Cumulative Constraint Interaction and Trigger Competition in Vowel Harmony

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1 Introduction

1.1 Trigger Asymmetries

- In languages with harmony processes, the ability to trigger harmony may be restricted to certain segments.
- In Yakut, non-high vowels preferentially trigger rounding harmony (Kaun, 1995); both high and non-high vowels can spread rounding to high targets (1a–b, 1e–f), but only non-high vowels can spread to non-high targets (1g–h, cf. 1c–d).

(1) **Yakut Rounding Harmony**

a.	mur**u**n-u	'nose–ACC'
b.	tuːnn**uː**g-u	'window–ACC'
c.	tuːnn**uː**k-ter	'window–PL'
d.	tob**u**k-ka	'knee–DAT'
e.	oɣ**o**-nu	'child–ACC'
f.	boːr**oː**-nu	'wolf–ACC'
g.	oh**o**χ-tor	'stoves–PL'
h.	s**o**n-ton	'jacket–ABL'

1.2 Transparency Asymmetries

- The ability to undergo harmony may also be restricted. Harmony systems with multiple non-undergoing segments may display both transparency and opacity
- In Hungarian (Hayes and Londe, 2006; Hayes et al., 2009), [i] behaves as transparent (2a–b), but [eː] and [ɛ] exhibit variable behaviour (2c–f).

(2) **Transparency and Opacity in Hungarian**

a.	gumi	gumi-nɔk	'rubber(-DAT)'	(*gumi-nɛk)
b.	pɔpiːr	pɔpiːr-nɔk	'paper(-DAT)'	(*pɔpiːr-nɛk)
c.	ɔrzeːn	ɔrzeːn-nɔk ∼ ɔrzeːn-nɛk	'arsenic(-DAT)'	
d.	hotɛl	hotɛl-nɔk ∼ hotɛl-nɛk	'hotel(-DAT)'	
e.	honveːd	honveːd-nɔk ∼ honveːd-nɛk	'Hungarian soldier-DAT'	
f.	dʒungɛl	dʒungɛl-nɔk ∼ dʒungɛl-nɛk	'jungle-DAT'	

1.3 Trigger Competition

- I follow Hayes and Londe (2006); Hayes et al. (2009); Kimper and Ylitalo (In press) in arguing that these two asymmetries are fundamentally related.

  i. Certain classes of segments are given status as preferential triggers of harmony.
  ii. The choice between transparency and opacity represents competition between two potential harmony triggers.
  iii. A segment's status as a preferred trigger interacts with a violable locality restriction, resulting in transparency/opacity asymmetries.

- In a V_1–V_2–V_3 sequence, where V_2 is a non-undergoer, V_1 and V_2 compete to determine the feature specifications of V_3

Transparency **Opacity**

- The formal implementation: a positive scalar constraint in Serial Harmonic Grammar (SHG). Rewards are scaled up for spreading from preferred triggers and scaled down for spreading across a distance

  – Cumulative constraint interaction means that these scaling factors can influence a V_1 vs. V_2 standoff; preferred triggers will be more likely to behave as opaque (and more likely to induce transparency).

1.4 Roadmap of the Talk

2 **Background: Serial Harmonic Grammar**

3 **Segmental trigger asymmetries**

- 3.1 What makes a good trigger?
- 3.2 Scaling
- 3.3 Privileging impoverished targets

4 **Locality as a property of triggers**

- 4.1 Privileging local triggers
- 4.2 Distance effects

5 **Transparency/opacity asymmetries**

- 5.1 Opacity and dominance
- 5.2 Quality/locality interactions

2 Background: Serial Harmonic Grammar

- Serial Harmonic Grammar (SHG) is the result of combining Harmonic Serialism (HS; McCarthy 2000, 2007a,b) and Harmonic Grammar (HG; Smolensky and Legendre 2006), two independently motivated variants of the standard model of Optimality Theory (OT; Prince and Smolensky 1993/2004).

- In HS, Gen is restricted to producing candidates that each differ from the input by at most a single application of a single change.[1]
  - Candidate set is evaluated by Eval; the optimum is sent back to Gen to serve as the input to a new step in the derivation.
  - The Gen→Eval loop continues until the changes made by Gen no longer increase harmony (*convergence:* faithful candidate is the winner).
  - As a consequence of this way of proceeding, HS derivations are necessarily gradual and harmonically improving.

- In HG, constraints are assigned numerical weights rather than strict rankings.
  - Each candidate's harmony score is calculated according to the formula below; the candidate with the highest harmony score is selected as the optimum.
  - $\mathcal{H}(A) = \sum_{i=1}^{n} w(C_i) \times C_i(A)$
  - Cumulative constraint interactions: multiple violations of C_2 (or violations of both C_2 and other lower-weighted constraints) can "gang up" on C_1.
  - Cumulative interaction is only possible when there is an asymmetrical tradeoff — that is, when one violation of C_1 can be traded for two or more violations of C_2 (Pater, 2009; Prince, 2004).

- SHG combines the gradual, serial derivations of HS with the weighted constraints of HG;Pater (2012, to appear) shows that a restricted Gen can resolve some of the problems that constraint weighting in HG suffers from in a parallel theory.

