Partial Vowel Height Harmony and Partial Transparency via Gestural Blending

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Introduction

- Harmony: spreading of some phonological property throughout domain
  - Rounding harmony: /o-a-a/ → [o-o-o]
  - Nasal harmony: /mawa/ → [mãl̃ãw̃ã]

- Transparency: some segments are apparently skipped by harmony process
  - Rounding harmony: /o-i-a/ → [o-i-o]
  - Nasal harmony: /mata/ → [mãtã]

- Partial harmony: segment takes on phonological property of trigger to only partial degree

Partial Height Harmony

- Partial height harmony: vowel approaches height of trigger vowel, but does not necessarily reach it
- Servigliano Italian metaphony (raising harmony that targets stressed vowel; Camilli 1929, Nibert 1998, Walker 2011):

Non-Metaphony Context	**Metaphony Context**
[kɾé̲d-o] ‘I believe’	[kɾí̲d-i] ‘you believe’
[fjó̲ɾ-e] ‘flower (masc. sg.)’	[fjú̲ɾ-i] ‘flower (masc. pl.)’
[pɛ̲́tten-e] ‘comb (masc. sg.)’	[pé̲ttin-i] ‘comb (masc. pl.)’
[mɔ̲́ɾ-e] ‘he dies’	[mó̲ɾ-i] ‘you die’

Difficulties of Analyzing Partial Height Harmony

- Different height changes may rely on manipulation of different vowel features (e.g.,[±high] vs. [±low] vs. [±ATR])

- Scalar height features make undesirable predictions about possible direction of feature change (low to high vs. high to low) in partial height harmony

- *Stepwise* (X → Y → Z) partial harmonies involve chain shifts, which require additional theoretical machinery in OT

Proposals

1. Subsegmental units of phonological representation are goal-based, dynamically-defined gestures

2. Harmony is result of extension of gesture to overlap gestures of other segments in a word

3. Transparency to harmony is result of blending/competition between gestures with different articulatory goals

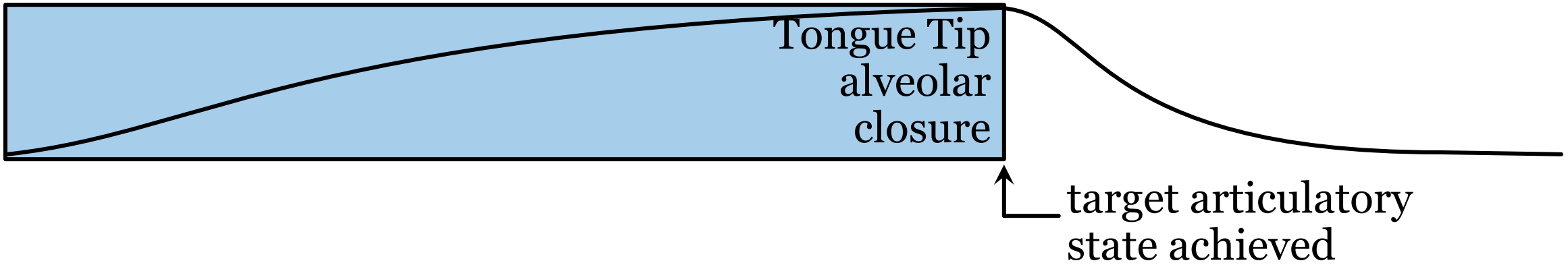
4. Partial transparency/partial undergoing is result of blending of gestures with similar strength parameter values

5. Partial height harmony is a type of *partial transparency*

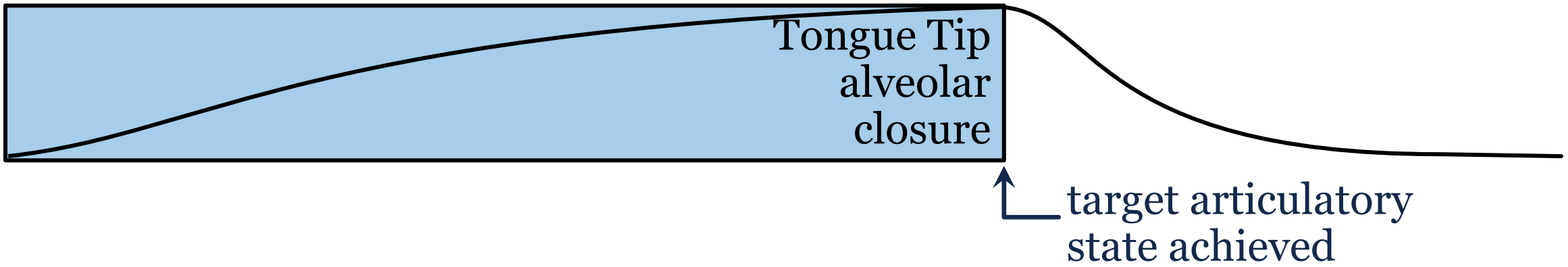
Gestures as Phonological Units

Gestural Units

Gestures: dynamically-defined, goal-based units of phonological representation (Browman & Goldstein 1986, 1989)

