Stepwise Height Harmony as Partial Transparency

NELS 50
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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

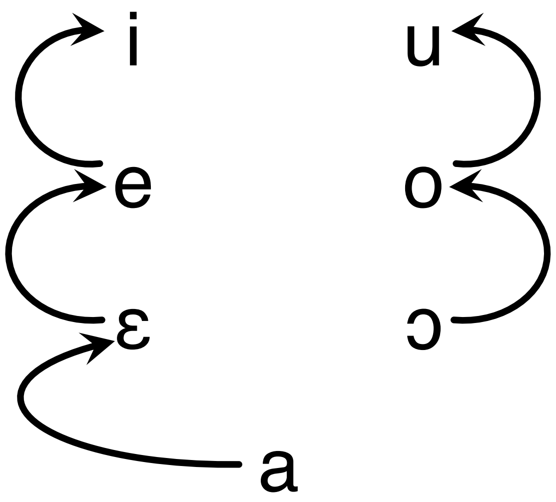
Stepwise/Partial Height Harmony

- Stepwise/partial height harmony: vowels raise one step along height scale, approaching height of trigger without necessarily reaching it
- Nzebi (Bantu; Gabon) raising harmony (Guthrie 1968, Clements 1991, Parkinson 1996, Kirchner 1996):

Non-Raising Context	Raising Context	Gloss
betə	bit-i	‘carry’
βoːmə	βuːm-i	'breathe’
sɛbə	seb-i	‘laugh’
mɔnə	mon-i	‘see’
salə	sɛl-i	‘work’

Difficulties of Analyzing Stepwise Height Harmony

Nzebi Raising Harmony



- Different height changes manipulate different vowel features (e.g., [±high] vs. [±low] vs. [±ATR])
- Scalar height features: undesirable predictions about possible direction of feature change (low to high vs. high to low) in stepwise harmony
- Stepwise harmonies involve chain shifts (X → Y → Z), requiring additional theoretical machinery in constraint-based grammars

Proposal: Partial Transparency in a Gestural Model of Harmony

Gestural Harmony Model (Smith 2016, 2017ab, 2018):

- Subsegmental units of phonological representation are goal-based, dynamically-defined *gestures*
- Harmony is result of extension of gesture to overlap gestures of other segments in a word
- Transparency to harmony is result of *blending* gestures with different target articulatory states

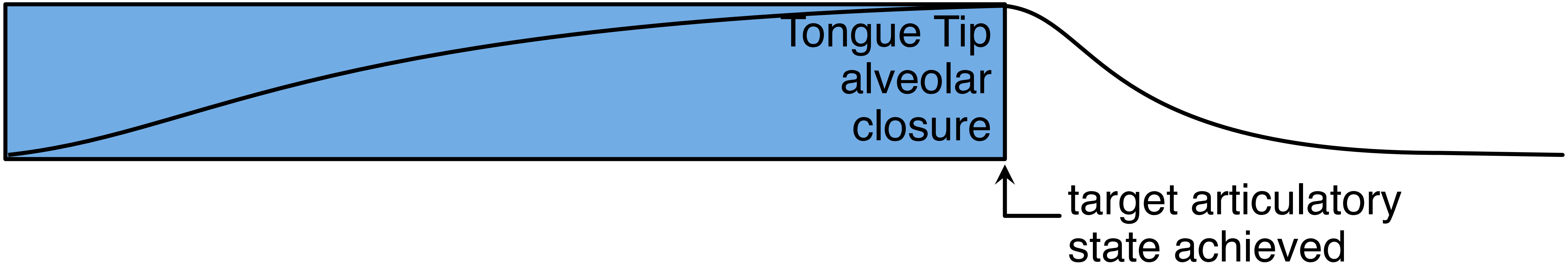
Proposals:

1) Partial transparency/partial undergoing is result of blending gestures of similar *strengths*
2) Stepwise partial height harmony is type of *partial transparency*

Gestures as Phonological Units

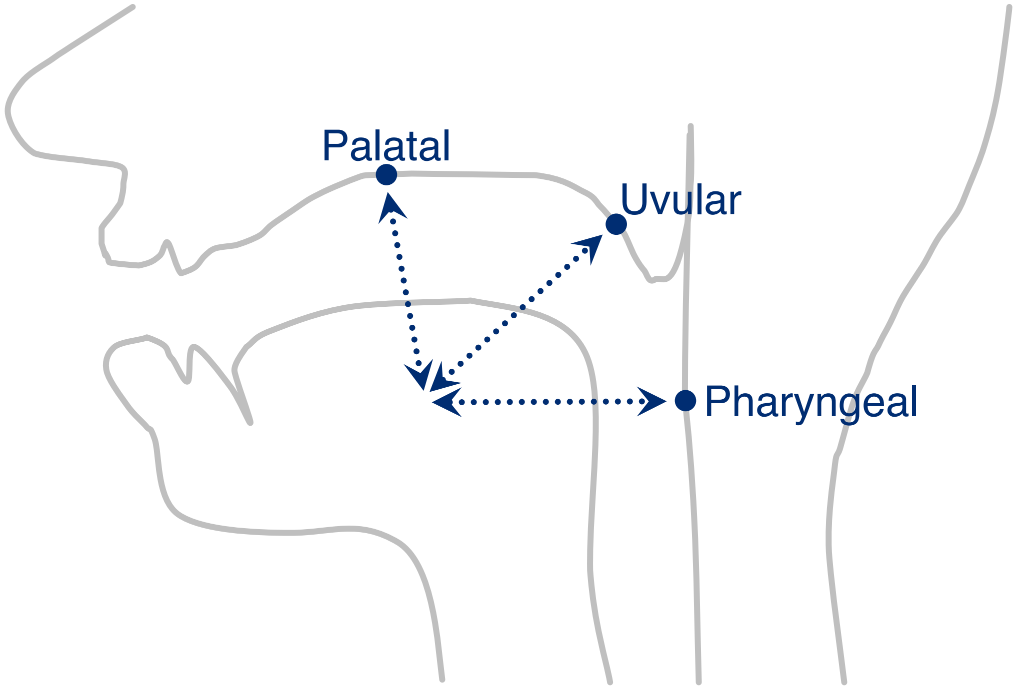
Gestural Parameters

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



- Target articulatory state:
  - Constriction location
  - Constriction degree
- Blending strength (α): ability to command vocal tract articulators
- Ability to self-activate and self-deactivate (Smith 2016, 2017ab, 2018)