2.1 The harmony constraint

- A negative harmony constraint assigns penalties for disharmony.
  - These constraints are sensitive to the number of unassimilated segments, and can interfere pathologically with unrelated processes.
  - e.g. blocking cluster repair through epenthesis `iff` there is blocked spreading (Wilson, 2004, 2006).

[1] What constitutes a single change is a matter of ongoing research, and is determined empirically rather than *a priori*; see for example McCarthy (2010) for a discussion of the kinds of evidence brought to bear on the question.

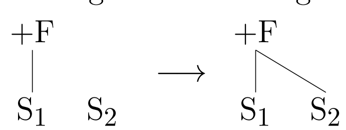
- A positive harmony constraint assigns rewards for harmony.
  - Not subject to the pathological predictions described above, because it is not sensitive to the number of unassimilated segments.
  - Sensitive to the number of *assimilated* segments, and could potentially protect them from processes which threaten their status as dependents.
    * This is attested! In Kera, vowels in a front/back harmony domain which are the targets of a prosodically-driven reduction process do not reduce along the F2 dimension (Pearce, 2008).

(3) SPREAD(±F): For a feature F, assign +1 for each segment linked to F as a dependent.

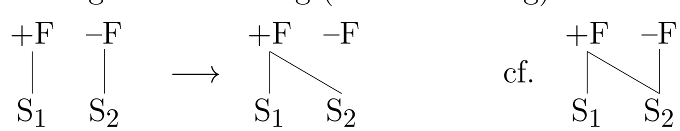
- Assumption: each feature is associated with at most one head, and all additional segments associated with that feature are dependents.[2]
- The single operation performed by GEN: autosegmental linking.

(4) For a feature $\pm F_i$ and a segment S, create an autosegmental association between F_i and S. If S is associated with another instance $\pm F_j$, the link between S and $\pm F_j$ is dissolved.

a. Autosegmental Linking:



b. Autosegmental Linking (with de-linking)



(5) **Step 1**

[+] dig-a	SPREAD(+ATR) 2	IDENT(ATR) 1
a. [+] dig-a	W	L
b. ☞ [+] dig-ʌ	+1	–1

Step 2: *Convergence*

[2] I set aside, for now, the question of which segment is awarded head status; I assume (following Smolensky 2006, and others) that the segment which bears F underlyingly is the head, but nothing crucial rests on this assumption.

- A positive constraint, which would be untenable in parallel versions of OT because of the Infinite Goodness Problem (Prince, 2007), is viable in a framework with a restricted GEN (Kimper, to appear).
  - A constraint like SPREAD(F) has the potential to infinitely approach a forever-unattainable maximal satisfaction by epenthesizing an unbounded number of segments to which a feature could be linked.
  - Since epenthesis and autosegmental linking are distinct operations (and must occur in distinct steps), there is no gradual and harmonically improving path to infinite epenthesis.

3 Segmental trigger asymmetries

- In some harmony systems, certain segments are given a preferential status as triggers — either they are able to initiate harmony when other segments cannot, or they are able to initiate harmony in a broader range of circumstances than other segments.
- In Yakut (Krueger, 1962), both high and non-high vowels are possible triggers of root-controlled rounding harmony. However, non-high vowels can initiate harmony on both high and non-high targets, while high vowels can only initiate harmony on high targets.
  - When the trigger (the final vowel of the stem, in the case of suffix alternations) is high and round, suffixes with high vowels surface as round (6a–c).
  - Under these same conditions, suffixes with non-high vowels surface as unrounded (6de); harmony has failed to occur.
  - When the trigger is a non-high round vowel, both high suffix vowels (7a–c) and non-high suffix vowels (7de) surface as round.

(6) **Yakut Rounding Harmony: High Triggers**

a. mur**u**n-u ‘nose–ACC’
b. tuːnn**uː**g-u ‘window–ACC’
c. tob**u**g-u ‘knee–ACC’
d. tuːnn**uː**k-ter ‘window–PL’
e. tob**u**k-ka ‘knee–DAT’

(7) **Yakut Rounding Harmony: Non-High Triggers**

a. oɣ**o**-nu ‘child–ACC’
b. **o**χ-u ‘arrow–ACC’
c. boːr**oː**-nu ‘wolf–ACC’
d. oh**o**χ-tor ‘stoves–PL’
e. s**o**n-ton ‘jacket–ABL’

- Restrictions on the targets of harmony can be captured via independently-motivated markedness constraints, e.g. *ROLO (Kaun, 1995).

- In Yakut, a non-high trigger is able to overcome this restriction, while a high trigger finds it unsurmountable.
  - Restrictions on potential triggers do not follow automatically from general markedness considerations; some additional mechanism is required.
- Triggering asymmetires can be expressed formally if the harmony constraint is scalar, with higher rewards for better triggers.

