Oral Constriction Gestures II
Constriction Location and Orientation

Contrasting Oral Constriction Locations

- Traditional notion of "place articulation" can be modeled as constricting organ differences (correspond to "major" phonological features)

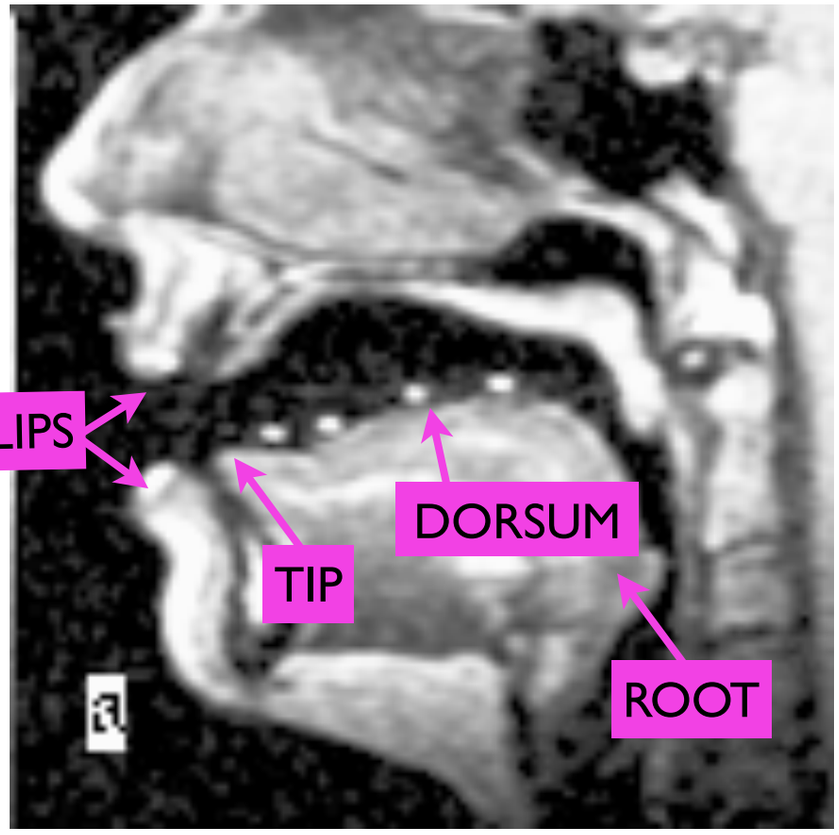
(1) lips — labial

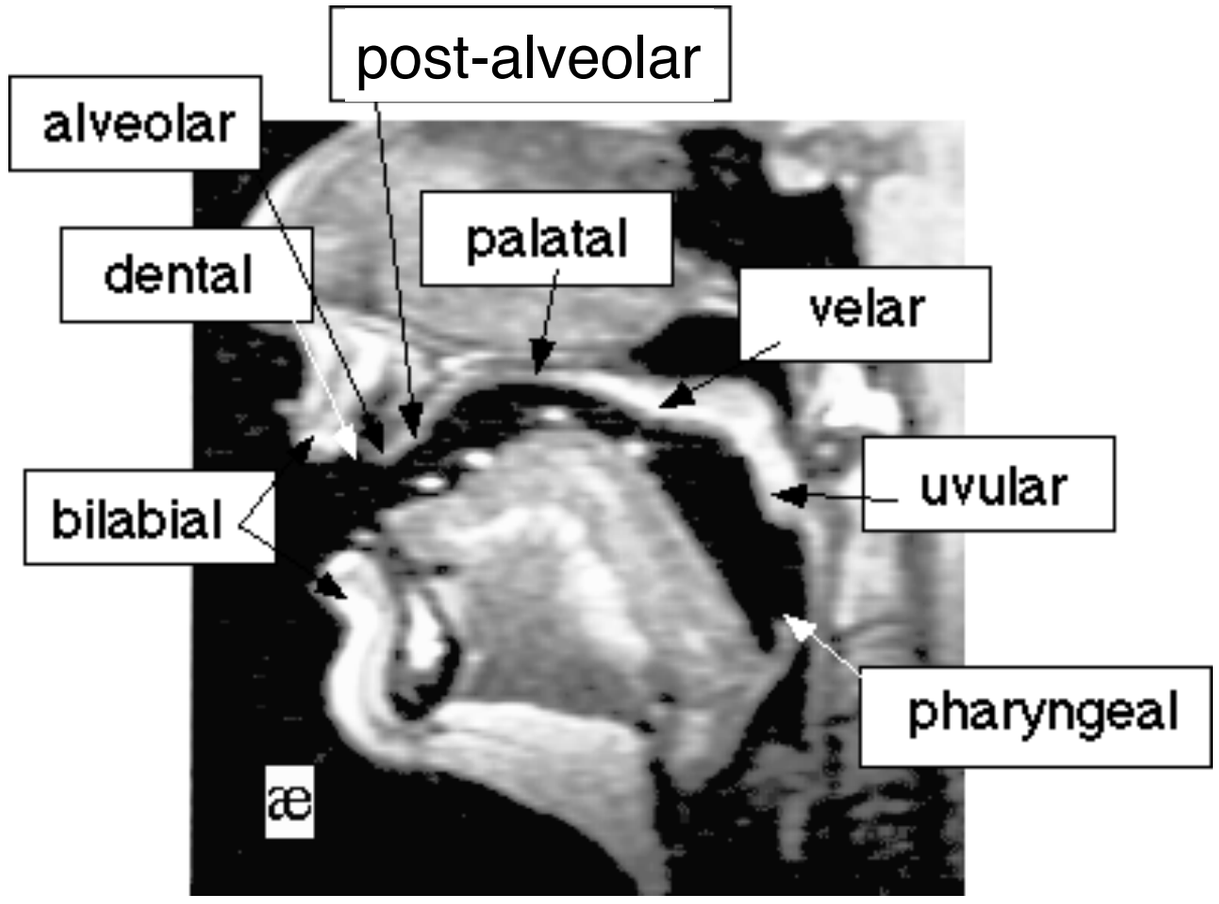
(2) tongue tip — coronal

(3) tongue body — dorsal

- But location of constriction produced by a given constricting organ
  - can differ from language to language
  - can contrast within a language

Oral Constrictors and Locations





Constrictor	Locations
labial	bilabial, labiodental
coronal (tip)	labial, (inter-)dental, alveolar, post-alveolar, palatal
dorsal	post-alveolar, palatal, velar, uvular, pharyngeal
radical (root)	pharyngeal

Coronal Constrictor

- Coronal constrictor exhibits the most possibilities for locations (CL)
  - Tongue tip is most flexible articulator
  - Tongue tip has richest neural innervation
- Coronal constrictions can vary in posture of the tip (how it is oriented), even for the same CD and CL
  - Synergy for coronal constrictions includes: jaw, tip, body
  - Body can be low and tip curled up
  - Body can be high and tip not curled

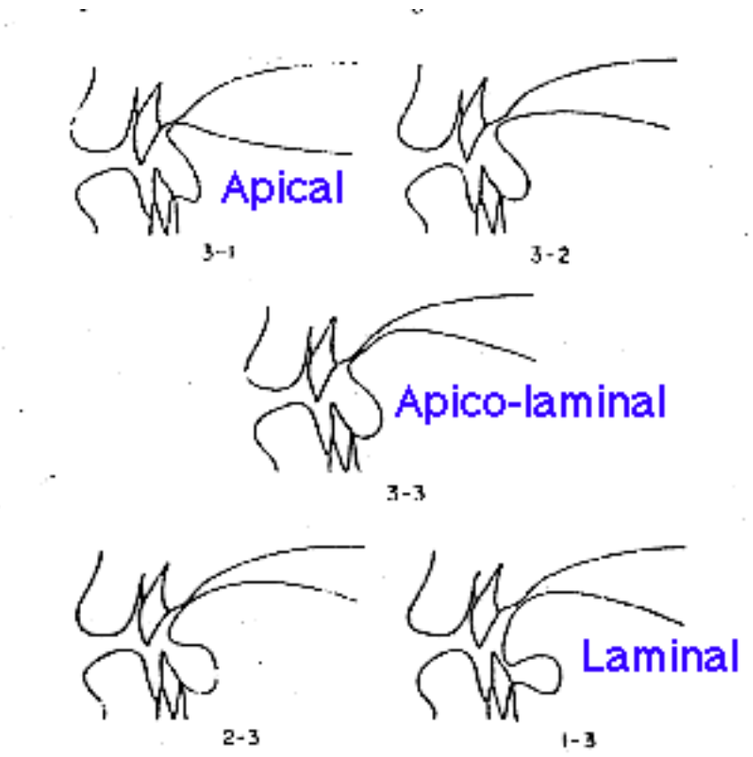
Coronal Stops: Articulator Synergies

- Variability in posture as a function of context

"heed"
body raised
tip down

"hod"
body low
tip curled

Coronal Stops: Individual Production Differences



After Bladon & Nolan (1977)

Contrasts in Tip Posture

- Languages can contrast in the posture or orientation of the tongue tip (TTCO) for a given location.
  - Apical - Tip raised and making contact
  - Laminal - Tip flat or lowered, Blade (Lamina) makes contact
- Most Australian languages contrast 4 coronal stops
- Location (anterior vs. non) X Posture (apical vs. laminal)

	apical	laminal
anterior alveolar ridge forward	t d n	t̪ d̪ n̪
non-anterior post-alveolar ridge	ʈ ɖ ɳ	t̠ d̠ n̠

