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

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>murun-\textsuperscript{u}</td>
</tr>
<tr>
<td>b.</td>
<td>tunnu:rg-\textsuperscript{u}</td>
</tr>
<tr>
<td>c.</td>
<td>tunnuk-\textsuperscript{ter}</td>
</tr>
<tr>
<td>d.</td>
<td>tobuk-\textsuperscript{ka}</td>
</tr>
<tr>
<td>e.</td>
<td>oyo-\textsuperscript{n}u</td>
</tr>
<tr>
<td>f.</td>
<td>borro-\textsuperscript{nu}</td>
</tr>
<tr>
<td>g.</td>
<td>oho\textsuperscript{e}x-\textsuperscript{ter}</td>
</tr>
<tr>
<td>h.</td>
<td>son-\textsuperscript{ton}</td>
</tr>
</tbody>
</table>

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 [e:] and [e] exhibit variable behaviour (2c–f).

(2) Transparency and Opacity in Hungarian

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>gumi</td>
</tr>
<tr>
<td>b.</td>
<td>p\textsuperscript{o}pi\textsuperscript{r}</td>
</tr>
<tr>
<td>c.</td>
<td>\textsuperscript{\v{r}}\v{c}\v{z}en</td>
</tr>
<tr>
<td>d.</td>
<td>hotel</td>
</tr>
<tr>
<td>e.</td>
<td>hon\textsubscript{v}ved</td>
</tr>
<tr>
<td>f.</td>
<td>d\textsuperscript{\v{z}}\textsuperscript{u}ng\textsuperscript{e}\textsuperscript{l}</td>
</tr>
</tbody>
</table>
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 $V_3$

  \[
  \begin{array}{c}
  \text{Transparency} \\
  \begin{array}{c}
  (+) \\
  V_1 \\
  \end{array} \\
  \begin{array}{c}
  (-) \\
  V_2 \\
  \end{array} \\
  \begin{array}{c}
  V_3 \\
  \end{array}
  \end{array}
  \]

  \[
  \begin{array}{c}
  \text{Opacity} \\
  \begin{array}{c}
  (+) \\
  V_1 \\
  \end{array} \\
  \begin{array}{c}
  (-) \\
  V_2 \\
  \end{array} \\
  \begin{array}{c}
  V_3 \\
  \end{array}
  \end{array}
  \]

- 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.
  - $H(A) = \sum_{i=1}^{n} w(C_i) \times C_i(A)$
  - 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).

¹What 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 ±F₁ and a segment S, create an autosegmental association between F₁ and S. If S is associated with another instance ±F₂, the link between S and ±F₂ is dissolved.

a. **Autosegmental Linking:**

```
+F
S₁ S₂ → S₁ S₂
```

b. **Autosegmental Linking (with de-linking)**

```
+F –F
S₁ S₂ → S₁ S₂
cf. +F –F
S₁ S₂
```

(5) **Step 1**

<table>
<thead>
<tr>
<th></th>
<th><strong>Spread(+atr)</strong></th>
<th><strong>Ident(ari)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>[+] dig-a</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>a. [+] dig-a</td>
<td>W</td>
<td>L</td>
</tr>
<tr>
<td>b. [+] dig-a</td>
<td>+1</td>
<td>-1</td>
</tr>
</tbody>
</table>

**Step 2: Convergence**

²I 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 \textsc{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. murun-u ‘nose–ACC’
b. tunnuuŋ-u ‘window–ACC’
c. tubuŋ-u ‘knee–ACC’
d. tunnu:k-te ‘window–PL’
e. tubu:k-k ‘knee–DAT’

(7) Yakut Rounding Harmony: Non-High Triggers

a. oyo-nu ‘child–ACC’
b. oχ-n ‘arrow–ACC’
c. boro:-nu ‘wolf–ACC’
d. ohox-tor ‘stoves–PL’
e. stolen ‘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 asymmetries can be expressed formally if the harmony constraint is scalar, with higher rewards for better triggers.

