Partial Height Harmony as Partial Transparency

2019 Annual Meeting on Phonology
October 11, 2019

Caitlin Smith

Johns Hopkins University
with support from Microsoft Research AI

Introduction

- Harmony: spreading of some phonological property throughout domain

/o-a-a/ → [o-o-o]

- Transparency: some segments are apparently skipped by harmony process

/o-i-a/ → [o-i-o]

- 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 (Romance; Italy) metaphony (raising harmony targeting stressed vowel; Camilli 1929, Nibert 1998, Walker 2011):

Non-Metaphony Context	**Metaphony Context**
[kr̲éd-o] ‘I believe’	[kr̲íd-i] ‘you believe’
[fj̲ór-e] ‘flower (masc. sg.)’	[fj̲úr-i] ‘flower (masc. pl.)’
[p̲ɛ́tten-e] ‘comb (masc. sg.)’	[p̲éttin-i] ‘comb (masc. pl.)’
[m̲ɔ́r-e] ‘he dies’	[m̲ór-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 constraint-based grammars

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* gestures with different articulatory goals

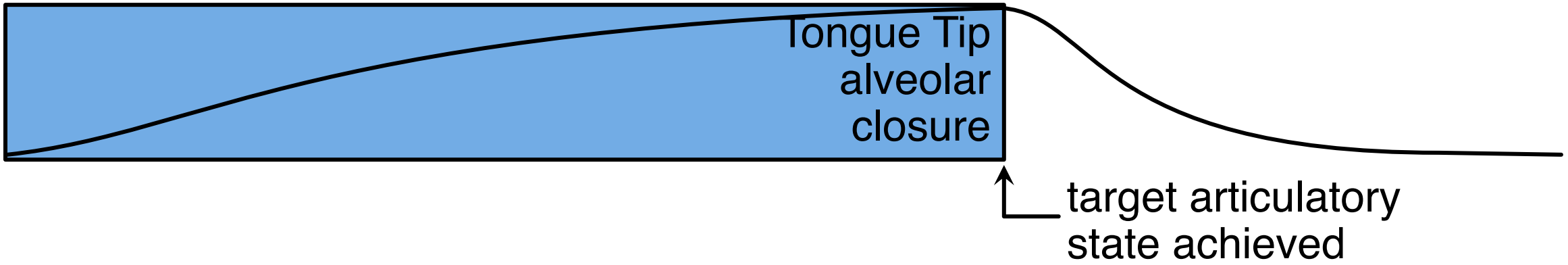
4. Partial transparency/partial undergoing is result of blending gestures of similar *strengths*

