the Yakut pattern. Second, the ganging constraints in question each find independent motivation in Kaun's (1995, 2004) typological study of RH and in other work. Applications of *RoLo are abundant (e.g. Kirchner 1993, Beckman 1997, Sasa 2009, Kimper 2011), and GesturalUniformity-type constraints have also been employed in several other studies (Cole & Kisseberth 1995, Majors 1998, Walker 2001, 2011, 2016).[14]

A third important property of this account is that it obtains the apparent locality effect as an epiphenomenon of an asymmetric trade-off among weighted constraints. An alternative account of (apparent) local triggers in Yakut, proposed by Kimper (2011, 2014), has introduced triggers and targets as formal concepts in the assessment of the harmony-driving constraint, defined in terms of their proximity to each other and involving reference to both input and output representations. Such steps enlarge the theoretical apparatus. Yet in the HG-ATO account, the constraints involved do not require a restriction on trigger-target locality, nor do inputs need to be considered for evaluation of the harmony driver. In many autosegmental accounts of harmony in OT, locality is constrained by a NoGap constraint or its equivalent, which restricts feature association to adjacent elements, either at the segmental level or at the level of a prosodic anchor such as the syllable head (Itô et al. 1995, Pulleyblank 1996, Walker 1998, Ní Chiosáin & Padgett 2001, Uffmann 2004).[15] I assume that a NoGap constraint is likewise enforced in Yakut RH (for present purposes I will not discriminate crucially between locality at the segment or syllable-head level). A benefit of NoGap is that it is not specific to harmony; it applies to shared feature representations in general. Introducing a separate trigger-target locality statement for patterns like Yakut RH runs the risk of partial duplication of labor with NoGap. In addition, harmony patterns are attested that show nonlocal trigger-target relations, even in contexts where harmony propagates locally and transparent segments are not involved, as in Mọ̀bà Yorùbá and Baiyina Oroqen (Archangeli & Pulleyblank 2007, Walker 2014). Such patterns indicate a need for constraints that evaluate dependencies in harmony that may be *nonlocal*, and they are consistent with a harmony driver for weak trigger patterns that promotes spreading not just to an adjacent or closest element, but to all elements in the word, as formulated in Spread[F].

As touched on here, these properties of the HG-ATO analysis have implications for general theoretical issues surrounding locality, harmony drivers, marked featural representations, and cumulative constraint interactions. They come also into play in considering alternatives in OT-LC, discussed in the next section.

5. Apparent local triggering in OT-LC

In this section I consider approaches to apparent local triggering in Yakut as a cumulative constraint interaction implemented in OT-LC. The evaluation of a local conjunction of two distinct constraints C_1 and C_2 is defined in (18), following Itô & Mester (2003: 23).

(18) Evaluation of local conjunction

The local conjunction of $C_1\&_DC_2$ is violated by a candidate if and only if it has accrued a pair of violation marks ($*C_1$, $*C_2$) for C_1 and C_2 in some domain D.

Local conjunction is a means for capturing cumulative constraint interactions because the conjunction is only activated in contexts where both C_1 and C_2 are violated. In a grammar with the ranking $C_1\&_DC_2 >> C_3 >> C_1, C_2$, constraints C_1 and C_2 may be individually violated to satisfy a constraint, C_3, but when violations of *both* C_1 and C_2 are incurred in domain D, satisfaction of C_1 and C_2 is enforced at the cost of violating C_3.

[14] To be sure, the typological predictions of *RoLo and GestUni[Rd] have not been fully tested in HG; however, debates centered around constraints in the analysis of harmony in HG have chiefly centered on the harmony driver and faithfulness.

[15] See also Levergood (1984) and Archangeli & Pulleyblank (1994) for proposals in other frameworks that restrict gapped association of features.