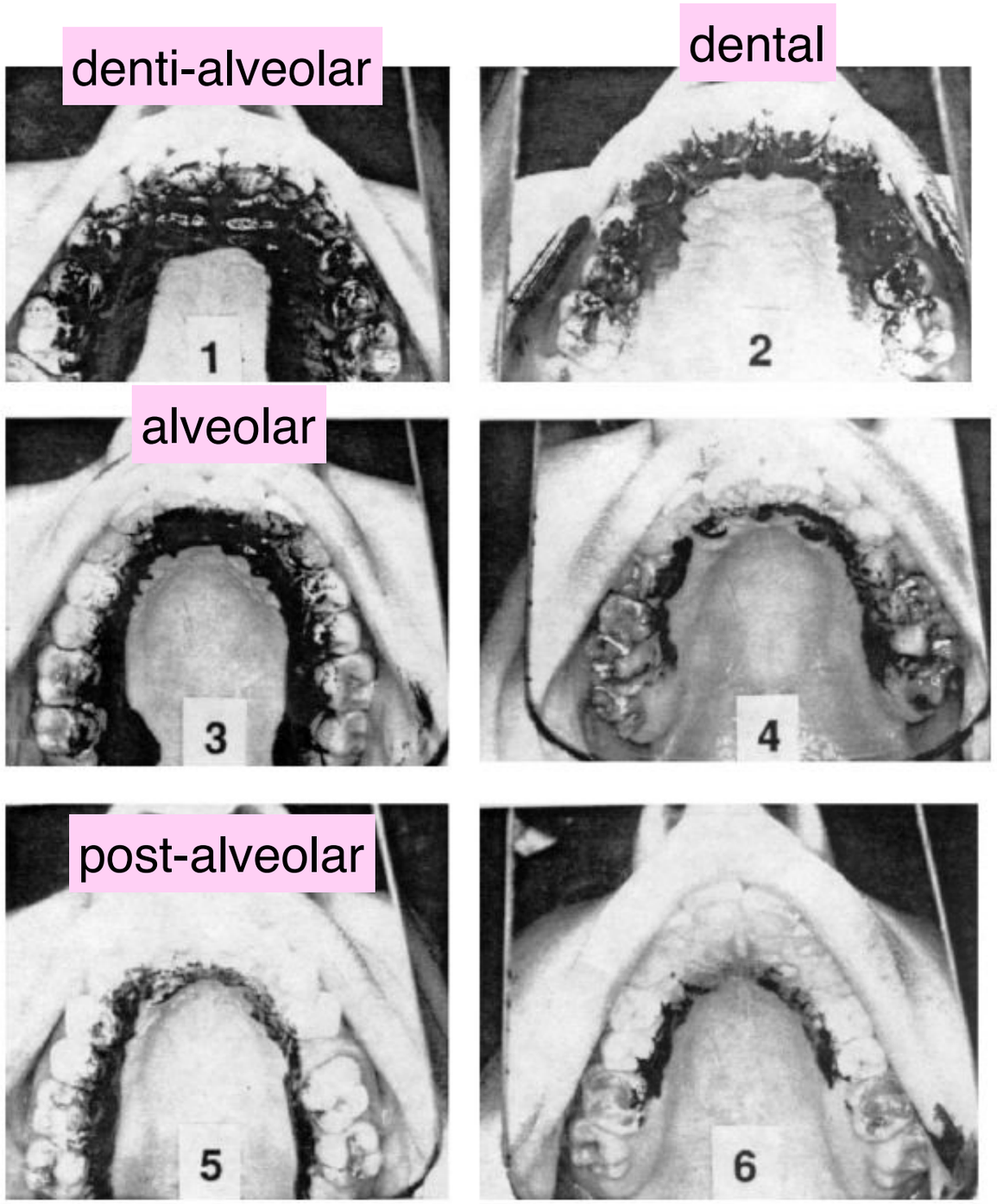
Direct Palatography

- shows pattern of contact between tongue and palate
- Technique:

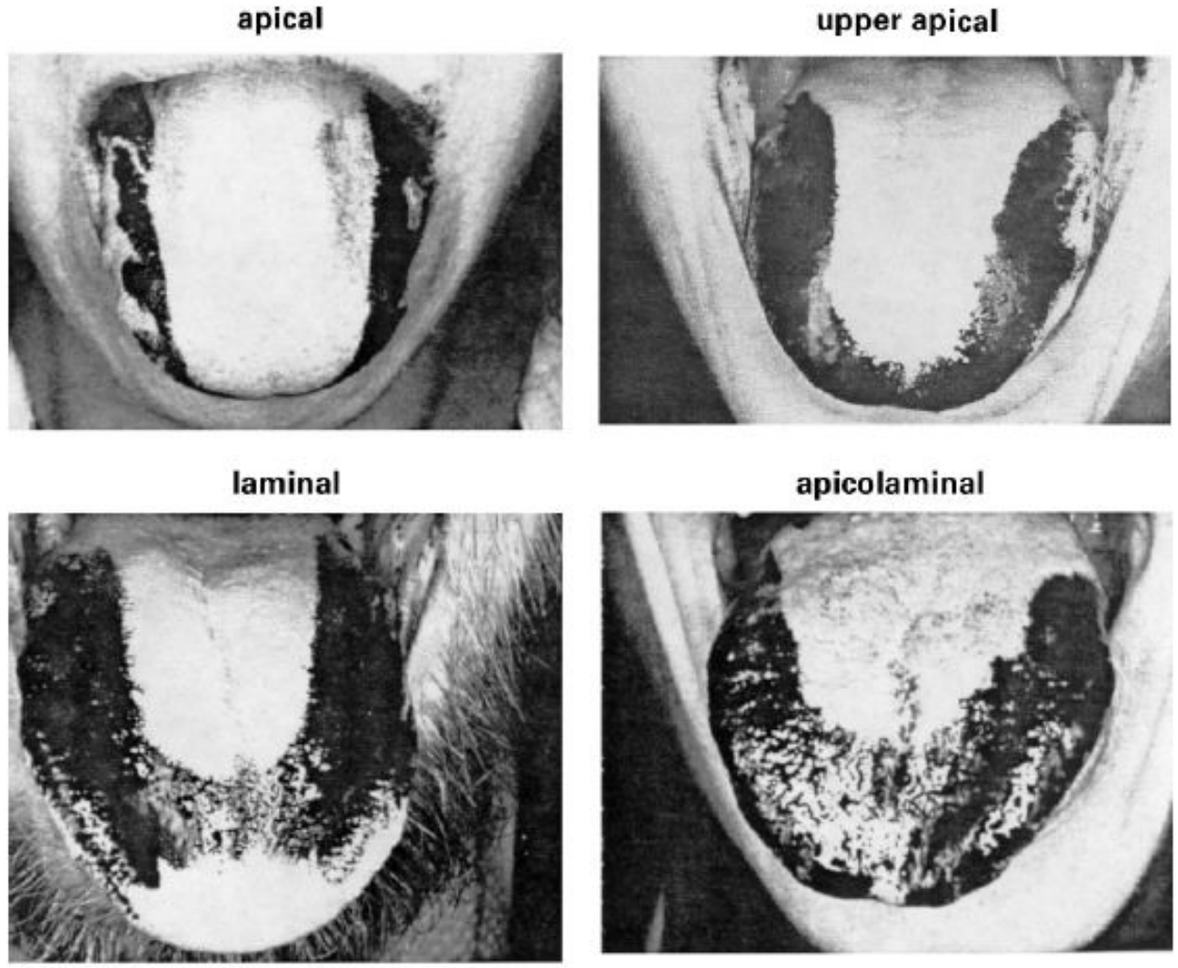
1. Phonetician's salad dressing (olive oil, charcoal, lemon) is applied to surface of tongue tip and blade.
2. Utterance with single coronal is produced.
3. Blackened area of palate: palatogram
4. Salad dressing applied to palate and utterance is repeated.
5. Blackened area of tongue: linguogram

- Limitation of technique:
  Areas contacted may not all be contacted simultaneously. (No dynamics represented).

CL and CO (Postures)