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

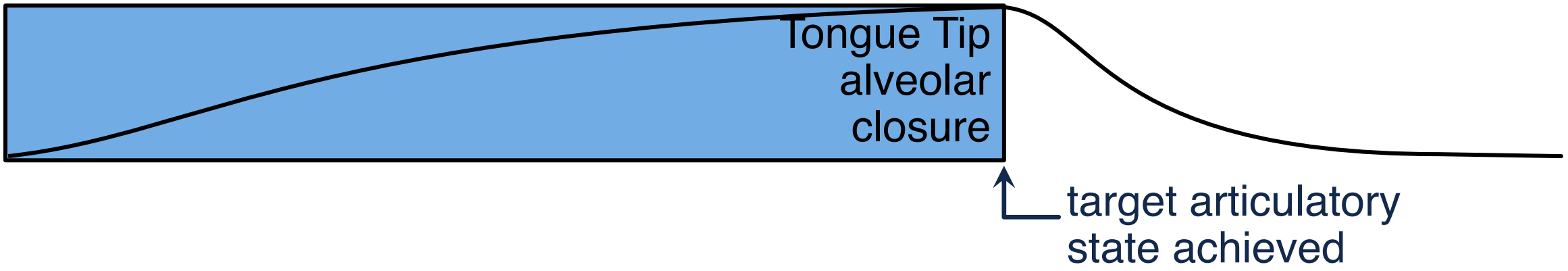
Gestures as Phonological Units

Gestural Representational Units

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

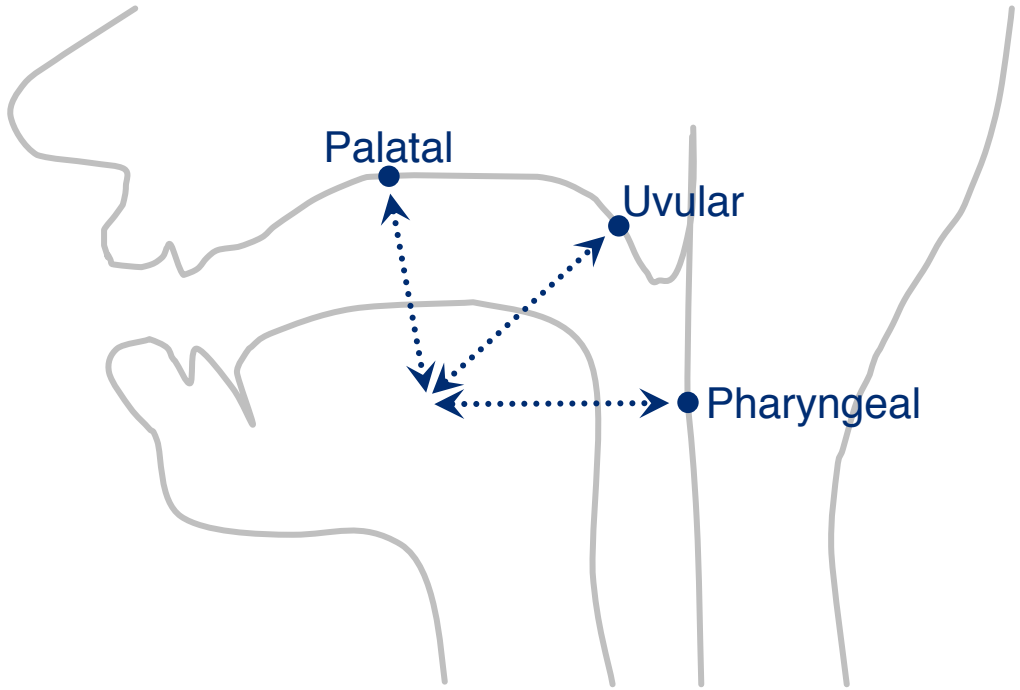


Gestural Parameters



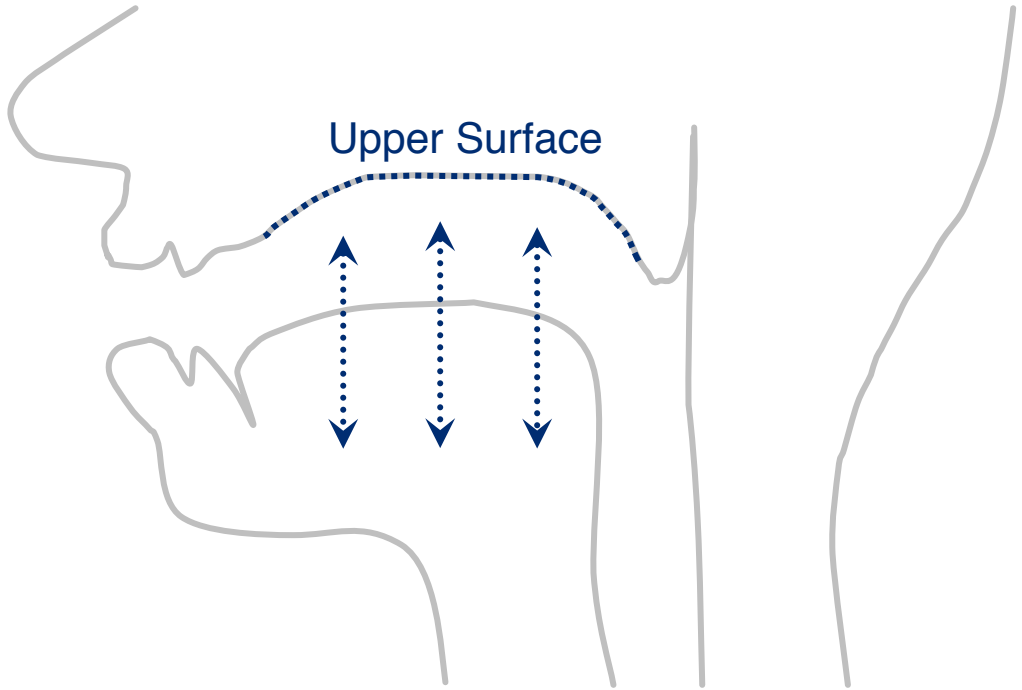
- Target articulatory state:
  - Constriction location
  - Constriction degree
- Stiffness (k): how quickly a gesture's target articulatory state is reached
- Blending strength (α): ability to command vocal tract articulators
- Ability to self-activate and self-deactivate (Smith 2016, 2017ab, 2018)

Constriction Location and Degree for Lingual Consonantal Gestures



- Constriction location of gesture specifies target point along vocal tract surface
- Constriction degree of gesture specifies distance between active articulator and constriction location point

Constriction Location and Degree for Vowel Gestures



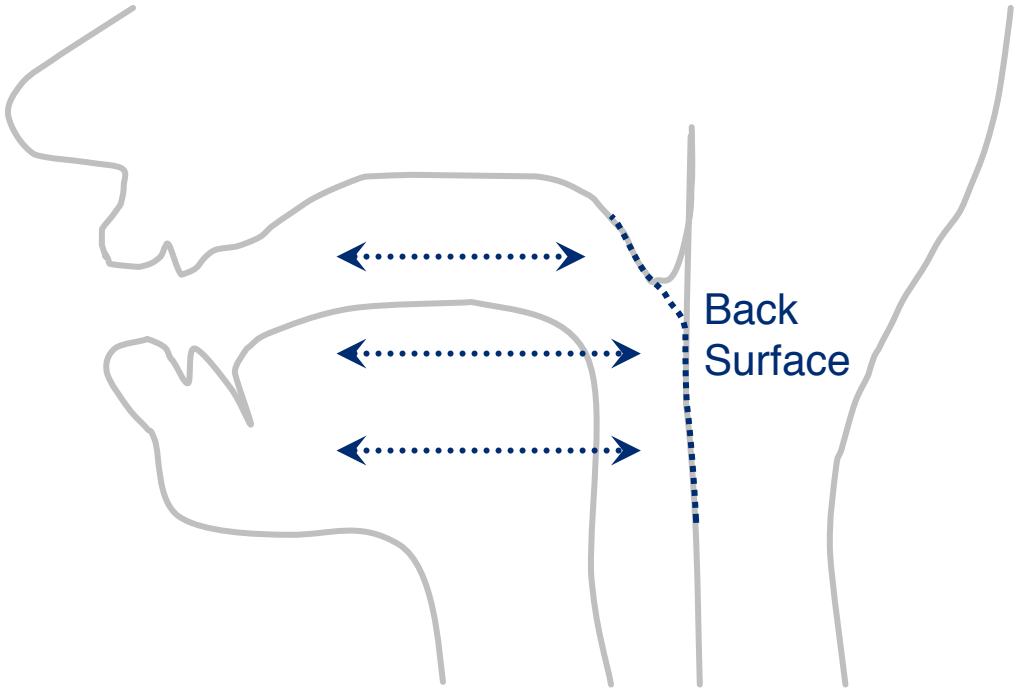
Each vowel includes two tongue body gestures:

- 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

Constriction Location and Degree for Vowel Gestures



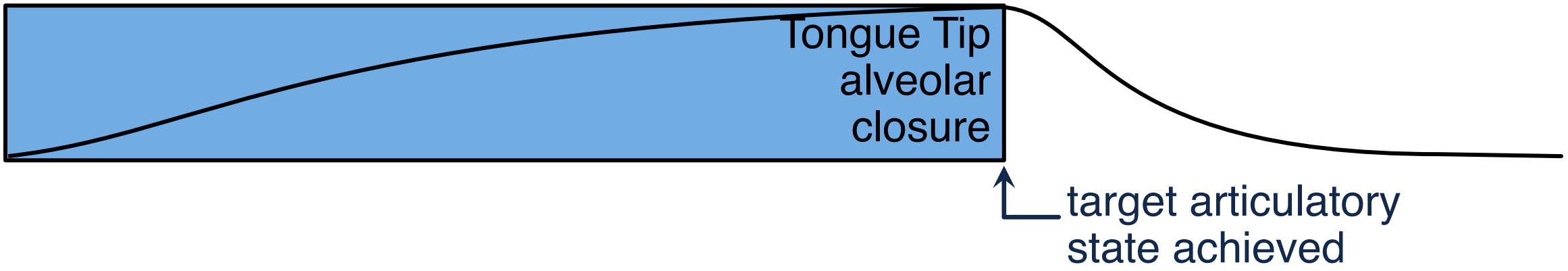
Each vowel includes two tongue body gestures:

- 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

Gestural Parameters

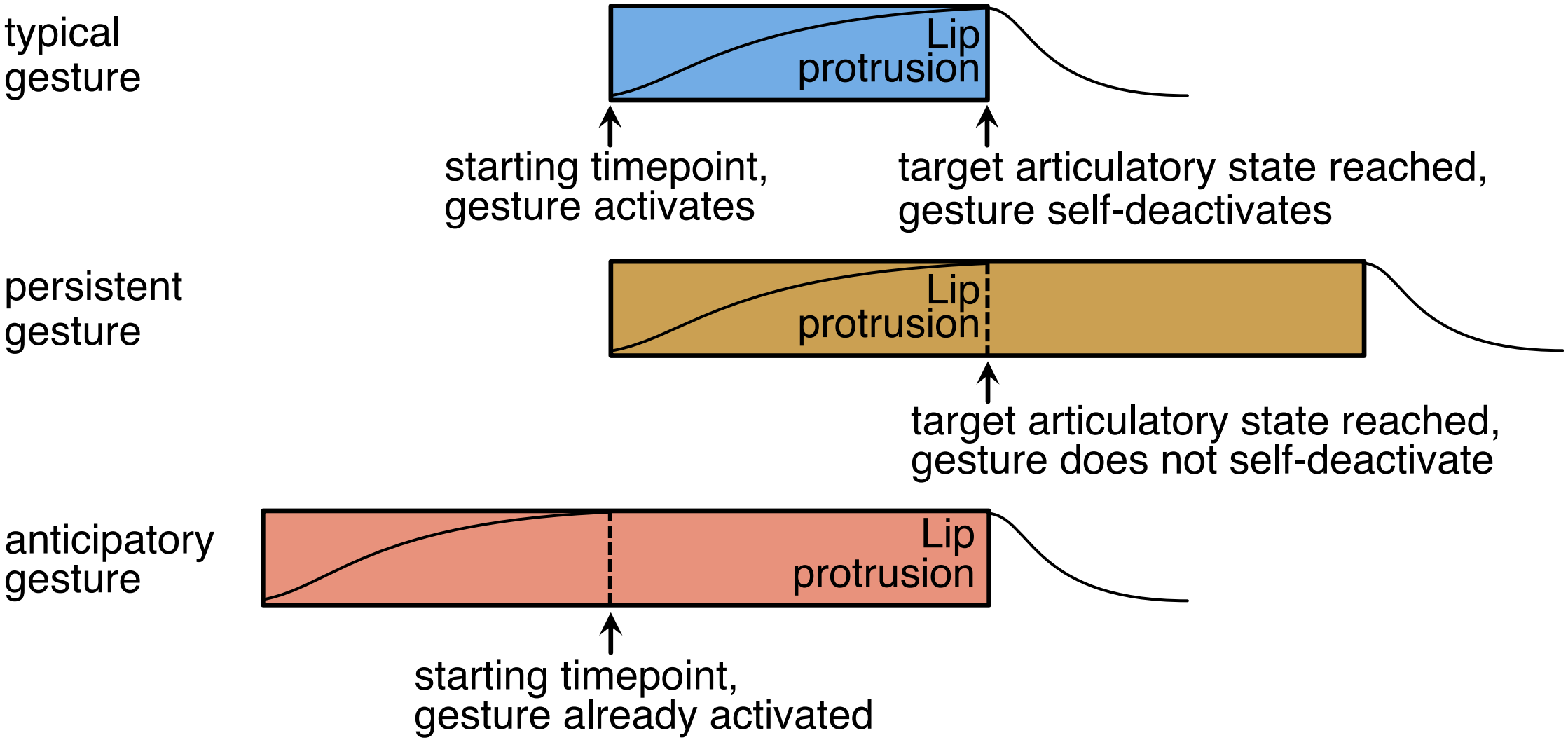


- Target articulatory state:
  - Constriction location
  - Constriction degree
- Stiffness (k): how quickly a gesture's target articulatory state is reached
- Blending strength (α): ability to command vocal tract articulators
- Ability to self-activate and self-deactivate (Smith 2016, 2017ab, 2018)

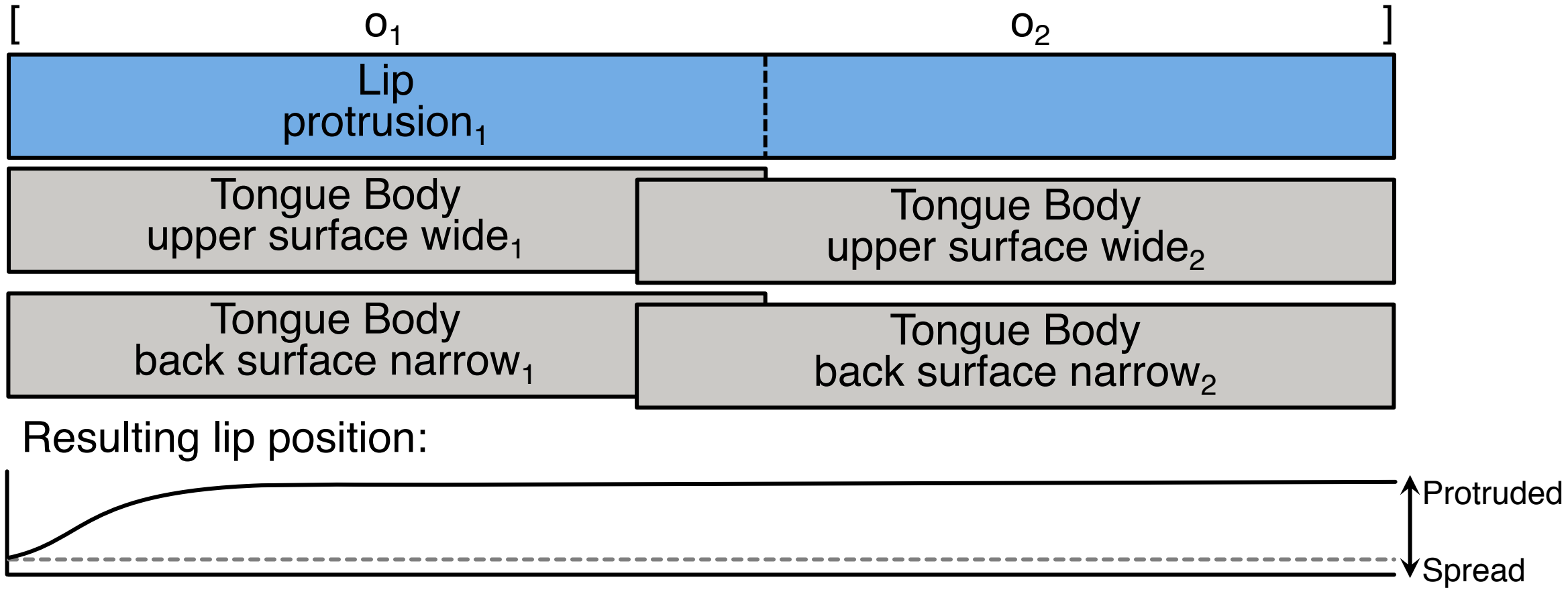
Harmony and Transparency via Gestural Blending

