Phonological Idiosyncrasy as Contrastive Gestural Strength

Situating Contrast within the Production-Perception Loop
Workshop at LabPhon 17
July 9, 2020

Caitlin Smith

Johns Hopkins University
with support from Microsoft Research

Introduction

- Phonological idiosyncrasy (a.k.a. exceptionality): two versions of same sound participate in phonological processes in different ways

$$/ti/_1 \rightarrow [ci] \qquad /ti/_2 \rightarrow [ti]$$

- Bemba (Bantu; Zambia): two series of high vowels that are phonetically indistinguishable but pattern differently phonologically
  - Susceptibility to vowel height harmony
  - Ability to trigger consonant mutation

Vowel Inventory from Proto-Bantu to Bemba

(Meinhof 1932; Meeussen 1967; Guthrie 1967-71)

Proto-Bantu (reconstructed) vowel inventory:

ɨ ʉ

i u

e o

a

Modern Bemba vowel inventory:

i u

e o

a

‘Superclose’ vowels and high vowels phonetically merged in Bemba, but still pattern differently phonologically

Bemba Height Harmony
(Hyman 1994, 1995; Zoll 1995; Kula 2002)

Height harmony (common throughout Bantu) lowers suffix high vowels after mid stem vowels:

Applicative /-il-/	Reversive/Separative /-ul-/
a. [ʃit-il-a] 'buy (appl.)'	a. [fimb-ul-a] 'uncover'
b. [ful-il-a] 'forge (appl.)'	b. [put-ul-a] 'cut'
c. [sek-el-a] 'laugh at (appl).'	c. [sel-ul-a] 'knock over'
d. [sos-el-a] 'speak (appl.)'	d. [kont-ol-a] 'break (trans.)'
e. [kak-il-a] 'tie (appl.)'	e. [aŋg-ul-a] 'peel'

no /u/ → [o] after [e]
(common throughout Bantu)

Bemba Height Harmony

(Hyman 1994, 1995; Zoll 1995; Kula 2002)

Reflexes of ‘superclose’ vowels in suffixes:

- Resist lowering due to height harmony
- Trigger mutation of root-final non-nasal consonants

Base Form	Causative /-i-/ < *į Passive /-w-/
a. [pet-a] ‘fold (intrans.)’	[peʃ-i-w-a] ‘be folded’
b. [end-a] ‘walk (intrans.)’	[enʃ-i-w-a] ‘be walked’
c. [sel-a] ‘move (intrans.)’	[seʃ-i-w-a] ‘be moved’
d. [kos-a] ‘be strong’	[koʃ-i-w-a] ‘be strengthened’
e. [ond-a] ‘be slim’	[onʃ-i-w-a] ‘be slimmed’

Bemba Consonant Mutation

(Hyman 1994, 1995; Zoll 1995; Kula 2002)

Reflexes of ‘superclose’ vowels in suffixes trigger root-final consonant mutation:

Base Form	Causative /-i-/ < *j̨
a. [pit-a] ‘pass’	[piʃ-a] ‘make pass’
b. [end-a] ‘walk’	[enʃ-a] ‘walk (trans.)’
c. [kul-a] ‘grow (intrans.)’	[kuʃ-a] ‘grow (trans.)’
d. [kos-a] ‘be hard’	[koʃ-a] ‘make hard’

Bemba Consonant Mutation

(Hyman 1994, 1995; Zoll 1995; Kula 2002)

Reflexes of ‘superclose’ vowels in suffixes trigger root-final consonant mutation:

Base Form	Agentive /-i-/ < *ị
a. [ful-a] ‘forge’	[mu-fuʃ-i] ‘blacksmith’
b. [lind-a] ‘protect’	[mu-linʃ-i] ‘guardian’

Dealing with Phonological Idiosyncrasy

Contrast between /i/ < *i and /i/ < *į may be based on:

- Differences in underlying feature (under-)specification
- Differences in gradient activation level (Smolensky & Goldrick 2016; Hsu 2019)
- Morpheme/segment indexation to constraints (Pater 2000, 2009) or cophonologies (Inkelas & Zoll 2007)

Proposal:
Contrastive *gestural strength* is responsible for phonological idiosyncrasy in Bemba

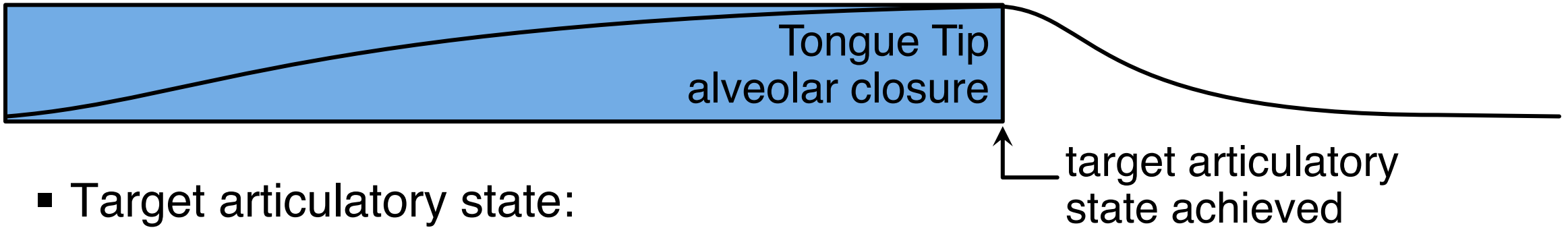
Why Gestural Strength?

- Recruits independently necessary element of gestural speech production model to account for cases of phonological idiosyncrasy
- Non-abstract/non-opaque, eliminating need for special grammatical mechanisms necessary for many featural analyses of phonological idiosyncrasy
- Captures relationship between consonant mutation and height harmony processes in Bemba with single gestural parameter

