A Gestural Account of Neutral Segment Asymmetries in Harmony

Caitlin Smith

Department of Linguistics,
University of Southern California

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Overview

• Neutral segments: non-participants in harmony
  – Blockers: block the spread of a harmonizing feature
  – Transparent segments: do not block the spread of a harmonizing feature

• Typical analysis: feature co-occurrence restriction between harmonizing feature and some feature of intended target
Overview

- Prediction of previous accounts: sets of attested transparent and blocking segments are identical

- Transparent segments are a subset of attested neutral segments in rounding harmony and nasal (vowel-consonant) harmony

Proposal: a gestural representation of harmony

- Allows for use of two distinct mechanisms of neutrality in harmony
- Accounts for limited set of transparent segments
Neutral Segment Asymmetry in Nasal Harmony

<table>
<thead>
<tr>
<th>Blockers</th>
<th>Neutral Segments</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Obstruents</td>
<td>Kayan (Blust 1972)</td>
</tr>
<tr>
<td></td>
<td>Obstruents, liquids</td>
<td>Warao (Osborn 1966)</td>
</tr>
<tr>
<td></td>
<td>Obstruents, liquids, glides</td>
<td>Sundanese (Robins 1957)</td>
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<table>
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<th>Transparent Segments</th>
<th>Neutral Segments</th>
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<tbody>
<tr>
<td></td>
<td>Obstruents</td>
<td>Tuyuca (Barnes &amp; Takagi de Silzer 1976)</td>
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</table>

## Neutral Segment Asymmetry in Rounding Harmony

<table>
<thead>
<tr>
<th>Neutral Segments</th>
<th>Language</th>
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</thead>
<tbody>
<tr>
<td>Non-high vowels</td>
<td>Turkish (Clements &amp; Sezer 1982)</td>
</tr>
<tr>
<td>High Vowels</td>
<td>Ulcha (Kaun 1995 citing Sunik 1985)</td>
</tr>
<tr>
<td>High front vowels</td>
<td>Halh Mongolian (Svantesson et al. 2005)</td>
</tr>
</tbody>
</table>

**typological generalization:** Kaun (1995)
A Solution for the Neutrality Asymmetry

Proposal: a gesture-based analysis of harmony

• Transparency and blocking are results of two distinct mechanisms of neutrality

• Transparency-inducing mechanism available to a limited set of segments

• Blocking mechanism available to all neutral segments
The Gestural Harmony Model

- Gestures: task-based, spatiotemporal units of representation (Browman & Goldstein 1986, 1989)
- Gestural parameters:
  - Goal articulatory state (open velum, protruded lips)
  - Activation duration
  - Articulators
  - Strength (ability to command articulators)
The Gestural Harmony Model

Harmony is the result of overlap by a non-self-deactivating gesture with extended duration.
Nasal Harmony in Warao

Nasal harmony is triggered by a nasal consonant or vowel and blocked by liquids and obstruents (Osborn 1966):

**Full harmony**

a. [mõ̞̆jõ̞̆] ‘cormorant’

b. [inã̞̆wã̞̆hã̞̆] ‘summer’

**Blocking**

c. [õ̞̆ĩ̞̆hõ̞̆rŏ̞] ‘kind of tree’

d. [nã̞̆õ̞̆te] ‘he will come’
Nasal Harmony via Extended Velum Opening Gesture

Subscript: segment-to-gesture correspondence
Rounding Harmony in Halh (Khalkha) Mongolian

- Rounding harmony is triggered by mid round vowel; high front vowel /i/ is transparent (Svantesson et al. 2005):

**Full harmony**

a. [og-ʒo] ‘give (past)’

cf. [it-ʒe] ‘eat (past)’

**Transparent /i/**

b. [poor-ig-o] ‘kidney (acc. refl.)’

cf. [piir-ig-e] ‘brush (acc. refl.)’
Rounding Harmony via Extended Lip Protrusion Gesture

\[
\begin{bmatrix}
  o_1 & g & \emptyset & o_2 \\
\end{bmatrix}
\]

- Lip protrusion
- Tongue Body uvular-pharyngeal narrow
- Tongue Body uvular-pharyngeal narrow
Incompatible vs. Antagonistic Gestures

- Gestural antagonism: two concurrently active gestures make directly opposing demands of an articulator
- Gestural incompatibility: concurrent activation of two gestures is articulatory or perceptually difficult

Antagonistic gestures are incompatible, but incompatible gestures are not necessarily antagonistic.
A Solution for the Neutrality Asymmetry

Proposal: gestural antagonism and gestural incompatibility as distinct motivators of neutrality

• Transparency: result of concurrent activation of two antagonistic gestures

• Blocking: result of a ban on concurrent activation of two incompatible gestures
Coactivation Transparency

Transparency is the result of the concurrent activation of two antagonistic gestures.