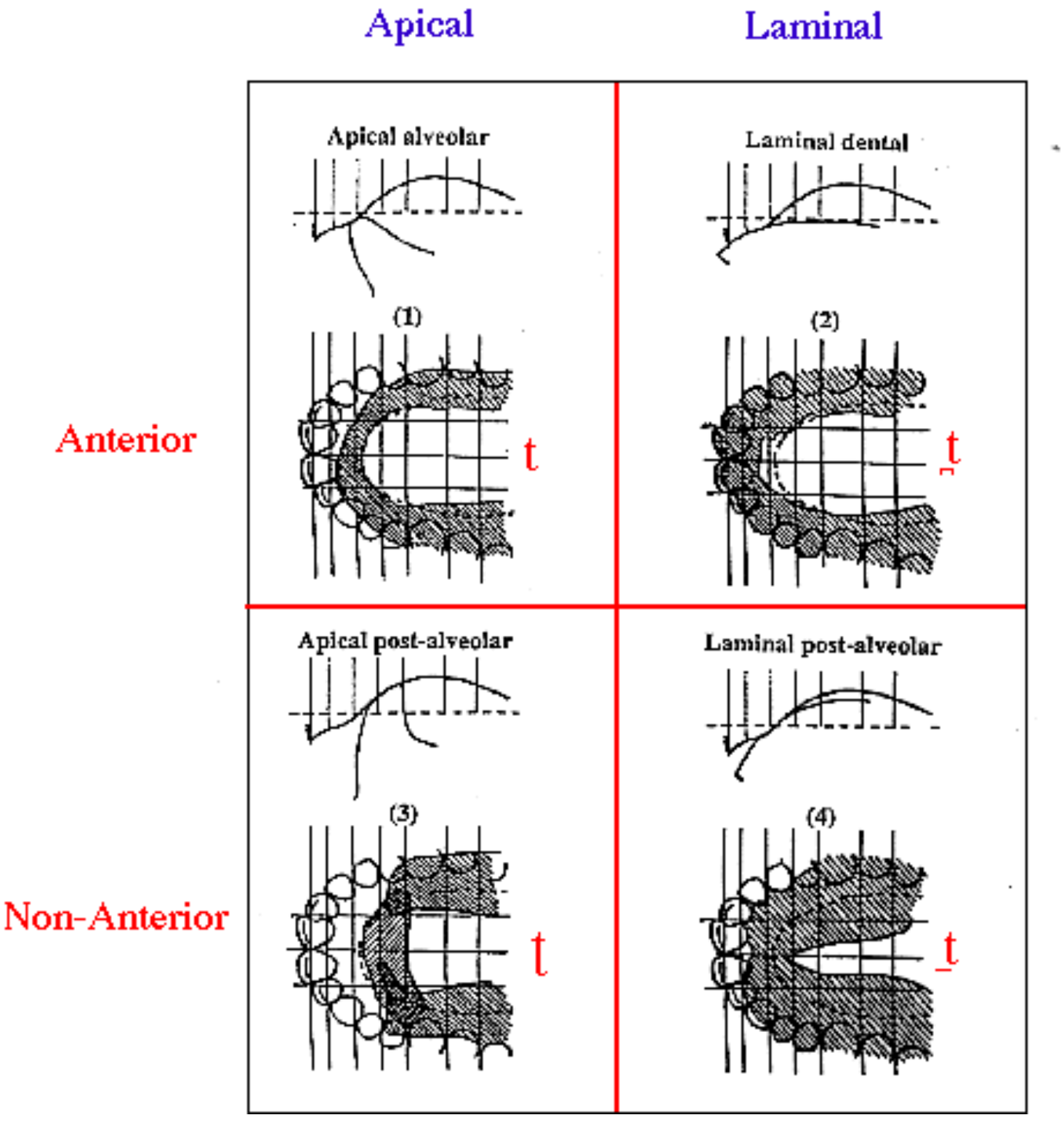
palatogram



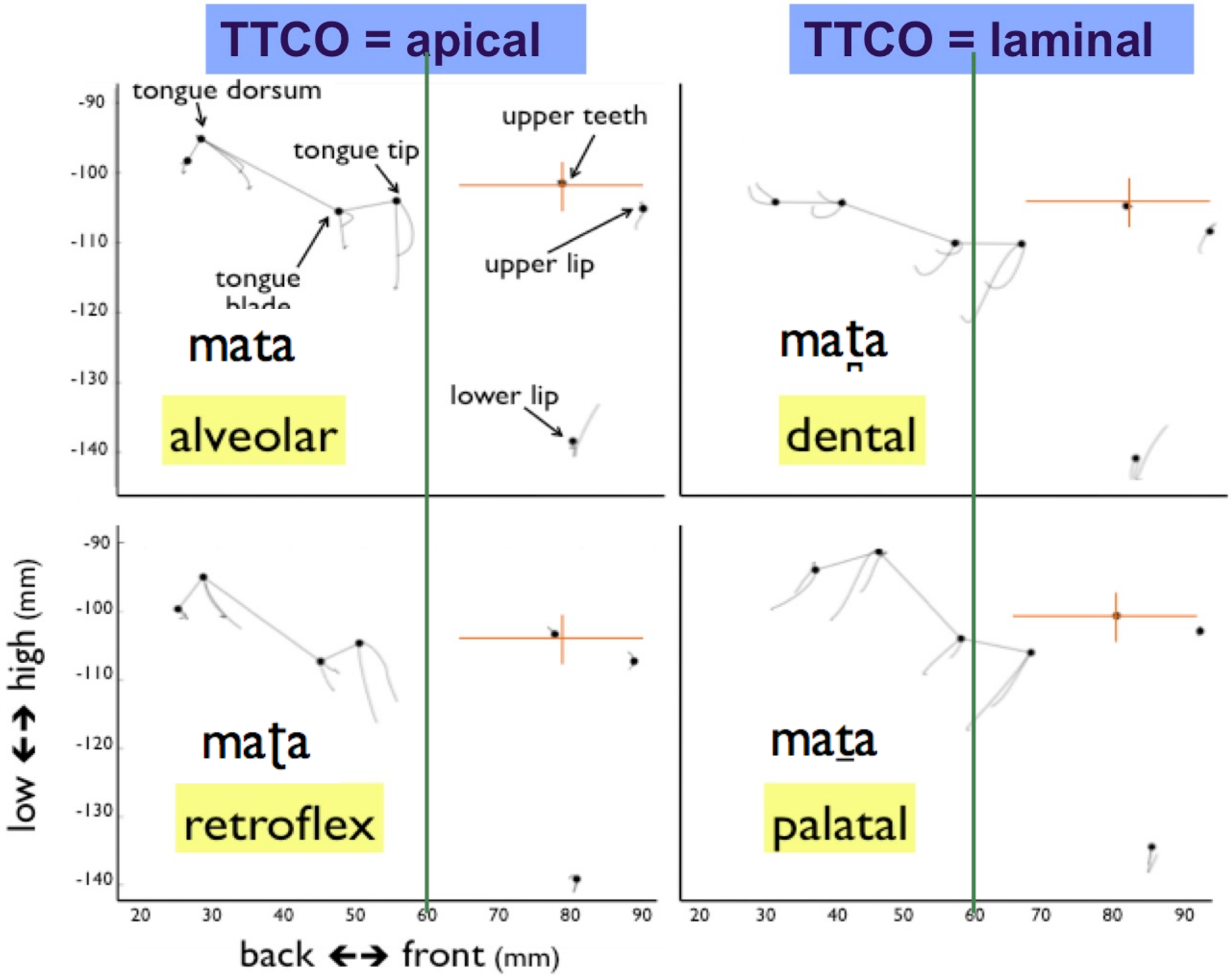
linguogram

Eastern Arrernte
Ladefoged & Maddieson (1986)

- Wubuy
- Yanyuwa
- Wangurri



Wubuy (Best et al., 2010)



Basis for within-organ contrasts

- Modal values along a constriction continuum can emerge through self-organization as consequence of mutual attunement in a population of agents.

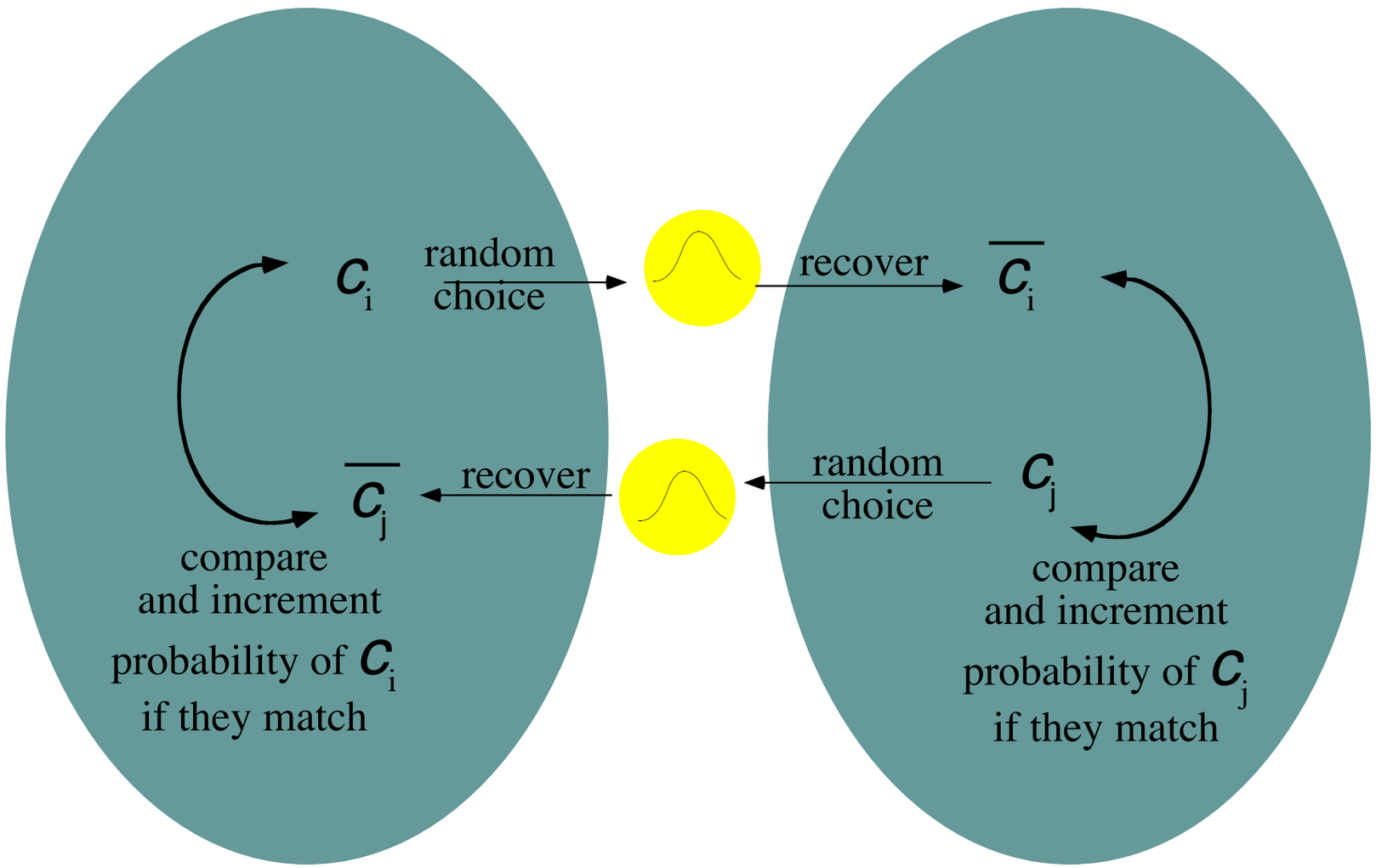
- Agents can all be assumed to select actions randomly (no modes) at the beginning of process

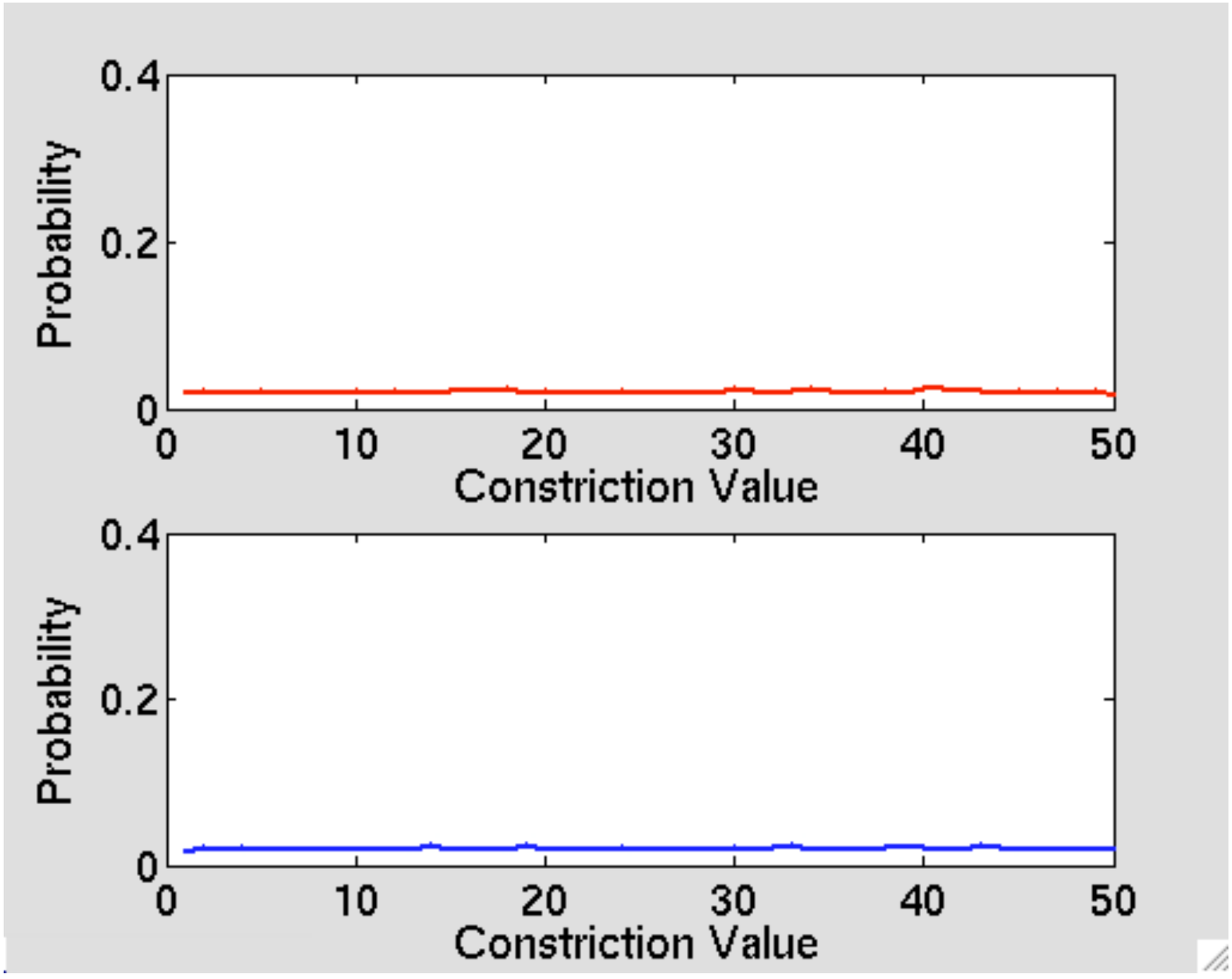
- Browman & Goldstein, 2000; deBoer, 2000; Oudeyer, 2002; Wedel, 2004; Nam et al. 2009

Attunement and modes

- Imagine two agents, who are trying to accommodate their actions to one another, through imitation.