The power of local conjunction increases considerably if any domain can be specified for a given conjunction of two constraints, yielding unwanted predictions (e.g. Baković 2000, Łubowicz 2002, 2005, Itô & Mester 2003). Accordingly, the domain for a conjunction has been proposed to be determined on a principled basis. The definition in (19), proposed by Łubowicz (2005), makes reference to the constraints' locus of violation (McCarthy 2003). This definition will be considered in the course of discussion of an OT-LC account of Yakut RH.[16]

(19) Restricted Local Conjunction
$C_1\&C_2$ is violated if the intersection of the loci of violation of C_1 and C_2 is a nonempty set.

In what follows, I first consider an OT-LC approach using the same constraints as in the classic OT analysis. This approach is faced with the problem of the local conjunction being overaggressive in the range of sequences where it prevents harmony. An alternative OT-LC account for Yakut that uses a different constraint set is also considered.

5.1. An OT-LC account using classic constraints

An OT-LC account constructed with the same cumulatively interacting constraints as in the HG-ATO account conjoins GESTUNI[Rd] and *ROLO. The aim is that GESTUNI[Rd]&*ROLO will prevent spreading of a [Round] feature that is associated with a nonhigh vowel from generating a high-nonhigh round vowel sequence later in the word. The local conjunction would therefore be ranked above SPREAD[Rd]if[-high] and the remainder of the ranking in the classic OT account. The effect of this ranking in a word that exhibits apparent local triggering is illustrated in (20).

(20) OT-LC attempt using GESTUNI[Rd]&*ROLO

/tobɯk-tar/	GESTUNI[Rd] &*ROLO	SPREAD[Rd]if[-high]	GESTUNI[Rd]	*ROLO	SPREAD[Rd]
a. ✓ tobuktar	*!	*	*	*	*
b. tobuktor	*!*W	L	**W	**W	L
c. ☹ tobɯktar	L	**W	L	*	**W

To evaluate the local conjunction, it is necessary to consider the loci of violation for each of its component constraints. For *ROLO, a locus of violation is a nonhigh round vowel. In (20a) and (20c), the locus of violation for this constraint is [o], and in (20b) there are two loci of violation, [o] in the first syllable and [o] in the third syllable. For GESTUNI[Rd], a locus of violation is a pair of vowels that share association with [Round] and are the site of a transition in vowel height (see (8)), that is, the locus is the minimal span where a single [Round] feature would be executed with nonuniform height. In (20a), GESTUNI[Rd] has a locus of violation in the sequence [o•u]. In (20b), [o•u] and [u•o] are each a locus of violation. Turning now to the local conjunction, in (20b), [o] in the third syllable is a place where violations of the conjoined constraints intersect; this vowel violates *ROLO and it is part of a locus of violation of GESTUNI[Rd]. The local conjunction thus succeeds in penalizing RH across an [u•o] sequence, as intended. However, the first [o] in (20b), and the vowel in the same context in (20a), is also a location where violations of the conjoined constraints intersect. Here the local conjunction assigns a problematic penalty; it penalizes RH in an [o•u] sequence, although harmony actually occurs in this context in Yakut. The result is that the desired winner, in (20a), where harmony operates only across [o•u], is not selected in this tableau. Instead, the selected candidate is the unwanted output in (20c), with no cross-height RH. GESTUNI[Rd]&*ROLO therefore does not predict apparent local triggering as appropriate for Yakut. It blocks RH in the desired context of a high-nonhigh vowel sequence, but it also blocks in the context of a nonhigh-high sequence, where harmony actually occurs.

[16] Itô & Mester (2003) propose another definition of the domain for local conjunction in terms of the minimal shared domain where C_1 and C_2 can be evaluated. However, the performance of the OT-LC accounts of apparent local triggering considered here do not improve under this definition.

As before, W' and 'L' marks are indicated with respect to the desired winner. These show that (20a) would be favored over (20c) if SPREAD[Rd]if[-high] dominates the local conjunction. Yet under this ranking the blocking effect of the conjunction is effectively neutralized, and (20a) loses to (20b), where RH from a nonhigh vowel operates across *any* cross-height sequence, even across a later high-nonhigh sequence, where it should be halted.