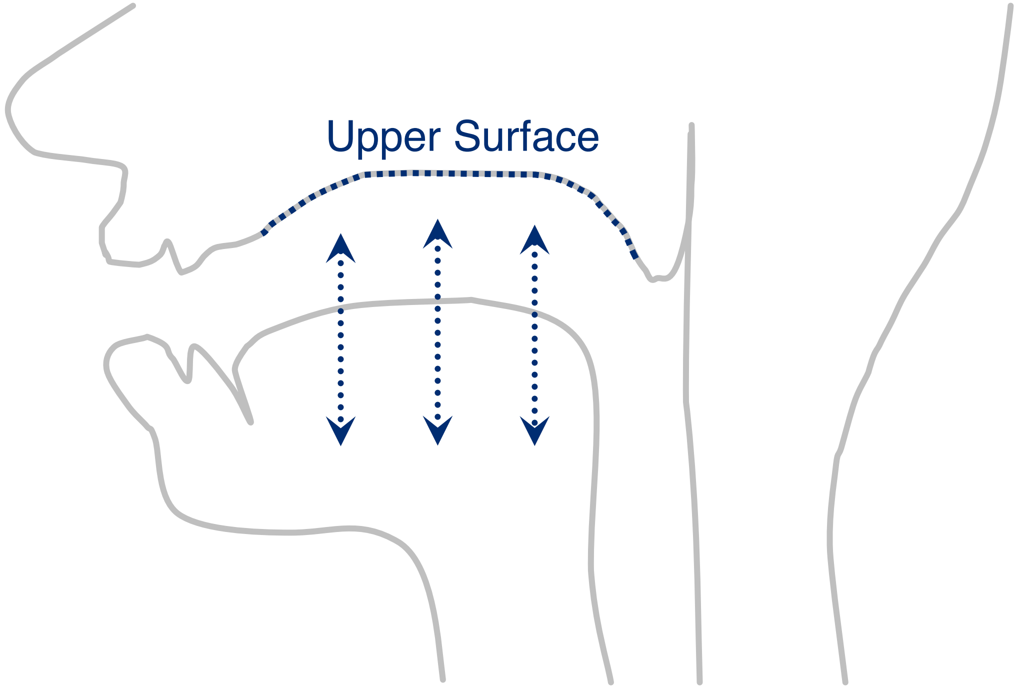
Constriction Location and Degree for Consonantal Gestures



- Constriction location of gesture specifies target point along vocal tract surface

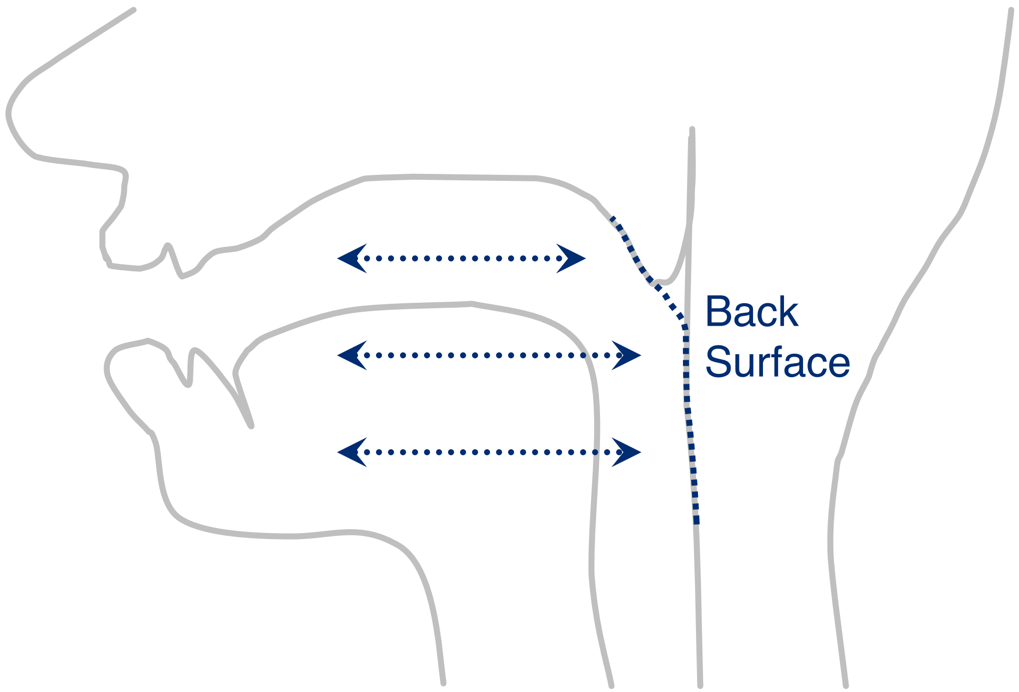
- Constriction degree of gesture specifies distance between active articulator and constriction location point

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



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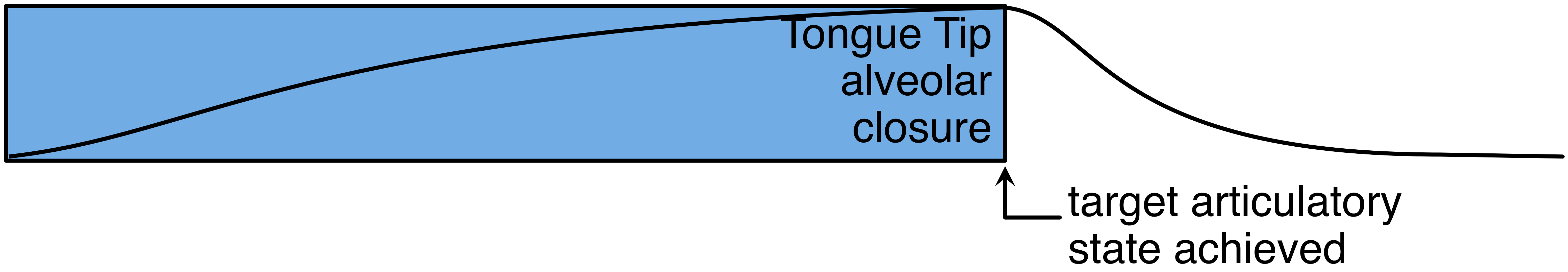