Gestural Activation and Deactivation

(Smith 2016, 2017ab, 2018)

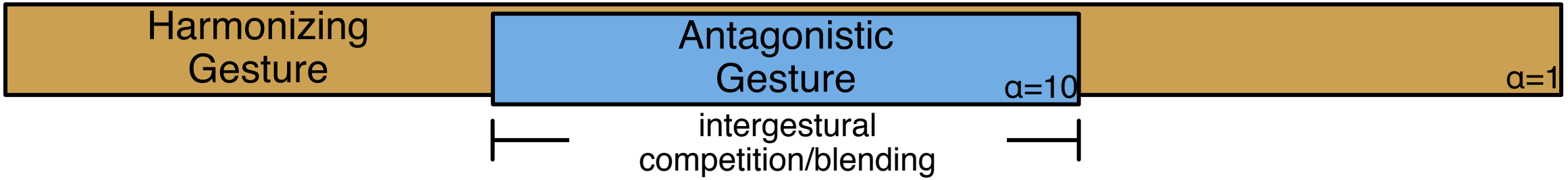


Example: Rounding Harmony



Transparency as Gestural Blending

- Transparency: competition between two concurrently active antagonistic gestures
- Gestural antagonism: two concurrently active gestures with opposing goal articulatory states
  - Lip protrusion vs. lip spreading
  - wide upper surface constriction vs. narrow upper surface constriction



Resulting state of vocal tract for some variable:

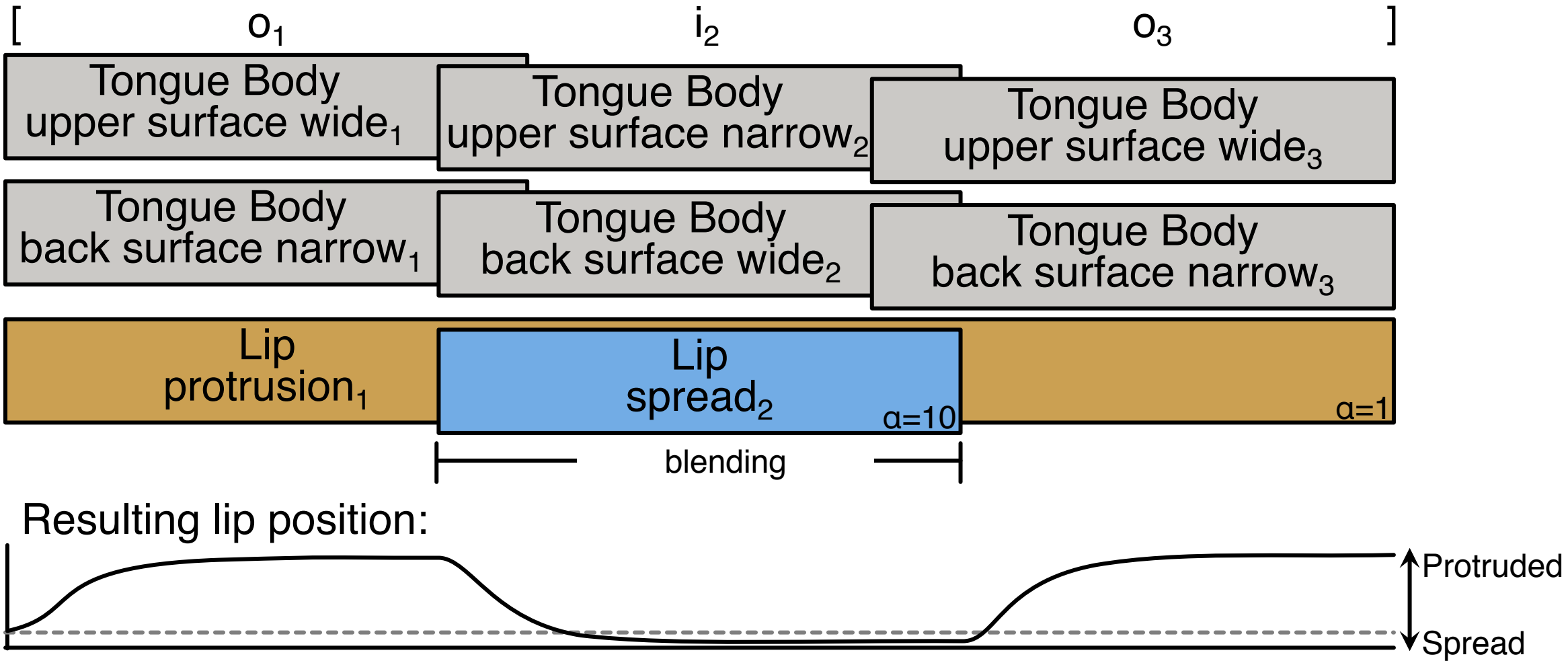
Gestural Strength and Blending

- 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)

$$\frac{\text{Target}_1 * \alpha_1 + \text{Target}_2 * \alpha_2}{\alpha_1 + \alpha_2} = \text{Blended Target}$$