The difference in predictions of an OT-LC approach versus the HG-ATO analysis involving cumulative interaction of GESTUNI[Rd] and *ROLO are illustrated alongside each other in (21-22). These tableaux show the application of these approaches in a word where the only vowel height transition is a nonhigh-high sequence, across which RH operates in Yakut. The tableau in (21) shows that the local conjunction is *overaggressive*, because it blocks RH from [o] to a following high vowel. In contrast, the HG-ATO account does not have this problem, as seen in (22). RH is not blocked in a nonhigh-high vowel sequence, because not spreading [Round] to the high vowel, as in (22b), does not avoid a violation of *ROLO.

(21) OT-LC attempt using GESTUNI[Rd]&*ROLO

/oʁa-nɯ/	GESTUNI[Rd] &*ROLO	SPREAD[Rd]if[-high]	GESTUNI[Rd]	*ROLO	SPREAD[Rd]
a. ✓ oʁonu	*!		*	**	
b. ☹ oʁonɯ	L	*W	L	**	*W

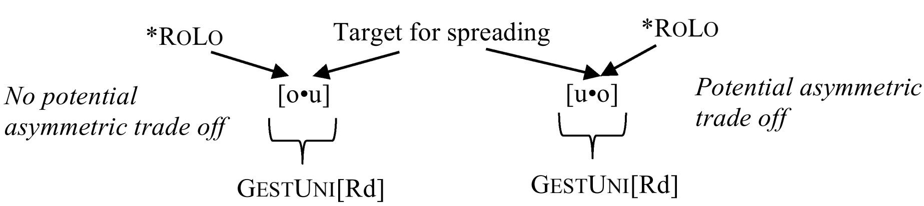
(22) HG-ATO account

/oʁa-nɯ/	SPREAD[Rd]if[-high] $w = 5$	GESTUNI[Rd] $w = 4$	*ROLO $w = 4$	SPREAD[Rd] $w = 1$	*H*
a. ☞ oʁonu		–1	–2		–12
b. oʁonɯ	–1		–2	–1	–14

The crux of the problem for OT-LC is that it does not discriminate between nonhigh vowels whose targeting causes violation of both GESTUNI[Rd] and *ROLO versus those whose triggering causes violations of both constraints. Only the former context trades off asymmetrically with constraint(s) that drive spreading.

The source of the different predictions of the HG-ATO and OT-LC accounts is illustrated visually in (23) with round harmonizing sequences [o•u] and [u•o]. In each of these sequences, both vowels together form the locus of violation of GESTUNI[Rd]. In [o•u] the first vowel is the locus of violation of *ROLO and in [u•o] it is the second vowel. In [u•o] this locus *converges* with the target for spreading ([o]), but in [o•u] it *diverges* from the spreading target ([u]). Because the target for spreading and the nonhigh vowel converge only in [u•o], only a high-nonhigh vowel sequence has the potential for GESTUNI[Rd] and *ROLO to trade-off asymmetrically with respect to SPREAD[Rd] constraints. This is a positive result for Yakut, because RH is blocked only in these sequences. Under local conjunction, the prospects for cumulative interaction are different. GESTUNI[Rd]&*ROLO is violated whenever the loci of violation of its conjoined constraints intersect. Both sequences in (23) meet the conditions for violating the local conjunction, which means that the local conjunction can be enforced at the cost of SPREAD[Rd]if[-high], even when doing so does not asymmetrically avoid violating both GESTUNI[Rd] and *ROLO.

(23)



Eliciting this difference between OT-LC and HG-ATO involves examining a constraint whose locus of violation encompasses a bipositional span, in this case GESTUNI[Rd]. This opens the possibility for it to intersect with the locus of violation of a conjoined constraint at each location in the span, one of which can show an asymmetric trade-off with respect to a conflicting constraint and another that does not. This difference is general to the two approaches to cumulative constraint interaction, beyond the specifics of RH in Yakut.