Gestures and Gestural Strength

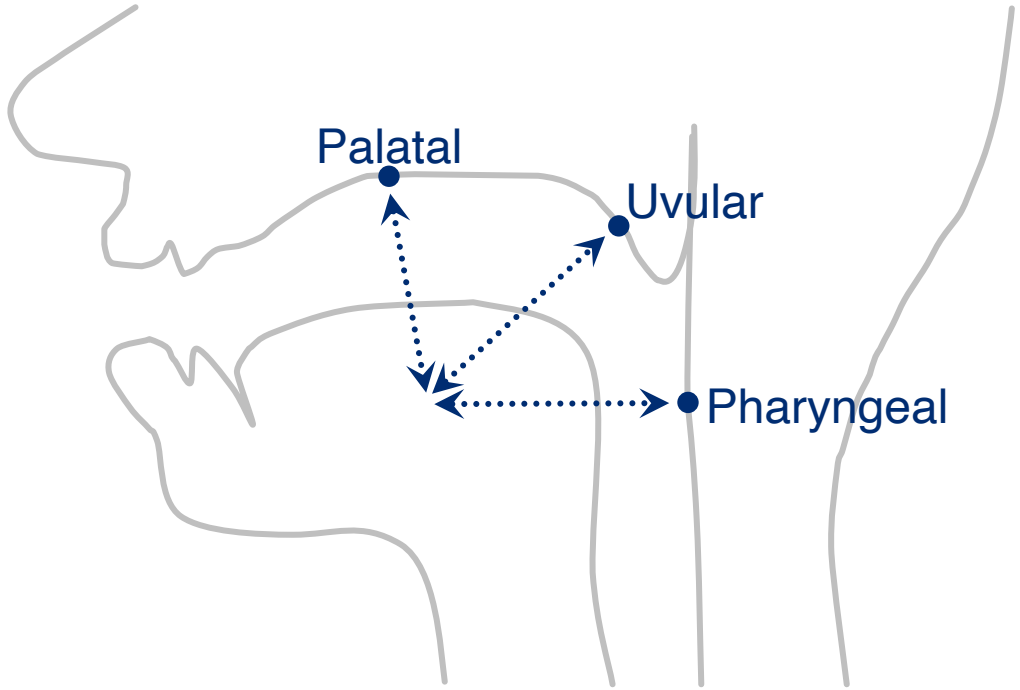
Gestural Parameters

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



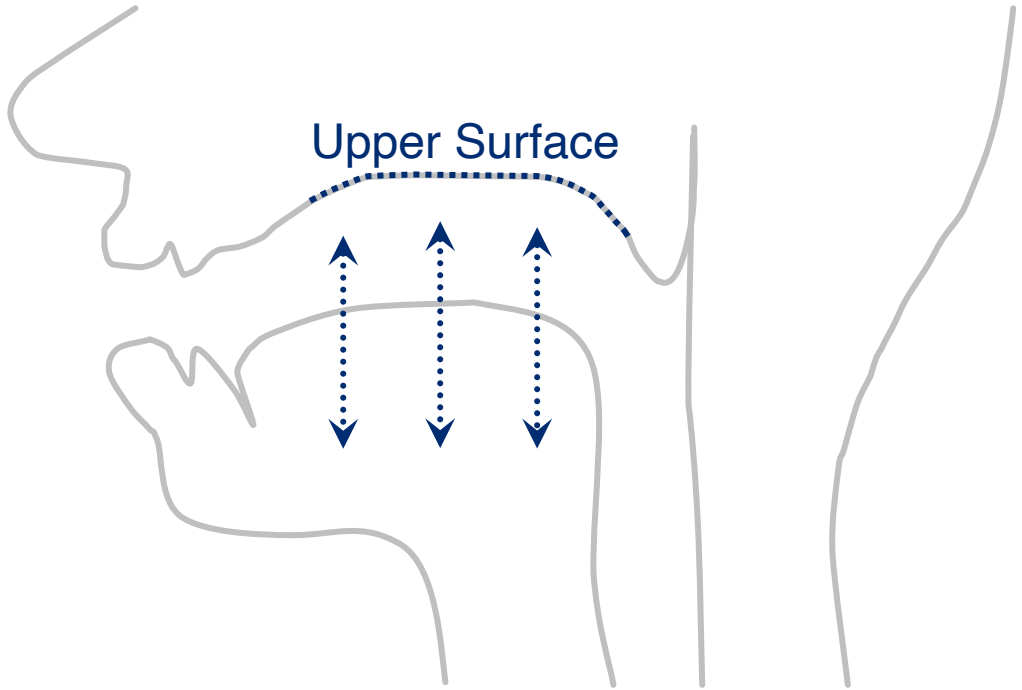
- Target articulatory state:
  - Constriction location
  - Constriction degree
- Stiffness (k): how quickly target state is achieved
- Ability to temporally extend activation (Smith 2017, 2018)
- Blending strength (α): ability to command vocal tract articulators

Constriction Location and Degree for Consonantal Gestures



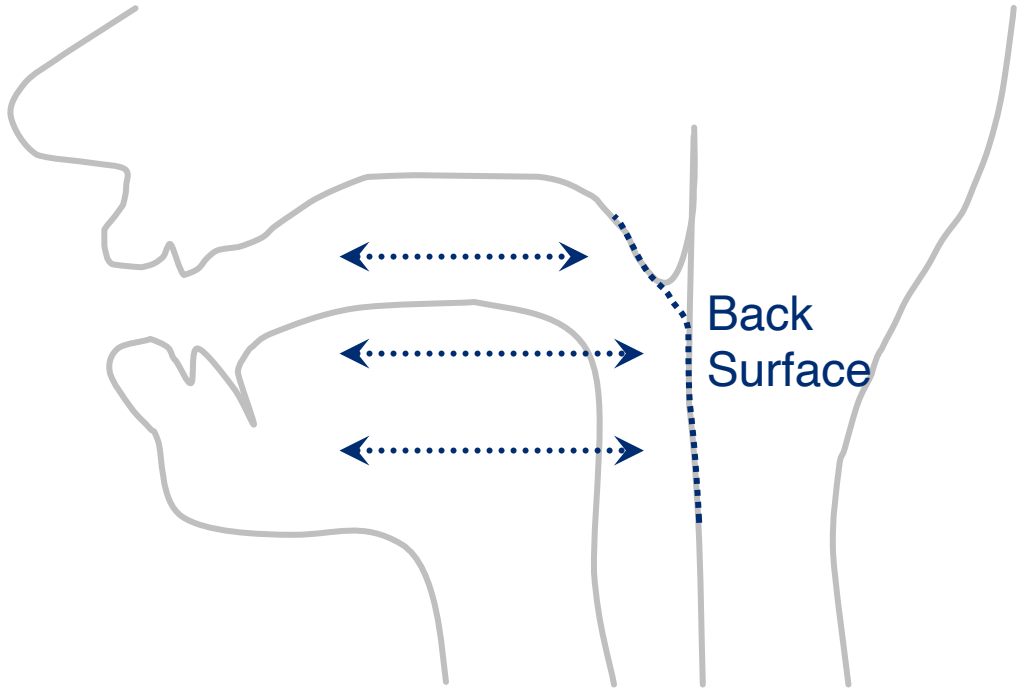
- Constriction location of gesture specifies target point along vocal tract surface
- Constriction degree of gesture specifies distance between active articulator and constriction location point

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

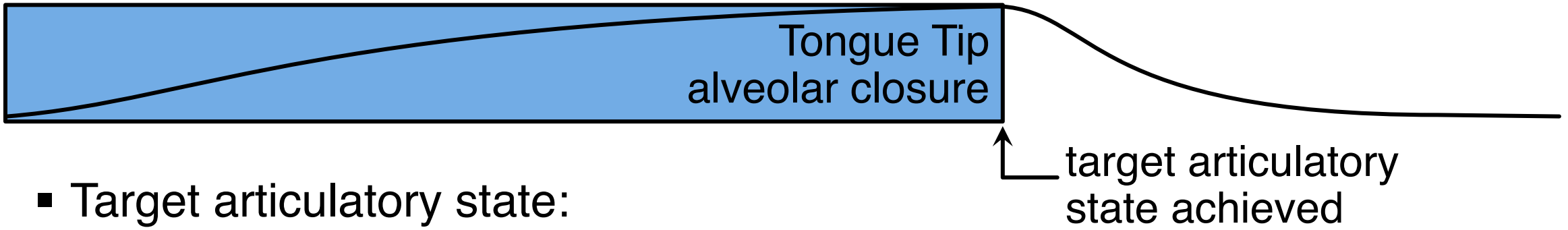
Constriction Location and Degree for Vowel Gestures