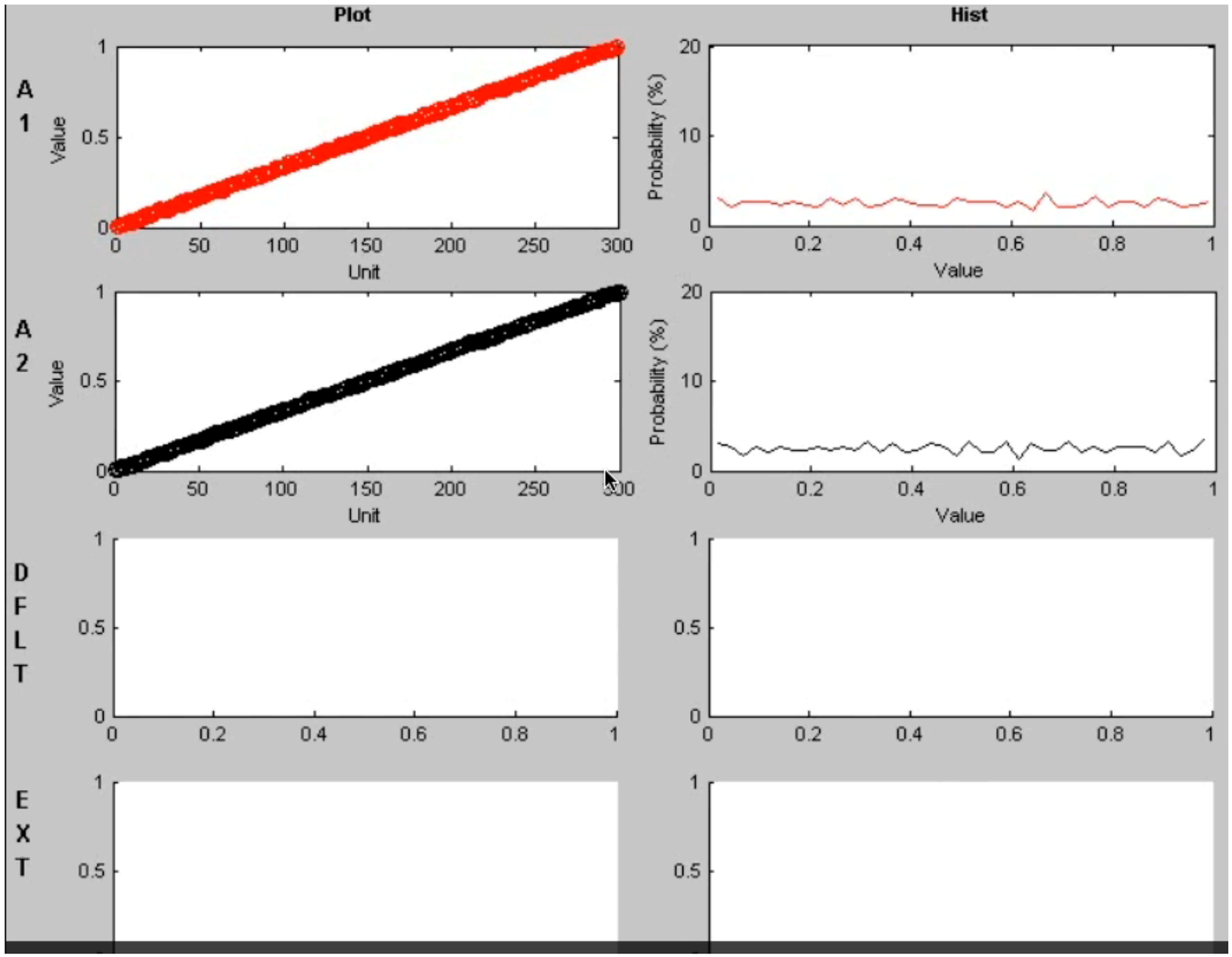
- They produce actions whose constriction goal value is randomly chosen from some constriction continuum, for example the Constriction Location (CL). Each time they happen to produce an action that matches the CL of their partner's action (within some tolerance), they increase the probability of producing that constriction.




0.4
0.2
0
Probability
0
10
20
30
40
50
Constriction Value
0.4
0.2
0
Probability
0
10
20
30
40
50
Constriction Value

Multiple Modes

Under certain conditions agents' behavior can settle into multiple modes.
These modes effectively partition a constriction dimension into distinctive values.



Bimodal distribution of Tongue Tip stops in Hindi?

- Given a contrast between retroflex and dental stops, a bimodal distribution of tongue tip constriction location (TTCL) of the would be expected at some level of abstraction.

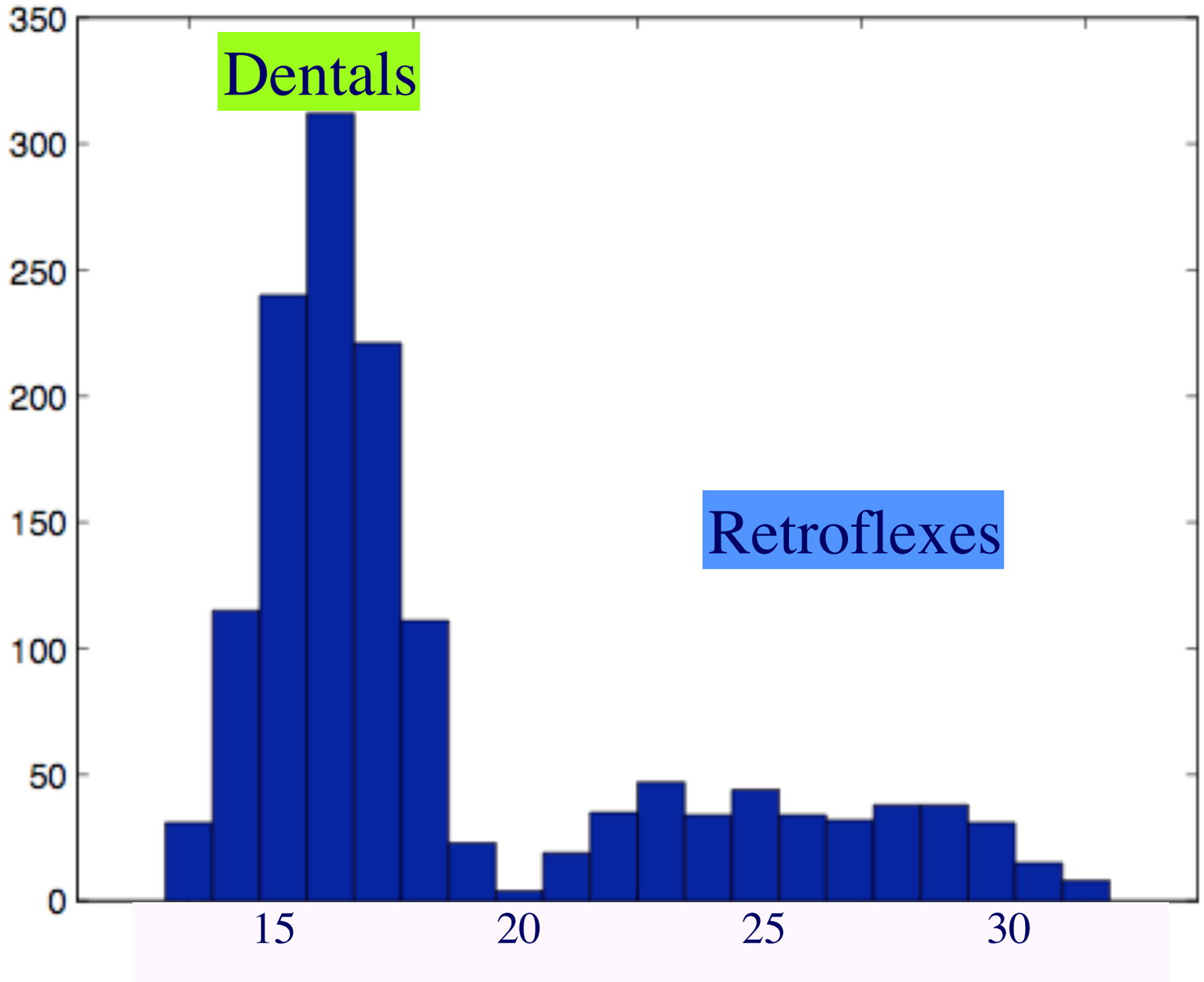
- Could be obscured in running speech by variability (contextual, prosodic).

- If the distribution is going to be useful to young infants, it should be directly observable in the speech signal.

