

# A Dynamic Model of Partial Transparency in Harmony

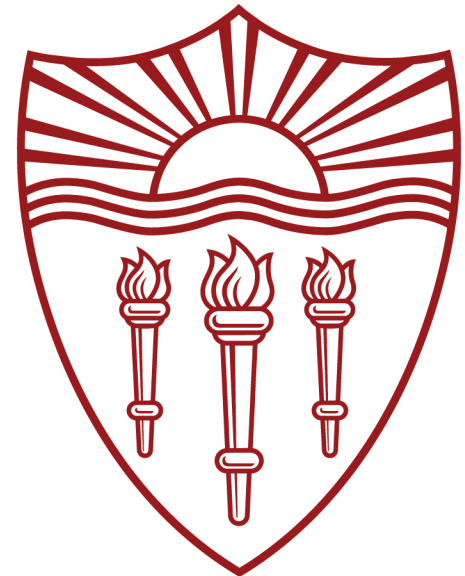
Dynamic Modeling in Phonetics & Phonology

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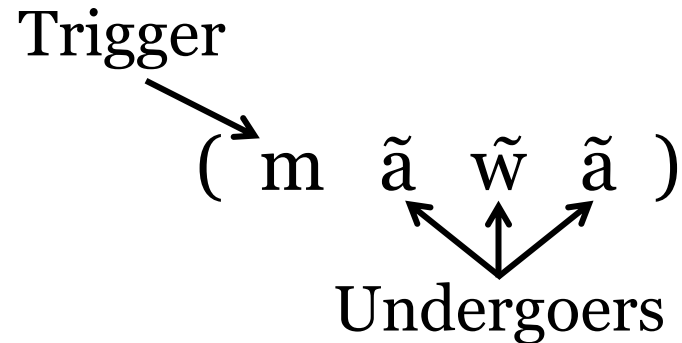
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# Introduction

Harmony: spreading of some property (nasality, tongue root position) throughout some domain



Transparent segments: apparently skipped by a harmony process

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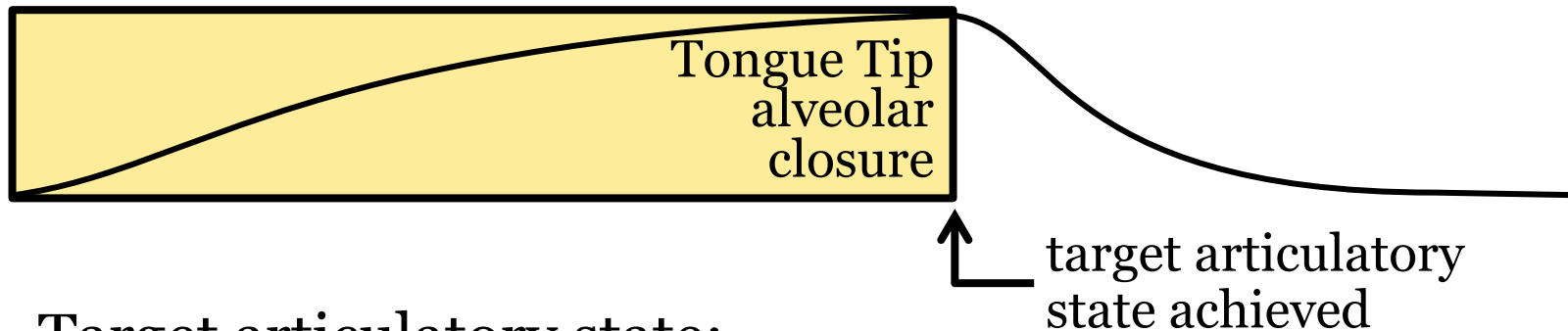
# Introduction

- Introduce Gestural Harmony Model (Smith 2016a, 2016b)
  - Harmony as gestural overlap
  - Transparency as gestural blending
- Provide analysis of apparent case of partial transparency in Coeur d'Alene Salish faucal harmony