- 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

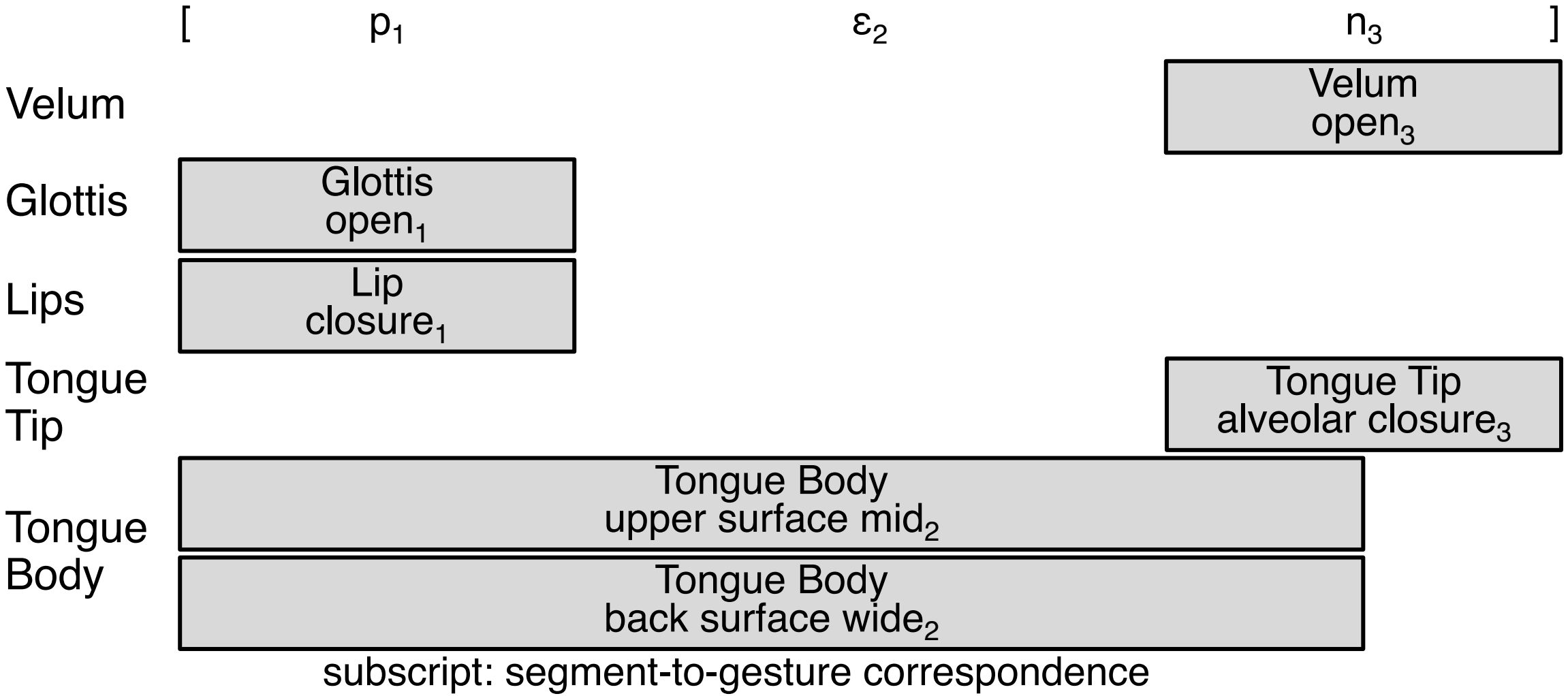
Gestural Parameters

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

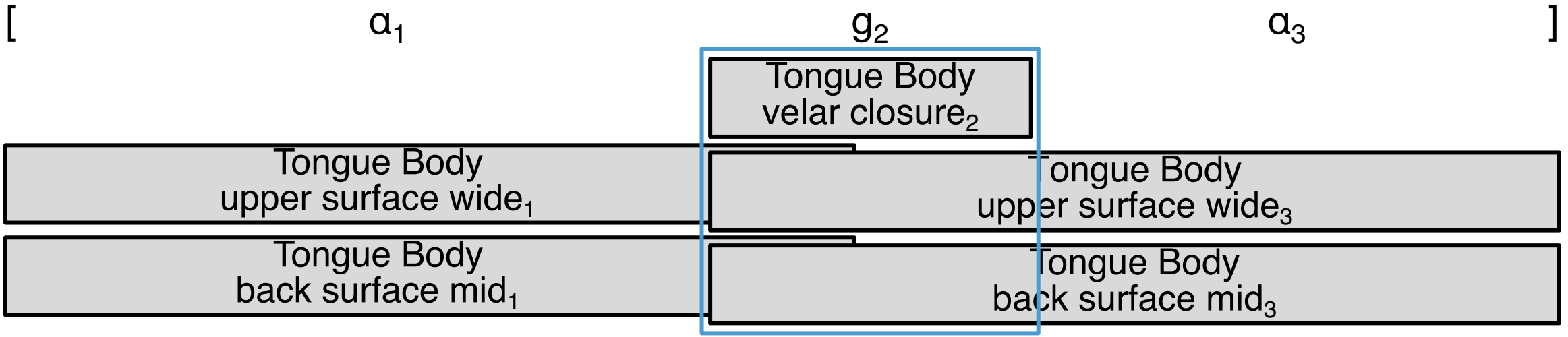


- Target articulatory state:
  - Constriction location
  - Constriction degree
- Stiffness (k): how quickly target state is achieved
- Ability to temporally extend activation (Smith 2017, 2018)
- Blending strength (α): ability to command vocal tract articulators

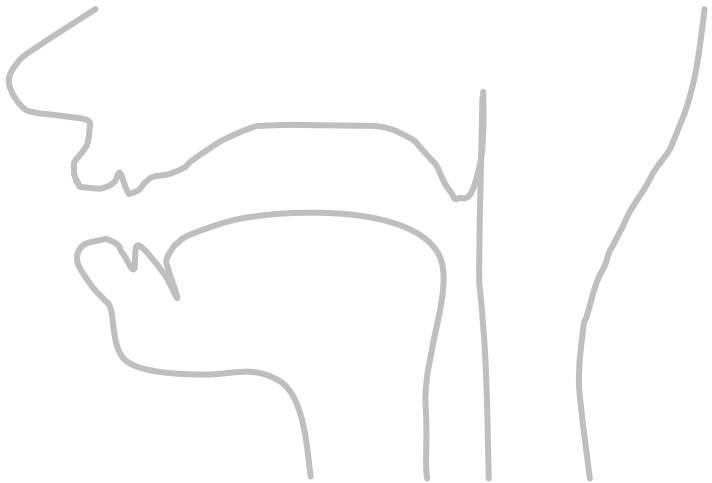
Representing Phonological Forms with Gestural Scores



Gestural Blending Between Consonants and Vowels



Tongue body posture for /ɑ/



Tongue body posture for /g/

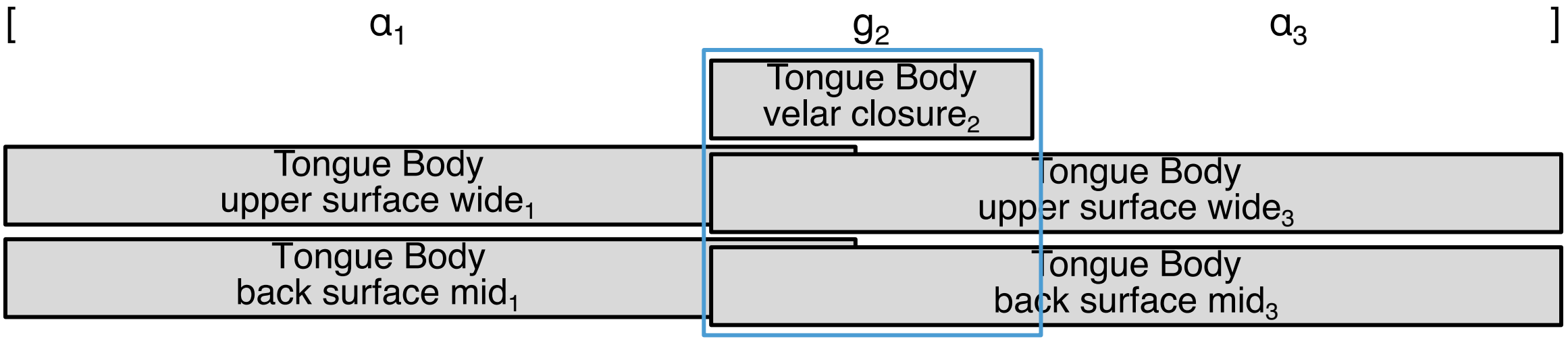
Gestural Strength and Blending

- Antagonistic gestures: gestures with conflicting target articulatory states

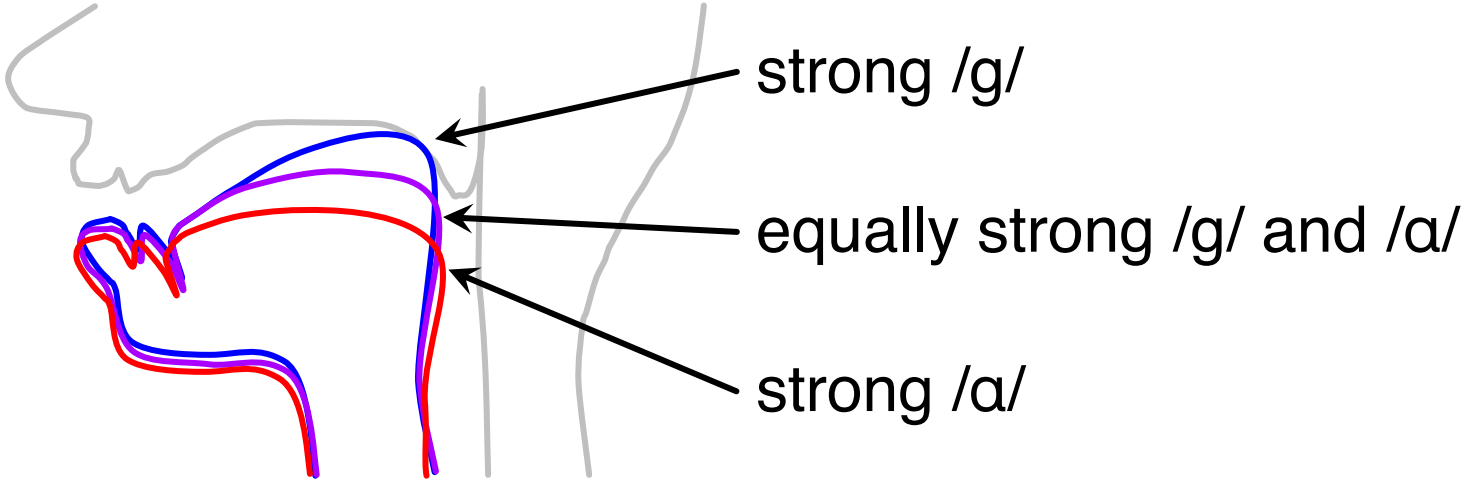
- Antagonism resolved by blending target articulatory states of concurrently active gestures according to Task Dynamic Model of speech production (Saltzman & Munhall 1989; Fowler & Saltzman 1993)