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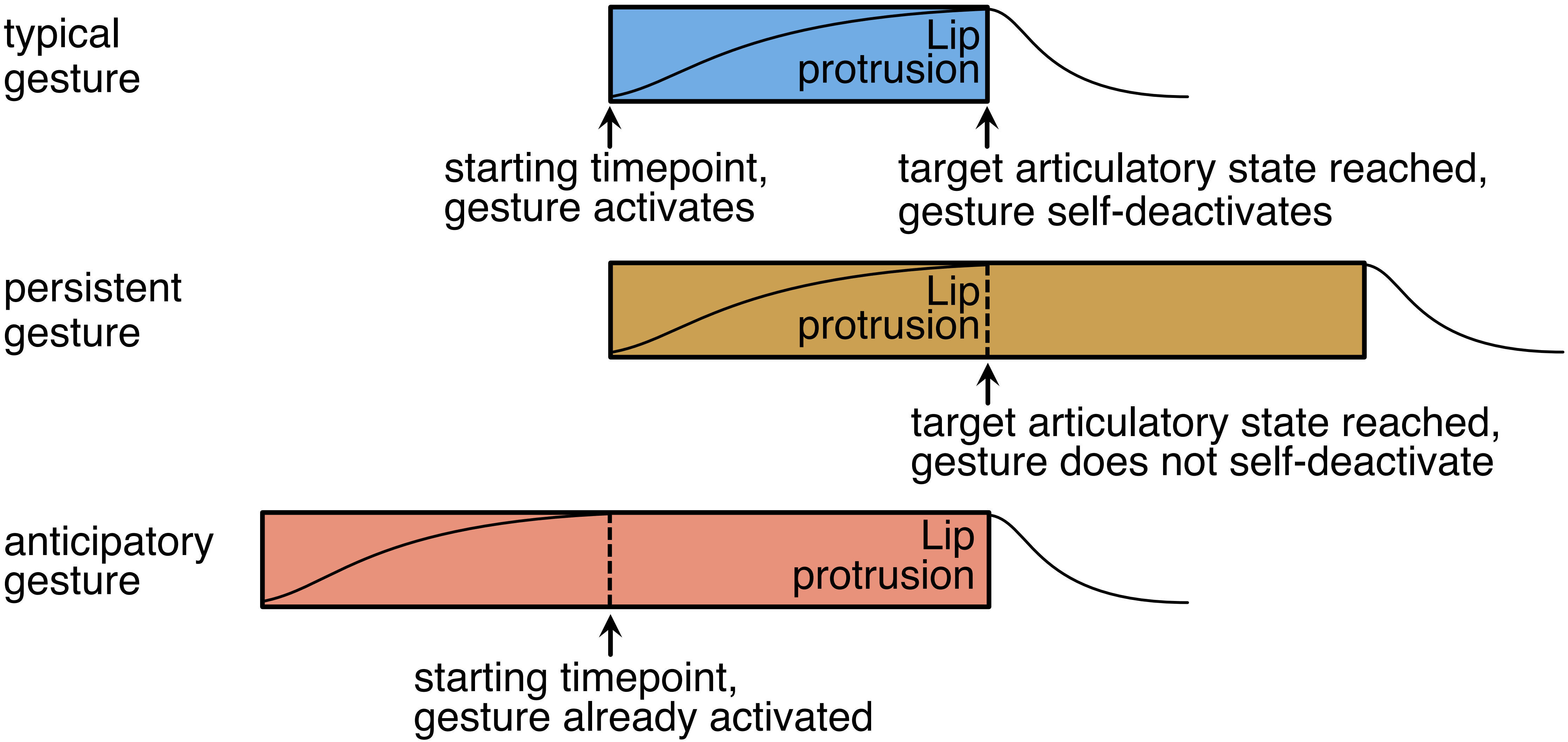
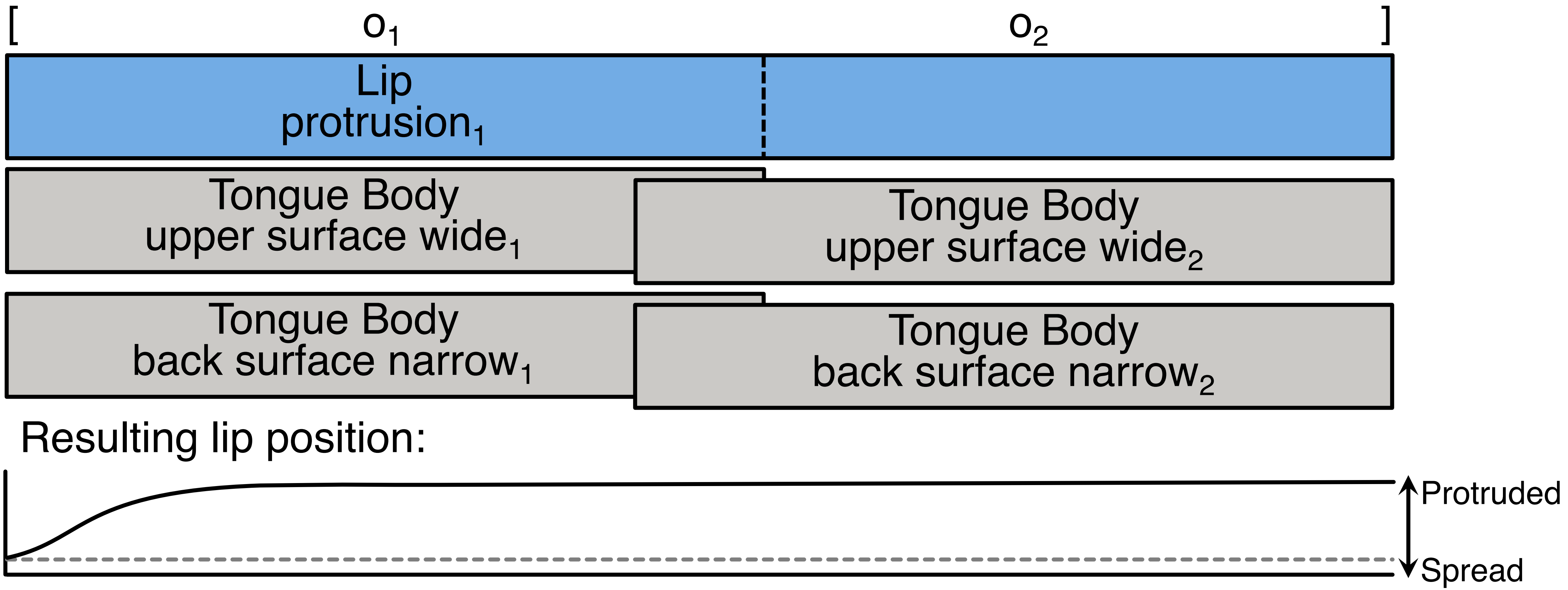
Harmony and Transparency via Gestural Blending