EMMA experiment: Hindi

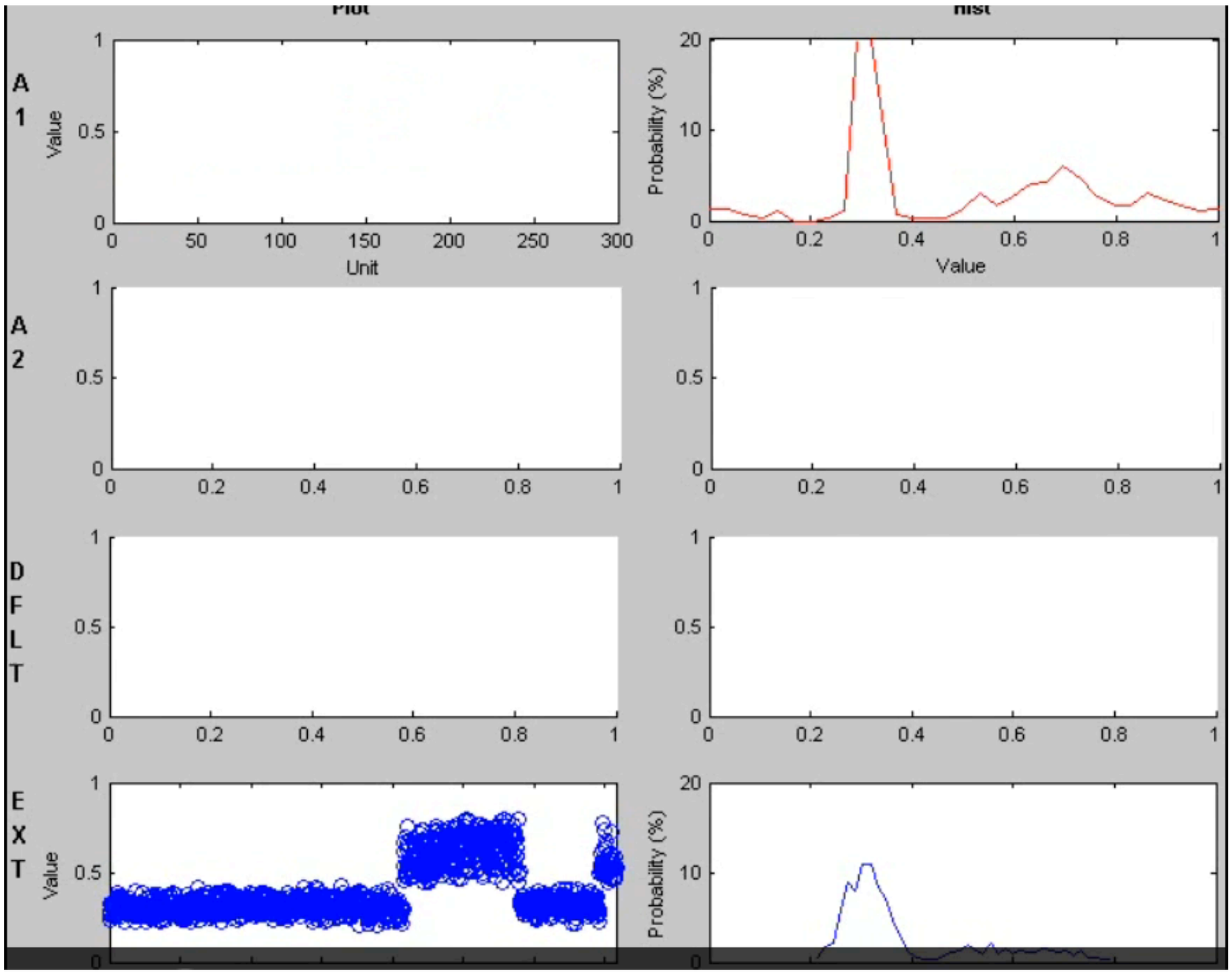
- Speaker of Hindi read a 6000 word story.
- Sensors on lips, jaw, and tongue (tip, body, dorsum).
- For each of the 1434 coronal stops in corpus, time of closest approximation of tongue tip sensor to palate was detected.
- Horizontal position of the tongue tip (with respect to upper teeth) was logged.

Hindi TTx Results



Partitioning Continuum in Learning

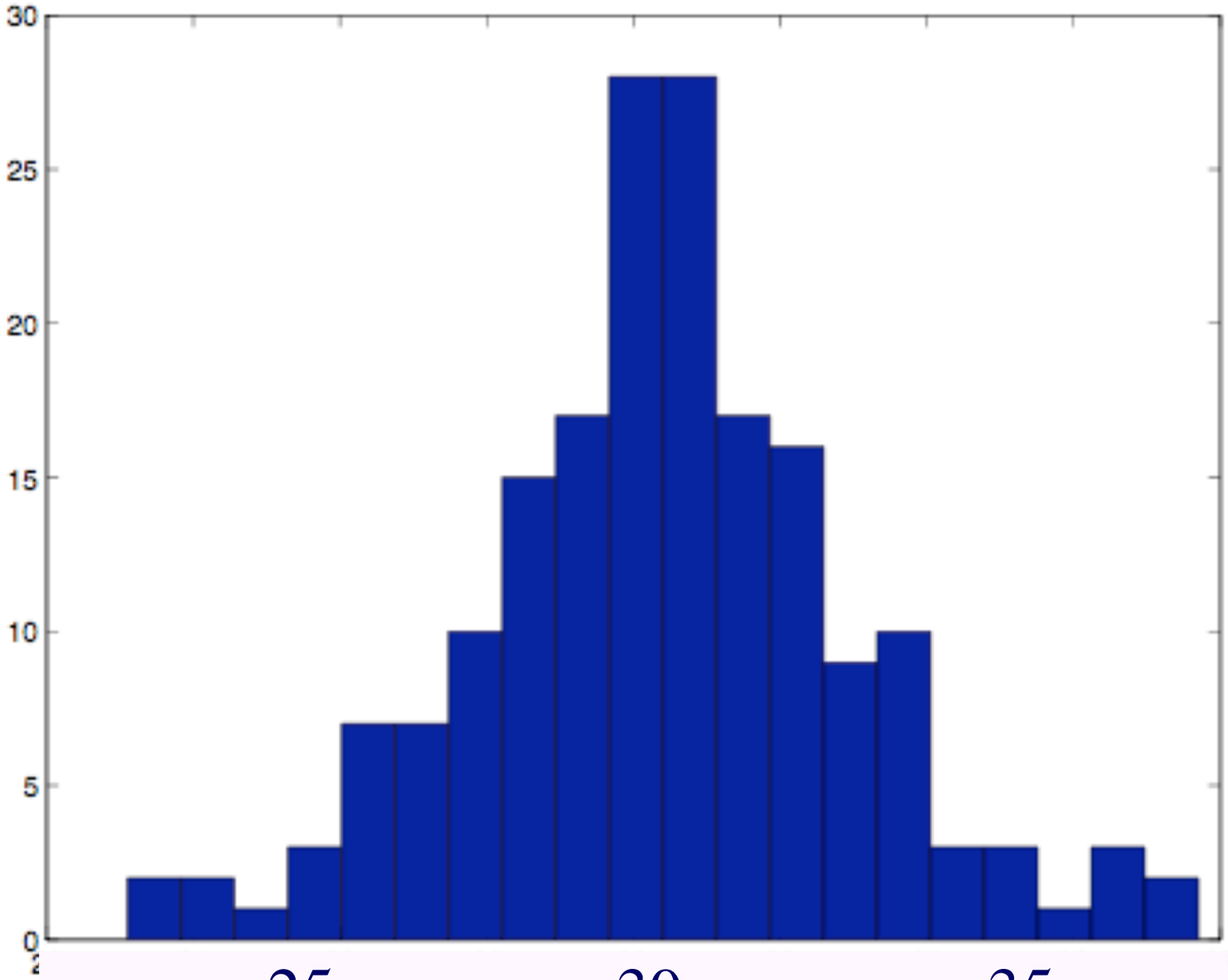
One agent already has adult distribution and it doesn't change over simulation



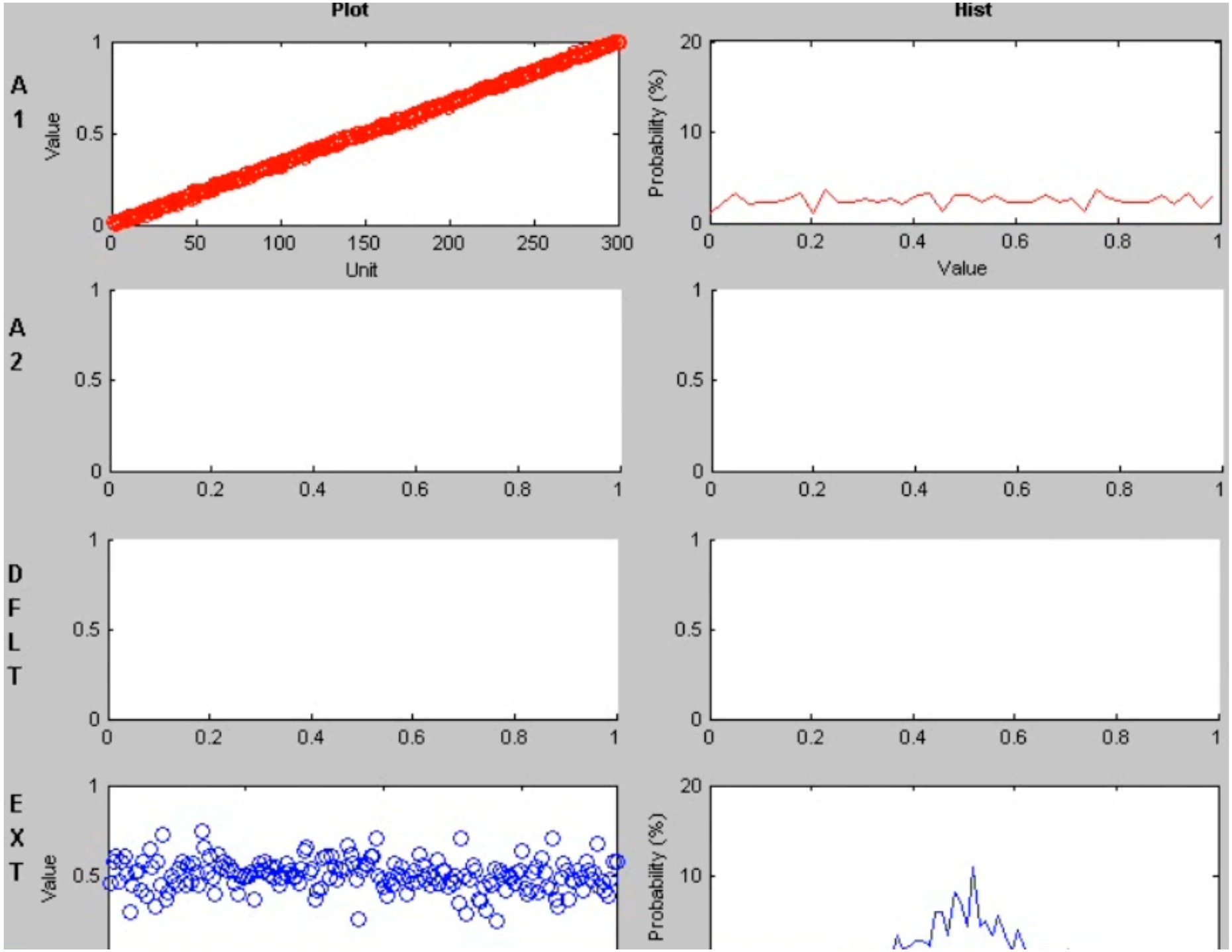
EMMA experiment: English

- Speaker of American English read a 1000 word story.
- Sensors on lips, jaw, and tongue (tip, body, dorsum).
- For each of the 184 coronal stops in corpus, time of closest approximation of tongue tip sensor to palate was detected.
- Horizontal position of the tongue tip (with respect to upper teeth) was logged.