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

Gestural Blending Between Consonants and Vowels

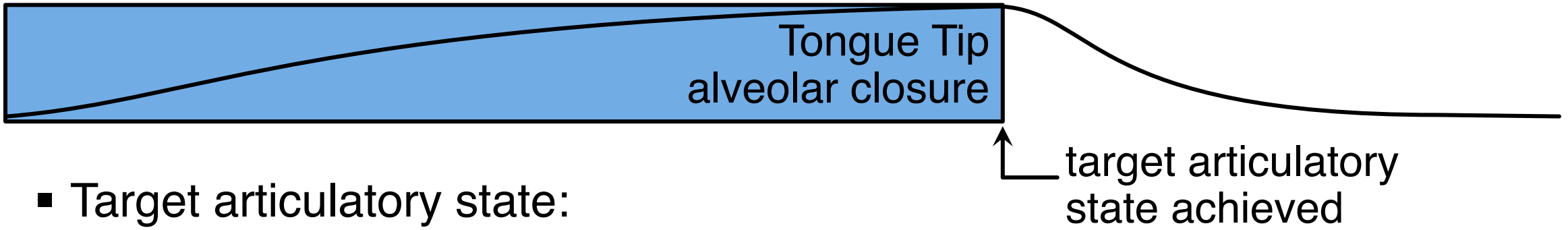


Blended tongue body postures for /ɑ/ and /g/



Gestural Parameters

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



- Target articulatory state:
  - Constriction location
  - Constriction degree
- Stiffness (k): how quickly target state is achieved
- Ability to temporally extend activation (Smith 2017, 2018)
- Blending strength (α): ability to command vocal tract articulators

Phonological Role of Gestural Strength

- Allophony of velar fricative in Navajo due to low gestural strength (Iskarous, McDonough, & Whalen 2012)
- Transparency in vowel(-consonant) harmony due to high gestural strength (Smith 2016, 2018)
- Phonotactics restrictions on liquids in English due to gestural strength settings (Walker & Proctor 2019)
- Stepwise (chain-shifting) height harmony due to gestural strength settings (Smith 2020)

Proposals: Contrastive Gestural Strength

1) Gestural strength parameter serves a *contrastive* function in phonology

2) Contrastive gestural strength is responsible for phonological idiosyncrasy (a.k.a. exceptionality) in Bemba

Analysis: Bemba Vowel Harmony and Consonant Mutation

Recap: Bemba Height Harmony and Consonant Mutation

- Vowel lowering harmony affects high vowels, but not reflexes of superclose vowels:

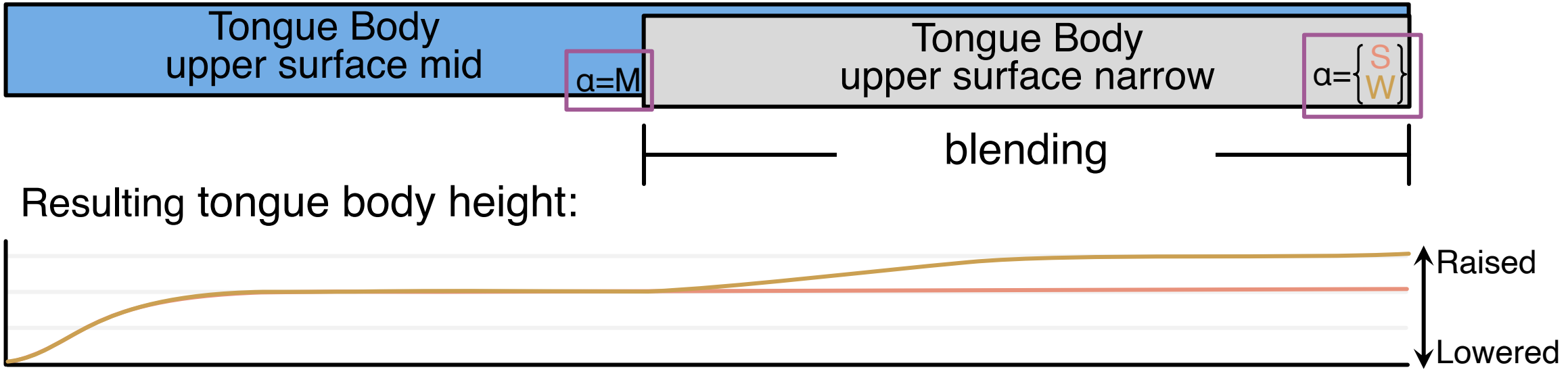
$$i < *i \rightarrow e \,/\, \{e, o\} \_\_ \qquad\qquad u < *u \rightarrow o \,/\, o \_\_$$

- Consonant mutation is triggered by reflexes of superclose vowels, but not high vowels:

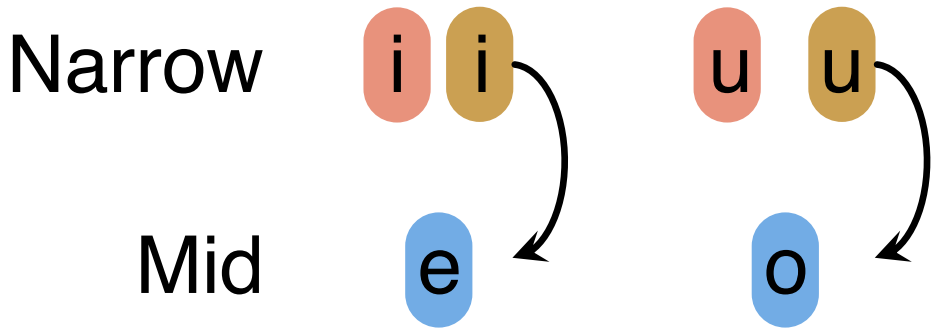
$$\{t, d, l, s\} \rightarrow ʃ \,/\, \_\_ \{i < *į, u < *ų\}$$

Bemba Height Harmony: Analysis

- Vowel lowering harmony due to overlap by persistent upper surface gesture of root vowels /e/ and /o/ (as in the Gestural Harmony Model (Smith 2016, 2018, 2020))
- Mid and high vowels have antagonistic target states for upper surface constriction degree, resulting in gestural blending