Gestural Activation and Deactivation

(Smith 2016, 2017ab, 2018)

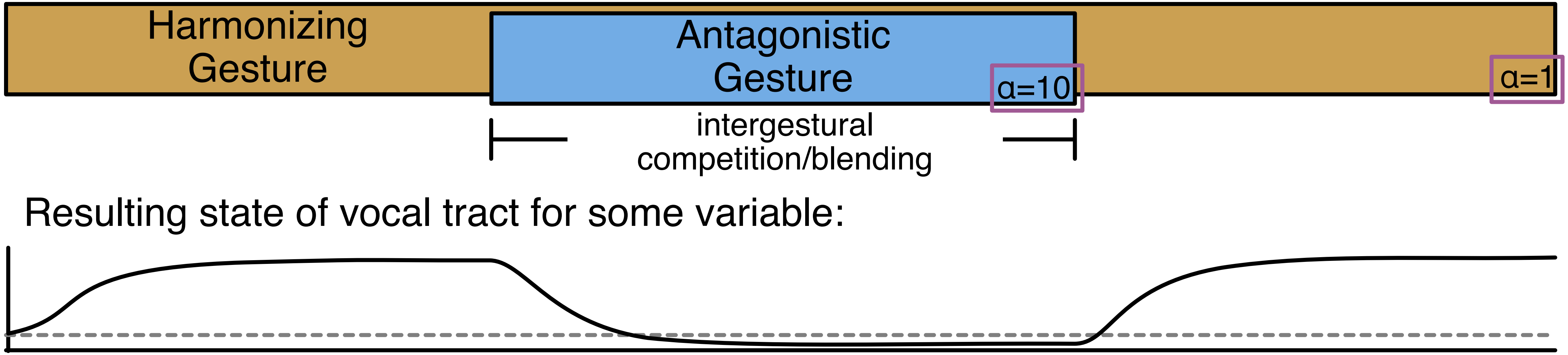


Example: Rounding Harmony



Transparency as Gestural Blending

- Transparency: competition between two concurrently active antagonistic gestures (Smith 2016, 2018)
- Gestural antagonism: two concurrently active gestures with opposing target articulatory states
  - Lip protrusion vs. lip spreading
  - wide upper surface constriction vs. narrow upper surface constriction