English TTx



mm from teeth


Plot
Hist
A
1
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Probability (%)
Value
A
2
D
F
L
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E
X
T
Value
Probability (%)

Non-contrastive language differences in anterior coronal stops

- Without a contrast, do languages have a preferred CL and posture for coronal stops?

- English-Spanish difference is robust.

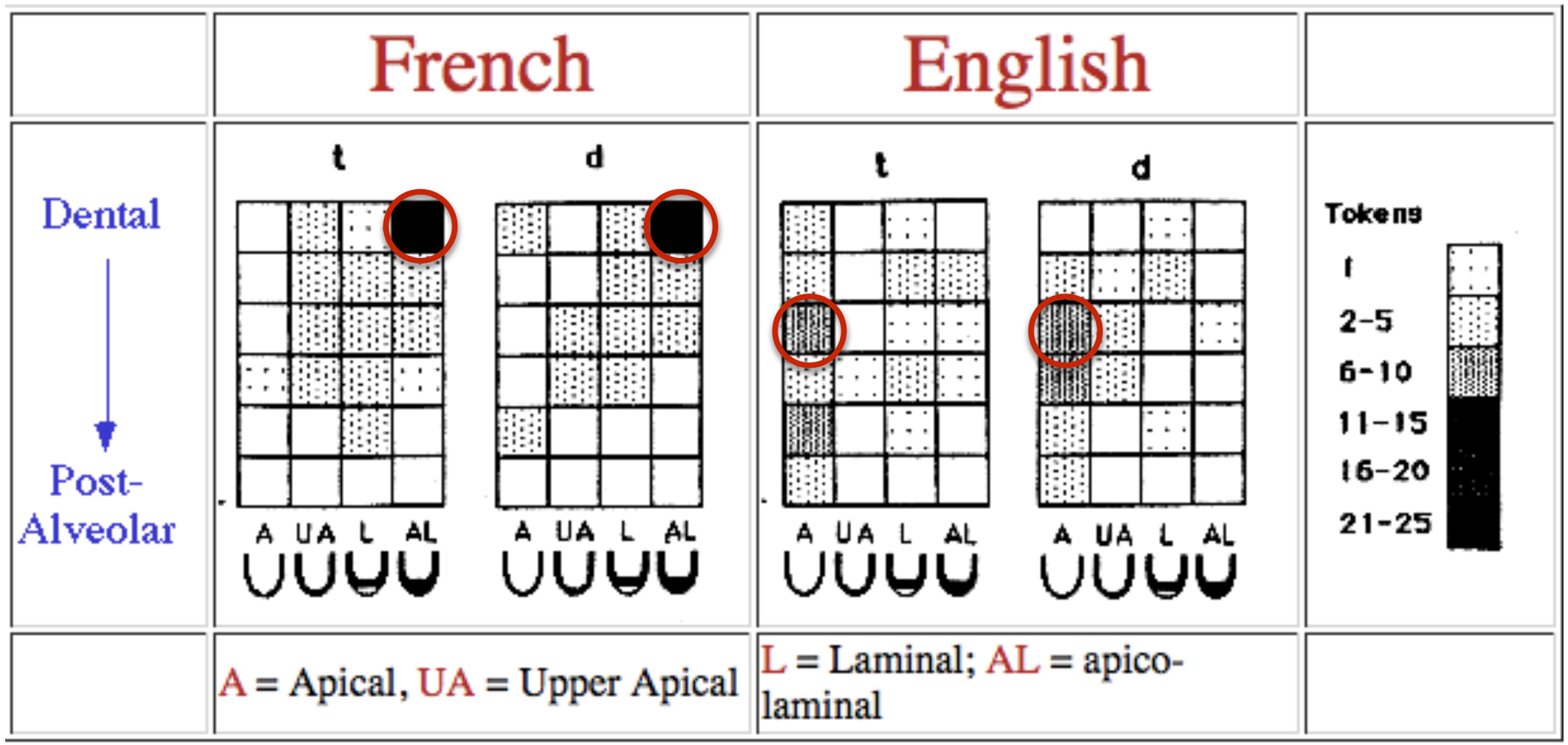
Laminal? dental

Apical alveolar

English vs. French coronal stops

- Traditional Description
  - French stops: laminal dental
  - English stops: apical alveolar
- Palatographic evidence (Dart, 1998):
  This pattern is statistically valid, but there is considerable variability across speakers.
- In languages without contrast, synergies can vary across speakers, as well as contexts.

Results (2 tokens per speaker)



Articulatory Setting

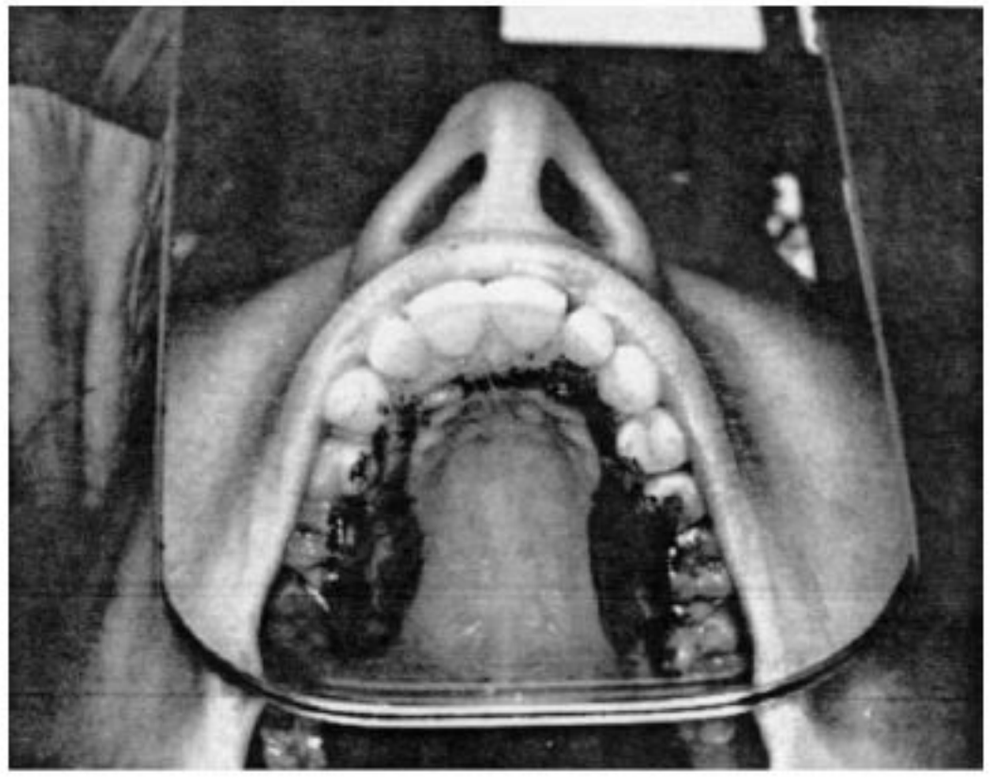
- Acoustic analysis suggests that Speakers of English and French are more consistent than would be indicated by palatography.

- Languages differ in articulatory setting: neutral postures.

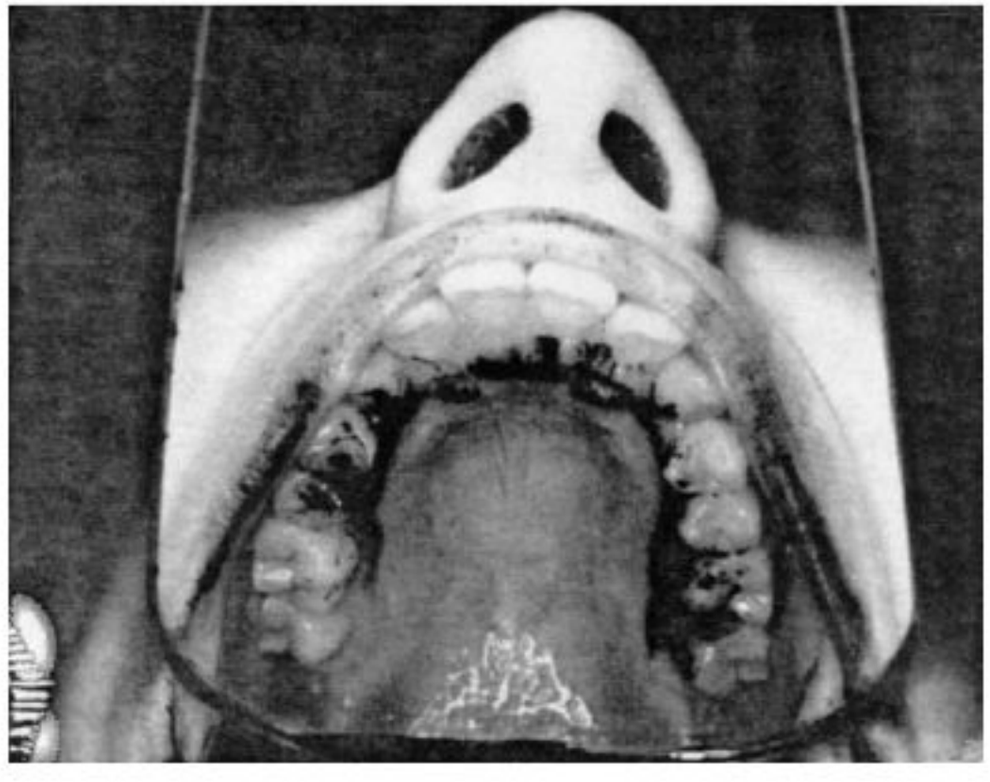
- Neutral posture of tongue body is higher in French than English (would explain acoustic differences).

- Because of differences in neutral posture of tongue, French and English would differ in relative contribution of tongue body height vs. tongue tip raising in coronal constrictions.