Example: Transparency in Rounding Harmony

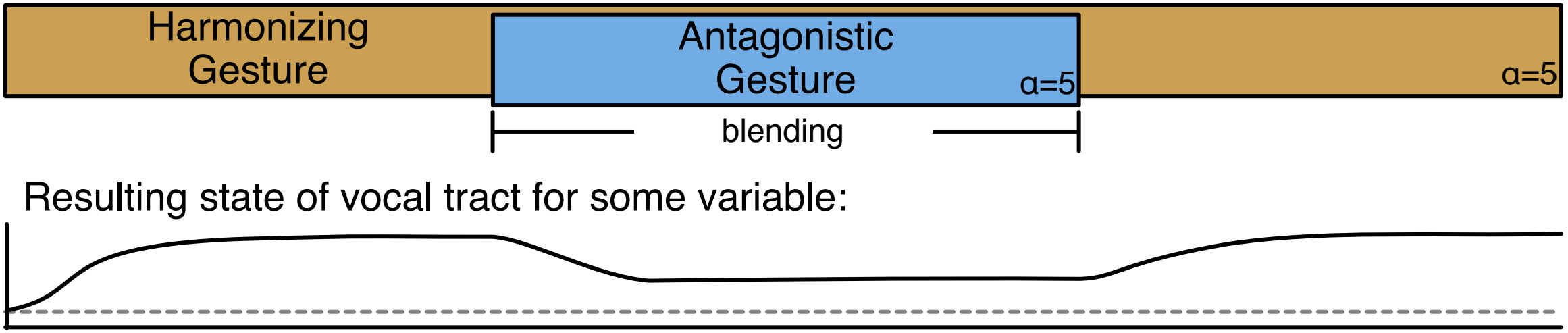


Advantages of Transparency via Gestural Blending

- Correctly predicts which segments can be transparent within nasal harmony and rounding harmony
- Avoids over-generation of predicted transparent segments (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 (Smith 2017c, 2018)

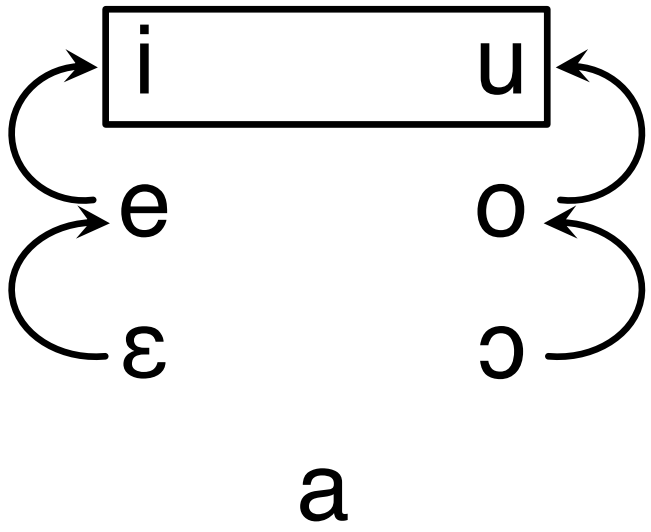


Partial Height Harmony in Servigliano Italian

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

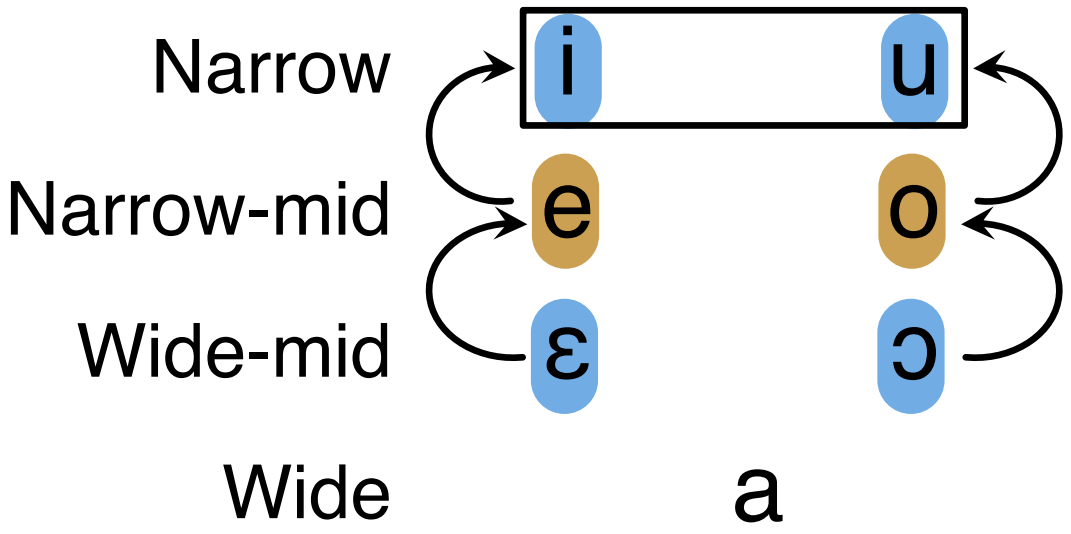
Non-Metaphony Context	Metaphony Context
[krḗd-o] ‘I believe’	[krī́d-i] ‘you believe’
[pḗs-a] ‘heavy (fem. sg.)’	[pī́s-u] ‘heavy (masc. sg.)’
[fjṓr-e] ‘flower (masc. sg.)’	[fjū́r-i] ‘flower (masc. pl.)’
[lṓŋg-a] ‘long (fem. sg.)’	[lū́ŋg-u] ‘long (masc.. sg.)’
[pɛ́tten-e] ‘comb (masc. sg.)’	[pḗttin-i] ‘comb (masc. pl.)’
[sgwɛ́ts-a] ‘suspicious (fem. sg.)’	[sgwḗts-u] ‘suspicious (masc. sg.)’
[mɔ́r-e] ‘he dies’	[mṓr-i] ‘you die’
[mɔ́ʃ-a] ‘dejected (fem. sg.)’	[mṓʃ-u] ‘dejected (masc. sg.)’