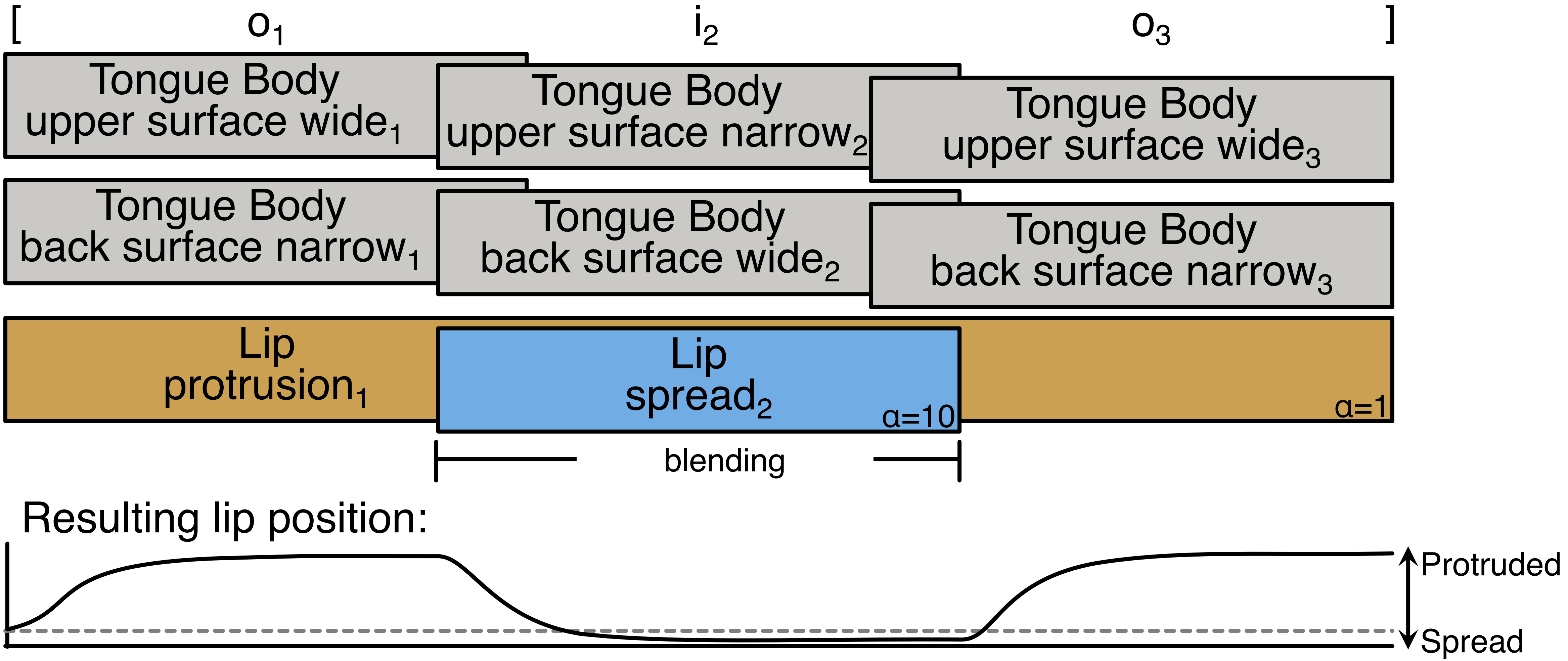
Gestural Strength and Blending

- Antagonistic gestures: gestures with conflicting target articulatory states

- Antagonism resolved by blending target 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

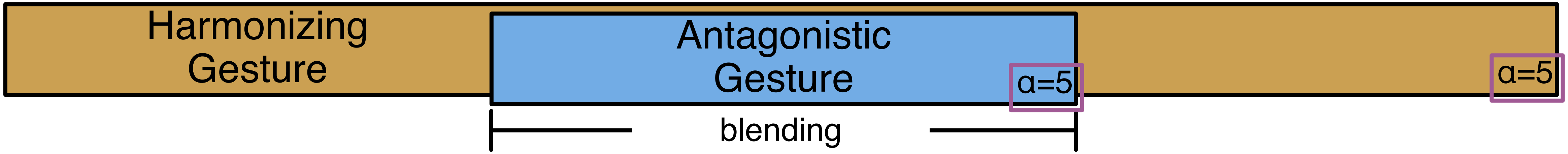
- Correctly predicts which segments can be transparent within nasal harmony and rounding harmony

- Avoids over-generation of predicted transparent segments (Smith 2016, 2018)

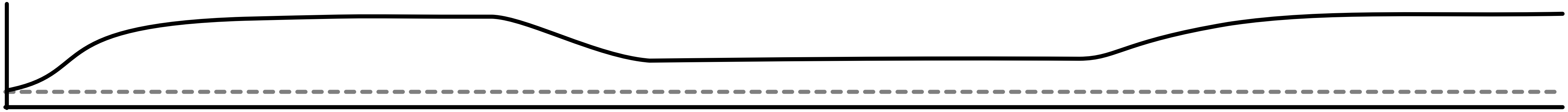
- Harmony is represented locally (without skipping), resulting in gestural antagonism with transparent segments

Prediction: Partial Transparency via Gestural Blending

- Full transparency: overlapped gesture of transparent segment is much stronger than harmonizing gesture (e.g. 10-to-1)
- 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)



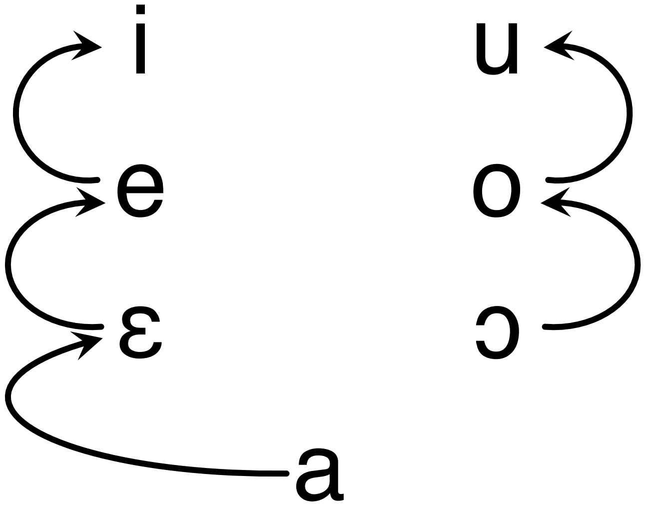
Resulting state of vocal tract for some variable:



Stepwise Height Harmony in Nzebi

Nzebi Stepwise/Partial Height Harmony

(Guthrie 1968, Clements 1991, Parkinson 1996, Kirchner 1996)