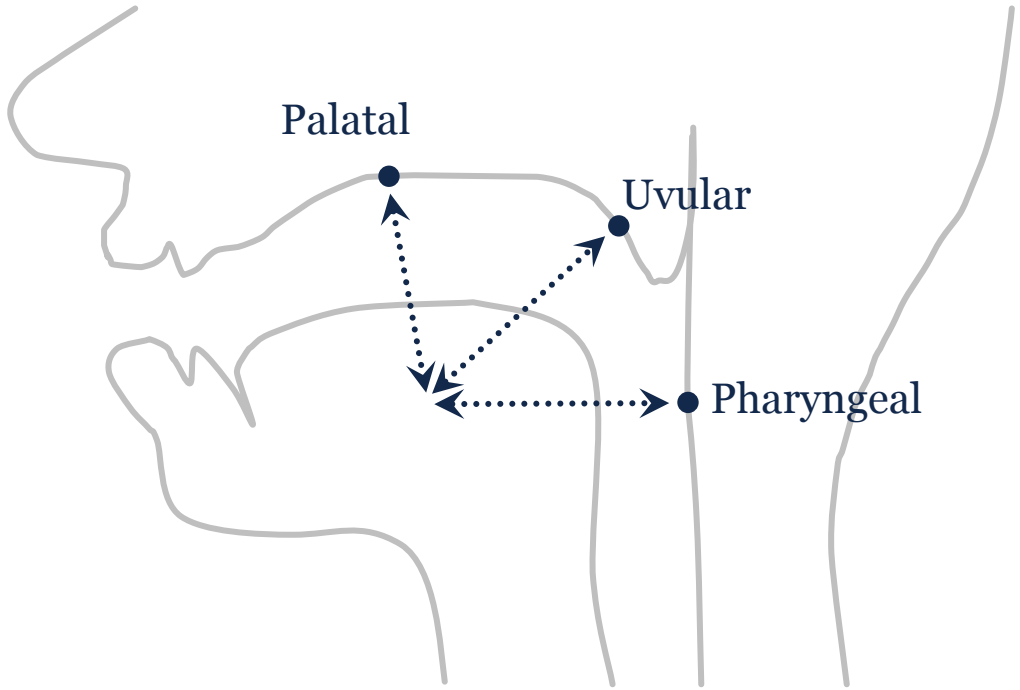


Gestural Parameters



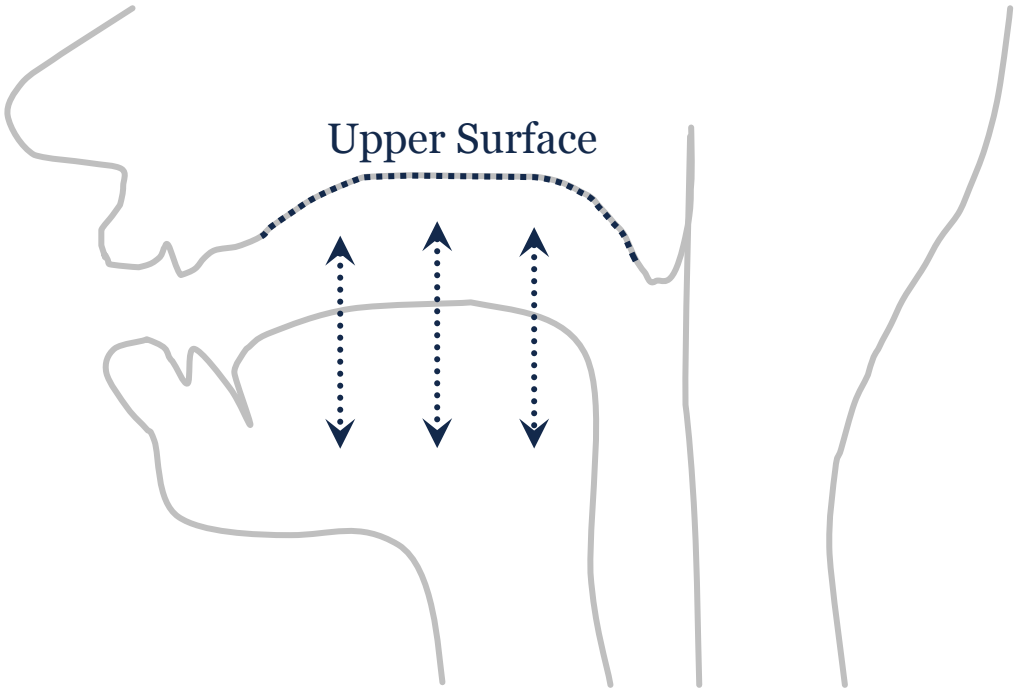
- Target articulatory state:
  - Constriction location
  - Constriction degree
- Stiffness (k): how quickly a gesture's target articulatory state is reached
- Blending strength (α): ability to command vocal tract articulators
- Ability to self-activate and self-deactivate (C. Smith 2016, 2018, inter alia)

Constriction Location and Degree for Lingual Gestures



- Constriction location of gesture specifies target point along polar coordinate system
- Constriction degree of gesture specifies distance between active articulator and constriction location point

Vowel Gestures



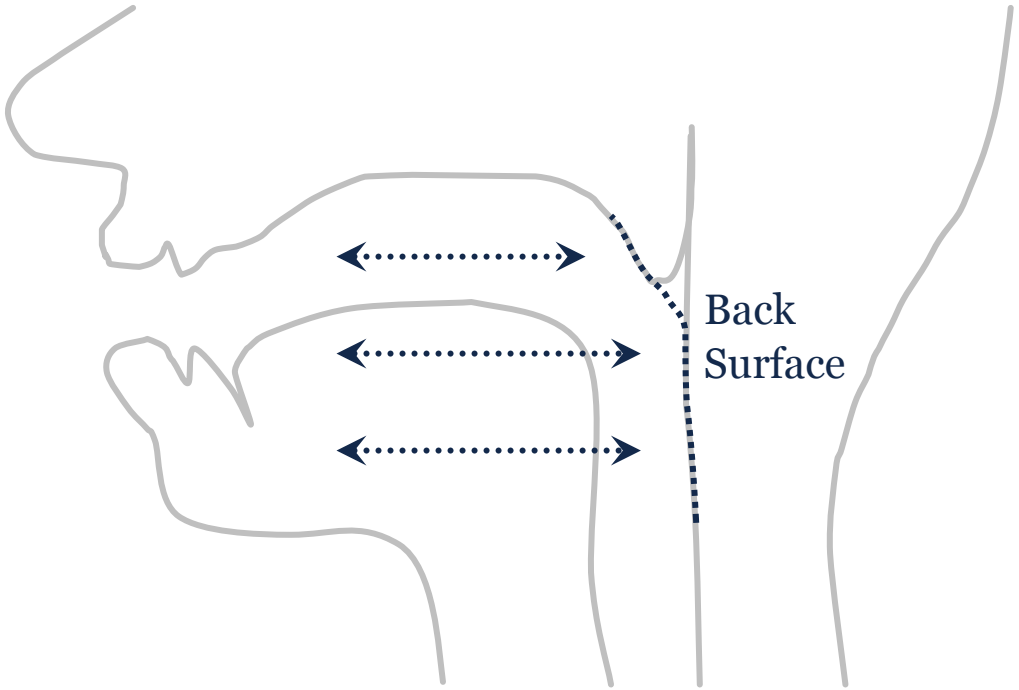
Each vowel includes two tongue body gestures:

- Constriction location ‘upper surface’
- Constriction location ‘back surface’

- Constriction degree of upper surface gesture determines vowel height

- Constriction degree of back surface gesture determines vowel backness

Vowel Gestures



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- Constriction location ‘upper surface’
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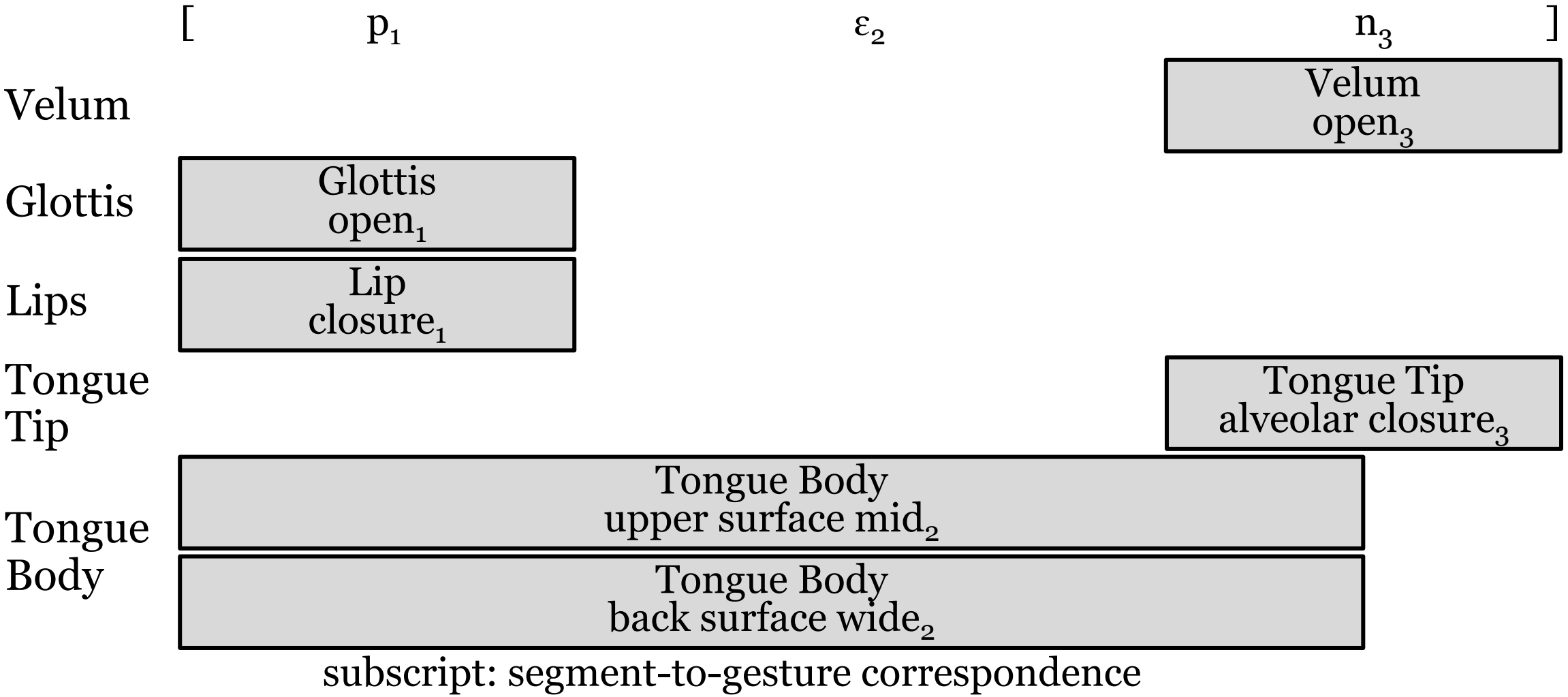
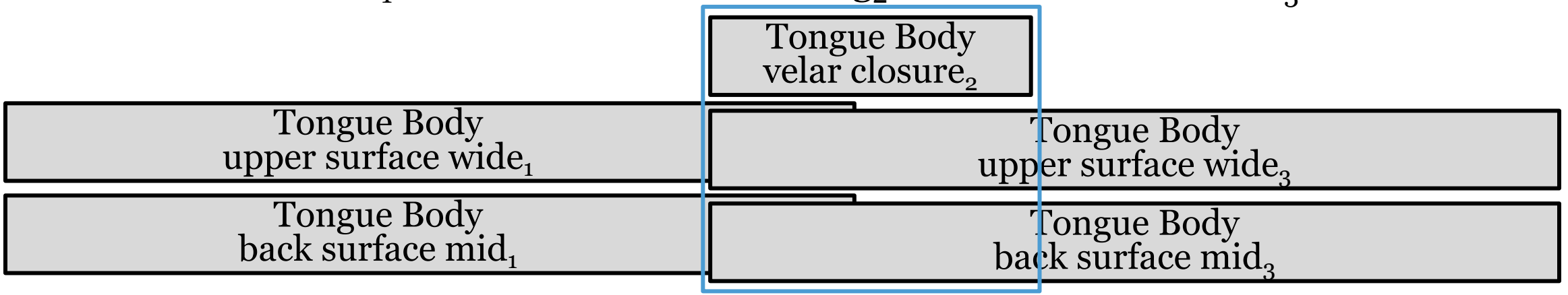
Representing Phonological Forms with Gestural Scores



