Deriving Apparent Exceptionality from Contrastive Gestural Strength

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Strength in Grammar
Leipzig University
November 10, 2017
Introduction

- Exceptionality: two versions of same sound participate in phonological processes in different ways

- Example: exceptional application of palatalization

\[
/ti/ _1 \rightarrow [ci] \quad \text{and} \quad /ti/ _2 \rightarrow [ti]
\]
Dealing with Exceptionality

Contrast between /ti\_1 and /ti\_2 may be based on:

• Differences in underlying feature (under-)specification
• Morpheme/segment indexation (Pater 2000, 2009)
• Differences in activation level (Smolensky & Goldrick 2016)

Proposal:
Contrastive *gestural strength* is responsible for cases of apparent exceptionality
Advantages of Gestural Analysis of Apparent Exceptionality

• Gestural strength parameter setting is non-abstract; no derivational opacity

• Provides unified account of multiple exceptional processes in same language

• Gradient strength parameter setting provides account of processes in which segments undergo to intermediate degrees
Overview

• Introduction to gestures and gestural strength

• Case studies of contrastive gestural strength
  – Barrow Inupiaq palatalization and dorsal assimilation
  – Coeur d’Alene Salish faucal harmony

• Issues with feature-based accounts of apparent exceptionality
  – Abstract phonemes and opacity
  – Constraint indexation
Gestures & Gestural Strength
Gestural Parameters

Gesture: dynamically-defined, goal-based unit of representation (Browman & Goldstein 1986, 1989)
Gestural Parameters

- Target articulatory state:
  - Constriction location
  - Constriction degree

- Stiffness (k): how quickly a gesture’s target articulatory state is reached

- Ability to self-deactivate (Smith 2017a, 2017b)

- Strength (α): ability to command articulators
Representing Phonological Forms with Gestural Scores

\[ [ \text{Velum open}_3, \text{Glottis open}_1, \text{Lip closure}_1, \text{Tongue Tip alveolar closure}_3, \text{Tongue Body palatal mid}_2, \text{Velum open}_3 ] \]

subscript: segment-to-gesture correspondence
Gestural Blending Based on Strength

\[
\begin{bmatrix}
    a_1 & g_2 & a_3
\end{bmatrix}
\]

Tongue Body
pharyngeal wide

Tongue Body
velar closure

Tongue body posture for /a/

Tongue body posture for /g/
Gestural Strength & Blending

- Antagonistic gestures: gestures with conflicting target articulatory states

- Antagonism resolved by blending goal articulatory states of concurrently active gestures according to Task Dynamic Model of speech production (Saltzman & Munhall 1989)

\[
\text{Target}_1 \times \alpha_1 + \text{Target}_2 \times \alpha_2 = \text{Blended Target}
\]
Gestural Blending Between Consonants and Vowels

\[
[ \quad a_1 \quad \quad g_2 \quad \quad a_3 \quad ]
\]

Tongue Body
pharyngeal wide$_1$

Tongue Body
velar closure$_2$

Tongue Body
pharyngeal wide$_3$

Blended tongue body postures for /a/ and /g/
Phonological Role of Gestural Strength

• Allophony of velar fricative in Navajo due to low gestural strength (Iskarous, McDonough, & Whalen 2012)

• Transparency in harmony due to high gestural strength (Smith 2016)

• Phonotactics restrictions on liquids in English due to gestural strength settings (Walker, Proctor, Smith, & Enzinger 2016)
Proposals: Contrastive Gestural Strength

1) Gestural strength serves a contrastive function in phonology

2) Contrastive gestural strength is responsible for cases of apparent exceptionality
Barrow Inupiaq
Vowel-Consonant Interactions in Barrow Inupiaq (Kaplan 1981)

- Coronal Palatalization:

\[ t \rightarrow s, c \]
\[ n \rightarrow n / i (C) \]
\[ l \rightarrow \lambda \]