- Antagonistic gestures: directly opposing goal articulatory states
- Transparency: harmonizing gesture and a gesture that it overlaps are antagonistic
Nasal Harmony Transparency in Tuyuca

Morphemes are either oral or nasal; obstruents are transparent (Barnes & Takagi de Silzer 1976):

Full harmony
a. [j̃ãmĩ] ‘night’
b. [wĩnõ] ‘wind’
c. [jõrẽ] ‘small hen’

Transparency
d. [mĩpĩ] ‘badger’
e. [wãtĩ] ‘demon’
f. [jõsõ] ‘bird’
Obstruent Transparency in Nasal Harmony

- Gestural representation of obstruents includes:
  - Oral constriction gesture
  - Glottal gesture (unless voiced)
  - Velum closure gesture

- Velum closure gesture: tight seal of velopharyngeal port necessary for obstruency

- Raising of velum reported during production of oral stops (Lubker 1968, Bell-Berti & Hirose 1975, Bell-Berti 1976)
Coactivation Transparency in Nasal Harmony

\[
\begin{bmatrix}
 m_1 \\
 \tilde{i}_2 \\
 \quad \\
 p_3 \\
 \tilde{i}_4
\end{bmatrix}
\]

- **Velum open**
- **Velum closure**
- **Tongue Body palatal narrow**
- **Lips closure**
- **Lips closure**

**Gestural score**
- \(S = \text{strong}\)
- \(W = \text{weak}\)

**Phonetic realization**
- nasal
- oral
- nasal

**Velum aperture**
High Front Vowel Transparency in Rounding Harmony

• Gestural representation of high front vowel includes:
  – Palatal constriction gesture
  – Lip spreading gesture

• Lip spreading gesture: raises F2, maximizing perceptual distance from back vowels

• Controlled lip spreading reported during production of /i/ (Hadding, Hirose, & Harris 1976; Sussman & Westbury 1981; Goldstein 1991)
Coactivation Transparency in Rounding Harmony

[ p o₁ r i₂ g o₃ ]

- Labial protrusion₁
- Labial spread₂
- Tongue Body uvular-pharyngeal narrow₁
- Tongue Body palatal narrow₂
- Tongue Body uvular-pharyngeal narrow₃

Gestural score

Lip protrusion

Phonetic realization

rounded | unrounded | rounded

S = strong
W = weak
Summary: Coactivation Transparency

• Correctly predicts which segments can be transparent within nasal harmony and rounding harmony

• Harmony is represented locally, resulting in gestural antagonism with transparent segments

• Derivational opacity is unnecessary (cf. Piggott 1992 and Walker 1998/2000 for nasal harmony)
Blocking as a Ban on Gestural Overlap

Blocking is the result of a ban on the concurrent activation of two incompatible gestures.

- Incompatible gestures: articulatorily or perceptually difficult
- Blocking: harmonizing gesture and a gesture that it overlaps are incompatible
Preventing Overlap with Gestural Inhibition

- Inhibition relation between gestures prevents their concurrent activation
- Representation of inhibition:

Inhibited Gesture • • • • Inhibiting Gesture

![Diagram showing activation and deactivation of gestures over time]
Nasal Harmony in Warao

Nasal harmony is triggered by a nasal consonant or vowel and blocked by liquids and obstruents (Osborn 1966):

<table>
<thead>
<tr>
<th>Full harmony</th>
<th>Blocking</th>
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<tr>
<td>a. [mõõ̱] ‘cormorant’</td>
<td>c. [õiõ̱õ̱] ‘kind of tree’</td>
</tr>
<tr>
<td>b. [inã̱wã̱ã̱] ‘summer’</td>
<td>d. [nãõ̱te] ‘he will come’</td>
</tr>
</tbody>
</table>
Gestural Inhibition in Nasal Harmony

[ n₁  ñ₂  ñ₃  t₄  e₅ ]

- **Velum open**₁
- **Tongue Tip alveolar closure**₁
- **Tongue Body pharyngeal wide**₂
- **Tongue Body uvular-pharyngeal narrow**₃
- **Tongue Body palatal mid**₅

**Velum aperture**

**Phonetic realization**

| nasal | oral |
Summary:

Blocking as Gestural Inhibition

• Harmonizing and blocking gestures are incompatible with one another

• Gestural incompatibility may lead to a ban on temporal overlap, enforced by gestural inhibition

• Incompatibility is articulatorily and perceptually based and not limited to gestural antagonism
Neutrality in Harmony via Feature Co-occurrence Constraints

• Analyses of harmony using feature co-occurrence restrictions to account for all neutral segments:
  
  – Embedded feature domains (Smolensky 1993)
  – Grounded path conditions (Archangeli & Pulleyblank 1994)
  – Optimal Domains Theory (Cole & Kisseberth, 1994, 1995)
  – Targeted constraints (Bakovic & Wilson 2000)
  – Span Theory (McCarthy 2004, O’Keefe 2005)