Bemba Gestural Strength Parameters

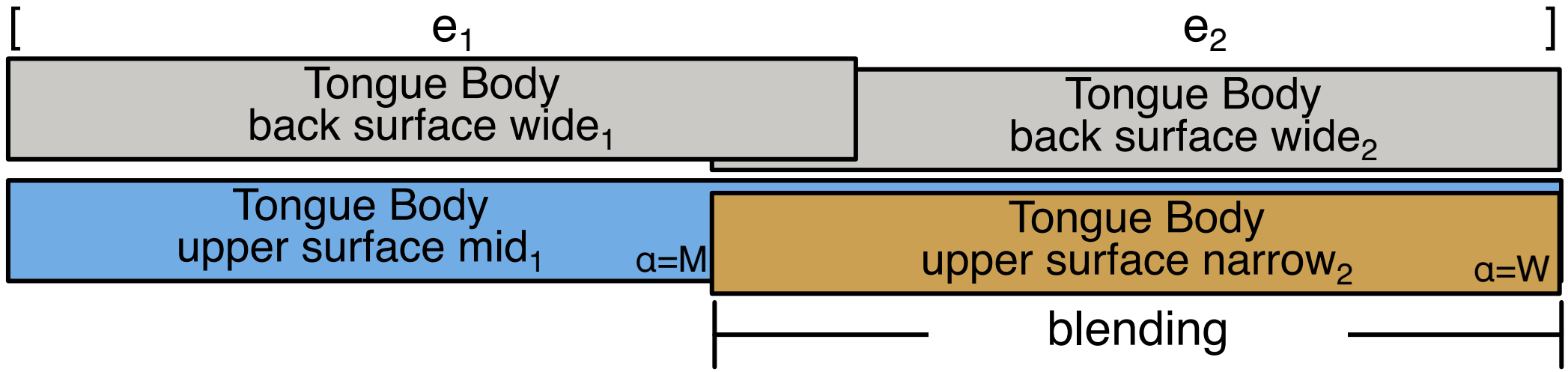


Strong = 100
Medium = 10
Weak = 1

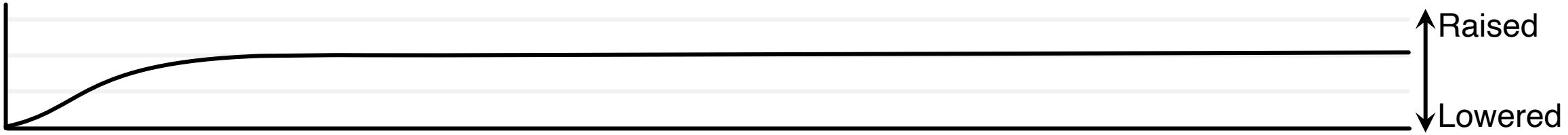
- Weak high vowels /i/ and /u/ undergo lowering triggered by medium-strength /e/ and /o/, surfacing as mid
- Strong high vowels /i/ and /u/ resist lowering, surfacing as high despite overlap by medium-strength /e/ and /o/

Bemba Height Harmony: Weak High Vowels

- Weak high vowels /i/ and /u/ undergo height harmony
- Relative gestural blending strengths favor target constriction degree (mid upper surface constriction) of medium-strength mid vowels

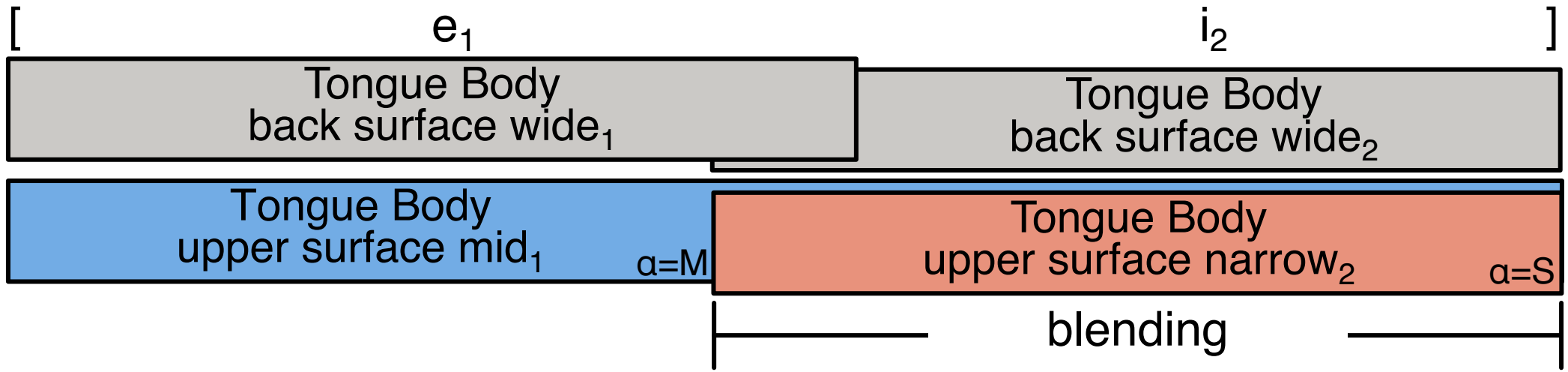


Resulting tongue body height:



Bemba Height Harmony: Strong High Vowels

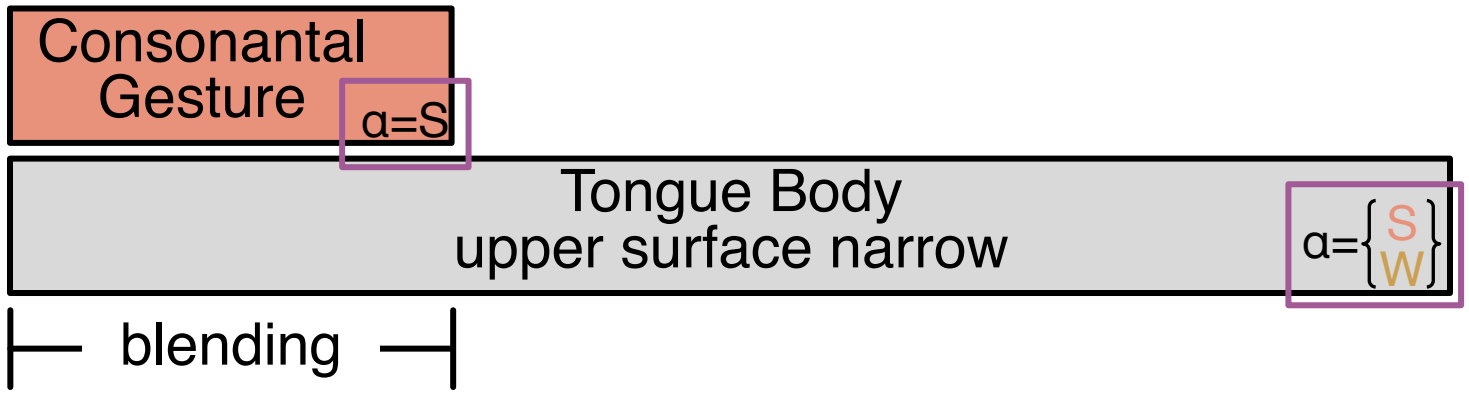
- Strong high vowels /i/ and /u/ resist effect of height harmony
- Relative gestural blending strengths favor target constriction degree (narrow upper surface constriction) of high vowels



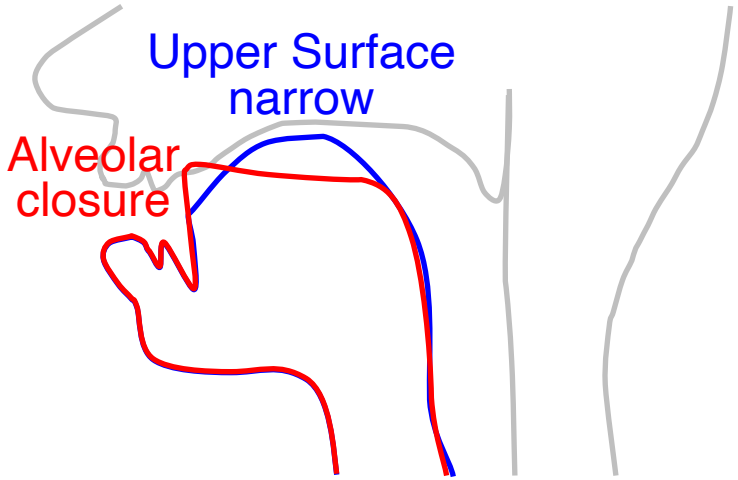
Resulting tongue body height:

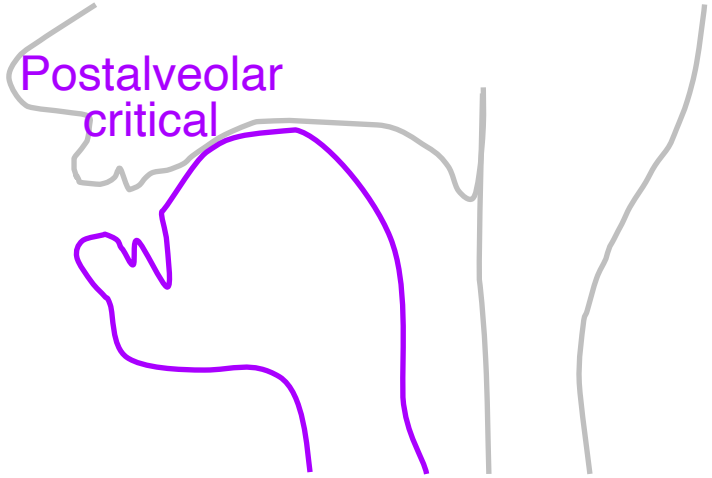
Bemba Consonant Mutation: Analysis

- Consonant mutation due to overlap between upper surface gesture of strong high vowels /i/ and /u/ and onset consonant's lingual gesture
- Gestures for alveolar consonants and high vowels have antagonistic target states for lingual constriction location and degree, resulting in gestural blending