3.1 What makes a good trigger?

3.2 Scaling

3.3 Privileging impoverished 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 ±F_1 and a segment S, create an autosegmental association between F_1 and S. If S is associated with another instance ±F_j, the link between S and ±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

\[
\begin{array}{c}
\uparrow \quad F \\
S_1 \\ S_2 \\ S_3 \\
\rightarrow \\
S_1 \\ S_2 \\ S_3
\end{array}
\]

b. Trigger = S_2, Target = S_3

\[
\begin{array}{c}
\uparrow \quad F \\
S_1 \\ S_2 \\ S_3 \\
\rightarrow \\
S_1 \\ S_2 \\ S_3
\end{array}
\]

(10) Scaling for segmental triggers

- **\text{Spread}(F)\_P**: For feature F, assign +1 for each segment linked to F by a preferred trigger.

- **\text{Spread}(F)\_P** and **\text{Spread}(F)** are in a specific-to-general relationship; each reward on **\text{Spread}(F)\_P** will also earn a reward on **\text{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**

<table>
<thead>
<tr>
<th></th>
<th>*RoLo</th>
<th>Spread(+rd)</th>
<th>Spread(+rd)p</th>
<th>Ident(rd)</th>
<th>( \mathcal{H} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>[+] tobūg-\text{\textit{u}}</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>b.</td>
<td>[+] tobūg-\text{\textit{u}}</td>
<td>-1</td>
<td>+1</td>
<td>+1</td>
<td>-1</td>
</tr>
</tbody>
</table>

**Step 2**

<table>
<thead>
<tr>
<th></th>
<th>*RoLo</th>
<th>Spread(+rd)</th>
<th>Spread(+rd)p</th>
<th>Ident(rd)</th>
<th>( \mathcal{H} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>[+] tobūg-\text{\textit{u}}</td>
<td>-1</td>
<td>+1</td>
<td>+1</td>
<td>-1</td>
</tr>
<tr>
<td>b.</td>
<td>[+] tobūg-\text{\textit{u}}</td>
<td>-1</td>
<td>+2</td>
<td>+1</td>
<td>-1</td>
</tr>
</tbody>
</table>

**Step 3: Convergence**

• In (13), a high trigger has failed to spread rounding to a non-high target, because \( w(*\text{RoLO}) > w(\text{Spread}(+rd)) \)

(13) **Step 2: Convergence**

<table>
<thead>
<tr>
<th></th>
<th>*RoLo</th>
<th>Spread(+rd)</th>
<th>Spread(+rd)p</th>
<th>Ident(rd)</th>
<th>( \mathcal{H} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>[+] tobūk-\text{\textit{ka}}</td>
<td>-1</td>
<td>+1</td>
<td>+1</td>
<td>-1</td>
</tr>
<tr>
<td>b.</td>
<td>[+] tobūk-\text{\textit{ko}}</td>
<td>-2</td>
<td>+2</td>
<td>+1</td>
<td>-1</td>
</tr>
</tbody>
</table>

• 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
Step 1

<table>
<thead>
<tr>
<th>[+]</th>
<th>*RoLo</th>
<th>Spread(+rd)</th>
<th>Spread(+rd)p</th>
<th>Ident(rd)</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>son-tan</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

a. [+] son-tan | -1

b. [+] son-ton | -2  | +1 | +1 | -1 | -8.0  

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

<table>
<thead>
<tr>
<th>[+ATR]</th>
<th>[−ATR]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ebe</td>
<td>‘heap for yams’  e. ṝẹẹ</td>
</tr>
<tr>
<td>b. ole</td>
<td>‘thief’  f. ṙẹẹ</td>
</tr>
<tr>
<td>c. epo</td>
<td>‘oil’  g. ṝẹpa</td>
</tr>
<tr>
<td>d. owo</td>
<td>‘money’  h. ṙọja</td>
</tr>
</tbody>
</table>

- High vowel do not undergo harmony; this can be attributed to a high-ranked feature cooccurrence 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 Ife Yoruba, but opaque in Oyo Yoruba (Pulleyblank, 1996; Orie, 2001, 2003).