subscript: segment-to-gesture correspondence

Gestural Blending Between Consonants and Vowels

[a_1 g_2 a_3]



Tongue body posture for /a/

Tongue body posture for /g/

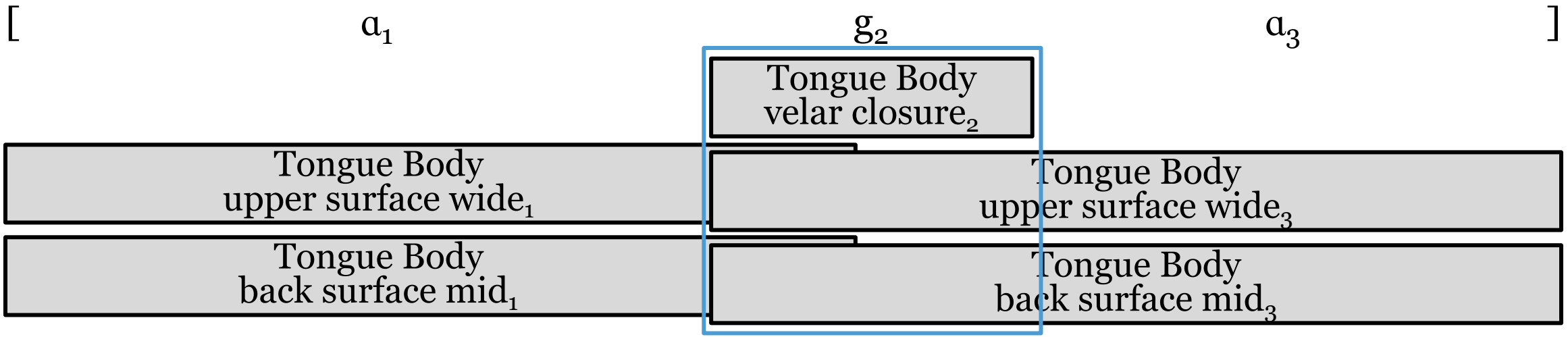
Gestural Strength and Blending

- Antagonistic gestures: gestures with conflicting target articulatory states

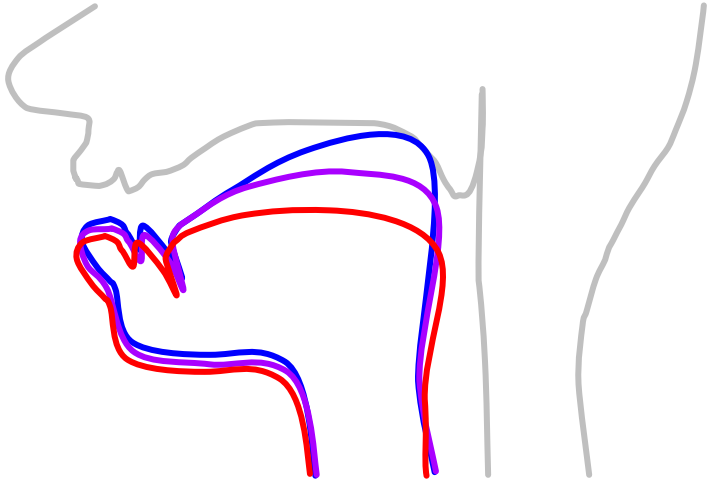
- Antagonism resolved by blending goal articulatory states of concurrently active gestures according to Task Dynamic Model of speech production (Saltzman & Munhall 1989, Fowler & Saltzman 1993)

$$\text{Target}_1 * \alpha_1 + \text{Target}_2 * \alpha_2 = \text{Blended Target}$$
$$(\text{where } \alpha_1 + \alpha_2 = 1)$$