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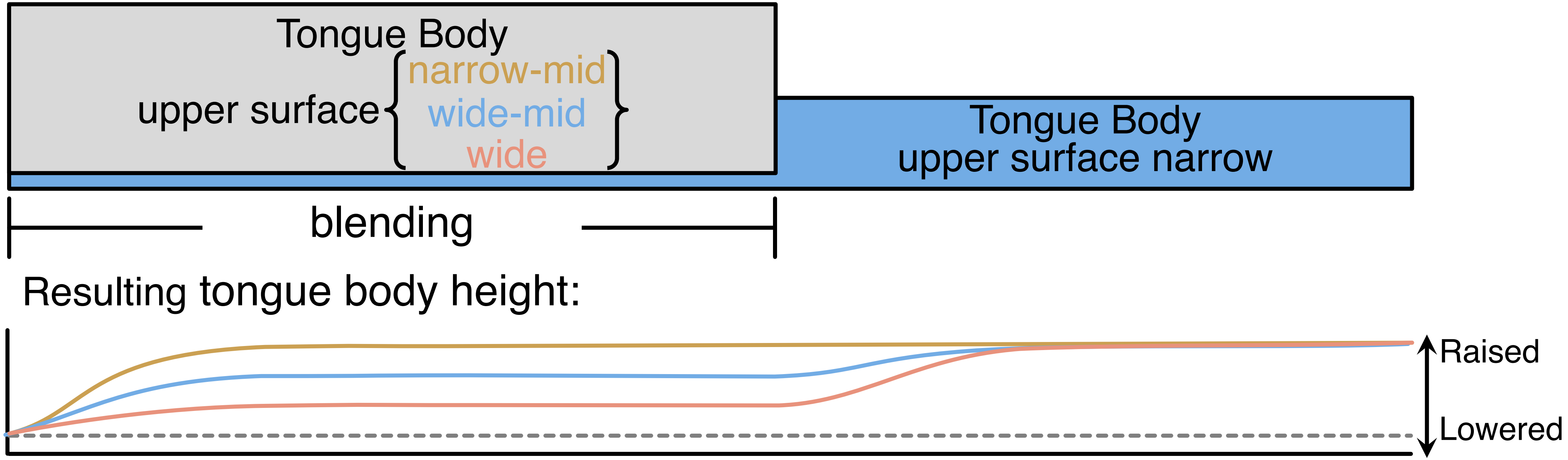
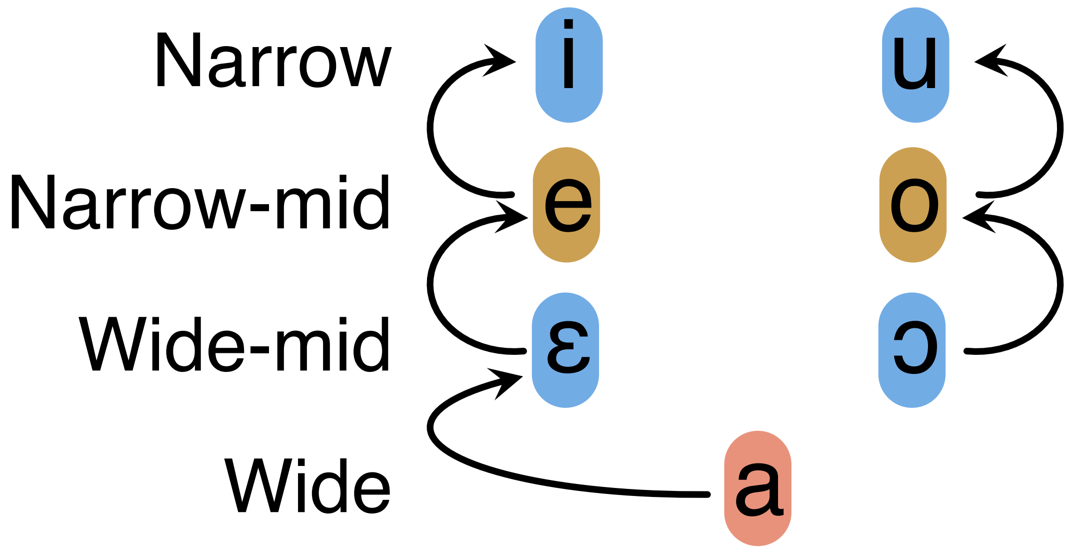
[salə]	[sɛl-i]	‘work’

Nzebi: Analysis

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



Nzebi Gestural Strength Parameters



- Relatively weak narrow-mid vowels /e/ and /o/ do not resist raising and surface as narrow
- Wide-mid vowels /ɛ/ and /ɔ/ surface as narrow-mid, partially resisting raising to narrow due to strength equal with trigger gesture
- Strong vowel /a/ surfaces as wide-mid, mostly resisting raising due to strength greater than trigger gesture

Gestural Blending Strength Calculations

Vowel	Target Constriction Degree	Strength
/i/, /u/	4 mm	10
/e/, /o/	8 mm	1
/ɛ/, /ɔ/	12 mm	10
/a/	16 mm	20

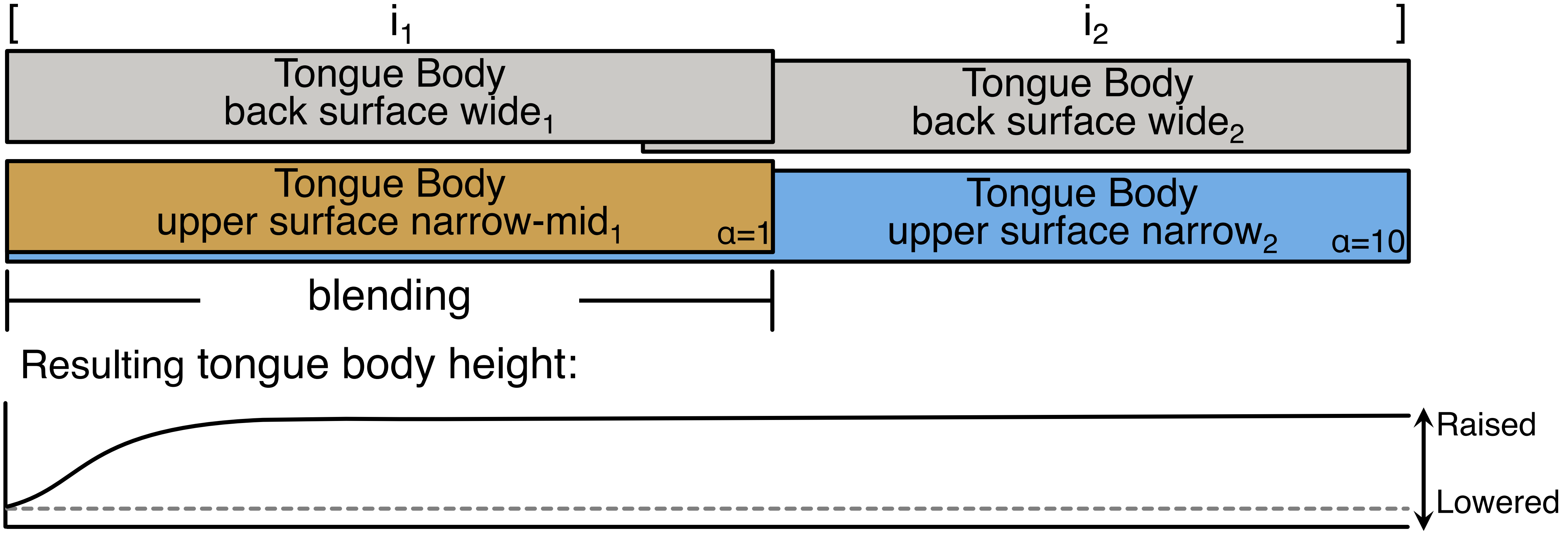
$$\frac{4*10 + 8*1}{10 + 1} = 4.36 \text{ mm}$$