• Incorrect prediction of these accounts: all attested blockers may also behave transparently
Neutral Segments in Optimal Domains Theory (ODT)

- Wide Scope Alignment (WSA): align the edge of a feature domain (F-domain) with the edge of a word/morpheme

- Expression: a feature must be affiliated with every segment in its F-domain

- Co-occurrence restriction: a segment may not bear features F and G
Overgeneration of Transparency

• Transparency:
  Wide Scope
  Alignment
  Co-occurrence
  restriction

  >> Expression

• Blocking:
  Expression
  Co-occurrence
  restriction

  >> Wide Scope
  Alignment

• Prediction: any attested neutral segment may behave transparently under some constraint ranking
Overgeneration of Transparent Segments in Nasal Harmony

• Liquid blocking of nasal harmony (attested):
  
  *NasalLiquid, Expression >> WSA(nasal)

• Liquid transparency in nasal harmony (not attested):
  
  *NasalLiquid, WSA(nasal) >> Expression
Overgeneration of Transparent Segments in Rounding Harmony

- Non-high vowel blocking of rounding harmony (attested):

  *ROLO, Expression >> WSA(round)

- Non-high vowel transparency in rounding harmony (not attested):

  *ROLO, WSA(round) >> Expression
Conclusion

• Gestural Harmony Model provides two distinct mechanisms responsible for neutrality:
  – Transparency via coactivation: concurrent activation of antagonistic gestures
  – Blocking via gestural inhibition: ban on temporal overlap of incompatible gestures
• Allows a local, non-derivationally opaque representation of transparency in harmony
• Avoids over-generation of predicted transparent segments in nasal harmony and rounding harmony
• Next step: extending harmony typology to additional non-self-deactivating gestures
References


References


Appendix I: Gestural Strength

- Gestural antagonism resolved by Task Dynamic Model of speech production (Saltzman & Munhall 1989)

- Articulatory state = weighted average of two gestures’ goal articulatory states

- Weights = gestural strengths
Appendix I: Gestural Strength

- Velum closure: goal velum aperture -2mm
- Velum opening: goal velum aperture 5mm

<table>
<thead>
<tr>
<th>Velum Closure Strength</th>
<th>Velum Opening Strength</th>
<th>Weighted Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.5</td>
<td>(-2 \times 0.5 + 5 \times 0.5 = 1.5 \text{ mm})</td>
</tr>
<tr>
<td>0.25</td>
<td>0.75</td>
<td>(-2 \times 0.25 + 5 \times 0.75 = 3.25 \text{ mm})</td>
</tr>
<tr>
<td>0.75</td>
<td>0.25</td>
<td>(-2 \times 0.75 + 5 \times 0.25 = -0.25 \text{ mm})</td>
</tr>
</tbody>
</table>
Appendix II: Blocking in Rounding Harmony in Ulcha

- Rounding harmony is triggered by a mid round vowel and blocked by high vowels (Kaun 1995):

  **Full harmony**
  a. [goro] ‘far’
  b. [totoŋgo] ‘multi-colored’

  **Blocking**
  c. [do:kila] ‘inside’
  d. orkiqtala ‘uncomfortably’

  *[do:kilo]*

  *[orkiqtolo]*
Appendix II: Blocking in Rounding Harmony in Ulcha

[ d  o₁ k i₂ l a₃ ]

- Labial protrusion₁
- Labial spread₂
- Tongue Body uvular-pharyngeal narrow₁
- Tongue Body palatal narrow₂
- Tongue Body pharyngeal wide₃

Lip protrusion

Phonetic realization | rounded | unrounded |
Appendix III: ODT Overgeneration of Transparent Segments in Nasal Harmony

- Liquid blocking of nasal harmony (attested):

*\textit{NasalLiquid}, Expression >> WSA(nasal)

<table>
<thead>
<tr>
<th>Input: /nala/</th>
<th>*\textit{NasLiq}</th>
<th>EXPRESSION</th>
<th>WSA(nasal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [ (nãĨã) ]</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [ (nãlã) ]</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>c. [ (nã)la ]</td>
<td></td>
<td></td>
<td>**</td>
</tr>
</tbody>
</table>
Appendix III: ODT Overgeneration of Transparent Segments in Nasal Harmony

- Liquid transparency in nasal harmony (not attested):

**NasalLiquid, WSA(nasal) >> Expression**

<table>
<thead>
<tr>
<th>Input: /nala/</th>
<th>*NasLiq</th>
<th>WSA(nasal)</th>
<th>EXPRESSION</th>
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<td>a. [ (nãlã) ]</td>
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<td>b. [ (nãlã) ]</td>
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<td></td>
<td>*</td>
</tr>
<tr>
<td>c. [ (nã)la ]</td>
<td></td>
<td>*!</td>
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