3.1 What makes a good trigger?

- Kaun (1995): the segments which tend to be preferred as harmony triggers are those which are relatively perceptually impoverished with respect to the spreading feature.
  - non-high vowels are consistently preferred as triggers in rounding harmony.
  - Linker (1982): Non-high round vowels are articulated with a less extreme rounding gesture than their high counterparts.
  - Terbeek (1977): listeners treat high round vowels as more round than non-high round vowels.
- Harmony confers a perceptual advantage (Suomi, 1983; Kaun, 1995; Gallagher, 2010; Kimper, 2011, 2012). Realizing a feature across multiple segments...
  - Gives the listener multiple opportunities to correctly identify the intended feature.
  - Renders contrasts predictable in non-prominent positions.
  - Increases the overall discriminability of words.
  - Facilitates processing (by e.g. allowing chunking in working memory or priming subsequent instances of a feature).
- Segments with the weakest perceptual cues for the relevant contrast have the most to gain from harmony and should be preferred as triggers.
- Generalising beyond rounding...
  - Height is predicted to affect a segment's propensity to trigger harmony along the front/back dimension; front and back high vowels are separated by a greater articulatory (and acoustic) distance than their non-high counterparts.
  - ATR harmony systems seem, at first, to present a challenge — high [+ATR] vowels tend to be preferred as triggers.
    - ∗ But high vowels are poorly cued for the [±ATR] *contrast*.

3.2 Expanding the Family

- A segment's status as a preferred trigger is relevant for the assessment of harmony.
  - This assessment is local to a particular autosegmental link.

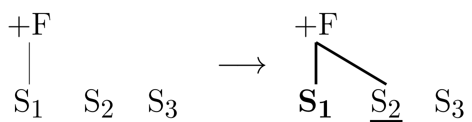
(8) For a feature $\pm F_i$ and a segment S, create an autosegmental association between F_i and S. If S is associated with another instance $\pm F_j$, the link between S and $\pm F_j$ is dissolved. For each instance of an operation creating a new autosegmental link (spreading)...

a. The target is a segment which is not associated with F in the input, but is associated with F in the output (candidate).

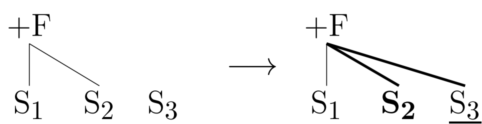
b. The trigger is the segment already associated with F in the input which is linearly closest to the target.[3]

(9) **Triggers and Targets**

a. Trigger = S_1, Target = S_2



b. Trigger = S_2, Target = S_3



(10) **Scaling for segmental triggers**

- SPREAD(F)$_P$: For feature F, assign +1 for each segment linked to F by a preferred trigger.

- SPREAD(F)$_P$ and SPREAD(F) are in a specific-to-general relationship; each reward on SPREAD(F)$_P$ will also earn a reward on SPREAD(F), but not vice versa.

3.3 Privileging impoverished triggers

(11) *Weighting conditions for preferential triggering*

$w(\text{Spread(F)}_P) + w(\text{Spread(F)}) > w(\text{blocking constraint}) > w(\text{Spread(F)})$

- The effect of this weighting condition in Yakut is demonstrated in the tableaux in (12–14). High vowels are able to trigger harmony on other high vowels (overcoming faithfulness), but are prevented from targeting non-high vowels by *ROLO. Non-high vowels, on the other hand, are privileged as triggers and are able to overcome *ROLO and trigger harmony on non-high vowels.

[3]This ensures that trigger/target relations are defined locally, rather than globally — see e.g. Jurgec (2011) for evidence in favour of trigger locality.

- In (12), a high trigger has succeeded in spreading rounding to a high target, because *Rolo remains unaffected.

(12) **Step 1**

[+] tobɯg-ɯ	*RoLo 8	Spread(+rd) 6	Spread(+rd)$_P$ 4	Ident(rd) 1	$\mathcal{H}$
a. [+] tobɯg-ɯ	–1				–8.0
b. ☞ [+] tobug-ɯ	–1	+1	+1	–1	+1.0

Step 2

[+] tobug-ɯ	*RoLo 8	Spread(+rd) 6	Spread(+rd)$_P$ 4	Ident(rd) 1	$\mathcal{H}$
a. [+] tobug-ɯ	–1	+1	+1		+2.0
b. ☞ [+] tobug-u	–1	+2	+1	–1	+7.0

Step 3: *Convergence*

- In (13), a high trigger has failed to spread rounding to a non-high target, because w(*Rolo) > w(Spread(+rd))

(13) **Step 2**: *Convergence*

[+] tobuk-ka	*RoLo 8	Spread(+rd) 6	Spread(+rd)$_P$ 4	Ident(rd) 1	$\mathcal{H}$
a. ☞ [+] tobuk-ka	–1	+1	+1		+2.0
b. [+] tobuk-ko	–2	+2	+1	–1	–1.0

- In (14), a non-high trigger has spread rounding to the non-high target (where before the high trigger had failed) because the combined weight of the specific and general constraints overcomes *Rolo

(14) **Step 1**

[+] son-tan	*RoLo 8	Spread(+rd) 6	Spread(+rd)$_P$ 4	Ident(rd) 1	$\mathcal{H}$
a. [+] son-tan	–1				–8.0
b. ☞ [+] son-ton	–2	+1	+1	–1	–7.0

Step 2: *Convergence*

- This is cumulative constraint interaction at work: a scaled-up reward for harmony is able to overcome the higher-weighted *Rolo, but an unscaled reward isn't.