Servigliano Italian Partial Height Harmony



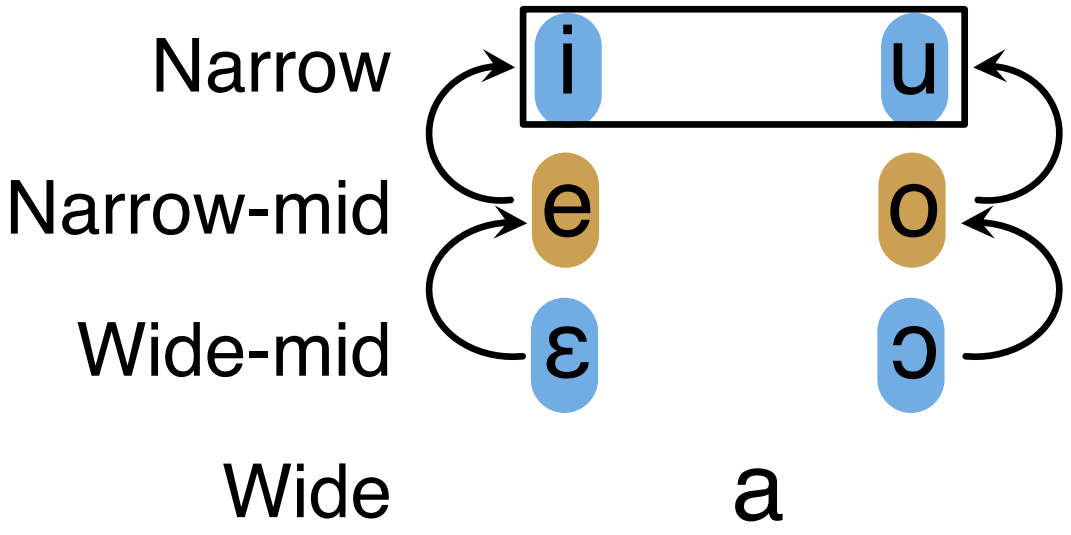
- Suffix high vowels trigger raising of preceding stressed vowels
- High-mid vowels raised to high
- Low-mid vowels raised to high-mid
- Partial step-wise raising harmony

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

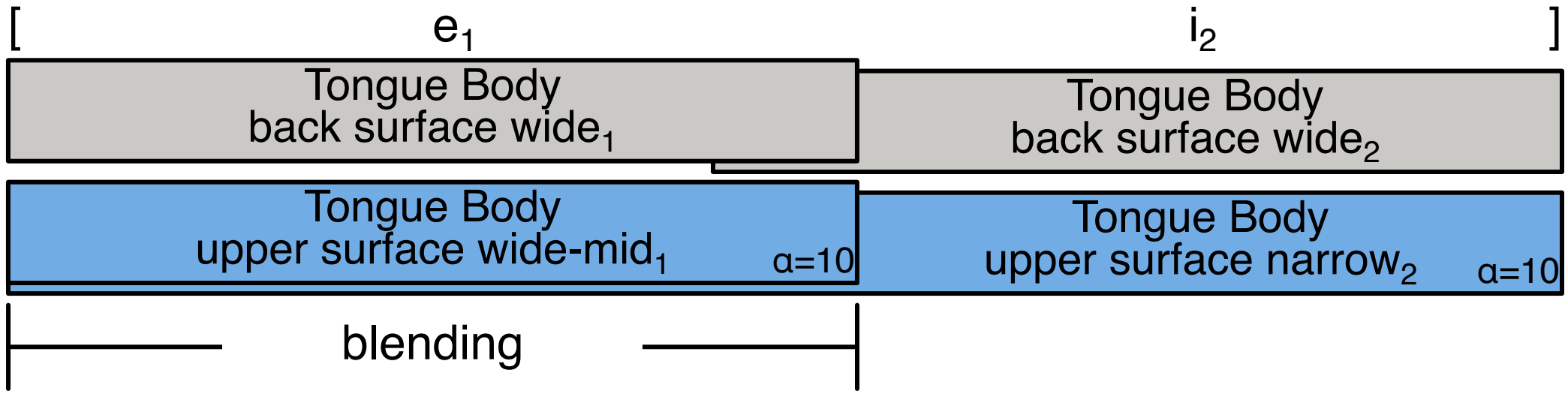
Gestural Blending Strength Calculations

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

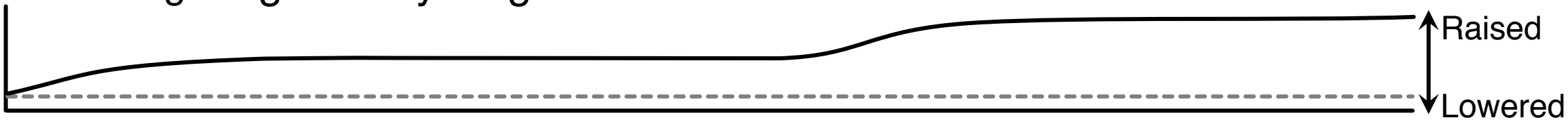
Vowel	Target Constriction Degree	Trigger Strength	Undergoer Strength	Blended Target Constriction Degree
/i/, /u/	4 mm	10		
/e/, /o/	8 mm	10	1	$\frac{4*10 + 8*1}{10 + 1} = 4.36$ mm
/ɛ/, /ɔ/	12 mm	10	10	$\frac{4*10 + 12*10}{10 + 10} = 8$ mm