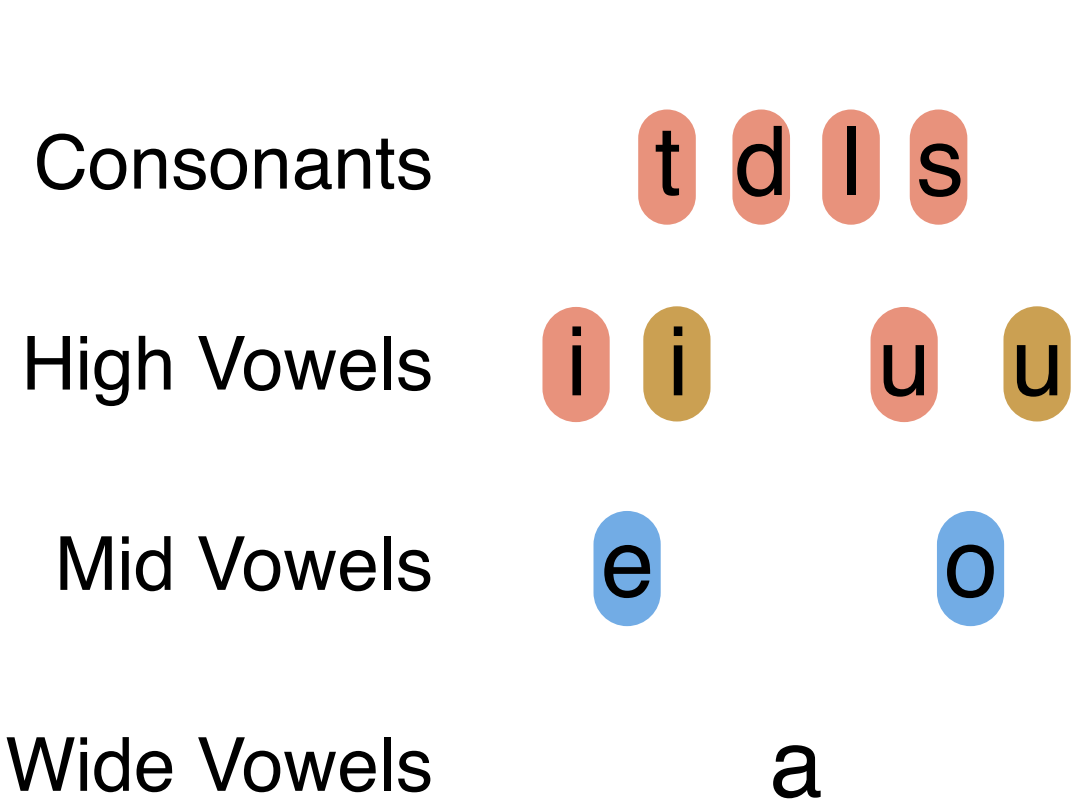
Bemba Consonant Mutation: Analysis





- Overlapped gestures for alveolar consonants and high vowels have antagonistic target states for constriction location and degree
- Consonant mutation: blending produces postalveolar critical (turbulent airflow-inducing) constriction

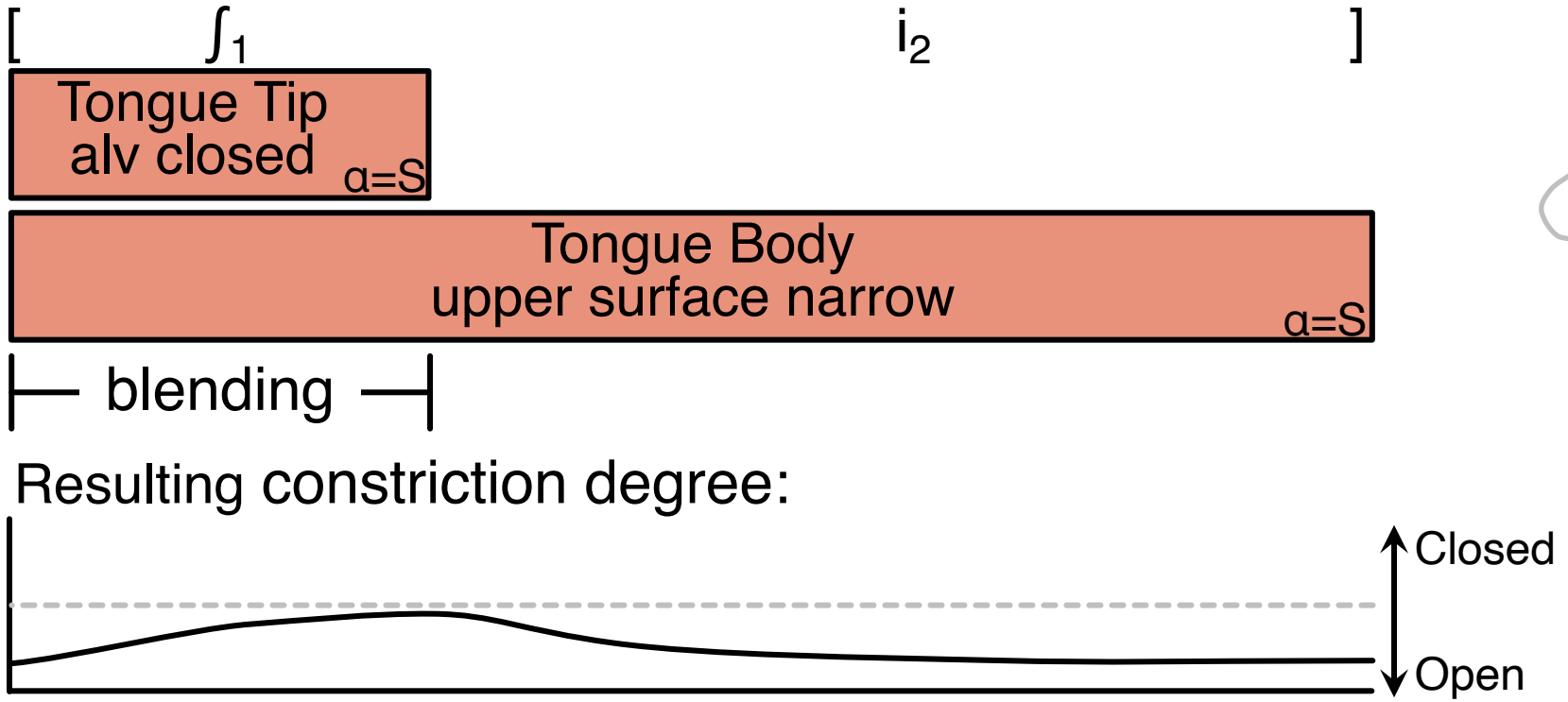
Bemba Gestural Strength Parameters

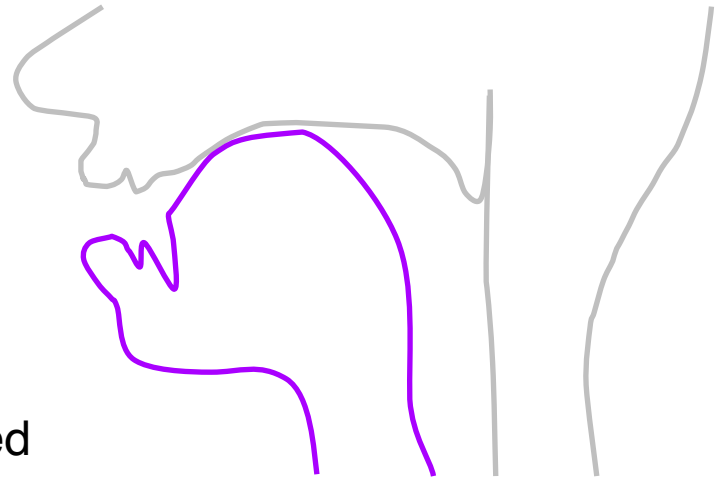


- Weak /i/ and /u/ and medium-strength /e/ and /o/ are unable to affect consonantal constrictions
- Strong /i/ and /u/ have strength equal to alveolar consonants, affecting constriction location and degree of consonants