4 Locality as a property of triggers

- The same theoretical machinery that produces segmental triggering asymmetries can be exploited to capture a preference for locality.

4.1 Privileging local triggers
4.2 Distance effects
4.3 Not-so-strict locality

4.1 Privileging local triggers

(15) **Scaling for non-locality**

- Spread(F)$_L$: For a feature F, assign +1 for each segment linked to F by a local trigger.

- Yoruba exhibits a right-to-left system of [–atr] dominant harmony among non-high vowels (Archangeli and Pulleyblank, 1994).

(16) **Yoruba ATR Harmony: Non-high Vowels**

	[+atr]			[–atr]
a.	ebe	'heap for yams'	e.	ɛsɛ	'foot'
b.	ole	'thief'	f.	ɔbɛ	'soup'
c.	epo	'oil'	g.	ɛpa	'groundnut'
d.	owo	'money'	h.	ɔja	'market'

- High vowel do not undergo harmony; this can be attributed to a high-ranked feature co-occurrence constraint prohibiting [–atr] high vowels.

- Two dialects of Yoruba differ with respect to the treatment of these non-undergoers in harmony — high [i] and [u] are transparent in Ifẹ Yoruba, but opaque in Ọyọ Yoruba (Pulleyblank, 1996; Orie, 2001, 2003).

(17) **Transparency and opacity in Yoruba**

	Ifẹ	**Ọyọ**	
a.	ɛúrɛ́	eúrɛ́	'goat'
b.	ɛ̀lùbɔ́	èlùbɔ́	'yam flour'
c.	ɔ̀títɔ́	òtítɔ́	'truth'
d.	ɔdí̱dɛ	odídɛ	'parrot'

- All else being equal, the choice between transparency and opacity is determined by the relative weights of the SPREAD(F) constraints and IDENT(F).

(18) a. *Weighting conditions for transparency*
$w(\text{SPREAD(F)}) > w(\text{IDENT(F)})$

b. *Weighting conditions for opacity*
$w(\text{SPREAD(F)}_{\text{L}}) + w(\text{SPREAD(F)}) > w(\text{IDENT(F)}) > w(\text{SPREAD(F)})$

- Transparency in Ifẹ is demonstrated in (19).

(19) **Step 1**

[–] odidɛ	*(+HI,–ATR) 8	SPREAD(–ATR) 3	SPREAD(–ATR)$_{\text{L}}$ 3	IDENT(ATR) 1	$\mathcal{H}$
a. [–] odidɛ					0.0
b. [–] odídɛ	–1	+1	+1	–1	–3.0
c. ☞ [–] ɔdidɛ		+1		–1	+2.0

Step 2: *Convergence*

[–] ɔdidɛ	*(+HI,–ATR) 8	SPREAD(–ATR) 3	SPREAD(–ATR)$_L$ 3	IDENT(ATR) 1	$\mathcal{H}$
a. ☞ [–] ɔdidɛ		+1			+3.0
b. [–] odidɛ				–1	–1.0
c. [–] ɔdɪdɛ	–1	+1		–1	–3.0

- Opacity in Ọyọ is demonstrated in (20). The candidates and violation/reward profiles are identical to those at the first step in (19); the difference is the increased weight of faithfulness.

(20) **Step 1**: *Convergence*

[–] odidɛ	*(+HI,–ATR) 8	SPREAD(–ATR) 3	SPREAD(–ATR)$_L$ 3	IDENT(ATR) 4	$\mathcal{H}$
a. ☞ [–] odidɛ					0.0
b. [–] odɪdɛ	–1	+1	+1	–1	–3.0
c. [–] ɔdidɛ		+1		–1	–1.0

- Local harmony *is* able to succeed — this can be seen in the tableau in (21), where all vowels are non-high and local harmony does not run afoul of feature co-occurrence.

(21) **Step 1**

[–] obɛ	*(+HI,–ATR) 8	SPREAD(–ATR) 3	SPREAD(–ATR)$_L$ 3	IDENT(ATR) 4	$\mathcal{H}$
a. [–] obɛ					0.0
b. ☞ [–] ɔbɛ		+1	+1	–1	2.0

Step 2: *Convergence*

- The harmony systems of Ifẹ and Ọyọ Yoruba differ with respect to their treatment of non-participating segments; the present analysis treats this as a difference in the relative weights of the harmony-driving constraint and faithfulness.
  - In Ifẹ, harmony outweighs faithfulness to such an extent that even diminished rewards for non-local spreading will win.
  - In Ọyọ the weights are close enough that the penalty for non-locality is sufficient to prevent harmony.