Nevertheless, in light of the problems found for the attempted OT-LC analysis using GESTUNI[Rd] and *ROLO, it is useful to consider whether the locus of violation for GESTUNI[Rd] could instead be interpreted as a single vowel. For instance, the constraint could be revised so as to punish a vowel that is associated to a [Round] feature that is associated with a vowel of a different height in the immediately preceding syllable. Under this reinterpretation, [o] would be the locus of violation in an [u•o] sequence and [u] would be the locus of violation in an [o•u] sequence, so the only intersection with *ROLO would be in [u•o], achieving the desired blocking context for Yakut RH in an OT-LC approach. However, this strategy for rescuing the OT-LC account for Yakut has drawbacks. Here, the understanding of what is marked in the vowel sequences in question is driven by the mechanics of local conjunction, not by general principles of markedness. Kaun's proposal about the representation that is penalized by GESTUNI[Rd] is that it is marked to execute the gesture associated with lip rounding across vowels of different height. This articulatory understanding of the basis for markedness in these contexts is reflected by a locus of violation that encompasses a *span* of round harmonizing vowels that differ in height. Indeed, in order to identify whether a round vowel violates GESTUNI[Rd] under the revised definition would still require examining the preceding vowel and association of both vowels' [Round] feature. Stipulating that a single vowel in the sequence is the locus of violation misses the intuition underpinning the constraint.[17] It is noteworthy that a revised understanding of the locus of violation is not required for the HG-ATO analysis of Yakut. In that case what matters is simply whether the conditions for an asymmetric trade-off are present.

Further, a revised single-segment locus of violation for GESTUNI[Rd] is not a general resolution for avoiding differences in predictions between OT-LC and HG-ATO involving spans. A span-sized locus of violation would need to be reconsidered for any other constraint where OT-LC predicted a potentially overaggressive scope of cumulative constraint interaction.

5.2. An OT-LC account with different constraints

An alternative account of RH in Yakut, proposed by Jurgec (2011), uses local conjunction of different constraints, which are based at least in part on different assumptions about featural representations. This approach conjoins a constraint *[ROUND high], which serves to penalize round spreading from a high vowel, and AGREE([round],high), which requires that harmonizing vowels agree in specification for the feature [high].[18] The local conjunction of these constraints is defined as in (24) for Yakut RH (Jurgec 2011: 317).

(24) *[ROUND high]$\&_{seg}$AGREE([round],high)
Assign a violation mark iff *[ROUND high] and AGREE([round],high) are violated within the domain of a segment.

This local conjunction has the effect of blocking RH from a high vowel to a nonhigh vowel, yielding the desired effect for Yakut. The local conjunction is specified to operate within the domain of a segment. As discussed above, arguments have been made for a theory of local conjunction where the domain follows from a restrictive principle rather than being freely specified. Nonetheless, Jurgec states that each of the constraints in the conjunction are evaluated at the level of root nodes, so violation of the conjunction could possibly be restricted to the segment without stipulation using Łubowicz's definition in (19).

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[17] An alternative approach where GESTUNI[Rd] is split into two constraints that separately penalize high-nonhigh and nonhigh-high vowel sequences is discussed in section 6.

[18] More specifically, AGREE([round],high) is enforced over root nodes that are "fully associated" with features [round] and [high], which means that there is some association to the feature via a nonbranching f-node (Jurgec 2011: 161, 286).

Yet some larger considerations raise questions about this account in comparison to the HG-ATO analysis. First, the constraints involved in the local conjunction in (24) do not have the abundance of support from independent studies and testing of typological predictions as the constraints used in the HG-ATO analysis. The ramifications of this different constraint set and accompanying assumptions about representations are still being examined. Second, the OT-LC account introduces greater complexity to the constraint set in the form of the local conjunction, while the HG-ATO account obtains the cumulative interaction of GESTUNI[Rd] and *ROLO and the context of their intersection for free. For further discussion of advantages of HG-ATO versus OT-LC along the lines of simplicity and restrictiveness, see Pater (2009a, b, 2016), Potts et al. (2010), Jesney (2016), and Ryan (to appear).