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

<table>
<thead>
<tr>
<th>Ife</th>
<th>Oyo</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ẹúrè ẹúrè ‘goat’</td>
<td></td>
</tr>
<tr>
<td>b. ẹłùbó ẹłùbó ‘yam flour’</td>
<td></td>
</tr>
<tr>
<td>c. ọtító ọtító ‘truth’</td>
<td></td>
</tr>
<tr>
<td>d. ọdídc ọdídc ‘parrot’</td>
<td></td>
</tr>
</tbody>
</table>

• 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*

\[ w(\text{Spread}(F)_L) + w(\text{Spread}(F)) > w(\text{Ident}(F)) > w(\text{Spread}(F)) \]

• Transparency in Ife is demonstrated in (19).

(19) **Step 1**

<table>
<thead>
<tr>
<th>[-]</th>
<th><em>(+HI,–ATR)</em></th>
<th><strong>Spread</strong>(–ATR)</th>
<th><strong>Spread</strong>(–ATR)_L</th>
<th><strong>Ident</strong>(ATR)</th>
<th>( \mathcal{H} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>odídè</td>
<td>8</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>b.</td>
<td>–1</td>
<td>+1</td>
<td>+1</td>
<td>–1</td>
<td>–3.0</td>
</tr>
<tr>
<td>c.</td>
<td>+1</td>
<td>–1</td>
<td>–1</td>
<td>+2.0</td>
<td></td>
</tr>
</tbody>
</table>

Cumulative constraint interaction and trigger competition in vowel harmony
Step 2: Convergence

<table>
<thead>
<tr>
<th>[-] ob</th>
<th>E</th>
<th>*(+H,–ATR) 8</th>
<th>SPREAD(–ATR) 3</th>
<th>SPREAD(–ATR)_L 3</th>
<th>IDENT(ATE) 1</th>
<th>( \mathcal{H} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ( \varepsilon ) [-] ob</td>
<td>E</td>
<td>0.0</td>
<td>+1</td>
<td>-1</td>
<td>-1.0</td>
<td>+3.0</td>
</tr>
<tr>
<td>b. ( \varepsilon ) [-] ob</td>
<td>E</td>
<td>-1</td>
<td>+1</td>
<td>+1</td>
<td>-1.0</td>
<td>-3.0</td>
</tr>
<tr>
<td>c. ( \varepsilon ) [-] ob</td>
<td>E</td>
<td>-1</td>
<td>+1</td>
<td>-1</td>
<td>-1.0</td>
<td>-3.0</td>
</tr>
</tbody>
</table>

- Opacity in Oyo 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

<table>
<thead>
<tr>
<th>[-] ob</th>
<th>E</th>
<th>*(+H,–ATR) 8</th>
<th>SPREAD(–ATR) 3</th>
<th>SPREAD(–ATR)_L 3</th>
<th>IDENT(ATE) 4</th>
<th>( \mathcal{H} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ( \varepsilon ) [-] ob</td>
<td>E</td>
<td>0.0</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>-3.0</td>
</tr>
<tr>
<td>b. ( \varepsilon ) [-] ob</td>
<td>E</td>
<td>-1</td>
<td>+1</td>
<td>+1</td>
<td>-1.0</td>
<td>-3.0</td>
</tr>
</tbody>
</table>

- 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

<table>
<thead>
<tr>
<th>[-] ob</th>
<th>E</th>
<th>*(+H,–ATR) 8</th>
<th>SPREAD(–ATR) 3</th>
<th>SPREAD(–ATR)_L 3</th>
<th>IDENT(ATE) 4</th>
<th>( \mathcal{H} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ( \varepsilon ) [-] ob</td>
<td>E</td>
<td>0.0</td>
<td>+1</td>
<td>+1</td>
<td>-1</td>
<td>0.0</td>
</tr>
<tr>
<td>b. ( \varepsilon ) [-] ob</td>
<td>E</td>
<td>+1</td>
<td>+1</td>
<td>-1</td>
<td>2.0</td>
<td></td>
</tr>
</tbody>
</table>

Step 2: Convergence
The harmony systems of Ife and Qyo 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 Ife, harmony outweighs faithfulness to such an extent that even diminished rewards for non-local spreading will win.
- In Qyo 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.