$$\frac{4*10 + 12*10}{10 + 10} = 8 \text{ mm}$$

$$\frac{4*10 + 16*20}{10 + 20} = 12 \text{ mm}$$

Nzebi: Analysis

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



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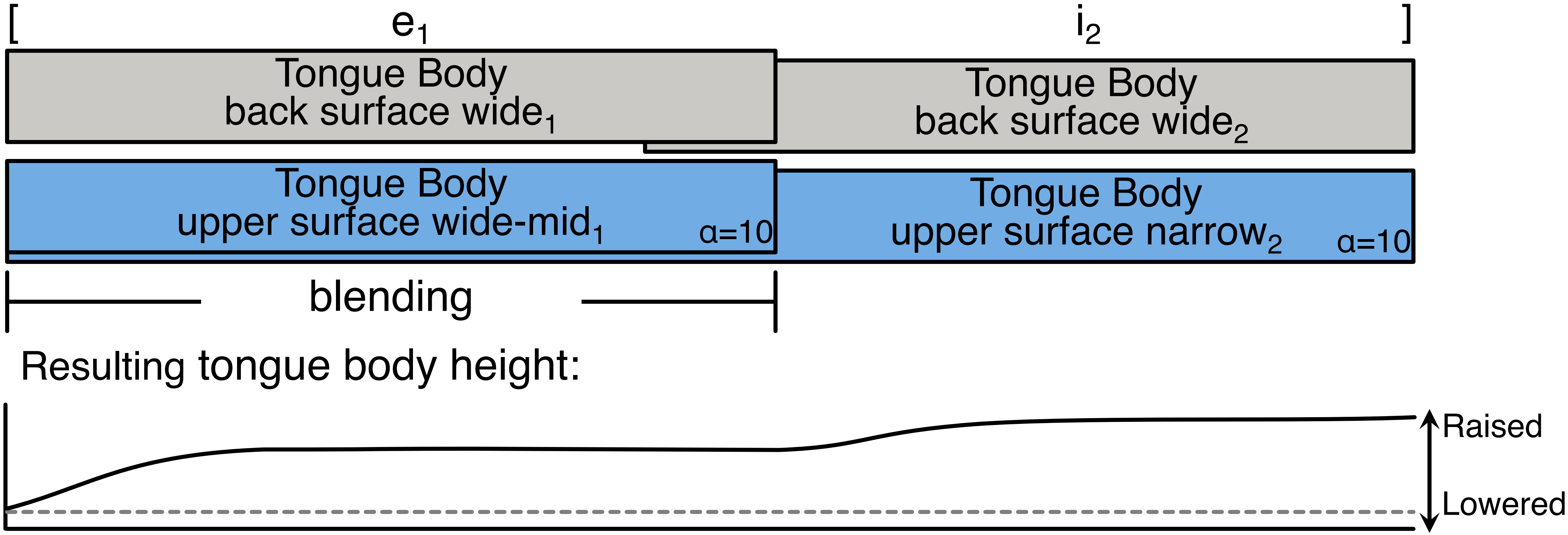
Nzebi: Analysis

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



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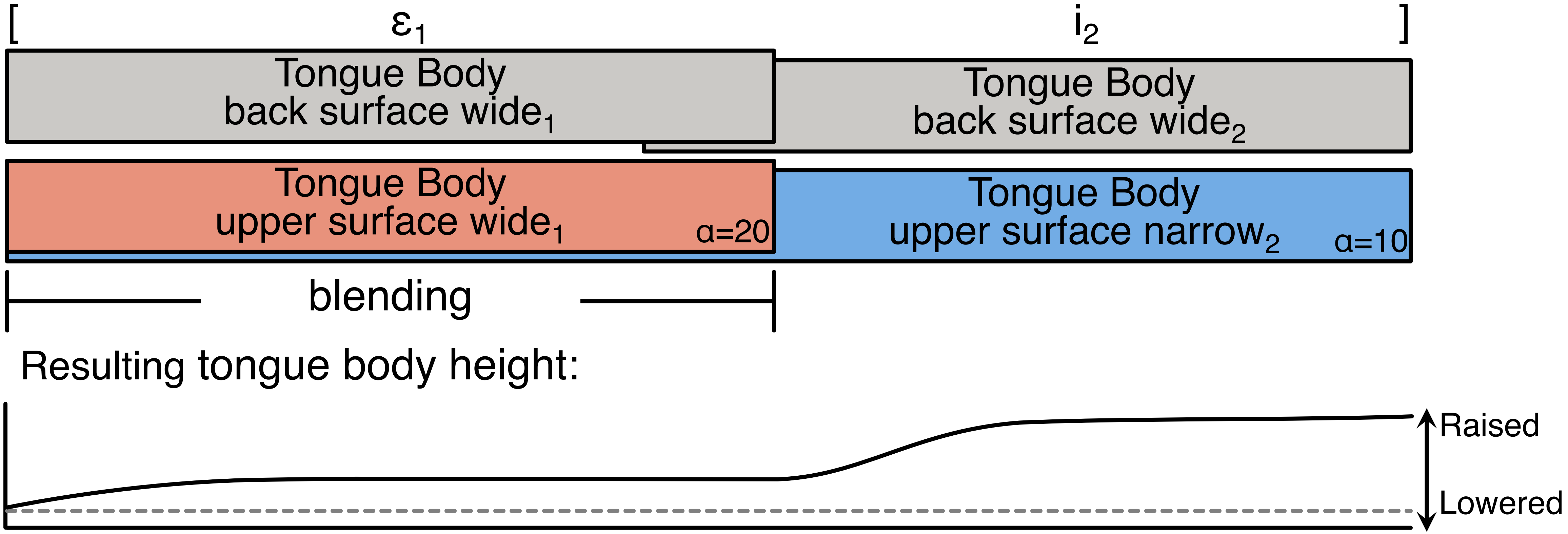
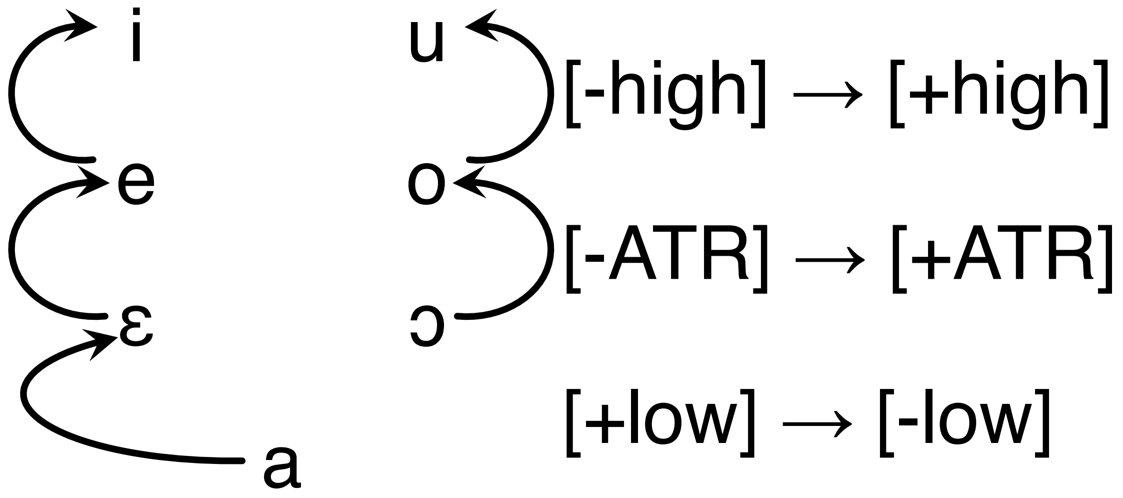
Nzebi: Analysis