- Dorsal Assimilation:

\[ i \rightarrow \alpha / \{k, q\} \]
## Barrow Inupiaq

<table>
<thead>
<tr>
<th>Stem</th>
<th>Coronal Palatalization</th>
<th>Dorsal Assimilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>iki</td>
<td>iki-ʎu ‘and wound’</td>
<td>iki-k ‘wound.DUAL’</td>
</tr>
<tr>
<td>savik</td>
<td>savig-ʎu ‘and knife’</td>
<td>savvi-k ‘knife.DUAL’</td>
</tr>
<tr>
<td>ini</td>
<td>ini-lu ‘and place’</td>
<td>innα-k ‘place.DUAL’</td>
</tr>
<tr>
<td>kamik</td>
<td>kamig-lu ‘and boot’</td>
<td>kammaα-k ‘boot.DUAL’</td>
</tr>
</tbody>
</table>

Data from Kaplan (1981)
Barrow Inupiaq: Two /i/ Phonemes

• Kaplan (1981) & Archangeli & Pulleyblank (1994) argue that Barrow Inupiaq has two /i/ phonemes

Proposal:
Two /i/ phonemes contrast with respect to gestural strength

• Strong /i/ triggers coronal palatalization, resists dorsal assimilation
• Weak /i/ does not trigger coronal palatalization, undergoes dorsal assimilation
Gestural Representation of Coronal Palatalization

/ \   \ i \ \ t \ /

Tongue Body
palatal narrow
Tongue Tip
alveolar closure

gestural blending

Tongue position for /i/
Tongue position for /t/
Gestural Representation of Coronal Palatalization

- Strong /ɪ/ palatalizes following coronal:
  \[ i_1 \quad c_2 \]

- Achievement of strong palatal constriction favored over achievement of weak alveolar constriction
- Result: palatalized consonants [c], [ɲ], [ʎ]
Gestural Representation of Coronal Palatalization

• Weak /\text{i}/ does not palatalize following coronal: $[i_1 \quad t_2 ]$

• Achievement of strong alveolar constriction favored over achievement of weak palatal constriction

• Result: coronal consonants [t], [n], [l]
Gestural Representation of Dorsal Assimilation

Tongue Body
uvular closure

Tongue Body
palatal narrow

gestural blending

Tongue position for /i/

Tongue position for /q/
Gestural Representation of Dorsal Assimilation

- Weak /ɨ/ retracted by following dorsal consonant:

\[
\text{Tongue Body} \\
\text{palatal narrow} \\
\text{Weak}
\]

\[
\text{Tongue Body} \\
\text{uvular closure}
\]

- Achievement of uvular constriction favored over achievement of weak palatal constriction
- Result: back vowel [a]
Gestural Representation of Dorsal Assimilation

• Strong /i/ resists retraction by dorsal consonant:

\[
\begin{align*}
\text{Tongue Body} & \quad \text{palatal narrow} \\
\text{Tongue Body} & \quad \text{uvular closure} \\
\text{gestural blending} & \\
\text{Degree of Retraction} &
\end{align*}
\]

- Retracted
- Advanced

• Achievement of strong palatal constriction favored over achievement of weak uvular constriction
• Result: front vowel [i]
Summary: Gestural Analysis of Barrow Inupiaq

- Recruits independently necessary element of gestural representation to account for cases of apparent exceptionality

- Captures relationship between palatalization and dorsal assimilation processes with single gestural strength parameter

- Eliminates reliance on purely abstract phonemes, derivational opacity, and special grammatical exceptionality mechanisms
Alternative Analyses in Feature-Based Phonology
Abstract Vowel in Barrow Inupiaq

- Kaplan (1981): weak [i] is underlyingly abstract schwa

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>u</th>
<th>i</th>
<th>ø</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>back</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Archangeli & Pulleyblank (1994): weak [i] is underspecified

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>u</th>
<th>i₁</th>
<th>i₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>back</td>
<td></td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>round</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

- Late rule merges abstract vowel with /i/
Ordered Rules

Ordering Dorsal Assimilation before rule merging /i/ and /ə/ generates desired surface forms:

<table>
<thead>
<tr>
<th>Input</th>
<th>/iki-k/</th>
<th>/ənə-k/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorsal Assimilation</td>
<td>—</td>
<td>ənə-k</td>
</tr>
<tr>
<td>[i] Neutralization</td>
<td>—</td>
<td>ɪnə-k</td>
</tr>
<tr>
<td>Output</td>
<td>[iki-k]</td>
<td>[inə-k]</td>
</tr>
<tr>
<td></td>
<td>‘wound (dual)’</td>
<td>‘place (dual)’</td>
</tr>
</tbody>
</table>
## Ordered Rules

Ordering Coronal Palatalization before rule merging /i/ and /ə/ generates desired surface forms:

<table>
<thead>
<tr>
<th>Input</th>
<th>/iki-.lu/</th>
<th>/ənə-.lu/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronal Palatalization</td>
<td>iki-ʎu</td>
<td>—</td>
</tr>
<tr>
<td>[i] Neutralization</td>
<td>—</td>
<td>ini-lu</td>
</tr>
<tr>
<td>Output</td>
<td>[iki-ʎu]</td>
<td>[ini-lu]</td>
</tr>
<tr>
<td></td>
<td>‘and wound’</td>
<td>‘and place’</td>
</tr>
</tbody>
</table>

Counter-feeding

Opacity
Alternative Analyses: Derivational Opacity

- Analyses relying on absolute neutralization/underspecification with counterfeeding opacity are incompatible with parallel frameworks (McCarthy 1999)

- Gestural strength account: no counterfeeding opacity or absolute neutralization
  - Contrastive element (gestural strength parameter $\alpha$) persists from underlying to surface form
  - Compatible with parallel frameworks
Alternative Analysis: Lexical Exceptionality

- Lexical exceptionality via constraint indexation (Pater 2000, 2009): weak and strong /i/ differentiated by constraint indices

- Exceptional triggering of palatalization:
  \[
  \text{PALATALIZE}_x \gg \text{IDENT}(\text{high}) \gg \text{PALATALIZE}
  \]

- Exceptional resistance to dorsal assimilation:
  \[
  \text{IDENT}(\text{back})_y \gg \text{ASSIMILATE} \gg \text{IDENT}(\text{back})
  \]
Issues with Morpheme Indexation

- Indexation of a *morpheme* to a constraint motivating palatalization predicts uniform /i/ behavior within a morpheme

- Morpheme will contain all palatalizing /i/ vowels, OR

  Morpheme will contain all non-palatalizing /i/ vowels

- Not predicted: morphemes with both types of /i/, such as \[ilvi-ʎʎi\] ‘and you, in your turn’ (*\[iʎvi-ʎʎi\], *\[ilvi-lli\])
Alternative Analysis: Segmental Exceptionality

• Possible solution: constraint indices borne by segments rather than entire morphemes (Temkin Martinez 2010)

• Exceptional triggering of palatalization:

\[ \text{PALATALIZE}_x \gg \text{IDENT}(\text{high}) \gg \text{PALATALIZE} \]

• Exceptional resistance to dorsal assimilation:

\[ \text{IDENT}(\text{back})_y \gg \text{ASSIMILATE} \gg \text{IDENT}(\text{back}) \]

• Barrow Inupiaq inventory: /a/, /u/, /i\text{XY}/, /i/
Issues with Segment Indexation

- Indexation of /i_{XY}/ to both PALATALIZE and IDENT(back) is accidental

- Also predicted: system in which PALATALIZE and IDENT(back) are not indexed to same set of /i/ vowels

  \[ \text{PALATALIZE}_X \gg \text{IDENT}(\text{high}) \gg \text{PALATALIZE} \]

  \[ \text{IDENT}(\text{back})_Y \gg \text{ASSIMILATE} \gg \text{IDENT}(\text{back}) \]

- Possible high front vowel inventory: /i_x/, /i_y/, /i_{XY}/, /i/
Issues with Segment Indexation