  - 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
   
   hød hød-nök ‘army(-DAT)’
   
   kuxt kuxt-nök ‘well(-DAT)’
   
   tœk tœk-nëk ‘pumpkin(-DAT)’
   
   fyst fyst-nëk ‘smoke(-DAT)’

b. High front [i,i:] is transparent
   
   gumi gumi-nök ‘rubber(-DAT)’
   
   popi:r popi:r-nök ‘paper(-DAT)’

c. Multiple neutral vowels can be variably opaque
   
   ɔspīrin ɔspīrin-nök ∼ ɔspīrin-nëk ‘aspirin(-DAT)’

- Spread(F)\textsubscript{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)\textsubscript{L}, Spread(F)\textsubscript{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**

\[ w(\text{Spread}(F)_L) > w(\text{Ident}(F)) > w(\text{Spread}(F)_{L1}) \]

• 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**

\[
\begin{array}{|c|c|c|c|c|c|c|}
\hline
& [+] \text{gumi-nek} & *(\text{-RD,+BK}) & \text{SPR}(\text{+BK})_L & \text{SPR}(\text{+BK})_{L1} & \text{SPR}(\text{+BK})_L & \text{ID(BK)} \\hline
\text{a. } [+] \text{gumi-nek} & & & & & & \\
\text{b. } [+] \text{gumun-nek} & -1 & +1 & +1 & +1 & -1 & -5.0 \\
\text{c. } [+] \text{gumi-nok} & +1 & +1 & & & -1 & 1.0 \\
\hline
\end{array}
\]

**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**

\[
\begin{array}{|c|c|c|c|c|c|c|}
\hline
& [+] \text{ospirin-nek} & *(\text{-RD,+BK}) & \text{SPR}(\text{+BK})_L & \text{SPR}(\text{+BK})_{L1} & \text{SPR}(\text{+BK})_L & \text{ID(BK)} \\hline
\text{a. } [+] \text{ospirin-nek} & & & & & & \\
\text{b. } [+] \text{ospuřin-nek} & -1 & +1 & +1 & +1 & -1 & -5.0 \\
\text{c. } [+] \text{ospirin-nek} & +1 & & & -1 & -1 & -1.0 \\
\hline
\end{array}
\]

• 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.  

- 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 \(V_3\)

\[
\begin{array}{ccc}
\text{Transparency} & \text{Opacity} \\
\begin{array}{c}
[+][-] \\
V_1 V_2 V_3
\end{array} & \begin{array}{c}
[+][-] \\
V_1 V_2 V_3
\end{array}
\end{array}
\]

- 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 \([-\text{ATR}]\)-dominant and root controlled (26).

(26) Wolof ATR Harmony

a. re:r-om  ‘wanted’
b. re:r-e    ‘be lost in’
c. xɔl-e    ‘look with’
d. dɛm-e    ‘go with’
e. dor-e    ‘hit with’
f. re:r-ɔm  ‘had dinner’

4I 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 \([-\text{ATR}]\) counterparts in the inventory, do not undergo harmony, and are transparent (27).

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

a. \(\text{moytule}:n\) ‘avoid!’ (cf. \(\text{gastule}:n\), ‘do research!’)
b. \(\text{te:ruwok}:n\) ‘welcomed’
c. \(\text{tekkile}:n\) ‘untie!’
d. \(\text{xolliwom}:n\) ‘peeled’
e. \(\text{yebbijina}\) ‘he went to unload’
f. \(\text{soppiwule}:n\) ‘you have not changed’

• The short low vowel alternates, surfacing as \([a]\) in \([-\text{ATR}]\) contexts, but \([\lambda]\) in \([+\text{ATR}]\) contexts (28), and is a full participant in the harmony system.

(28) **Wolof Short \([a/\lambda]\) Participation**

a. \(\text{to:lam}\) ‘his/her field’
b. \(\text{sofo:rim}\) ‘his/her driver’
c. \(\text{xol-am}\) ‘to look at each other’
d. \(\text{dor-an}\) ‘to hit each other’
e. \(\text{wett-ali}\) ‘to give company to’
f. \(\text{fccc-ali}\) ‘to fill completely’

The long low vowel \([a:]\) does not undergo harmony, it always surfaces as \([-\text{ATR}]\), and behaves as opaque (29).