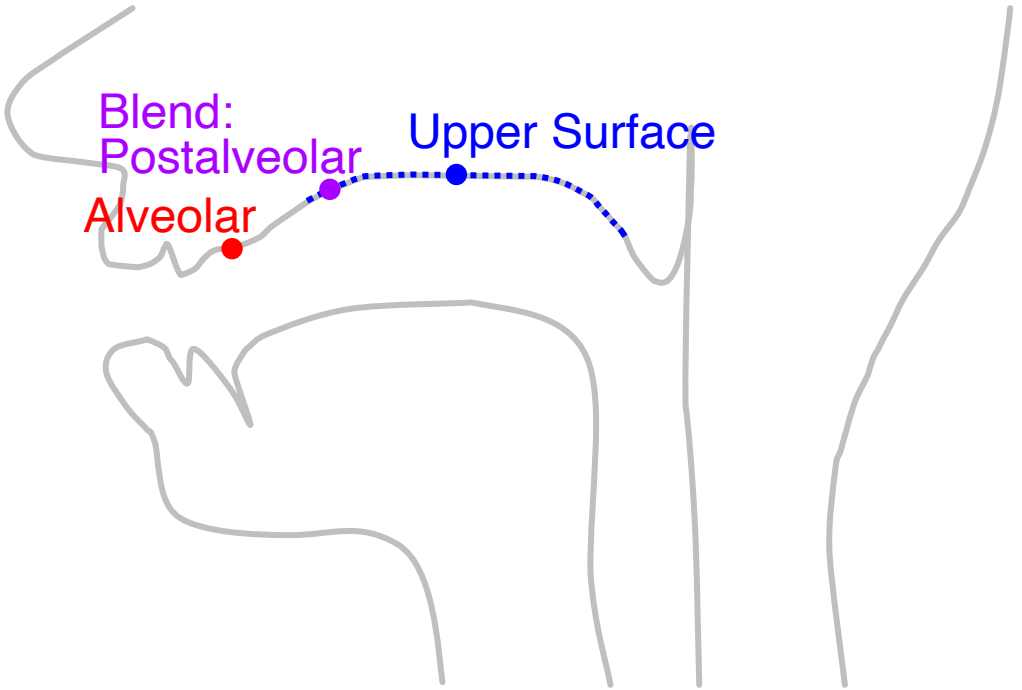
Bemba Consonant Mutation: Strong High Vowels

- Strong high vowels /i/ and /u/ trigger consonant mutation
- Intermediate blended constriction degree (critical) due to equal gestural strengths





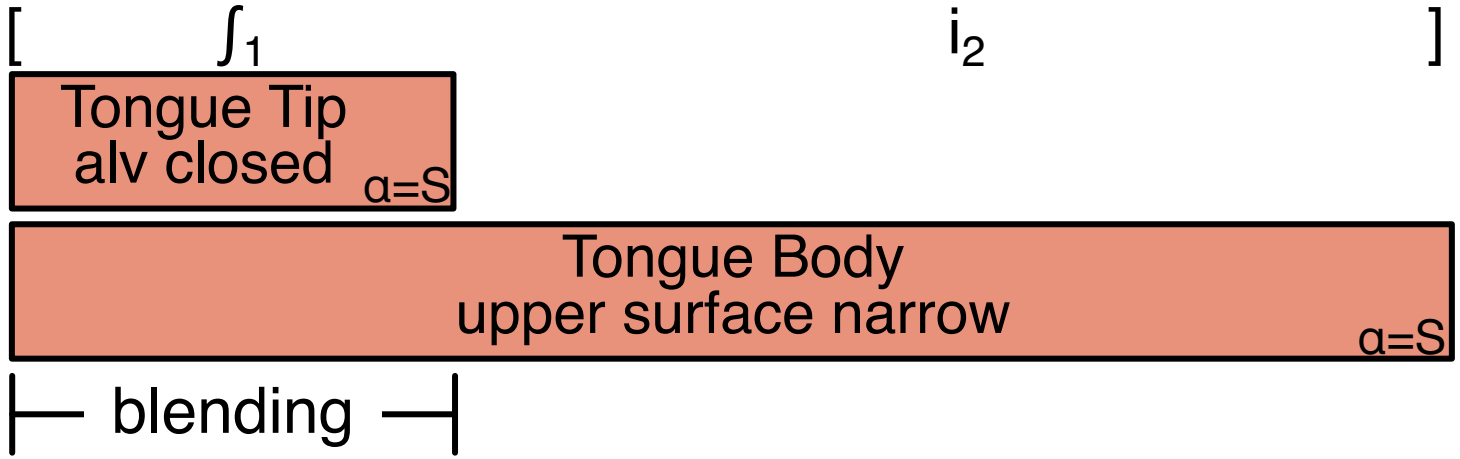
Blending for Constriction Location



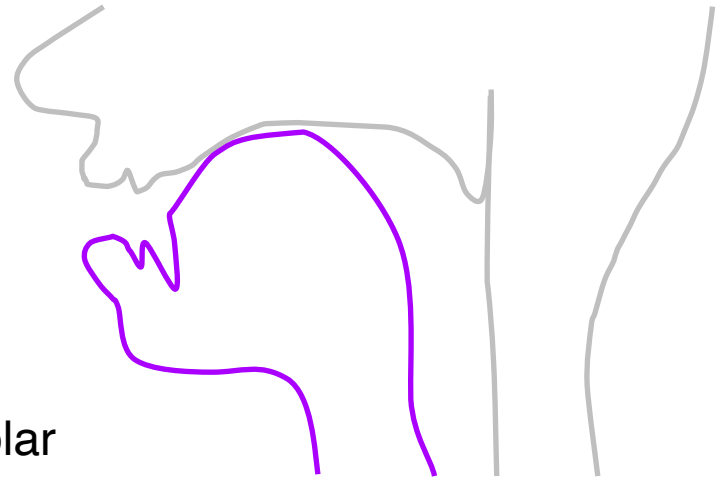
- Alveolar consonantal gestures and vocalic upper surface gestures have no overlap in lingual constriction location
- Blending occurs between alveolar constriction location and midpoint of upper surface constriction location region
- Result: blended postalveolar constriction location

Bemba Consonant Mutation: Strong High Vowels

- Strong high vowels /i/ and /u/ trigger consonant mutation
- Intermediate blended constriction location (postalveolar) due to equal gestural strengths