# Harmony, Transparency, and Gestural Overlap

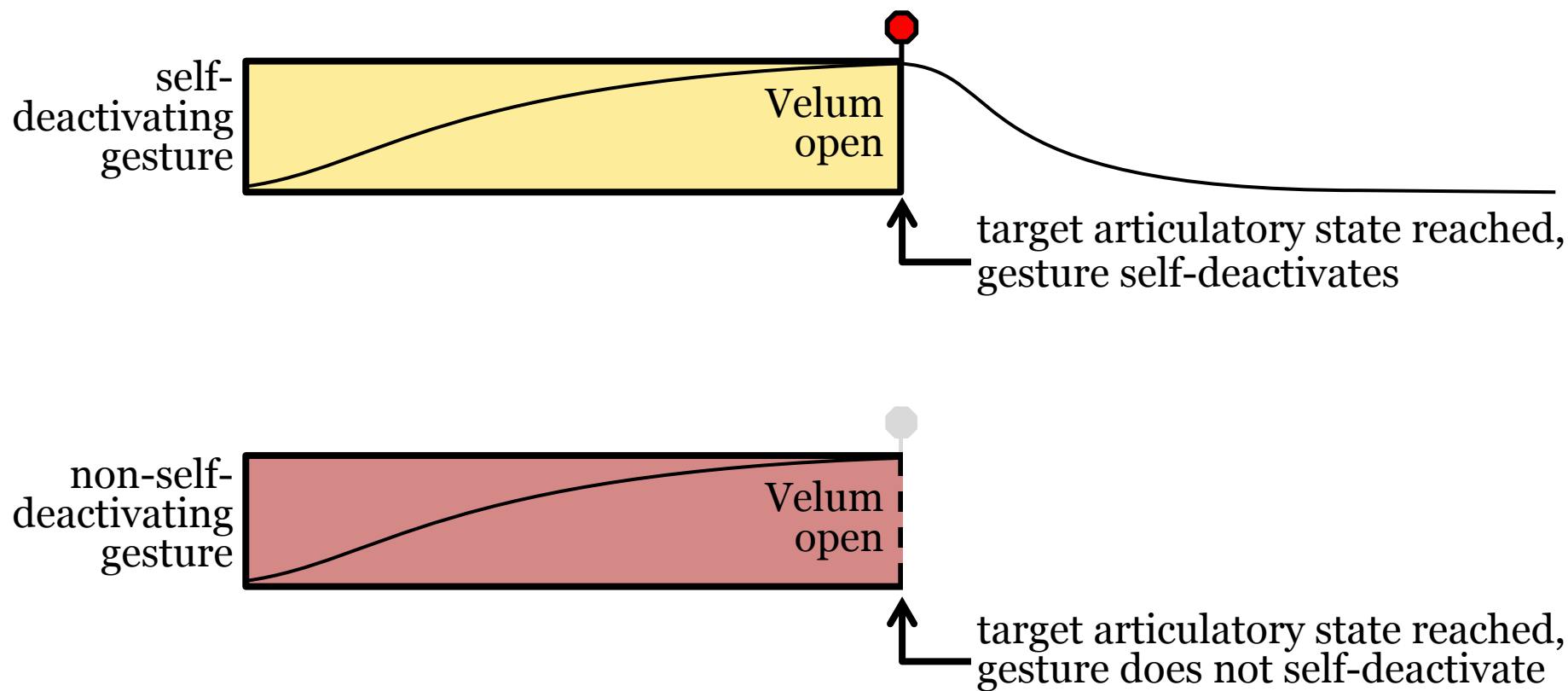
# Gestural Parameters

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



- Target articulatory state:
  - Constriction degree
  - Constriction location
- Stiffness ( $k$ ): how quickly a gesture's target articulatory state is reached
- Articulators involved
- Strength ( $\alpha$ ): ability to command articulators

# Gestural (Non-)Self-Deactivation



# Nasal Harmony in Tuyuca

Morphemes are either oral or nasal; obstruents are transparent (Barnes & Takagi de Silzer 1976):

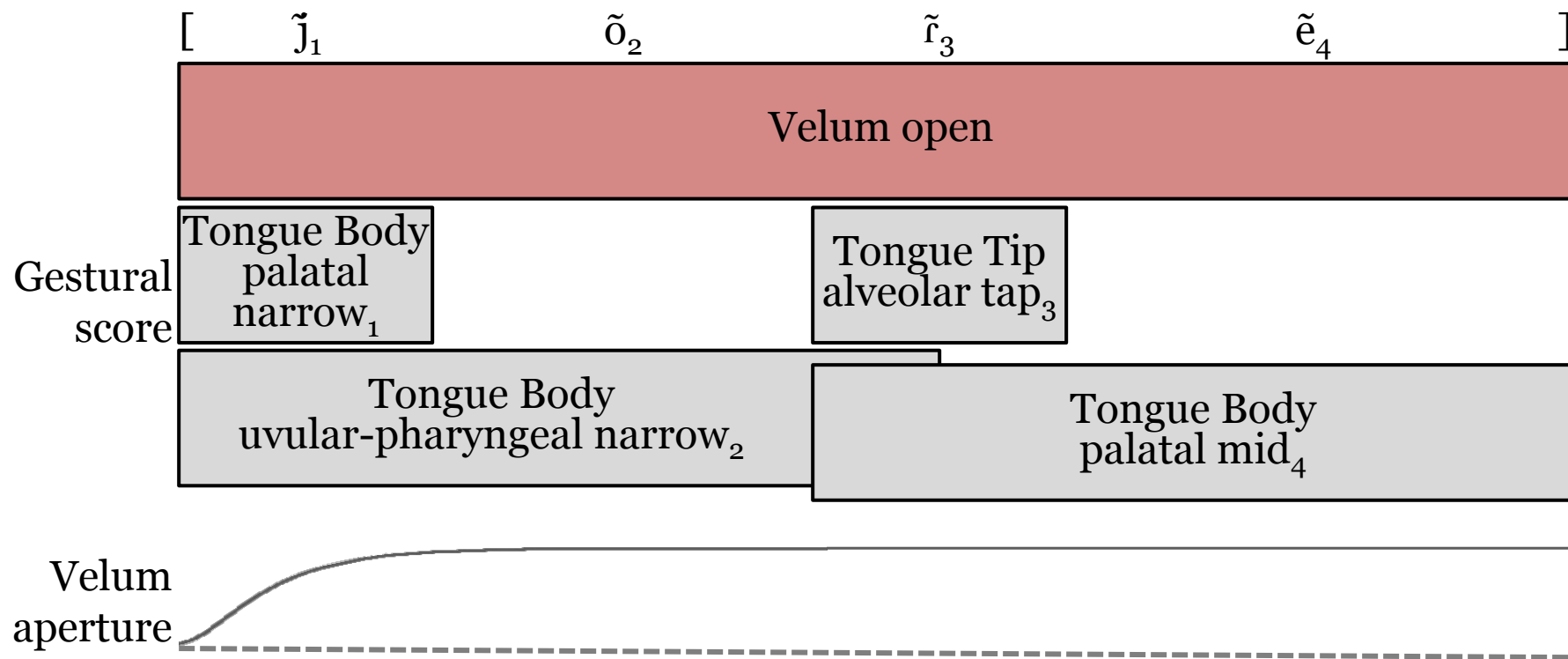
## Full harmony

- a. [jãmĩ] ‘night’
- b. [wĩnõ] ‘wind’
- c. [jõrẽ] ‘small hen’