Gestural Blending Between Consonants and Vowels

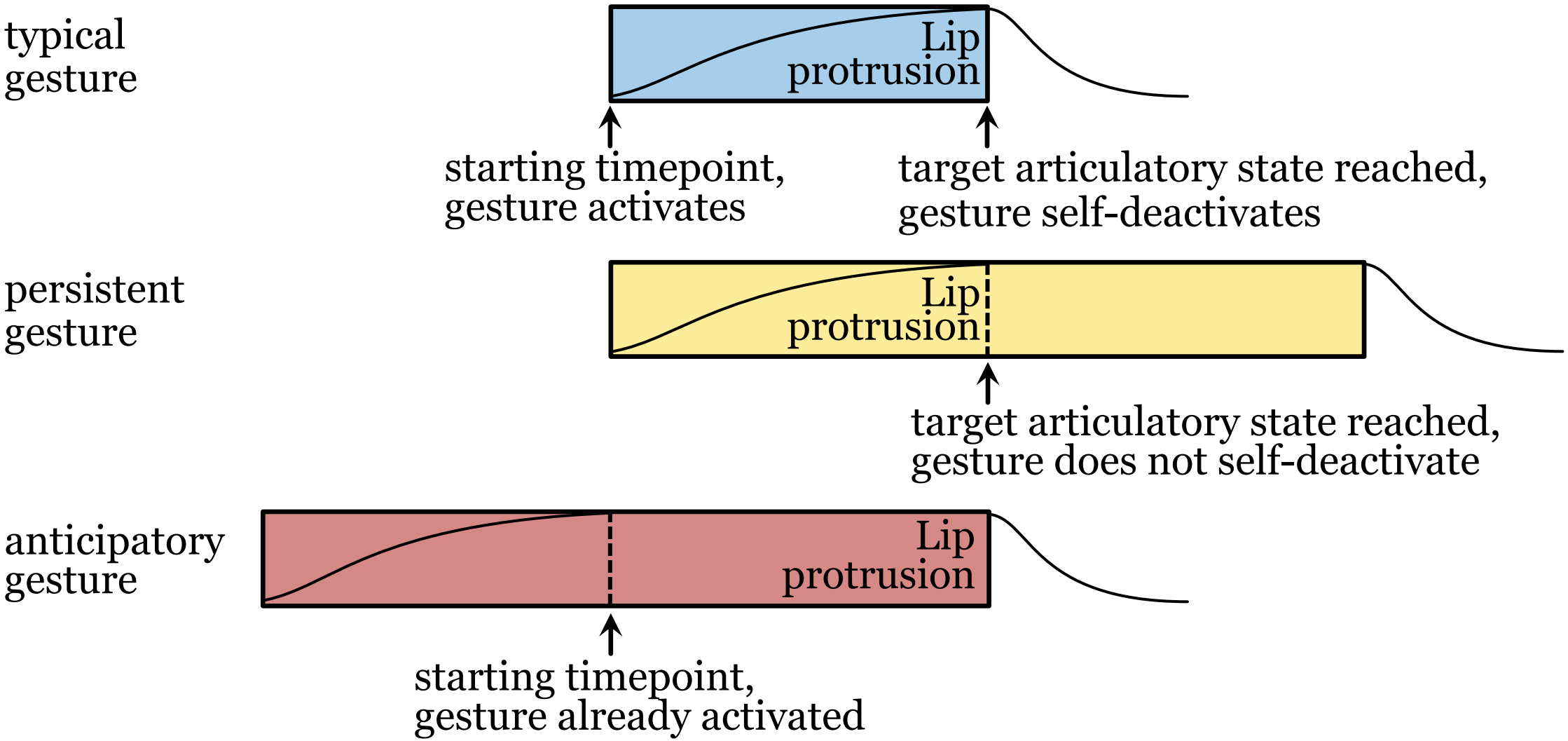


Blended tongue body postures for /ɑ/ and /g/



Gestural Activation and Deactivation

(C. Smith 2016, 2018, inter alia)



Transparency to Harmony via Gestural Blending

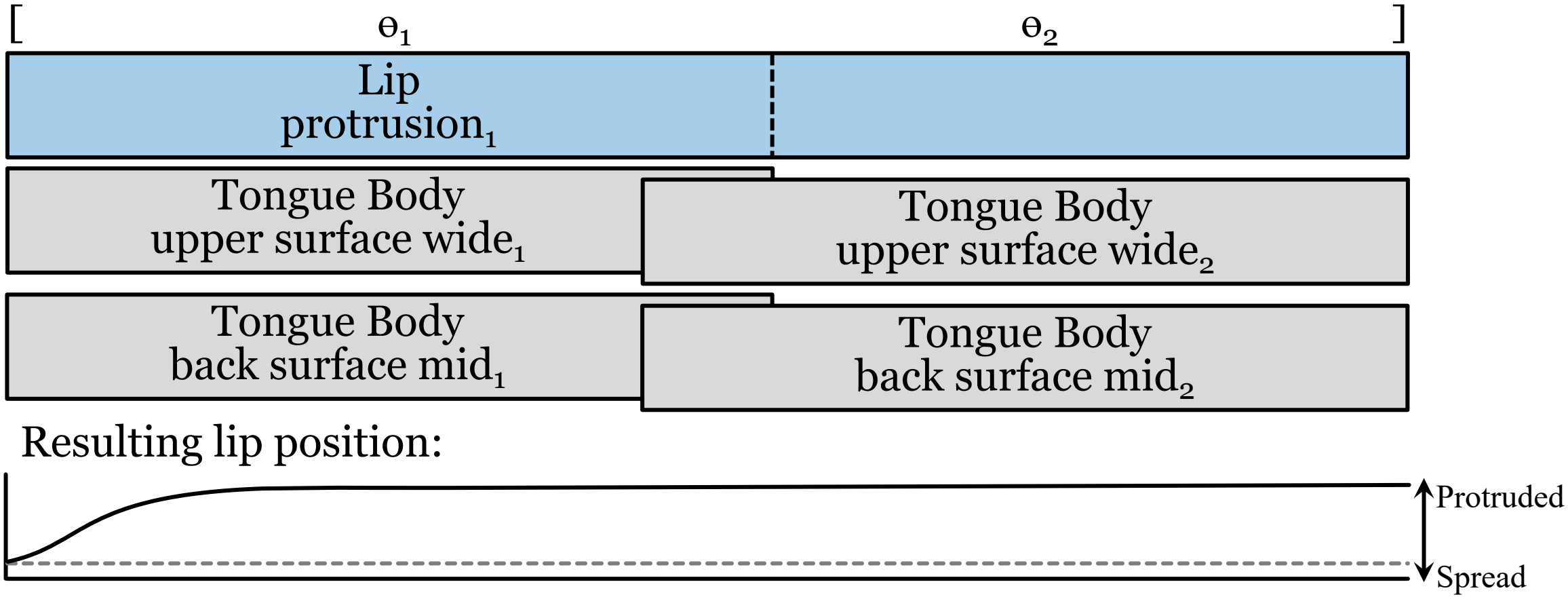
Halh Mongolian Rounding Harmony

(Svantesson 1985, Steriade 1987, van der Hulst & N. Smith 1987, Svantesson et al. 2005)

- Root-initial non-high round vowel triggers rounding of following non-high vowels
- High front /i/ and /ɪ/ are transparent

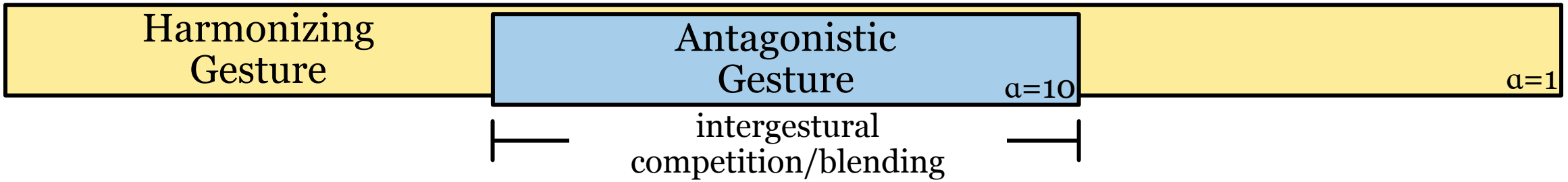
Full harmony	**Transparency**
[pɵːr-ɵ] ‘kidney (refl.)’	[pɵːr-ig-ɵ] ‘kidney (acc. refl.)’ cf. [piːr-ig-e] ‘brush (acc. refl.)’
[xɔːɮ-ɔ] ‘food (refl.)’	[xɔːɮ-ɪg-ɔ] ‘food (acc. refl.)’ cf. [chaːs-ɪg-a] ‘paper (acc. refl.)’