4.2 Distance effects

- The additional constraint for locality defined in (15) makes a binary distinction between local and non-local — but harmony is sensitive to the *degree* of non-locality.
- Hungarian: harmony along the front/back dimension (Hayes and Londe, 2006; Kiparsky, 1981; Kontra and Ringen, 1986; Kornai, 1991; Vago, 1976, and others).
  - Front unrounded [i] and [e:] are unpaired in the inventory, and do not undergo in harmony (attributable to a feature co-occurrence constraint against back unrounded vowels).
  - Non-participating vowels differ with respect to their treatment, but [i] is consistently treated as transparent (22b).
  - When a word contains a sequence of more than one [i], that sequence is optionally opaque (22c).

(22) **Distance Sensitivity in Hungarian**

a. Suffix vowels agree with back/front stems

hɔd	hɔd-nɔk	‘army(-DAT)’
kuːt	kuːt-nɔk	‘well(-DAT)’
tœk	tœk-nɛk	‘pumpkin(-DAT)’
fyst	fyst-nɛk	‘smoke(-DAT)’

b. High front [i,i:] is transparent

gumi	gumi-nɔk	‘rubber(-DAT)’
pɔpiːr	pɔpiːr-nɔk	‘paper(-DAT)’

c. Multiple neutral vowels can be variably opaque

ɔspirin ɔspirin-nɔk ∼ ɔspirin-nɛk ‘aspirin(-DAT)’

- SPREAD(F)$_{L1}$: For a feature F, assign +1 for each segment linked to F by a trigger that is at most 1 unit of distance away.
  - For now, the syllable will count as the relevant unit of distance.
- SPREAD(F)$_{L}$, SPREAD(F)$_{L1}$, and SPREAD(F) represent increasing degrees of generality, forming a stringent implicational hierarchy.

- The weighting conditions under which one non-participating vowel behaves as transparent, but a sequence of two (or more) behaves as opaque, are given in (23) below; to save space, each constraint weight represents that constraint plus the weights of its more general counterparts.

(23) a. *Weighting conditions for distance sensitivity*
$w(\text{Spread(F)}_{\text{L}}) > w(\text{Ident(F)}) > w(\text{Spread(F)}_{\text{L1}})$

- Distance sensitivity in Hungarian is modeled in the tableaux in (24) and (25). In (24), there is a single transparent vowel, and the derivation is much the same as the one in (19) above.

(24) **Step 1**

[+] gumi-nɛk	*(-rd,+bk) 8	Spr(+bk) 2	Spr(+bk)$_{\text{L1}}$ 2	Spr(+bk)$_{\text{L}}$ 2	Id(bk) 3	$\mathcal{H}$
a. [+] gumi-nɛk						0.0
b. [+] gumɯ-nɛk	-1	+1	+1	+1	–1	–5.0
c. ☞ [+] gumi-nɔk		+1	+1		–1	1.0

Step 2: *Convergence*

- In (25), on the other hand, a sequence of two non-participating vowels intervenes between the initial and suffix vowels.

(25) **Step 1**: *Convergence*

[+] ɔspirin-nɛk	*(-rd,+bk) 8	Spr(+bk) 2	Spr(+bk)$_{\text{L}}$ 2	Spr(+bk)$_{\text{L1}}$ 2	Id(bk) 3	$\mathcal{H}$
a. ☞ [+] ɔspirin-nɛk						0.0
b. [+] ɔspɯrin-nɛk	-1	+1	+1	+1	–1	–5.0
c. [+] ɔspirin-nɛk				+1	–1	–1.0

- Expanding the stringent family to handle non-locality as in (15) succeeds in capturing the effect of increasing distance in Hungarian — increasing degrees of distance are predicted to be less likely to be overcome.

5 Locality asymmetries

- Two sources of opacity: the failure of non-local harmony to overcome faithfulness (seen above) and the failure of non-local harmony to overcome local harmony initiated by the non-participating segment.[4]

- The choice between transparency and opacity represents a competition between potential harmony triggers — the segment bearing the dominant feature value on the one hand, and the local trigger on the other hand.
  - The likelihood of transparency increases when V_1 is a good trigger, while the likelihood of opacity increases when V_2 is a good trigger.

- Trigger Competition: in a V_1–V_2–V_3 sequence, where V_2 is a non-undergoer, V_1 and V_2 compete to determine the feature specifications of V_3

Transparency **Opacity**

- Locality asymmetries of the kind seen in Hungarian are an *emergent effect* of the independently motivated scaling factors discussed above.

  5.1 Opacity and dominance
  5.2 Quality/locality interactions

5.1 Opacity and dominance

- Segments which fail to undergo harmony are usually assumed to belong to the non-dominant feature class.
  - Where segments bearing the dominant feature are unable to undergo harmonic alternations, there is no conflict between locality and dominance.

- ATR harmony in Wolof is [–ATR]-dominant and root controlled (26).

(26) **Wolof ATR Harmony**

a.	reːr-oːn	‘wanted’
b.	reːr-e	‘be lost in’
c.	xɔːl-ɛ	‘look with’
d.	dɛm-ɛ	‘go with’
e.	doːr-e	‘hit with’
f.	rɛːr-ɔːn	‘had dinner’

[4] I assume that at least some features are equipollent, but it would be possible to make adjustments to accommodate privative features.

- High vowels, which have no [−ATR] counterparts in the inventory, do not undergo harmony, and are transparent (27).