## Transparency

- d. [mĩpĩ] ‘badger’
- e. [wãfi] ‘demon’
- f. [jõsõ] ‘bird’

# Nasal Harmony in Tuyuca





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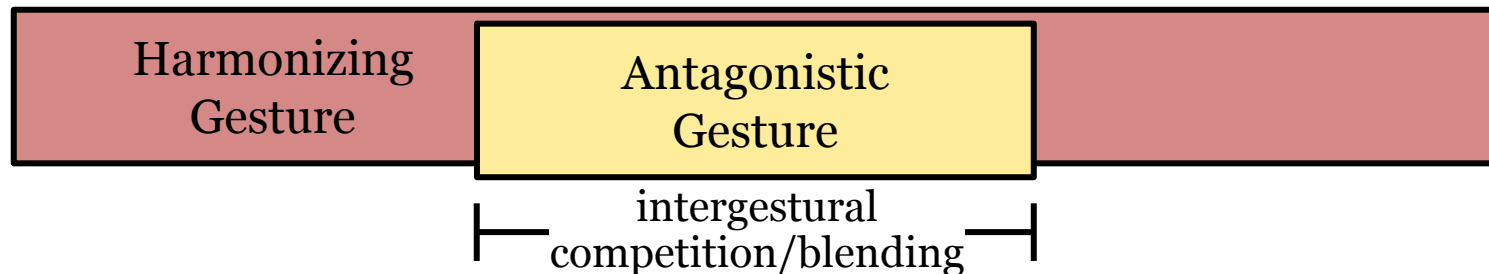
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## Transparency

- d. [mĩpĩ] ‘badger’
- e. [wãtĩ] ‘demon’
- f. [jõsõ] ‘bird’

# Transparency as Gestural Antagonism

- Transparency: result of competition between two concurrently active *antagonistic* gestures
- Gestural antagonism: two concurrently active gestures with directly opposing goal articulatory states
  - Velum open vs. velum closed
  - Palatal tongue body constriction vs. pharyngeal tongue body constriction



Resulting state of vocal tract for some variable:



# Gestural Strength & Blending

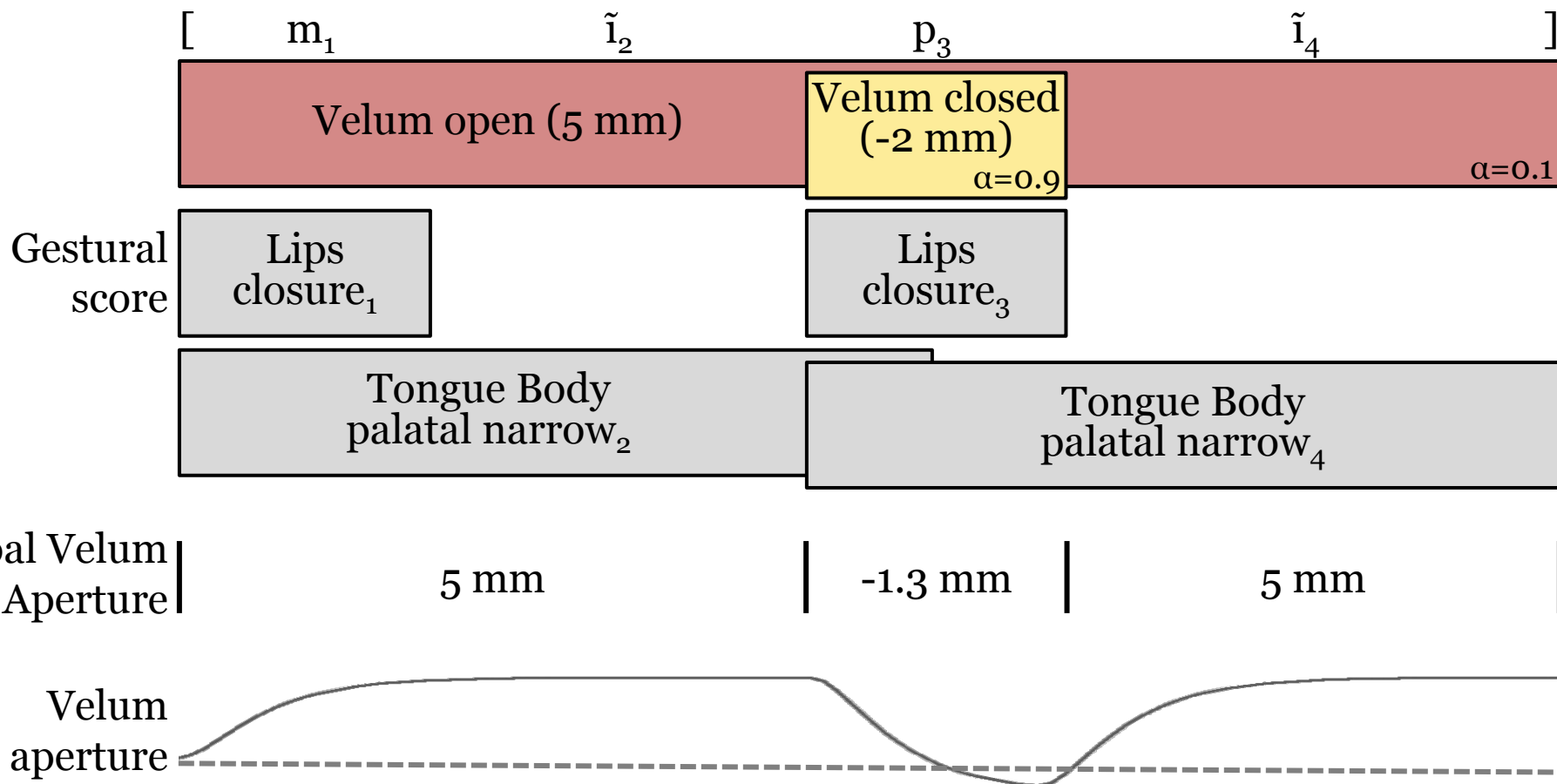
- Gestural antagonism resolved by blending target articulatory states of concurrently active gestures
- Blending occurs according to Task Dynamic Model of speech production (Saltzman & Munhall 1989)
- Blended articulatory state = average of gestures' individual target articulatory states, weighted according to strengths ( $\alpha$ )