Halh Mongolian Rounding Harmony



Transparency as Gestural Blending

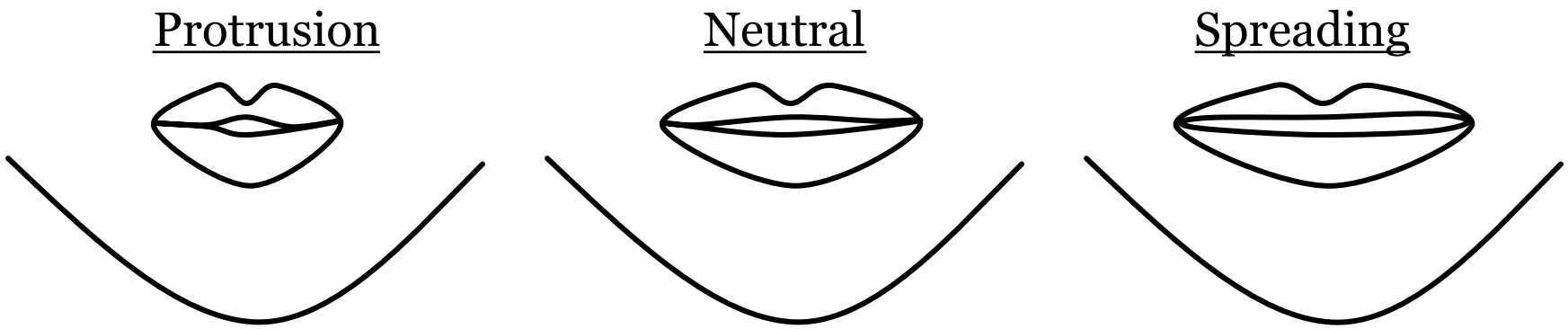
- Transparency: competition between two concurrently active antagonistic gestures
- Gestural antagonism: two concurrently active gestures with directly opposing goal articulatory states
  - Lip protrusion vs. lip spreading
  - Velum opening vs. velum closure



Resulting state of vocal tract for some variable:

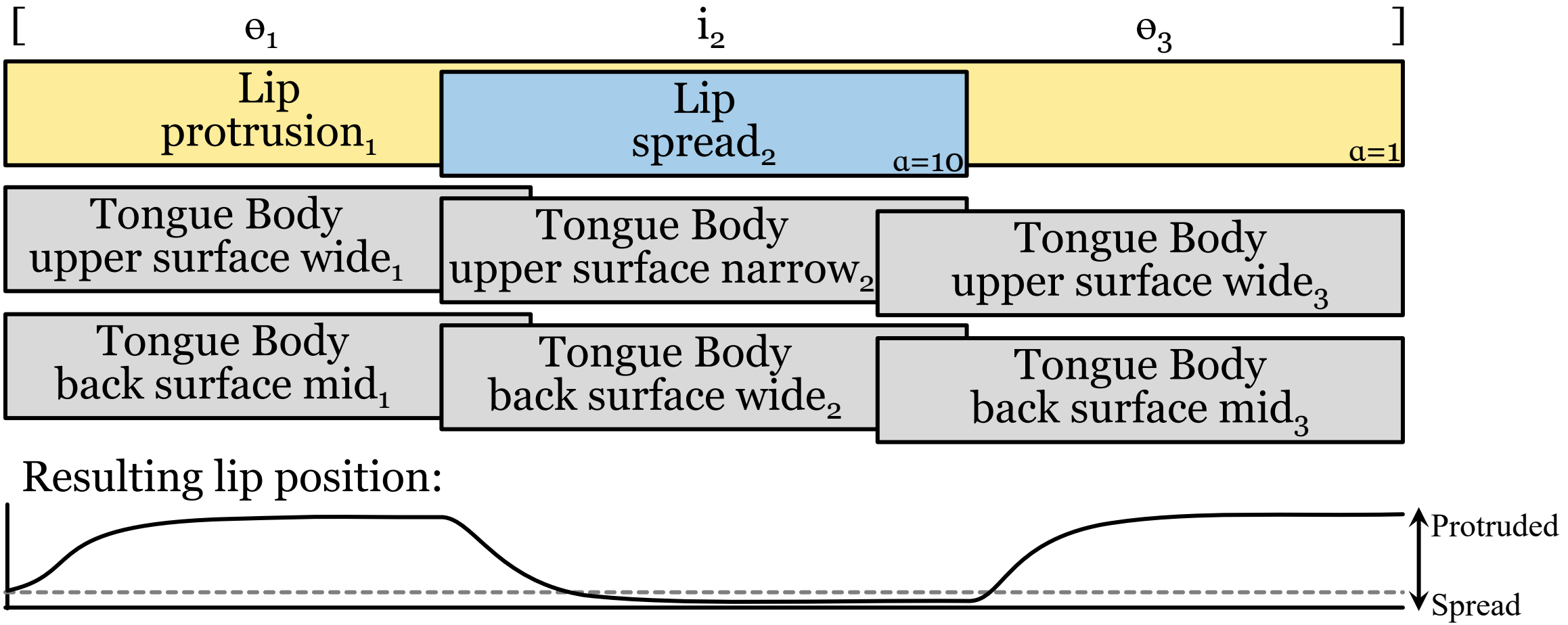
Gestural Representation of High Front Vowels

- Lip spreading gesture for /i/: 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)

Transparency in Halh Mongolian Rounding Harmony

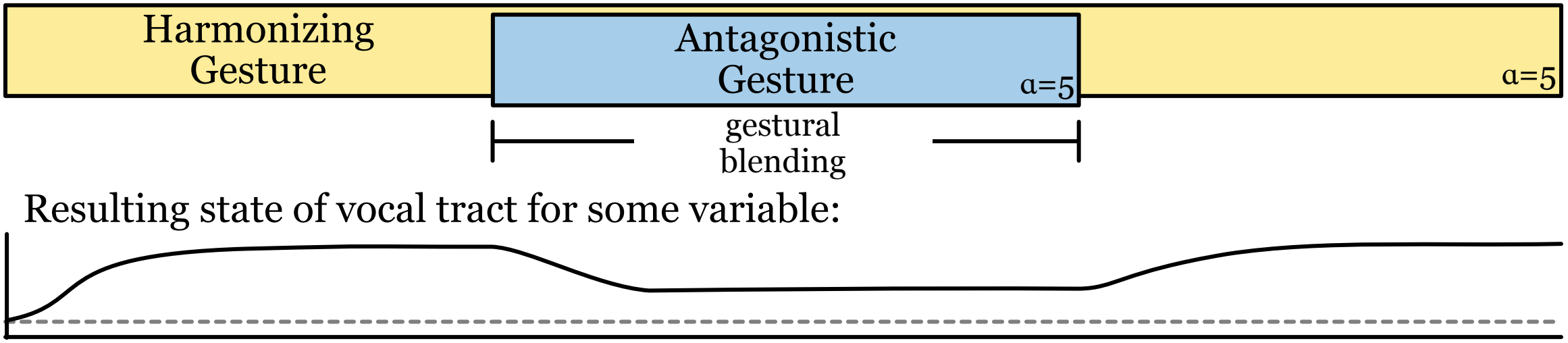


Advantages of Transparency via Gestural Blending

- Correctly predicts which segments can be transparent within nasal harmony and rounding harmony
- Avoids over-generation of predicted transparent segments (C. Smith 2016, 2018)
- Harmony is represented locally (without skipping), resulting in gestural antagonism with transparent segments

Prediction: Partial Transparency via Gestural Blending

- Full transparency: overlapped gesture of transparent segment is much stronger than harmonizing gesture
- Identical or similar blending strengths of harmonizing gesture and overlapped gesture predicts partial transparency/partial undergoing of harmony
- Partial transparency attested in Coeur d'Alene Salish faucal (retraction) harmony (C. Smith 2017, 2018)

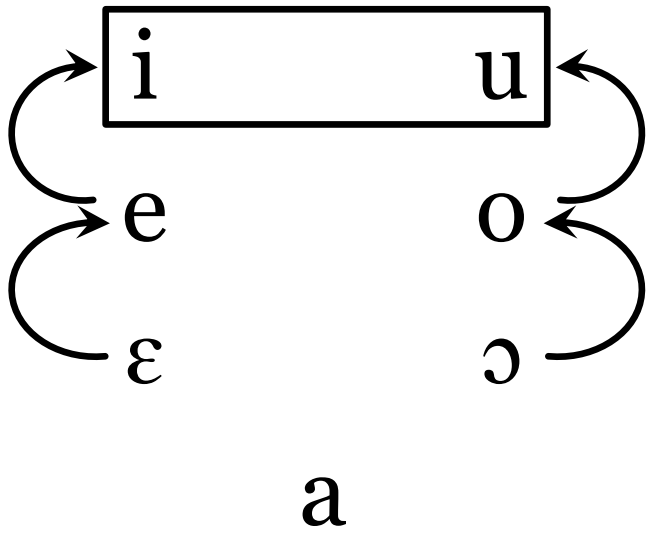


Partial Height Harmony in Servigliano Italian

Servigliano Italian Partial Height Harmony
(Camilli 1929, Nibert 1998, Walker 2011)