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

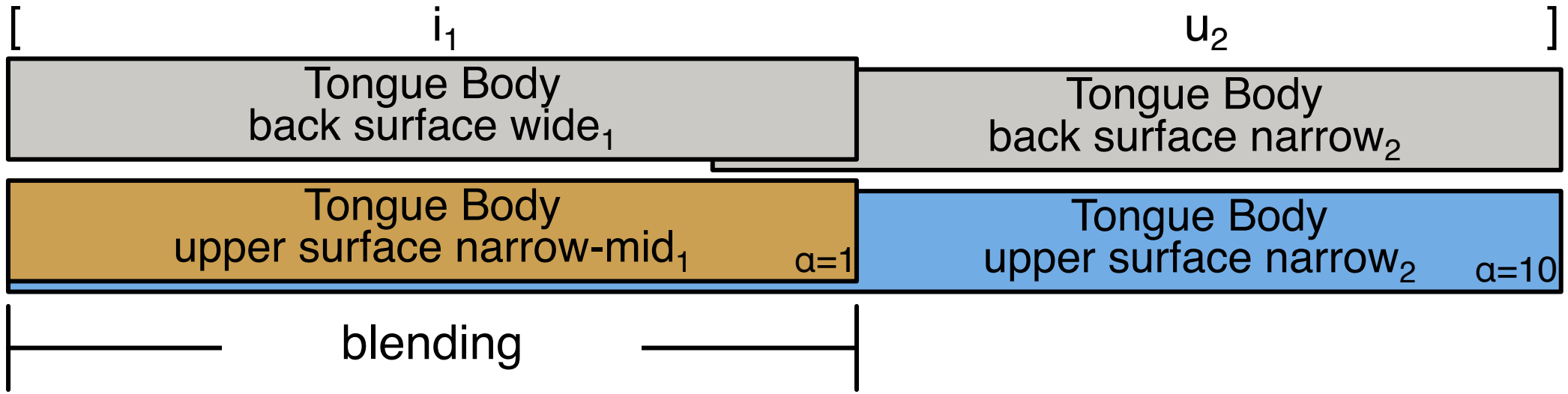


Resulting tongue body height:

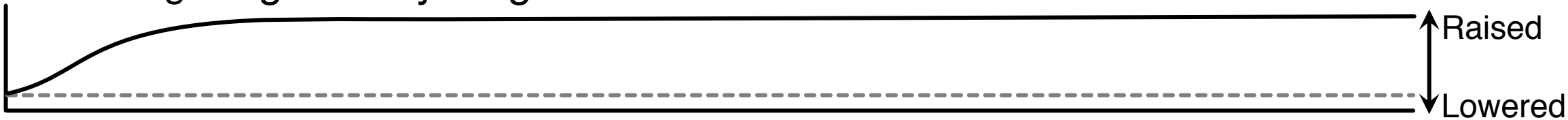


Servigliano Italian: Analysis

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

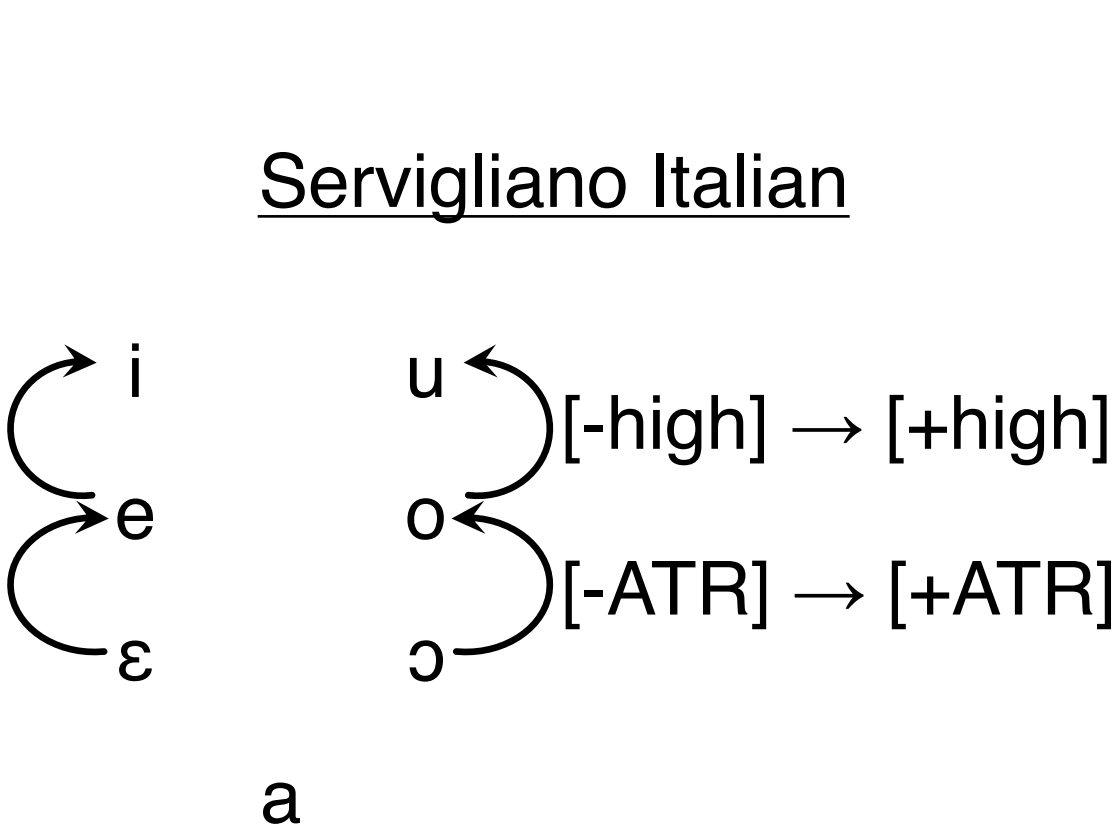


Resulting tongue body height:



Featural Approaches to Partial Height Harmony

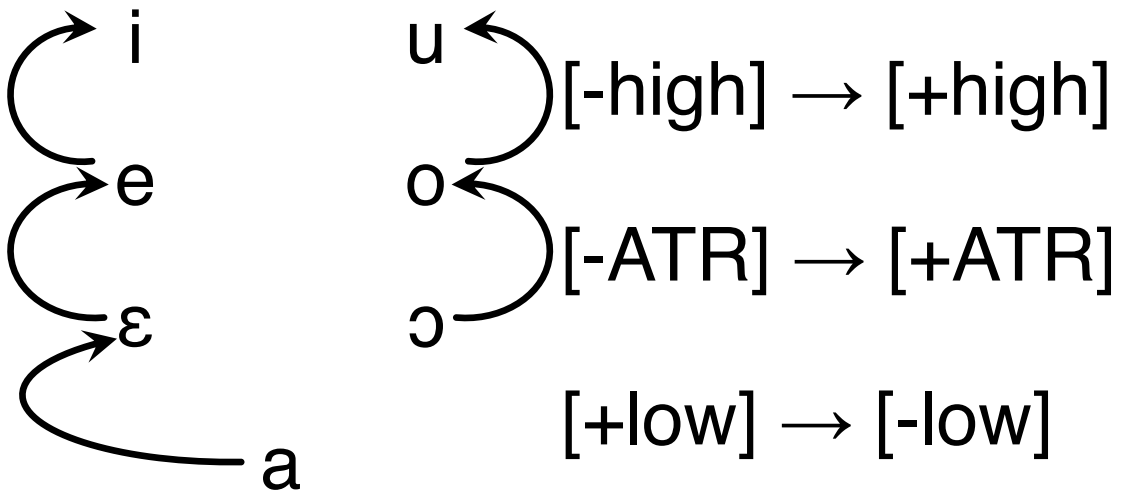
Binary Vowel Height Features



- 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

Nzebi (Bantu; Gabon)