# Gestural Strength & Blending

- Velum opening: goal velum aperture 5 mm
- Velum closure: goal velum aperture -2 mm

Velum Opening Strength	Velum Closure Strength	Weighted Average
0.5	0.5	$5 * 0.5 + -2 * 0.5 = 1.5 \text{ mm}$
0.9	0.1	$5 * 0.9 + -2 * 0.1 = 4.3 \text{ mm}$
0.1	0.9	$5 * 0.1 + -2 * 0.9 = -1.3 \text{ mm}$

# Coactivation Transparency in Nasal Harmony

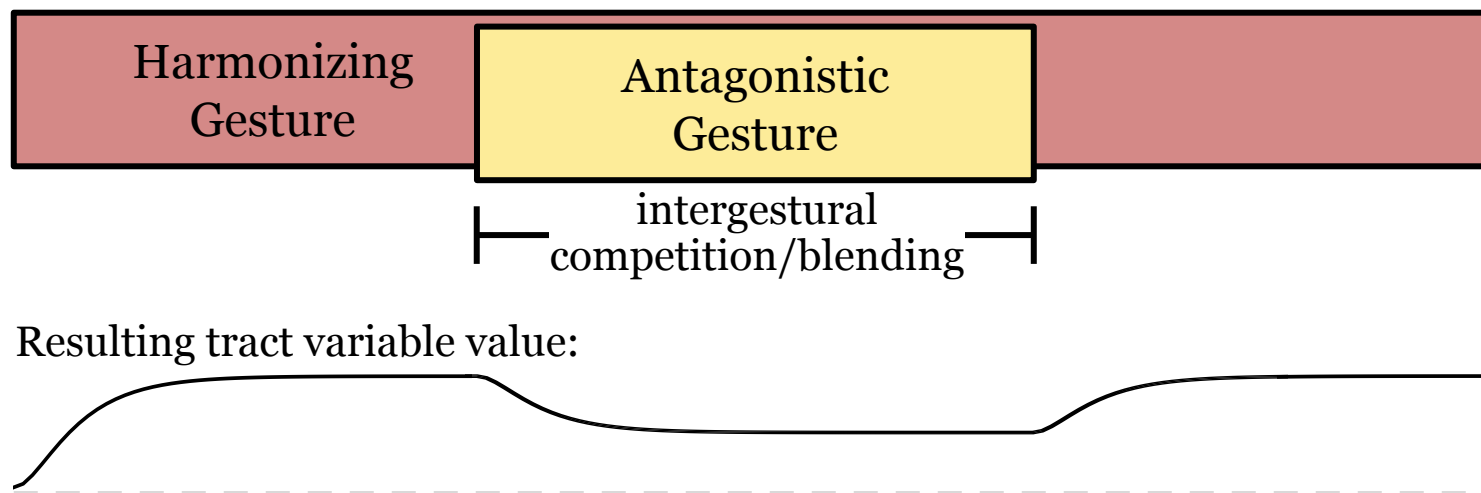


# Advantages of Coactivation Transparency

- Correctly predicts which segments can be transparent within nasal harmony and rounding harmony
- Avoids over-generation of predicted transparent segments (see Smith (2016) for details)
- Harmony is represented locally, resulting in gestural antagonism with transparent segments

# Predicted: Partial Transparency?

- Possible scenario: harmonizing gesture and overlapped gesture have similar strengths
- Result: partial transparency/partial undergoing of harmony



# Coeur d'Alene Salish Faucal Harmony



# Coeur d'Alene Salish

## Faucal Harmony

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

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### Non-Faucal Context

### Faucal Context

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[t<sup>s</sup>i<sub>ɨ</sub>-t] 'it is long'

[t<sup>s</sup>ɛ<sub>ɨ</sub>-alq<sup>w</sup>] 'he is tall'