(27) **Wolof Transparent [i,u]**

a. mɔytulɛːn	'avoid!'	(cf. [gʌstuleːn], 'do research!')
b. tɛːruwɔːn	'welcomed'	
c. tɛkkilɛːn	'untie!'	
d. xɔlliwɔːn	'peeled'	
e. yɛbbijina	'he went to unload'	
f. sɔppiwulɛːn	'you have not changed'	

- The short low vowel alternates, surfacing as [a] in [−ATR] contexts, but [ʌ] in [+ATR] contexts (28), and is a full participant in the harmony system.

(28) **Wolof Short [a/ʌ] Participation**

a. tɔːl-am	'his/her field'
b. sofoːr-ʌm	'his/her driver'
c. xɔːl-ante	'to look at each other'
d. doːr-ʌnte	'to hit each other'
e. wett-ʌli	'to give company to'
f. fɛcc-ali	'to fill completely'

The long low vowel [aː] does not undergo harmony, it always surfaces as [−ATR], and behaves as opaque (29).

(29) **Wolof Opaque [aː]**

a. genaːlɛ	'to go out also'
b. yobbuwaːlɛ	'to carry away also'
c. doːraːtɛ	'to hit usually'
d. jeːmʌntuwaːlɛːti	'to try also without conviction once more'

- The difference between [i,u] and [aː] is attributable to the fact that the transparent segments are non-dominant feature value, while the opaque segments are dominant.

(30) a. *Weighting conditions for feature dominance*
$w(\textsc{Spread}(\alpha\text{F})) > w(\textsc{Spread}(-\alpha\text{F}))$

b. *Weighting conditions for transparency (revised)*
$w(\textsc{Spread}(\alpha\text{F})) > w(\textsc{Ident}(\text{F})) + w(\textsc{Spread}(-\alpha\text{F}))$

- Transparency in Wolof is demonstrated in the tableau in (31).

(31) **Step 1**

[+] [−][+] doːraːte	(*ʌː) 14	Spr(−A) 6	Spr(−A)$_L$ 6	Spr(+A) 2	Spr(+A)$_L$ 2	Id(ATR) 1	$\mathcal{H}$
a. [−][+] [+] tɛːruwoːn							0.0
b. [−][+] [+] tɛːrʊwoːn	–1	+1	+1			–1	–3.0
c. ☞ [−][+] [+] tɛːruwɔːn		+1				–1	+5.0
d. [−][+] [+] tɛːruwoːn				+1	+1		+4.0

Step 2: *Convergence*

- The tableau in (32) shows what happens when low [aː] is the intervening non-participant; there is no conflict between locality and dominance.

(32) **Step 1**

[+] [−][+] doːraːte	M (*ʌː) 14	Spr(−A) 6	Spr(−A)$_L$ 6	Spr(+A) 2	Spr(+A)$_L$ 2	Id(ATR) 1	$\mathcal{H}$
a. [+] [−][+] doːraːte							0.0
b. [+] [−][+] doːrʌːte	–1			+1	+1	–1	–11.0
c. [+] [−][+] doːraːte				+1			+2.0
d. ☞ [+] [−][+] doːraːtɛ		+1	+1			–1	+11.0

Step 2: *Convergence*

5.2 Quality/locality interactions

- Hungarian [i,iː] is reliably transparent; examples are reproduced in (33).

(33) **High front [i,iː] is transparent**

a. gumi gumi-nɔk 'rubber(-DAT)' (*gumi-nɛk)
b. pɔpiːr pɔpiːr-nɔk 'paper(-DAT)' (*pɔpiːr-nɛk)

- Hayes and Londe (2006); Hayes et al. (2009) identify several zones of variation in Hungarian harmony; for example, while [i,i:] are consistently transparent, lower neutral vowels may optionally be opaque (34).

(34) **Hungarian Variable Opacity**

a.	ɔrzeːn	ɔrzeːn-nɔk ∼ ɔrzeːn-nɛk	‘arsenic(-DAT)’
b.	hotɛl	hotɛl-nɔk ∼ hotɛl-nɛk	‘hotel(-DAT)’
c.	honveːd	honveːd-nɔk ∼ honveːd-nɛk	‘Hungarian soldier-DAT’
d.	dʒungɛl	dʒungɛl-nɔk ∼ dʒungɛl-nɛk	‘jungle-DAT’

- In both corpus studies and wug tests, Hayes and Londe (2006); Hayes et al. (2009) found height asymmetries in the probability of transparency in back–neutral sequences.
  - The probability of transparency was highest (at ceiling) when the neutral vowel was [i,i:], lower when the neutral vowel was [e:], and lowest of all when the neutral vowel was [ɛ].
  - This asymmetry is consistent with what would be expected in cases of preferential triggering.

(35) *Weighting conditions for quality sensitivity*

$$w(\textsc{Spread}(\alpha\mathrm{F})_{\mathrm{L}}) > w(\textsc{Spread}(-\alpha\mathrm{F})_{\mathrm{P}}) > w(\textsc{Spread}(\alpha\mathrm{F})) > w(\textsc{Spread}(-\alpha\mathrm{F})$$

- Transparency, as demonstrated in (24), is shown in the tableau in (36) below.