French



English



Non-contrastive language differences in NON-anterior coronal stops

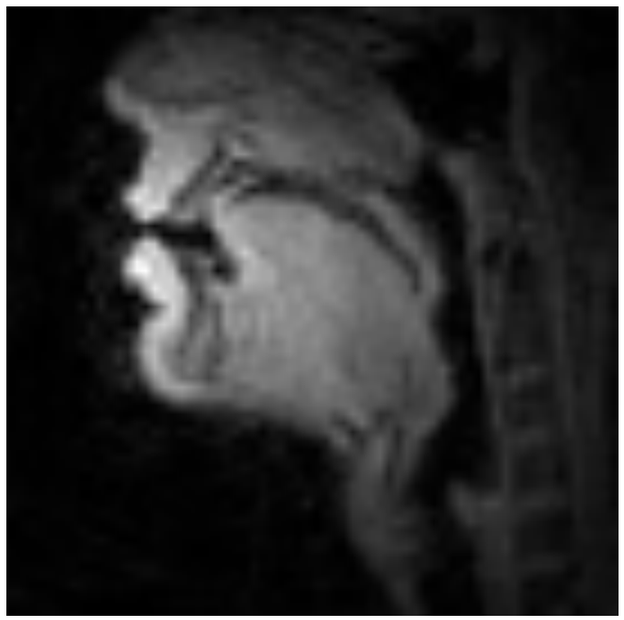
- "Retroflex" (=apical post-alveolar stops)

ʂ ʂ ʂ or ʂ

Tamil

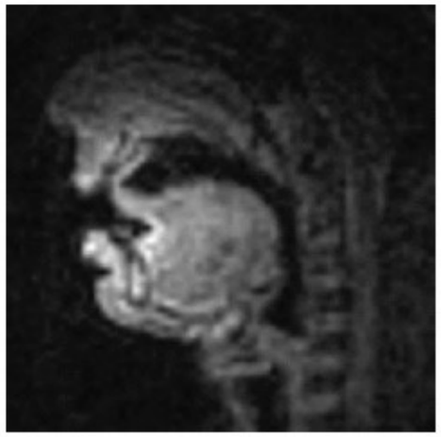
Extreme retroflexion

CL=Palatal

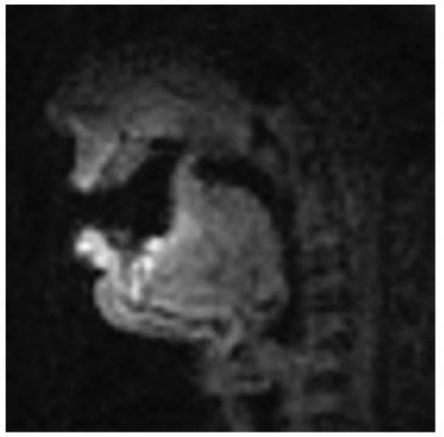


dental (post)-alveolar retroflex

Lateral:



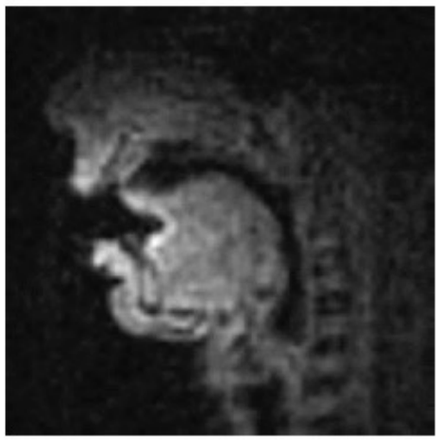
[pali]



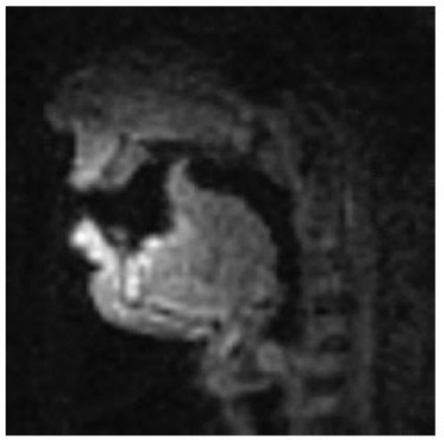
[paɭi]

Rhotic:

[pari]



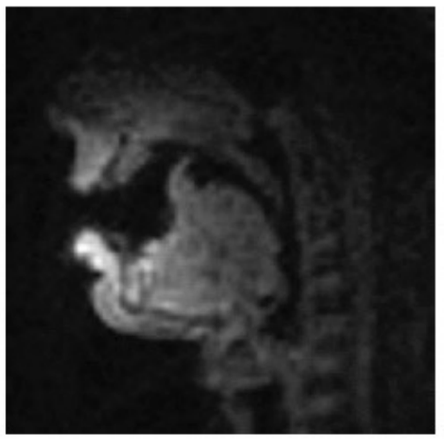
[paɾi]



[paɻi]

Nasal:

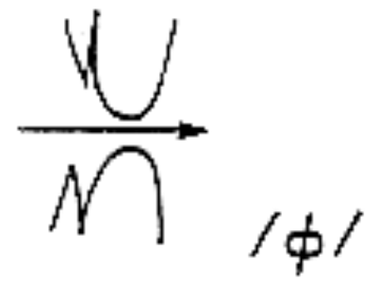
[pani]

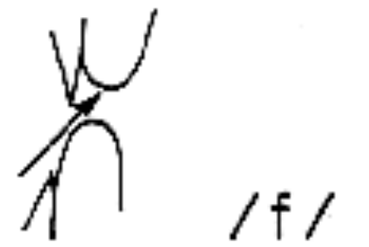


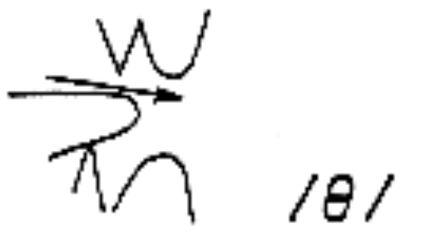
[paɳi]

Contrasts in Coronal Fricatives: sibilance

- Sibilant vs. non-sibilant fricatives
- Sibilant fricatives (s,ʃ) involve wake turbulence
  - Air stream is nozzled onto obstacle.
  - Collision with obstacle is major source of turbulence.
- Non-sibilant fricatives involve channel turbulence
  - Air stream sliding against sides of channel causes turbulence.

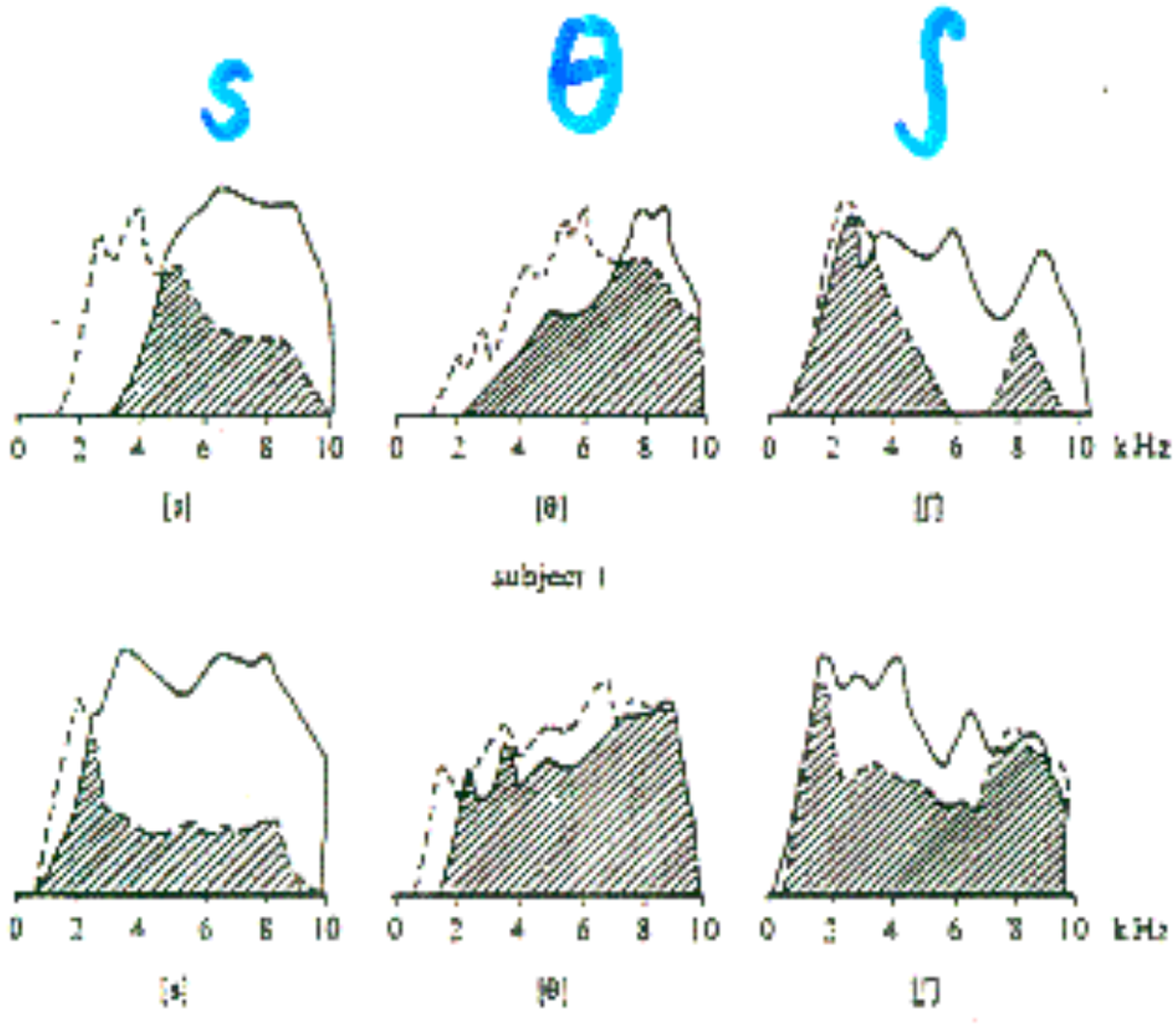






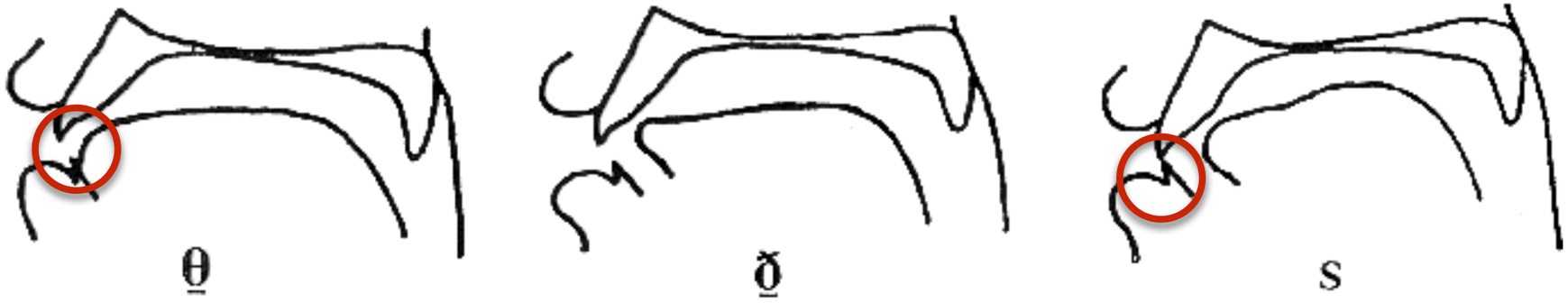
Evidence for role of teeth Catford (1977)

- Frequency spectrum of sibilant fricatives (s,ʃ) changes radically when false teeth are removed.
- Little effect on non-sibilant fricative (θ).