[dlim] 'he galloped hither'

[t<sup>ʃ</sup>-dlam-alq<sup>w</sup>] 'train'

[sɛtt<sup>ʃ</sup>-nt<sup>s</sup>] 'he twisted it'

[nɛ<sub>ɨ</sub>-satt<sup>ʃ</sup>-ɛ<sub>ɨ</sub>qs-n] 'crank (on a car)'

[ʔɛ-ni<sub>ɨ</sub>-k<sub>ɨ</sub>s-ɛlst<sup>ʃ</sup>n] 'hair curls  
back from forehead'

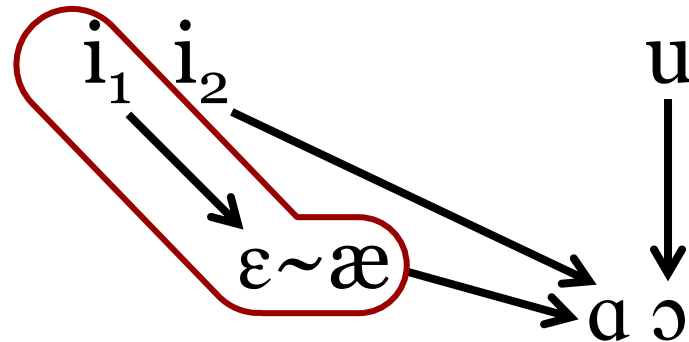
[ʔat-k<sub>ɨ</sub>s-qn] 'his hair is curled'

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data from Doak (1992) & Bessell (1998)

# Coeur d'Alene Salish Faucal Harmony

Vowel shift in domain of faucal harmony:



- $/\epsilon \sim \text{æ}/$ ,  $/i_2/$ ,  $/u/$  all fully undergo faucal harmony
- $/i_1/$  undergoes faucal harmony to an intermediate degree

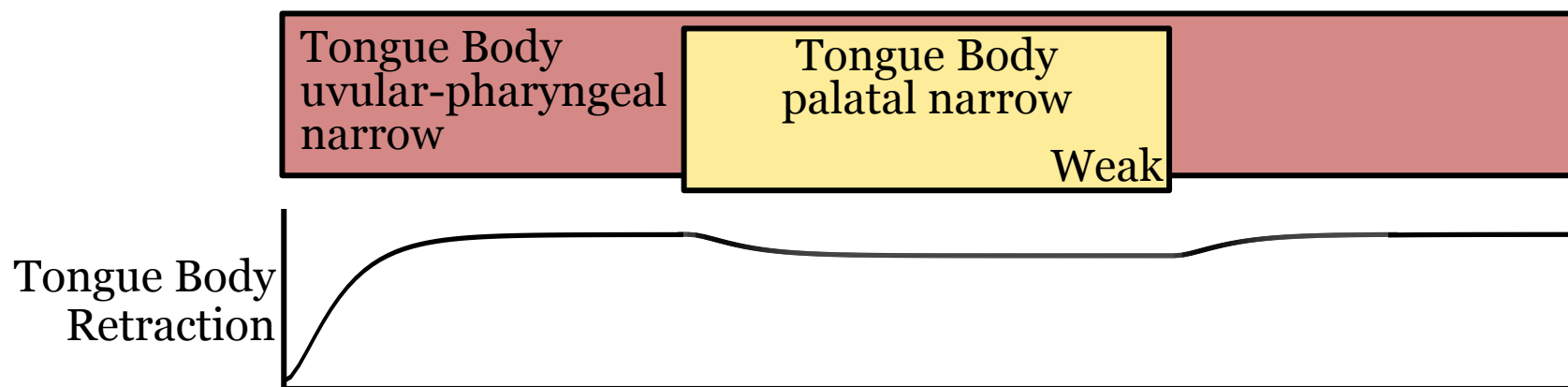
# Coeur d'Alene Salish

## Faucal Harmony: Proposals

- Faucal harmony is result of overlap by harmonizing tongue body retraction gesture
- Medium-strength  $/i_1/$  partially resists (remains transparent to) effect of retraction gesture due to similar gestural blending strengths
- Weak  $/i_2/$  is fully overpowered by retraction gesture when gestural blending occurs

# Full Retraction of Weak /i/

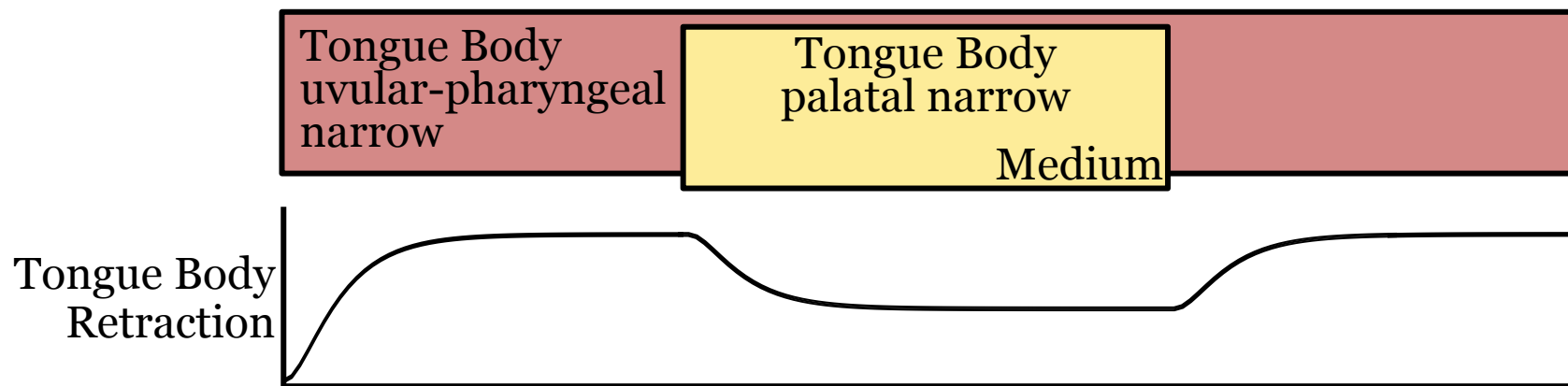
- Weak /i<sub>2</sub>/ is fully overpowered by harmonizing retraction gesture:



- Surfaces as fully retracted [ɑ]

# Partial Transparency of Medium-Strength /i/

- Medium-strength /i<sub>1</sub>/ partially resists (remains transparent to) effect of retraction gesture due to similar gestural blending strengths:

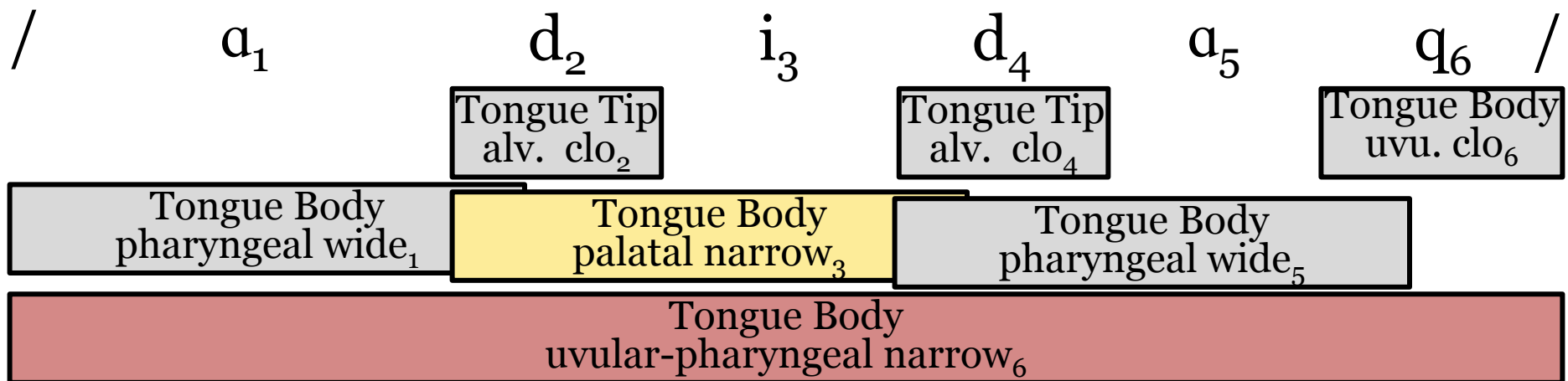


- Surfaces as partially retracted [ɛ] or [æ]

# Computational Modeling in TADA

# TADA Modeling of Partial/Full Retraction

- TADA (Task Dynamic Application; Nam et al. 2004): MATLAB toolkit for synthesizing articulatory trajectories and acoustic outputs from gestural scores
- Synthesized sequence with /i/ in medial syllable:



# TADA Modeling of Partial/Full Retraction

- Three conditions distinguished by relative strengths of palatal constriction and uvular retraction gestures:

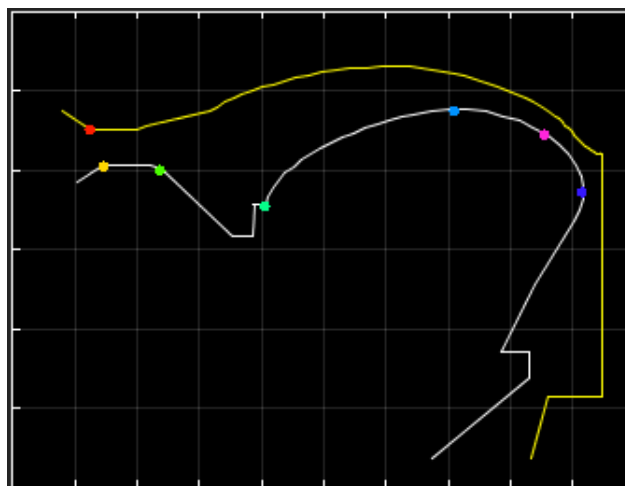
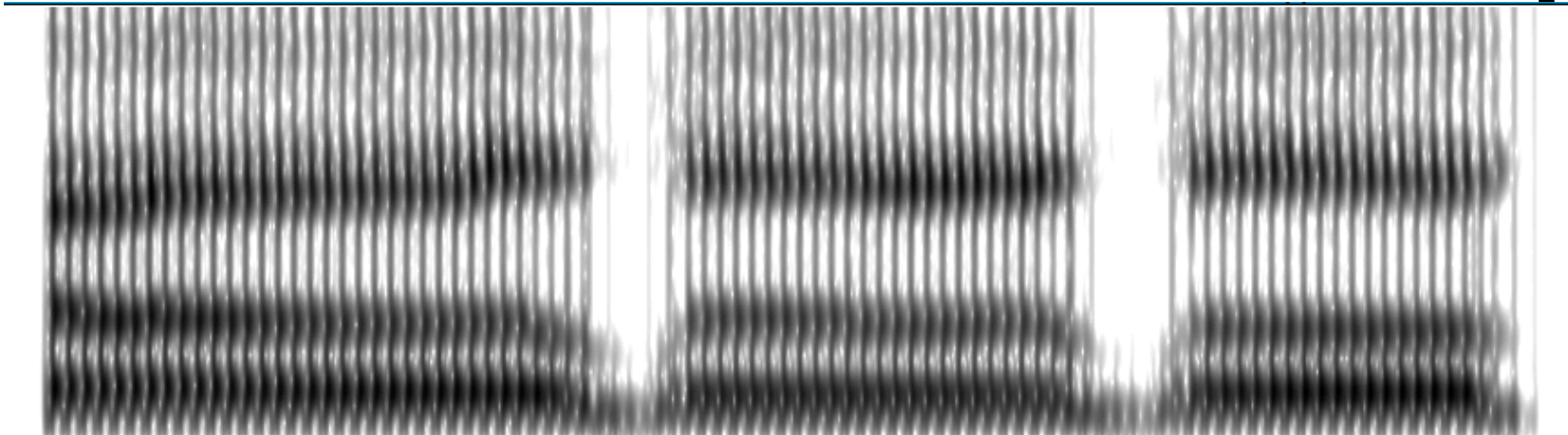
	$\alpha$ for /i/	$\alpha$ for Retraction
<b>Strong /i/</b>	25	5
<b>Medium /i/</b>	5	5
<b>Weak /i/</b>	1	5