(36) **Step 1**

[+] [−] [+] gumi-nɔk	*(-R,+B) 8	SPR(+B) 3	SPR(+B)$_{\mathrm{L}}$ 2	SPR(-B) 2	SPR(-B)$_{\mathrm{P}}$ 2	ID(B) 0	$\mathcal{H}$
a. [+] [−] [+] gumi-nɔk							0.0
b. [+] [−] [+] gumɯ-nɔk	-1	+1	+1			–1	–2.0
c. [+] [−] [+] gumi-nɛk				+1		–1	+2.0
d. ☞ [+] [−] [+] gumi-nɔk		+1				-1	+3.0

Step 2: *Convergence*

- The opaque example in the tableau in (37) differs from that in (36) in that its medial non-undergoing vowel is [ɛ], a preferred trigger, rather than [i].

(37) **Step 1**

[+] [−] [+] dʒungɛl-nɔk	*(-R,+B) 8	SPR(+B) 3	SPR(+B)$_L$ 2	SPR(-B) 2	SPR(-B)$_P$ 2	ID(B) 0	ℋ
a. [+] [−] [+] dʒungɛl-nɔk							0.0
b. [+] [−] [+] dʒungɔl-nɔk	-1	+1	+1			-1	–2.0
c. ☞ [+] [−] [+] dʒungɛl-nɛk				+1	+1	-1	+4.0
d. [+] [−] [+] dʒungɛl-nɔk		+1					+3.0

Step 2: *Convergence*

- The weighting conditions required to produce transparency of [i] and opacity of [ɛ] are consistent, meaning that the two outcomes can co-exist in the same language, as indeed they do in Hungarian.
  - All things being equal, the choice between transparency and opacity will come down in favour of transparency in Hungarian.
  - When the local trigger is also a preferred trigger for featural reasons, the strength of the preferred trigger tips the scales in favour of the opaque outcome.
- The competing triggers approach predicts that the status of the dominant trigger should also influence the outcome.
  - Kimper and Ylitalo (In press) present results of a nonce-word study on disharmonic Finnish loanwords showing that this is the case.
    - In Finnish disharmonic loanwords, otherwise-undergoing vowels are optionally transparent (Campbell, 1980; Ringen and Heinämäki, 1999).
    - In a nonce-word task, subjects were more likely to choose transparency if the dominant trigger was non-high (a preferred trigger) than if it was high.
  - Alternative explanations of the kind of segmental asymmetries in intervenors seen in Hungarian (Kaun, 1995; Nevins, 2004; Benus and Gafos, 2007) fail to account for the influence of the non-local trigger.

6 Conclusion

- The proposal In this talk unifies two seemingly distinct restrictions on harmony — a preference for particular segmental triggers, and a preference for locality.
  - Both can be accomplished with a single theoretical mechanism: families of stringent constraints which serve to increase or diminish the reward for harmony.

  - In a weighted-constraint framework like SHG, where constraints can interact cumulatively, such increases or decreases in reward can affect the success or failure of harmony.

- Segmental asymmetries in transparency and opacity emerge straightforwardly from the interaction of these two preferences.
  - The choice between transparent and opaque harmony can be understood as a competition between potential harmony triggers — one which bears the dominant feature but is non-local, and one which is local but non-dominant.
  - If one of these competitors is inherently a better trigger, this can be sufficient to affect the outcome, resulting in transparency generally but blocking just in case the intervenor is a segmentally privileged trigger.

- Capturing this asymmetry in transparency and opacity requires no dedicated theoretical device; mechanisms for expressing segmental trigger preferences, locality restrictions, and feature dominance are all independently necessary, and nothing beyond their interaction is needed to model the attested patterns.

References

Archangeli, Diana, and Douglas Pulleyblank. 1994. *Grounded phonology*. MIT Press.

Benus, Stefan, and Adamantios I. Gafos. 2007. Articulatory characteristics of Hungarian transparent vowels. *Journal of Phonetics* 35.

Campbell, Lyle. 1980. The psychological and sociological reality of Finnish vowel harmony. In *Issues in vowel harmony*, ed. Robert M. Vago, 245–269. John Benjamins.

Gallagher, Gillian. 2010. The perceptual basis of long-distance laryngeal restrictions. Doctoral Dissertation, MIT.

Hayes, Bruce, and Zsuzsa Cziráky Londe. 2006. Stochastic phonological knowledge: The case of Hungarian vowel harmony. *Phonology* 23:59–104.

Hayes, Bruce, Kie Zuraw, Péter Siptár, and Zsuzsa Cziráky Londe. 2009. Natural and unnatural constraints in Hungarian. *Language* 85:822–863.

Jurgec, Peter. 2011. Feature spreading 2.0: A unified theory of assimilation. Doctoral Dissertation, University of Tromsø.

Kaun, Abigail. 1995. The typology of rounding harmony: An Optimality Theoretic approach. Doctoral Dissertation, University of California, Los Angeles.