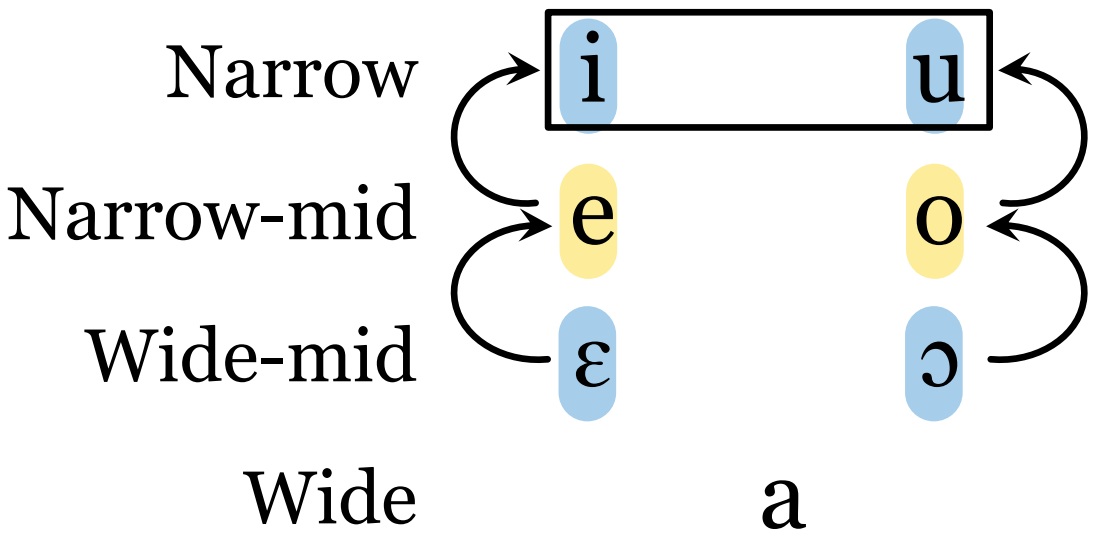
Non-Metaphony Context	**Metaphony Context**
[kɾéd-o] ‘I believe’	[kɾíd-i] ‘you believe’
[pés-a] ‘heavy (fem. sg.)’	[pís-u] ‘heavy (masc. sg.)’
[fjóɾ-e] ‘flower (masc. sg.)’	[fjúɾ-i] ‘flower (masc. pl.)’
[lóŋg-a] ‘long (fem. sg.)’	[lúŋg-u] ‘long (masc.. sg.)’
[pɛ́tten-e] ‘comb (masc. sg.)’	[péttin-i] ‘comb (masc. pl.)’
[sgwɛ́ts-a] ‘suspicious (fem. sg.)’	[sgwéts-u] ‘suspicious (masc. sg.)’
[mɔ́ɾ-e] ‘he dies’	[móɾ-i] ‘you die’
[mɔ́ʃ-a] ‘dejected (fem. sg.)’	[móʃ-u] ‘dejected (masc. sg.)’

Servigliano Italian Partial Height Harmony



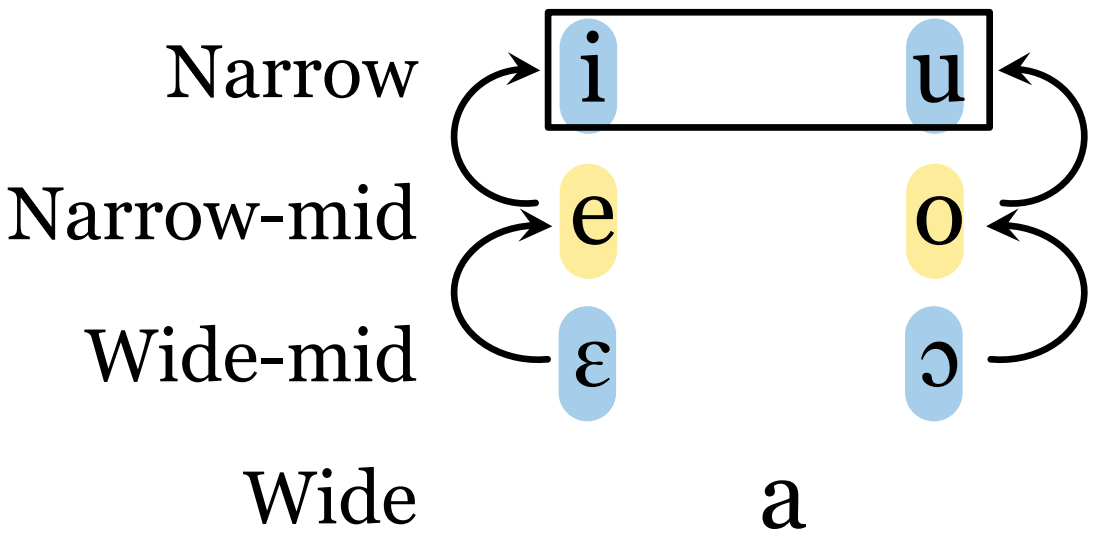
- Suffix high vowels trigger raising of preceding stressed vowels
- High-mid vowels raised to high
- Low-mid vowels raised to high-mid
- Partial step-wise raising harmony

Servigliano Italian Partial Height Harmony



- Vowel raising harmony due to overlap by anticipatory upper surface narrowing gesture of suffix high vowels /i/ and /u/
- Vowels of different heights have antagonistic target states for upper surface constriction degree, resulting in gestural blending

Servigliano Italian Partial Height Harmony



- Wide-mid vowels /ɛ/ and /ɔ/ surface as narrow-mid, partially resisting raising to narrow due to strength equal with trigger gesture

- Relatively weaker narrow-mid vowels /e/ and /o/ do not resist raising and surface as narrow