- Strong /i/ = fully transparent /i/ found in other varieties of Salish
- Medium /i/ = /i<sub>1</sub>/ in Coeur d'Alene
- Weak /i/ = /i<sub>2</sub>/ in Coeur d'Alene



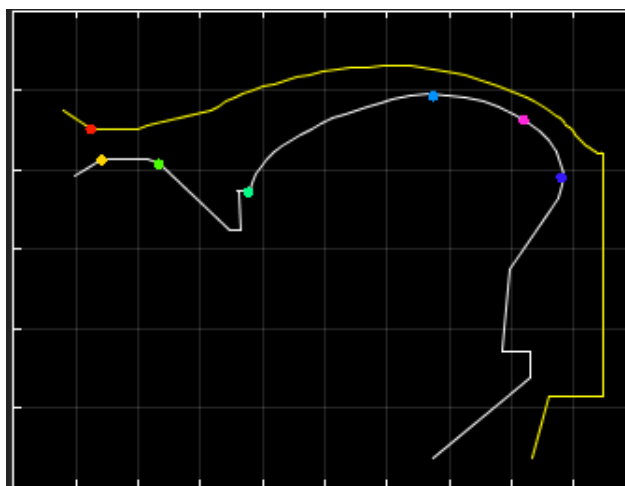
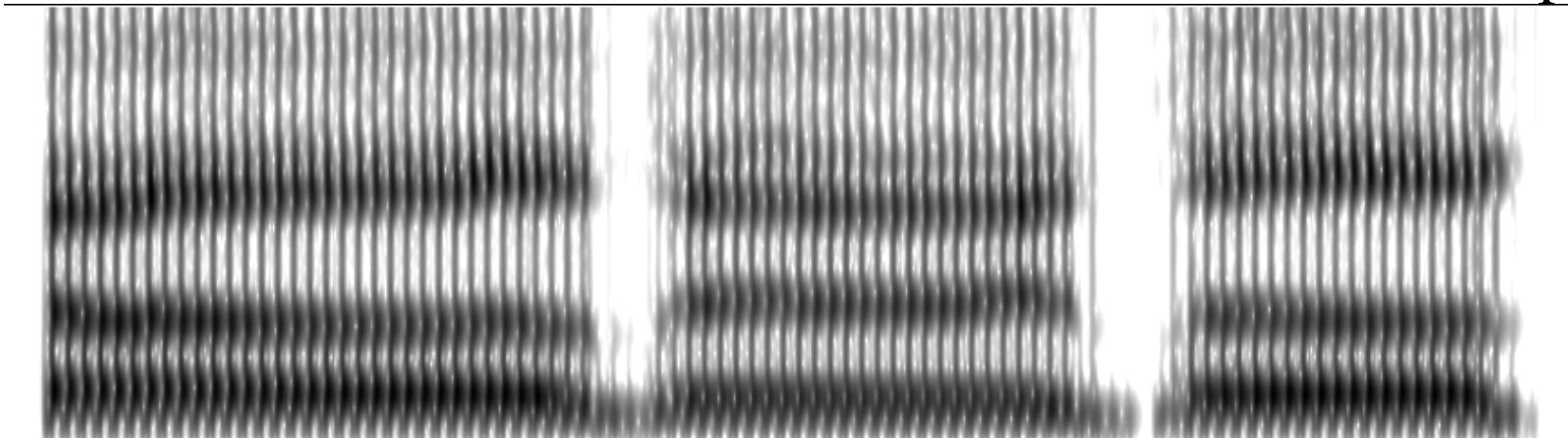
# TADA Modeling: Weak /i/

[ a d a d a q ]