• Additional processes in Barrow Inupiaq rely on distinction between strong and weak /i/:
  – Weak /i/ retraction to [u]
  – Weak /i/ syncope

• Number of possible indexed vowels in inventory = \(2^n\), where \(n\) = number of indexed constraints
Contrasting Featural and Gestural Analyses of Barrow Inupiaq

• Appealing to contrastive gestural strength rather than potentially disjoint sets of segment-to-constraint indexations unifies behavior of strong /i/ and weak /i/

• Avoids explosion of possible segment inventories predicted by constraint indexation
Coeur d’Alene Salish
Faucal Harmony
Coeur d’Alene Salish Faucal Harmony (Doak 1992, Bessell 1998)

Vowels surface as retracted variants before faucal (uvular and pharyngeal) consonants

<table>
<thead>
<tr>
<th>Non-Faucal Context</th>
<th>Faucal Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>[tʰʃ-t] ‘it is long’</td>
<td>[tʰɛʃ-alqʷ] ‘he is tall’</td>
</tr>
<tr>
<td>[dli̇m] ‘he galloped hither’</td>
<td>[tʃ-dla̱m-alqʷ] ‘train’</td>
</tr>
<tr>
<td>[sɛtʃ-nə] ‘he twisted it’</td>
<td>[nɛʔ-sqttʃ-ɛʔqs-n] ‘crank (on a car)’</td>
</tr>
<tr>
<td>[ʔɛ-niʔ-kus-ɛlʃʔn] ‘hair curls back from forehead’</td>
<td>[ʔat-kəs-qn] ‘his hair is curled’</td>
</tr>
</tbody>
</table>

Data from Doak (1992) & Bessell (1998)
Coeur d’Alene Salish
Faucal Harmony

Vowel shift in domain of faucal harmony:

- \(/\varepsilon/, /i_2/, /u/\) all fully undergo faucal harmony
- \(/i_1/\) undergoes faucal harmony to an intermediate degree
Transparency in Harmony as Gestural Antagonism (Smith 2016)

Transparency: result of competition between two concurrently active antagonistic gestures
Faucal harmony is result of overlap by harmonizing tongue body retraction gesture

- Medium-strength /i/ partially resists (remains transparent to) effect of retraction gesture due to similar gestural blending strengths

- Weak /i/ is fully overpowered by retraction gesture when gestural blending occurs
Gestural Representation of Faucaull Harmony

Tongue Body
uvular-pharyngeal constriction

Tongue Body
palatal narrow

gestural blending

Tongue position for /i/

Tongue position for /q/
Full Retraction of Weak /i/

- Weak /i/ is fully overpowered by harmonizing retraction gesture:

- Surfaces as fully retracted [ɑ]
Partial Transparency of Medium-Strength /i/

- Medium-strength /i/ partially resists (remains transparent to) effect of retraction gesture due to similar gestural blending strengths:

- Surfaces as partially retracted [ɛ]
Summary: Gestural Analysis of Coeur d’Alene Salish

• Gestural strength parameter setting preserved from input to output

• Gradient gestural strength:

  - Produces full retraction of /i₂/, /ɛ/, and /u/ from low gestural strength

  - Produces partial transparency of /i₁/ from medium gestural strength
Conclusion & Looking Forward
Conclusion

• Contrastive gestural strength accounts for patterns of apparent exceptionality without relying on:
  – Abstract underlying phonemes
  – Opaque rule ordering
  – Exploding number of constraint indices

• Provides unified account of multiple processes in Barrow Inupiaq that make reference to two sets of high front vowels

• Provides account of segments that undergo process to different degrees, as in Coeur d’Alene Salish
Work in Progress & Future Work

• Broader typology of contrastive strength:
  – Contrastive strength for vowels other than /i/
  – Contrastive strength for consonants

• Manipulation of gestural strength by phonological grammar:
  – Gestural strength varying by prosodic position
  – Gestural strength interacting with temporal organization
  – Phonotactic restrictions based on gestural strength