- 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

Stepwise Partial Height Harmony as Chain Shift

- Partial height harmony produces apparent chain shifts:

ɛ → e → i ɔ → o → u

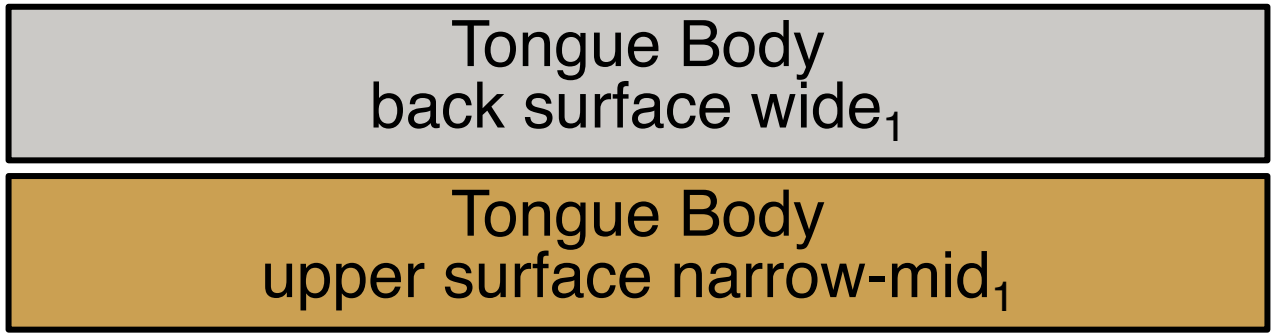
- Non-derivational frameworks (Optimality Theory, Harmonic Grammar) encounter difficulty with chain shifts and other derivationally opaque phonological patterns

Stepwise Partial Height Harmony as Chain Shift

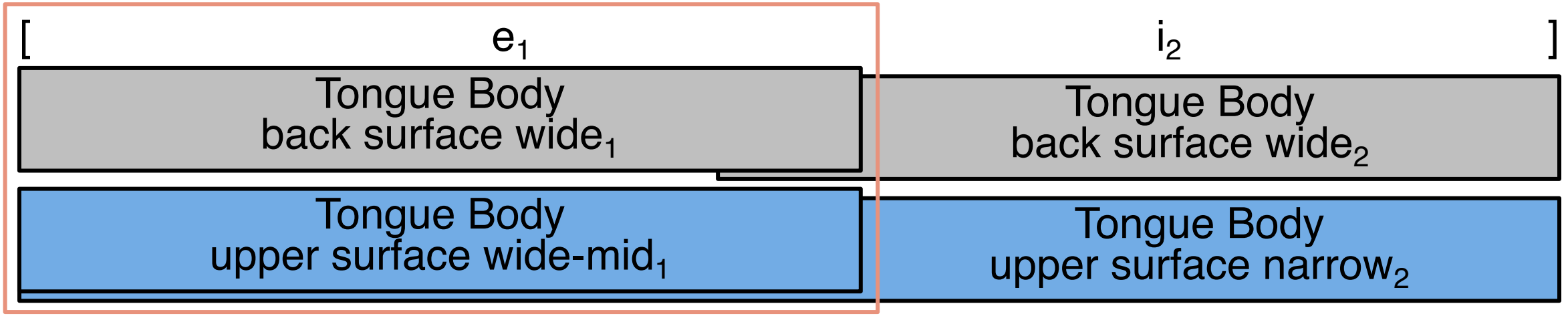
- Synchronic chain shifts in Optimality Theory via conjunction of faithfulness constraints (Kirchner 1996, Moreton & Smolensky 2002)
- Servigliano Italian (Walker 2011): conjoined constraint IDENT(high)&IDENT(ATR) prevents ɛ → i and ɔ → u
- Independently motivated individual constraints can produce unattested patterns when conjoined (Itô & Mester 1998, Fukazawa & Lombardi 2003, Pater 2009)
- Ganging of weighted constraints in Harmonic Grammar does not produce chain shifts (Magri 2018, this afternoon)

Underlying and Derived Vowels

- Underlying mid-high vowel /e/:

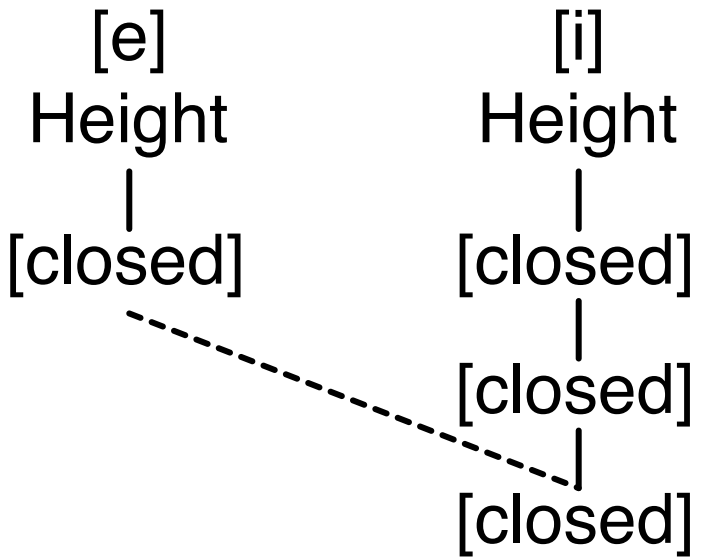


- Mid-high vowel [e] derived by blending /ɛ/$_1$ and /i/$_2$:



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 single-step vowel raising
  - Vowel lowering only accomplished by spreading entire Height node, resulting in full lowering

- 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 and additional grammatical mechanisms