6. A split version of GESTURALUNIFORMITY[Round]

Another approach to apparent local triggering in Yakut RH, proposed by Sasa (2001, 2009), does not involve cumulative constraint interaction. It instead alters the constraint set by splitting GESTUNI[Rd] into two constraints, one that prohibits [Round] associated to a high-nonhigh vowel sequence (*H-L[Rd]) and another that prohibits [Round] associated to a nonhigh-high vowel sequence (*L-H[Rd]). The former constraint is proposed for the avoidance of [u•o] and [y•ø] sequences in Yakut. However, the labor of *H-L[Rd] partially overlaps with that of *ROLO, a property captured by cumulative interaction of general GESTUNI[Rd] and *ROLO, as proposed here. Sasa (2009) applies *L-H[Rd] to RH in Kachin Khakass, where harmony operates among high vowels only, but this pattern is also readily handled with general GESTUNI[Rd] (and *ROLO), since no cross-height RH is allowed.

Beyond the lack of necessity for a split version of gestural uniformity constraints for [Round], *L-H[Rd] opens the door to unwanted typological predictions for RH. Kaun's (1995, 2004) typology shows that in systems where cross-height harmony is attested, RH from a high vowel to a nonhigh vowel, e.g. [u•o], [y•ø], in a progressive RH system (as in a dialect of Kirghiz), implies RH from a nonhigh vowel to a high vowel, e.g. [o•u], [ø•y]. However, RH from a nonhigh vowel to a high vowel may occur without high to nonhigh (as in Turkish). Since *L-H[Rd] penalizes progressive RH from a nonhigh vowel to high, inclusion of this constraint will prevent the constraint set from predicting the wanted implication for cross-height RH.

For these reasons, I conclude that a split version of gestural uniformity constraints for [Round] is not a fruitful path for the treatment of apparent local triggering in the Yakut pattern.

7. Conclusion and outlook

This paper started with two goals. The first was to show how apparent local triggering in Yakut RH can be understood as an epiphenomenon of an asymmetric trade-off of constraints in HG. The second was to contribute to understanding how the predictions of gang effects analyzed in HG differ from those in an OT-LC account. On the first point, the account developed here demonstrates that apparent local triggering in Yakut can be analyzed as a cumulative constraint interaction in HG using basic constraints from Kaun's classic OT account, which have strong typological and crosslinguistic support. Furthermore, it obtains this result without reference to a domain for the cumulative interaction or requiring process- or harmony-specific locality, and it leaves open the possibility of nonlocal trigger-target relations, as attested elsewhere.

On the second point, the OT-LC account using the same constraints illustrates that OT-LC has the potential to predict overaggressive cumulative constraint interactions, which could rule out the attested pattern in Yakut, at least if it is understood as a gang effect, as is proposed here. This difference between OT-LC and HG-ATO arises because a gang effect in HG is tied to an asymmetric trade-off of the ganging constraints with violation of a conflicting constraint, while a local conjunction does not have this property. The distinction in approaches is elicited in the context of a span-sized locus of violation, where the scope of a local conjunction is widened across multiple segments, enabling it to predict more liberal gang effects, with unwanted consequences for Yakut.

Nevertheless, there is the potential for an account of Yakut RH using OT-LC if the constraints (and representations) are formulated differently. These bring complexities to the account of Yakut, and they do not obviate the larger issue of the potential for different predictions of OT-LC versus HG-ATO in the face of constraints with a span-sized locus of violation. OCP constraints are an instance where the locus of violation plausibly spans more than one segment. Therefore, beyond harmony, the differences of these approaches could be tested further in patterns where the OCP participates in gang effects with other constraints. This is a direction that would be fruitful to investigate in future research.

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