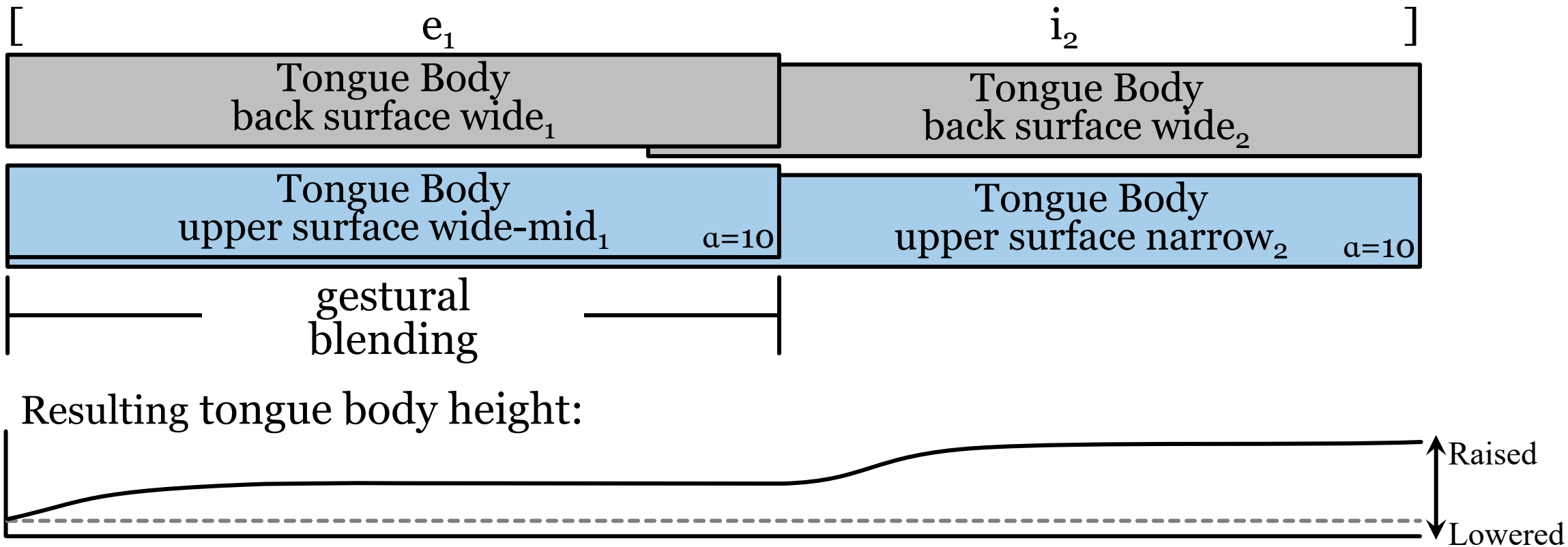
Gestural Blending Strength Calculations

Gestural blending successfully generates ɛ → e → i and ɔ → o → u patterns with the following strength parameter settings for their upper surface gestures:

Vowel	Target Constriction Degree	Trigger Strength	Undergoer Strength	Normalized Strengths	Blended Target Constriction Degree
/i/, /u/	4 mm	10			
/e/, /o/	8 mm	10	1	0.91 | 0.09	4*0.91 + 8*0.09 = 4.36 mm
/ɛ/, /ɔ/	12 mm	10	10	0.5 | 0.5	4*0.5 + 12*0.5 = 8 mm

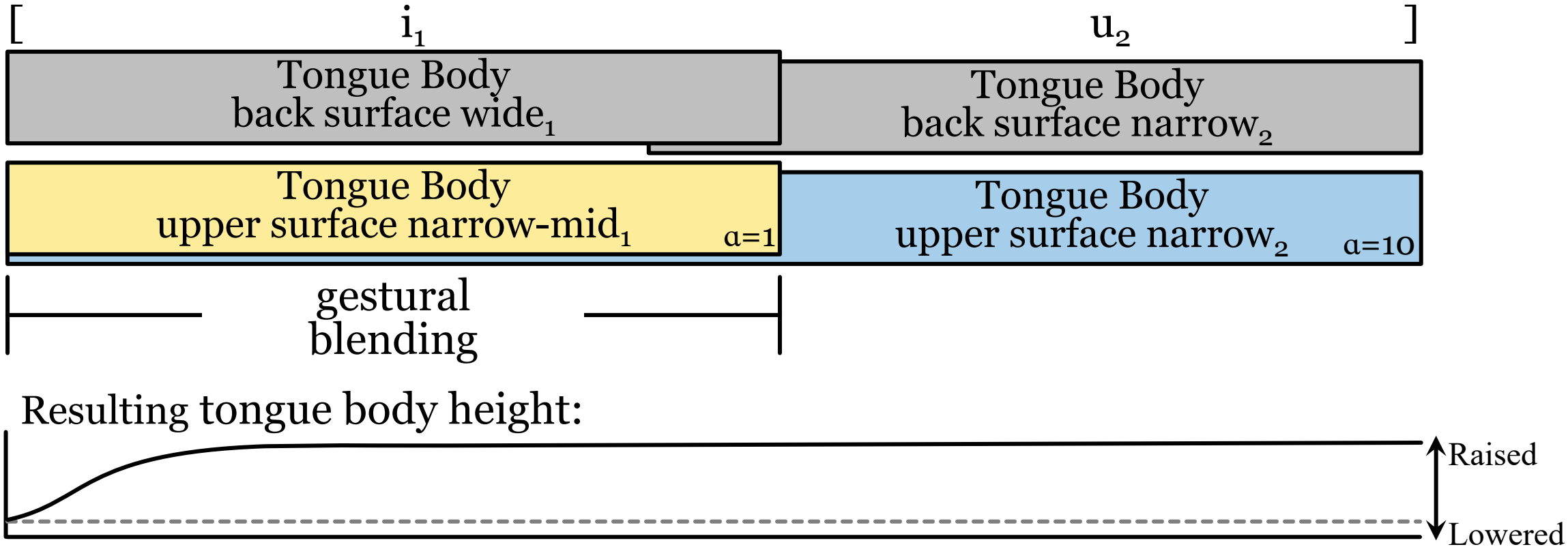
Servigliano Italian: Analysis

- Overlap between gestures of wide-mid vowels /ɛ/ and /ɔ/ and high /i/ and /u/ produces narrow-mid [e] and [o]
- Intermediate blended articulatory state due to equal gestural strengths



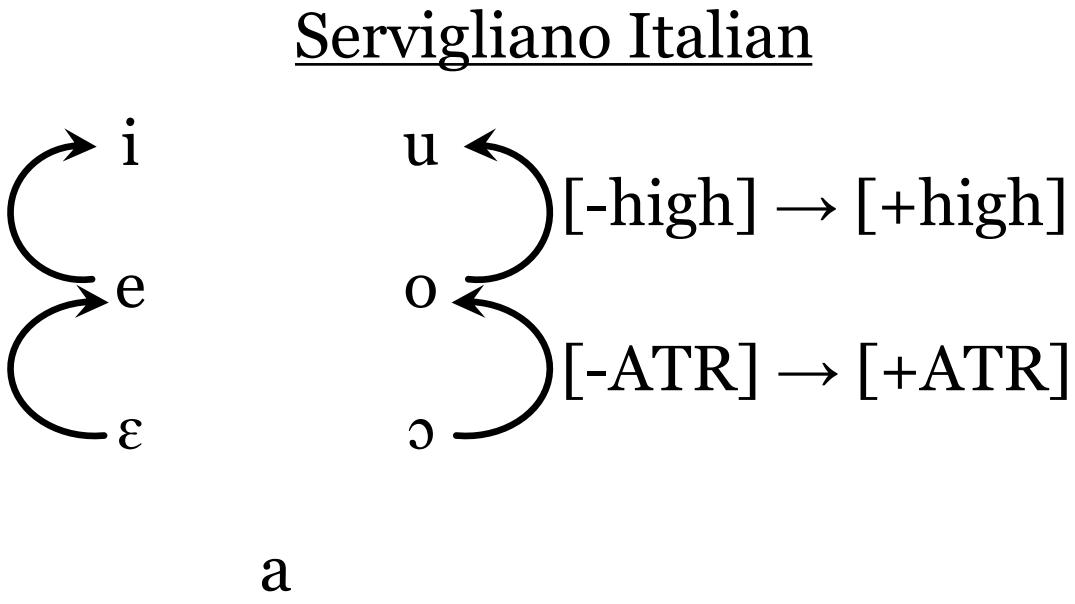
Servigliano Italian: Analysis

- Narrow-mid vowels /e/ and /o/ fully undergo harmony
- Relative gestural blending strengths favor goal articulatory state (narrow upper surface constriction) of high vowels