Kimper, Wendell. 2011. Parasitic harmony: A perceptual explanation. Paper presented at the Annual Meeting of the Linguistics Society of America, January 2011.

Kimper, Wendell. 2012. Non-locality and perceptual grounding in vowel harmony. Paper presented at the Annual Meeting of the Linguistics Society of America, January 2012.

Kimper, Wendell. to appear. Positive constraints and finite goodness in Harmonic Serialism. In *Harmonic serialism and harmonic grammar*, ed. John McCarthy and Joe Pater. Equinox Press.

Kimper, Wendell, and Riikka Ylitalo. In press. Variability and trigger competition in Finnish disharmonic loanwords. To be presented at WCCFL 30.

Kiparsky, Paul. 1981. Vowel harmony. MIT.

Kontra, Miklós, and Catherine Ringen. 1986. Hungarian vowel harmony: The evidence from loanwords. *Ural-Altaische Jahrbucher* 58:1–14.

Kornai, András. 1991. Hungarian vowel harmony. In *Approaches to Hungarian III*, ed. István Kenesei, 183–240.

Krueger, John. 1962. *Yakut manual*. Indiana University Press.

Linker, Wendy. 1982. Articulatory and acoustic correlates of labial activity in vowels: A cross-linguistic study. Doctoral Dissertation, UCLA.

McCarthy, John. 2000. Harmonic Serialism and parallelism. In *Proceedings of NELS 30*, ed. Masako Hirotani, 501–24. Amherst, MA: GLSA Publications.

McCarthy, John. 2007a. *Hidden generalizations: Phonological opacity in optimality theory*. London: Equinox Publishing.

McCarthy, John. 2007b. Restraint of analysis. In *Freedom of analysis*, ed. Sylvia Blaho, Patrick Bye, and Martin Krämer, 203–31. Berlin and New York: Mouton de Gruyter.

McCarthy, John. 2010. Studying Gen. *Journal of the Phonetic Society of Japan* .

Nevins, Andrew. 2004. Conditions on (dis)harmony. Doctoral Dissertation, Massachusetts Institute of Technology.

Orie, Ọlanike Ọla. 2001. An alignment-based account of vowel harmony in Ifẹ yoruba. *Journal of African Languages and Linguistics* 22:117–143.

Orie, Ọlanike Ọla. 2003. Two harmony theories and high vowel variability in two Benue-Congo languages. *The Linguistic Review* 20:1–35.

Pater, Joe. 2009. Weighted constraints in generative linguistics. *Cognitive Science* 33:999–1035.

Pater, Joe. 2012. Serial harmonic grammar and berber syllabification. In *Prosody matters: Essays in honor of Elisabeth O. Selkirk*, ed. Toni Borowsky, Shigeto Kawahara, Takahito Shinya, and Mariko Sugahara. London: Equinox Press.

Pater, Joe. to appear. Universal grammar with weighted constraints. In *Harmonic grammar and harmonic serialism*. Equinox Press.

Pearce, Mary. 2008. Vowel harmony domains and vowel undershoot. In *Ucl working papers in linguistics*, volume 20. Research Department of Linguistics, University College London.

Prince, Alan. 2004. Anything goes. In *A new century of phonology and phonological theory*, ed. Takeru Honma, Masao Okazuke, Toshiyuiki Tabata, and Shin ichi Tanaka, 66–90. Kaitakusha.

Prince, Alan. 2007. The pursuit of theory. In *Cambridge handbook of phonology*, ed. Paul de Lacy. Cambridge University Press.

Prince, Alan, and Paul Smolensky. 1993/2004. *Optimality theory: Constraint interaction in generative phonology*. Blackwell.

Pulleyblank, Douglas. 1996. Neutral vowels in Optimality Theory: A comparison of Yoruba and Wolof. *Canadian Journal of Linguistics* 41:295–347.

Ringen, Catherine, and Heinämäki. 1999. Variation in Finnish vowel harmony. *Natural Language and Linguistc Theory* 17:303–337.

Smolensky, Paul. 2006. *Optimality in phonology II: Harmonic completeness, local constraint conjunction, and feature domain markedness*, volume 2, chapter 14, 27–160. The MIT Press.

Smolensky, Paul, and Géraldine Legendre. 2006. *The harmonic mind*. MIT Press.

Suomi, Kari. 1983. Palatal harmony: A perceptually motivated phenomenon? *Nordic Journal of Linguistics* 6:1–35.

Terbeek, Dale. 1977. A cross-language multi-dimensional scaling study of vowel perception. Doctoral Dissertation, UCLA.

Vago, R. M. 1976. Theoretical implications of Hungarian vowel harmony. *Linguistic Inquiry* 7:243–263.

Wilson, Colin. 2004. Analyzing unbounded spreading with constraints: marks, targets, and derivations. UCLA.

Wilson, Colin. 2006. Unbounded spreading is myopic. Bloomington, IN: PhonologyFest 2006.

Woock, Edith Bavin, and Michael Noonan. 1979. Vowel harmony in Lango. In *Papers from the 15th Annual Regional Meeting of the Chicago Linguistic Society*, ed. Paul R. Clyne, William F. Hanks, and Carol L. Hofbaur.