(29) **Wolof Opaque \([a:]\)**

a. \(\text{genale}\) ‘to go out also’
b. \(\text{yobbuwale}\) ‘to carry away also’
c. \(\text{dorrar}\) ‘to hit usually’
d. \(\text{jemantuwa:le:ti}\) ‘to try also without conviction once more’

• The difference between \([i,u]\) and \([a:]\) 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**

\[ w(\text{SPREAD}(\alpha F)) > w(\text{SPREAD}(-\alpha F)) \]

b. **Weighting conditions for transparency (revised)**

\[ w(\text{SPREAD}(\alpha F)) > w(\text{IDENT}(F)) + w(\text{SPREAD}(-\alpha F)) \]

• Transparency in Wolof is demonstrated in the tableau in (31).
### Step 1

<table>
<thead>
<tr>
<th>do:ra:te</th>
<th>(*M:</th>
<th>SPR(−A)</th>
<th>SPR(−A)L</th>
<th>SPR(+A)</th>
<th>SPR(+A)L</th>
<th>ID(ATR)</th>
<th>$\mathcal{H}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>+1</td>
<td>+1</td>
<td>−1</td>
<td>+1</td>
<td>−1</td>
<td></td>
<td>−3.0</td>
</tr>
<tr>
<td>b.</td>
<td>+1</td>
<td>+1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+5.0</td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+4.0</td>
</tr>
</tbody>
</table>

### Step 2: Convergence

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

### Step 2

#### Convergence

#### 5.2 Quality/locality interactions

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

---

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

- a. gumi gumi-nök ‘rubber(-DAT)’ (**gumi-nęk**)
- b. popiir popiir-nök ‘paper(-DAT)’ (**popiir-nęk**)

---

Cumulative constraint interaction and trigger competition in vowel harmony
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. őszen őszen-nôk  ~ őszen-nêk ‘arsenic(DAT)’
b. hotel hotel-nôk  ~  hotel-nêk ‘hotel(DAT)’
c. honved honved-nôk  ~  honved-nêk ‘Hungarian soldier-DAT’
d. dzungel dzungel-nôk  ~  dzungel-nêk ‘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 [e].
  − This asymmetry is consistent with what would be expected in cases of preferential triggering.

(35) **Weighting conditions for quality sensitivity**

\[ w(\text{SPREAD}(\alpha F)_{\text{L}}) > w(\text{SPREAD}(-\alpha F)_{\text{P}}) > w(\text{SPREAD}(\alpha F)) > w(\text{SPREAD}(-\alpha F)) \]

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

(36) **Step 1**

<table>
<thead>
<tr>
<th>[+][-][+] gumi-nôk</th>
<th>*(-R,+B)</th>
<th>SPR(+B)</th>
<th>SPR(+B)L</th>
<th>SPR(-B)</th>
<th>SPR(-B)P</th>
<th>ID(B)</th>
<th>( \mathcal{H} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [+][-][+] gumi-nôk</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>b. [+][-][+] gumi-nôk</td>
<td>-1</td>
<td>+1</td>
<td>+1</td>
<td></td>
<td></td>
<td>-1</td>
<td>-2.0</td>
</tr>
<tr>
<td>c. [+][-][+] gumi-nêk</td>
<td></td>
<td></td>
<td>+1</td>
<td></td>
<td></td>
<td>-1</td>
<td>+2.0</td>
</tr>
<tr>
<td>d. [+][-][+] gumi-nôk</td>
<td></td>
<td></td>
<td>+1</td>
<td></td>
<td></td>
<td>-1</td>
<td>+3.0</td>
</tr>
</tbody>
</table>

**Step 2: Convergence**

• The opaque example in the tableau in (37) differs from that in (36) in that its medial non-undergoing vowel is [e], a preferred trigger, rather than [i].
Step 1

\[
\begin{array}{|c|c|c|c|c|c|}
\hline
& 1 & 2 & 3 & 4 & 5 \\
\hline
\text{a. } [+] & 8 & 3 & 2 & 2 & 0 \\
\hline
\text{b. } [+] & -1 & +1 & +1 & -1 & -2 \\
\hline
\text{c. } [+] & +1 & +1 & +1 & -1 & +4 \\
\hline
\text{d. } [+] & +1 & +1 & +1 & +1 & +3 \\
\hline
\end{array}
\]

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 interveners 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


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