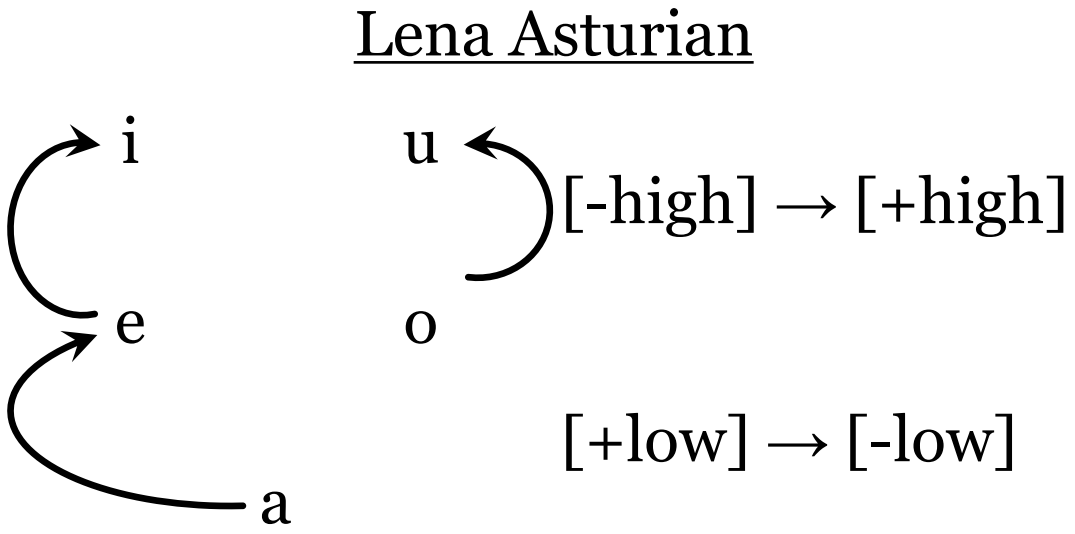
Featural Approaches to Partial Height Harmony

Binary Vowel Height Features



- In vowel inventory with more than two heights, multiple binary features must be used to distinguish them (e.g., [±high], [±low], [±ATR])
- Stepwise height harmony may involve spreading/assimilation of two or more different features in a single harmony process

Binary Vowel Height Features



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Stepwise Partial Height Harmony as Chain Shift

- Height harmony can produce apparent chain shifts:

ɛ → e → i ɔ → o → u

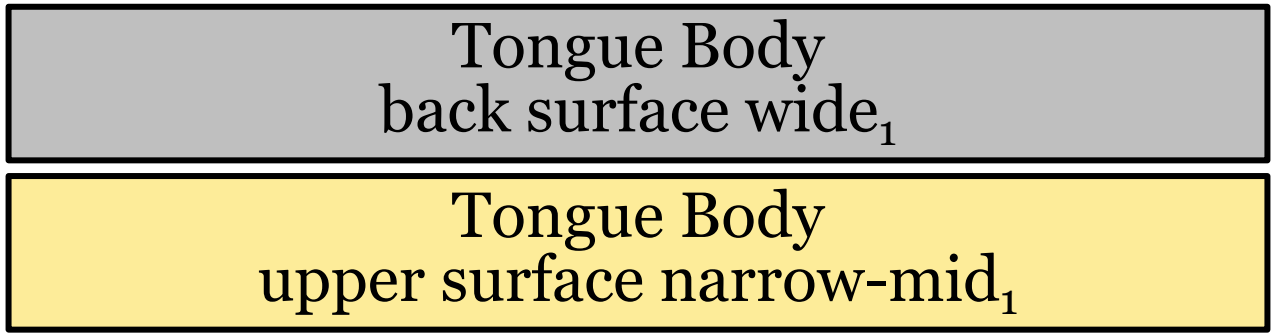
- Synchronic chain shifts in non-derivational framework via conjunction of faithfulness constraint (Kirchner 1996, Moreton & Smolensky 2002)

- Servigliano Italian (Walker 2011): conjoined constraint IDENT(high)&IDENT(ATR) prevents ɛ → i and ɔ → u

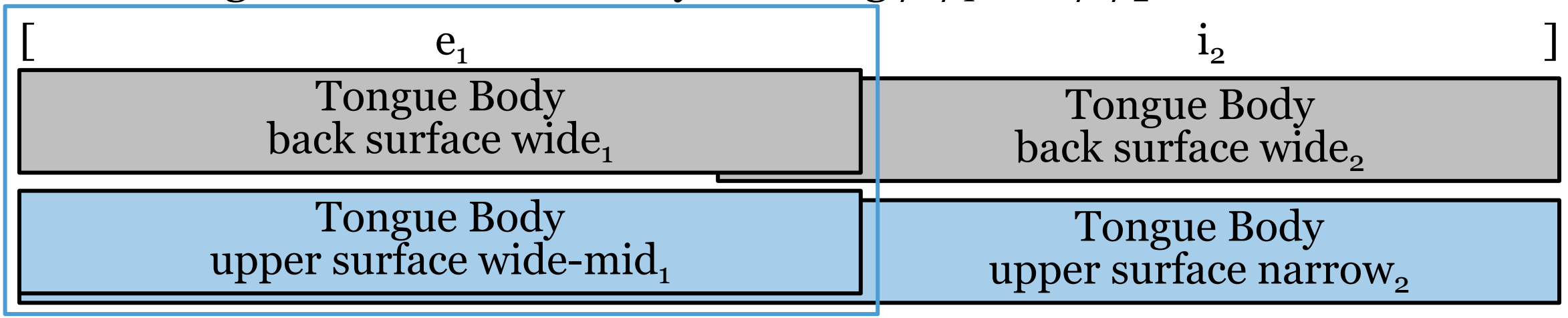
- Independently motivated individual constraints can produce unattested patterns when conjoined (Itô & Mester 1998, Fukazawa & Lombardi 2003, Pater 2009)

Underlying and Derived Vowels

- Underlying mid-high vowel /e/:

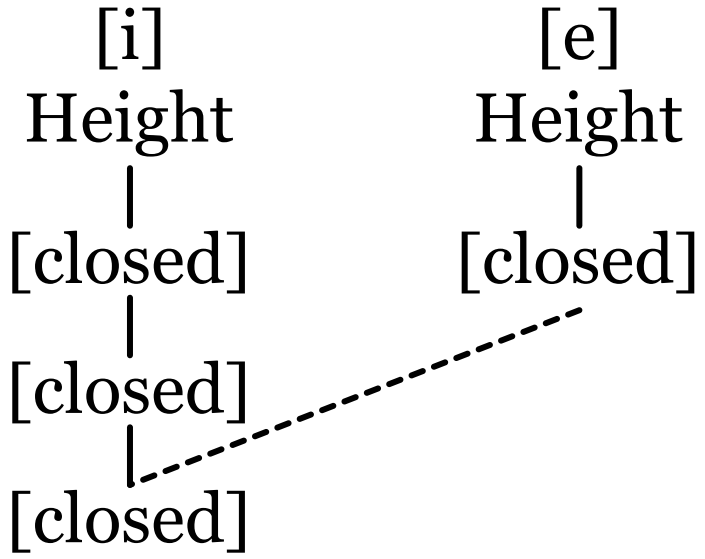


- Mid-high vowel [e] derived by blending /ɛ/$_1$ and /i/$_2$:



Scalar Vowel Height Features

- Incremental Constriction Model (Parkinson 1996): stacked [closed] features attached to Height node
- Partial height harmony is result of autosegmental spreading of lowest [closed] feature only



Scalar Vowel Height Features

- Incremental Constriction Model incorrectly predicts that partial height harmony always involves vowel raising
  - Spreading single [closed] features results in vowel raising
  - Vowel lowering only accomplished by spreading entire Height node

- Partial vowel lowering attested in Pende (Hyman 1999) and Herero (Kula & Marten 2000, Kula 2002)

Conclusion

Conclusion

- Partial height harmony can be analyzed as case of partial transparency to harmony
- Partial transparency is predicted by gestural model of harmony in which transparency is modeled as competition/blending of gestures with antagonistic goal states
- Avoids issues that arise in analyses that rely on binary or scalar height features

Work in Progress & Next Steps

- Work in progress: Extend analysis to vowel lowering harmonies (common in Bantu languages)
  - Partial vowel lowering in Pende and Herero
  - Lowering of some high vowels and not others in Bemba—a possible case of contrastive gestural strength?

- Next steps: computational modeling of speech production in TADA (Task Dynamic Application; Nam et al. 2004) using new vowel gesture constriction locations