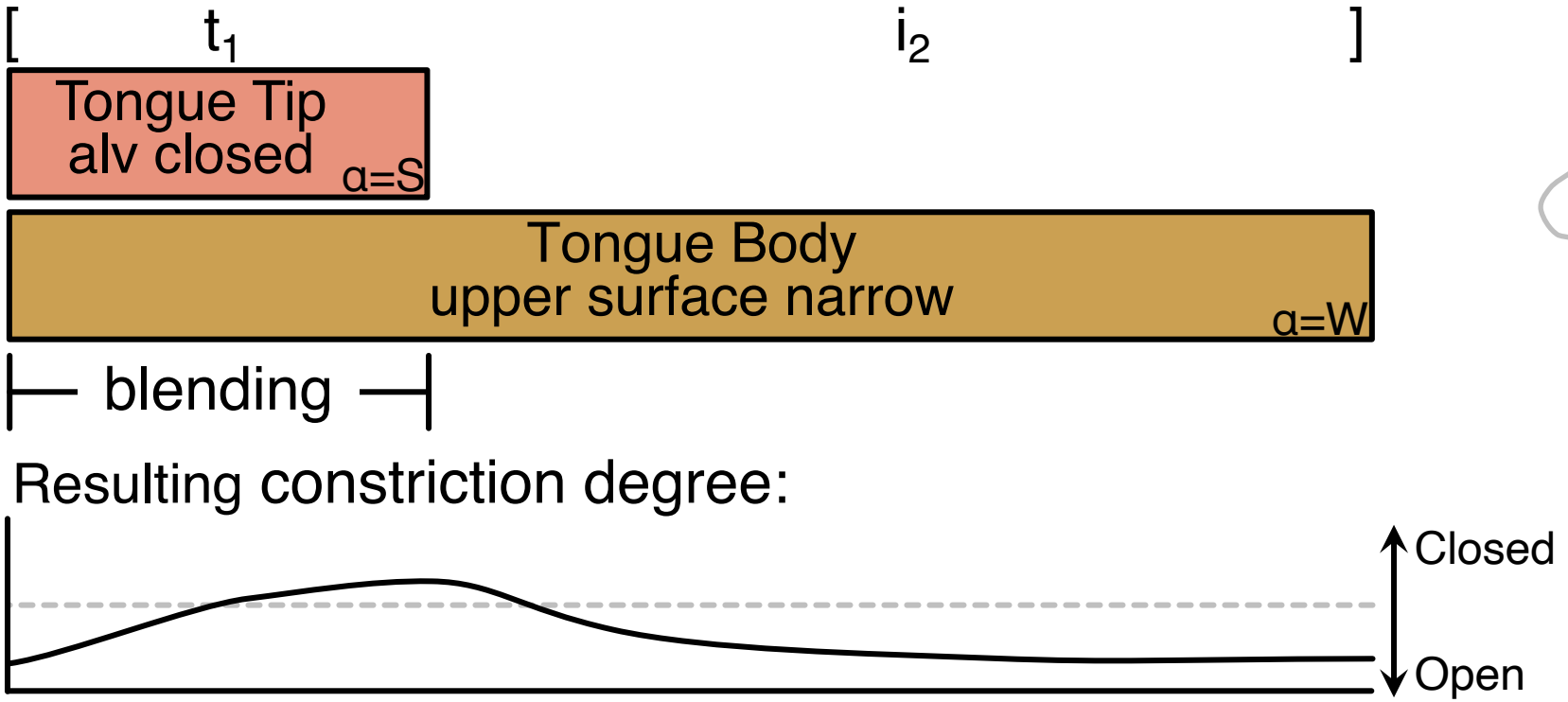


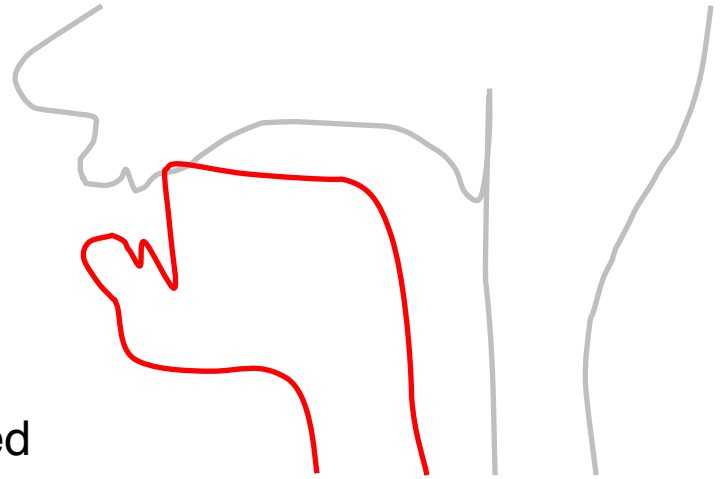
Resulting constriction location:



Bemba Consonant Mutation: Weak High Vowels

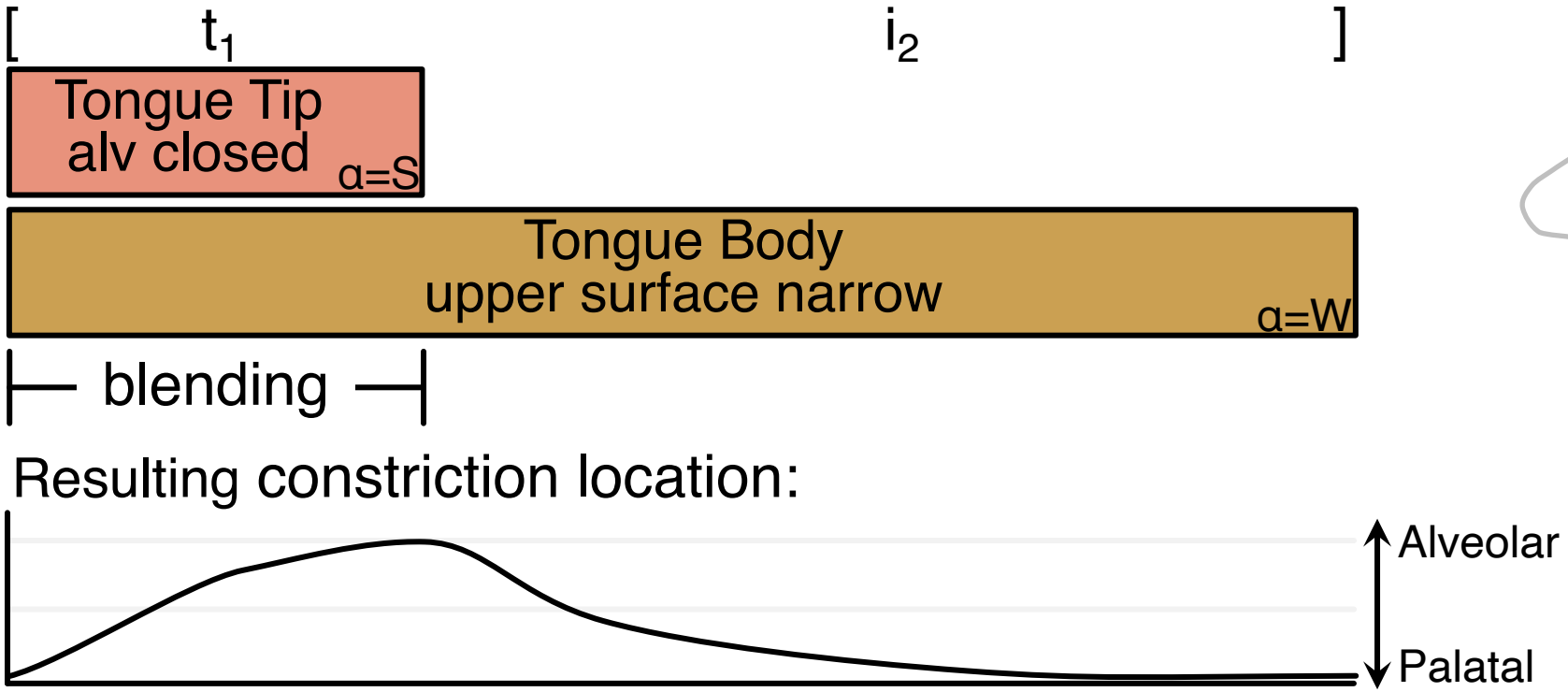
- Weak high vowels /i/ and /u/ do not trigger consonant mutation
- Relative gestural blending strengths favor target constriction degree (closed) of strong consonantal gesture

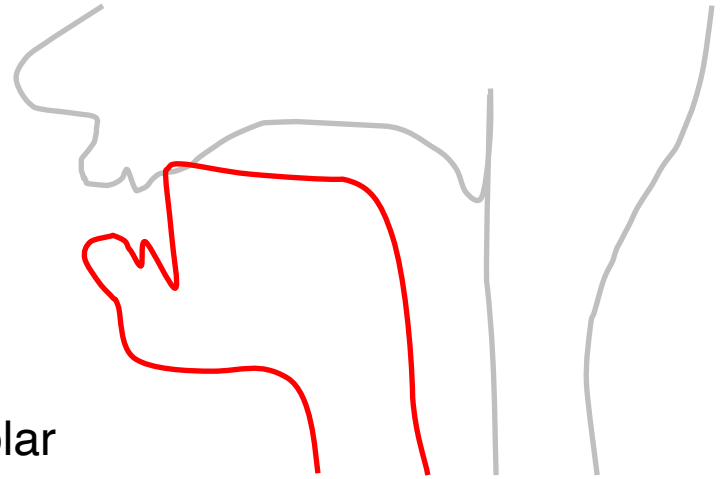




Bemba Consonant Mutation: Weak High Vowels

- Weak high vowels /i/ and /u/ do not trigger consonant mutation
- Relative gestural blending strengths favor target constriction location (alveolar) of strong consonantal gesture





Summary of Phonological Patterns in Bemba

- Strong high vowels:
  - resist vowel lowering height harmony
  - trigger consonant mutation

- Weak high vowels:
  - undergo vowel lowering height harmony
  - do not trigger consonant mutation

Conclusion

Conclusion

- Distinct phonological patterning of Bemba high vowels and reflexes of Proto-Bantu superclose vowels analyzed as contrast in gestural strength parameter
- Recruits independently necessary element of gestural speech production model to account for a case of apparent phonological idiosyncrasy
- Non-abstract/non-opaque, eliminating need for special grammatical mechanisms necessary for many featural analyses of phonological idiosyncrasy
- Captures relationship between consonant mutation and height harmony processes in Bemba with single gestural parameter