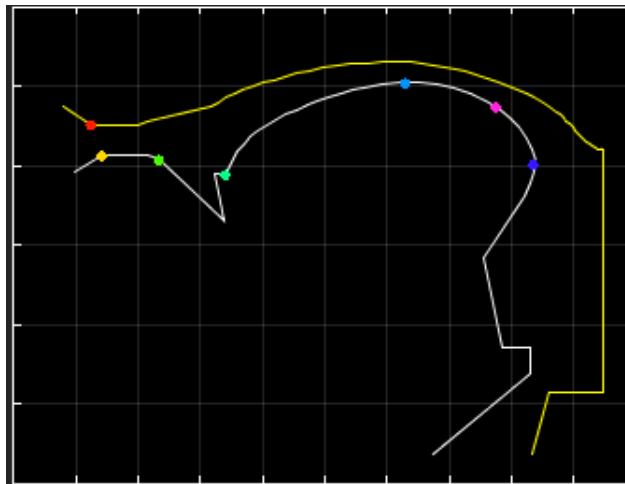
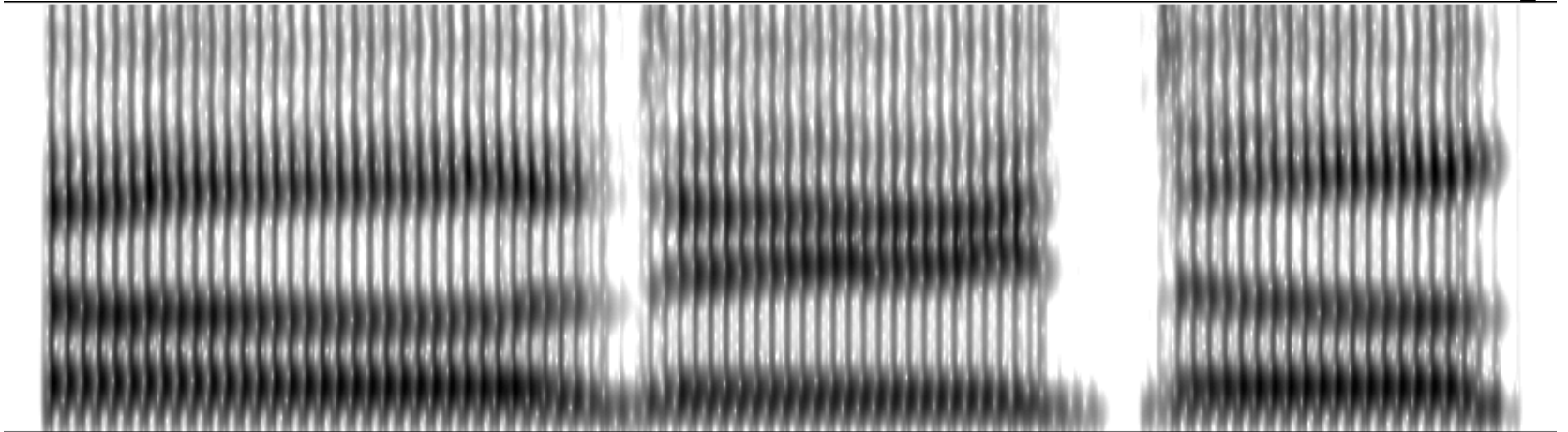
# TADA Modeling: Medium /i/

[ a d ε d a q ]



# TADA Modeling: Strong /i/

[ a d i d a q ]



# Results of TADA Modeling

- /i/ → [ɑ], /i/ → [ɛ], and /i/ → [i] can all be modeled as blending between gestures of palatal constriction and uvular-pharyngeal retraction
- Gestures can be specified for strength parameter settings beyond ‘strong’ and ‘weak’
  - Weak /i/ corresponds to Coeur d’Alene /i<sub>2</sub>/, undergoing full retraction
  - Medium /i/ corresponds to Coeur d’Alene /i<sub>1</sub>/, exhibiting partial retraction/partial transparency
  - Strong /i/ corresponds to transparent /i/ in other Interior Salish languages (e.g., Montana Salish), fully resisting retraction

# Alternative Analysis

# Alternative Analysis: Chain Shift in Coeur d'Alene

- Faucal harmony produces apparent chain shift in vowel quality

$$i_1 \rightarrow \varepsilon \rightarrow \alpha$$

- Synchronic chain shifts in non-derivational framework via conjunction of faithfulness constraint (Kirchner 1996)
- Coeur d'Alene Salish:
  - Conjoined constraint IDENT(high)&IDENT(back)
  - Difference in degree of uvularization in /i<sub>1</sub>/ and /i<sub>2</sub>/ due to /i<sub>1</sub>/ being indexed to conjoined faithfulness

# Strengths of Coactivation Transparency Analysis

Representing faucal harmony as blending of vocalic gestures of different strengths with retraction gesture:

- Eliminates need to represent pattern of retraction in domain of faucal harmony as chain shift
- All underlying gestures and their parameter settings are preserved in output
- Produces full uvularization of  $/i_2/$ ,  $/\varepsilon/$ , and  $/u/$  from low gestural strength and partial transparency of  $/i_1/$  from medium gestural strength

# Conclusion



# Conclusion

- Transparency in Gestural Harmony Model: result of competition between target states of dynamically-defined units of representation
- Partial transparency in Coeur d'Alene Salish faucal harmony fulfills prediction of model of transparency as competition/resistance
- Future work: examination of potential contrastive function of gestural strength