- Overlap between gestures of wide vowel /a/ and narrow /i/ produces wide-mid vowel [ɛ]
- Blending strengths slightly favor target constriction degree of wide vowel



Featural Approaches to Stepwise/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

Stepwise Partial Height Harmony as Chain Shift

- Stepwise height harmony produces apparent chain shifts:

  a → ɛ → e → i   ɔ → o → u

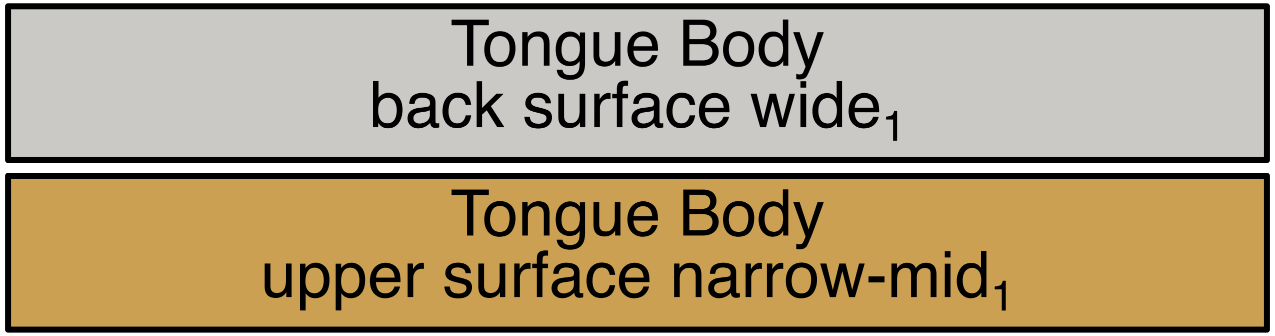
- Non-derivational frameworks (Optimality Theory, Harmonic Grammar) encounter difficulty with chain shifts and other derivationally opaque phonological patterns

Stepwise Partial Height Harmony as Chain Shift

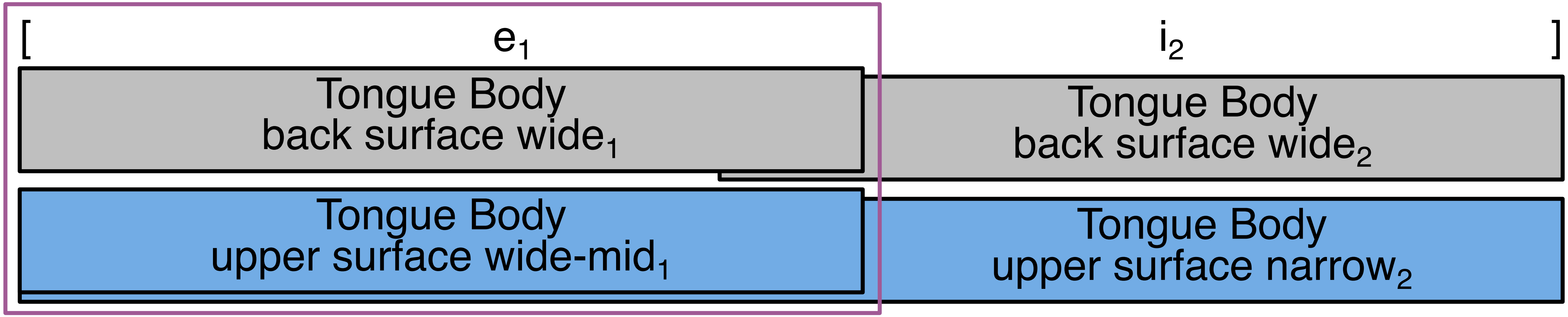
- Synchronic chain shifts in Optimality Theory via conjunction of faithfulness constraints (Kirchner 1996, Moreton & Smolensky 2002)
- Nzebi (Kirchner 1996): conjoined constraints IDENT(high)&IDENT(ATR) and IDENT(low)&IDENT(ATR) prevent raising more than single step
- Independently motivated individual 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)

Underlying and Derived Vowels

- Underlying mid-high vowel /e/:



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



Conclusion

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- Stepwise/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 target states
- Avoids issues that arise in analyses that rely on binary or scalar height features and additional grammatical mechanisms