Minimal contrast of sibilance

- Icelandic contrasts an alveolar sibilants ([s]) with alveolar non-sibilant ([θ̲]) fricatives.



(after Pétursson, 1971)

English CL contrasts for TT fricatives

alveolar

palatoalveolar

/s/-/ʃ/ contrast

- What are goals?
    - Constriction Location differences are most robust in the X-ray microbeam corpus of 45 English speakers.
    - Most speakers show bimodal distribution of CL
    - Also:palatal vs. velar dorsal constriction
- Other differences ?

English	s	ʃ
Constrictor	coronal	coronal
Distance to obstacle	short	longer
Constriction Width	narrow	wider
Cross-sectional shape	grooved	domed
Sublingual cavity	absent or small	present, larger

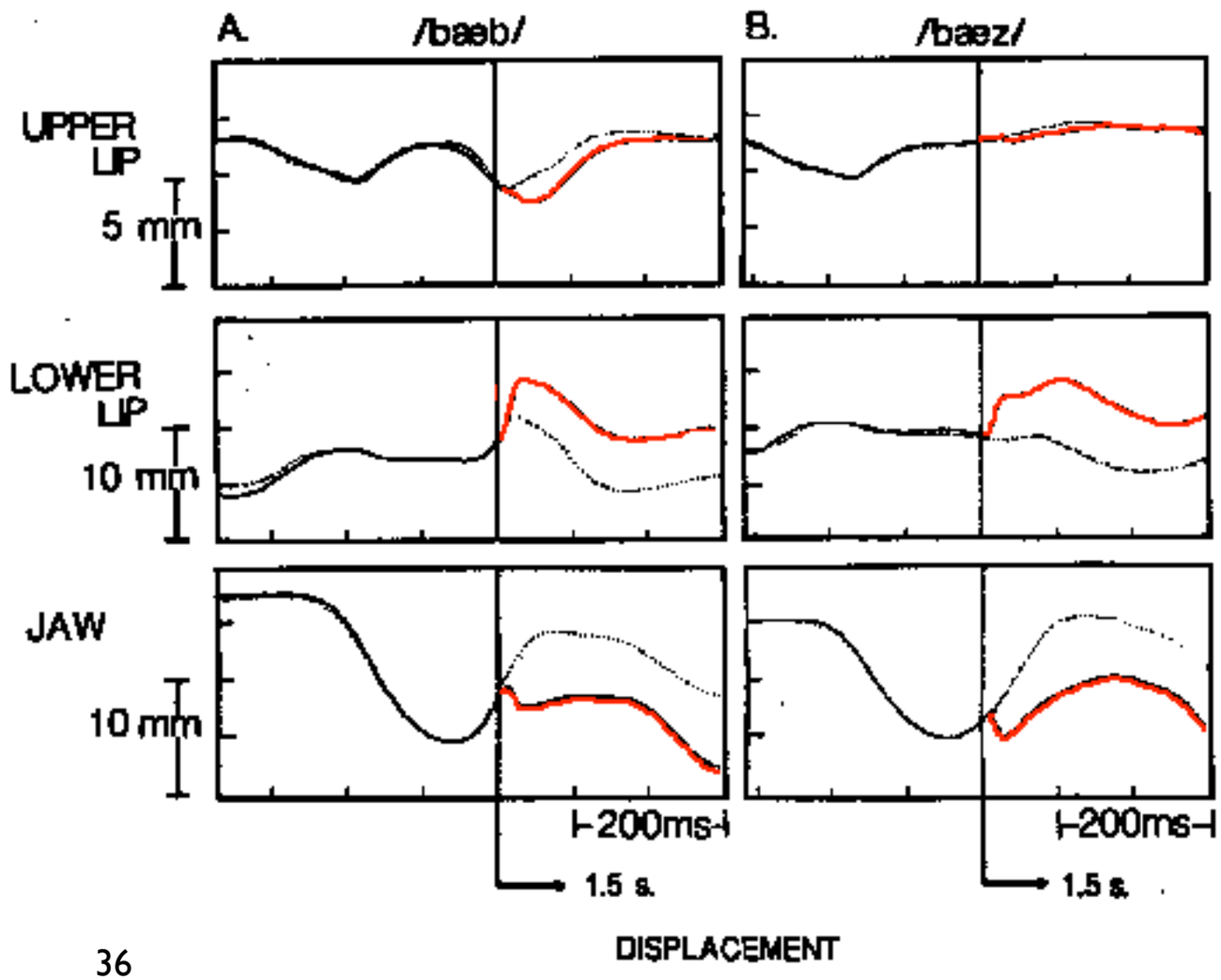
/s/-/ʃ/ contrast

/s/-/ʃ/ contrast

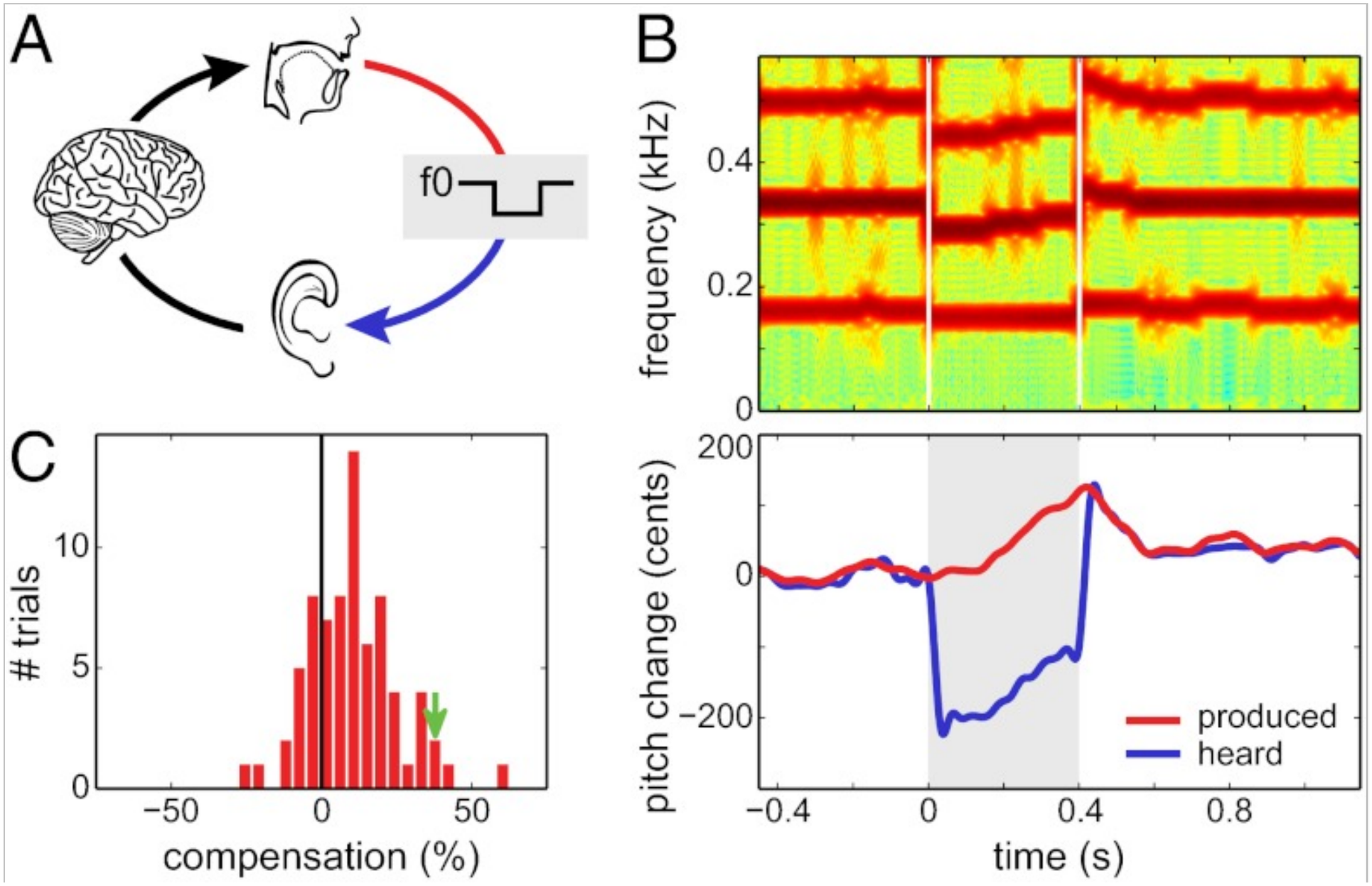
- Given the variety of goals, could there be a single acoustic goal?
- What would it be?
- How could you tell?

Compensation for perturbation

- **Compensation**
  When the task is threatened by a perturbation of one articulator (e.g., yanking on the speaker's jaw as (s)he is about to produce a lip closure), other articulators, remote from the site of the perturbation, act to to meet the challenge (e.g., increased displacement c
- **Speed**
  Compensatory action is extremely fast (20 ms or so). This implicates direct inter-articulator cooperation. There is not enough time for an executive to "manage" responses to perturbation.
- **Task-specificity**
  Response to perturbation is task-specific, not hard-wired. If the subject is producing /z/, instead of /b/, response is not seen.



Perturbed Auditory feedback: compensation for auditory perturbation

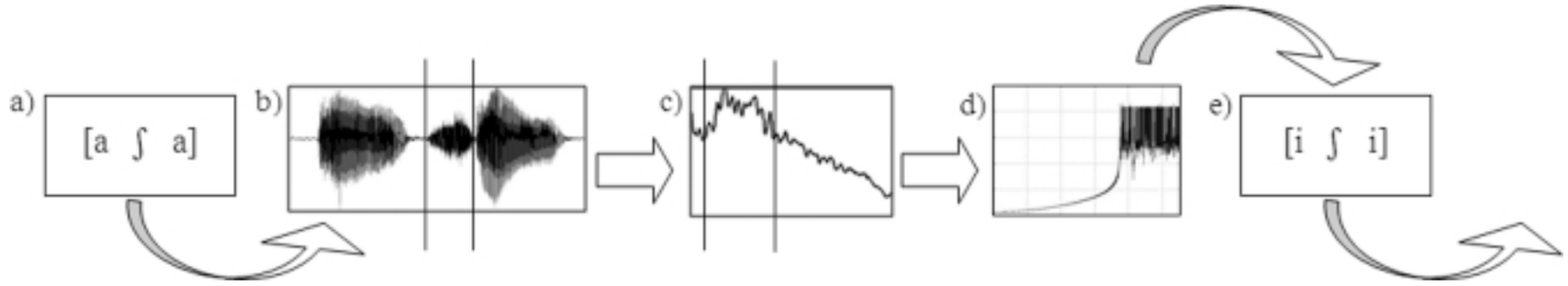


Human cortical sensorimotor network underlying feedback control of vocal pitch

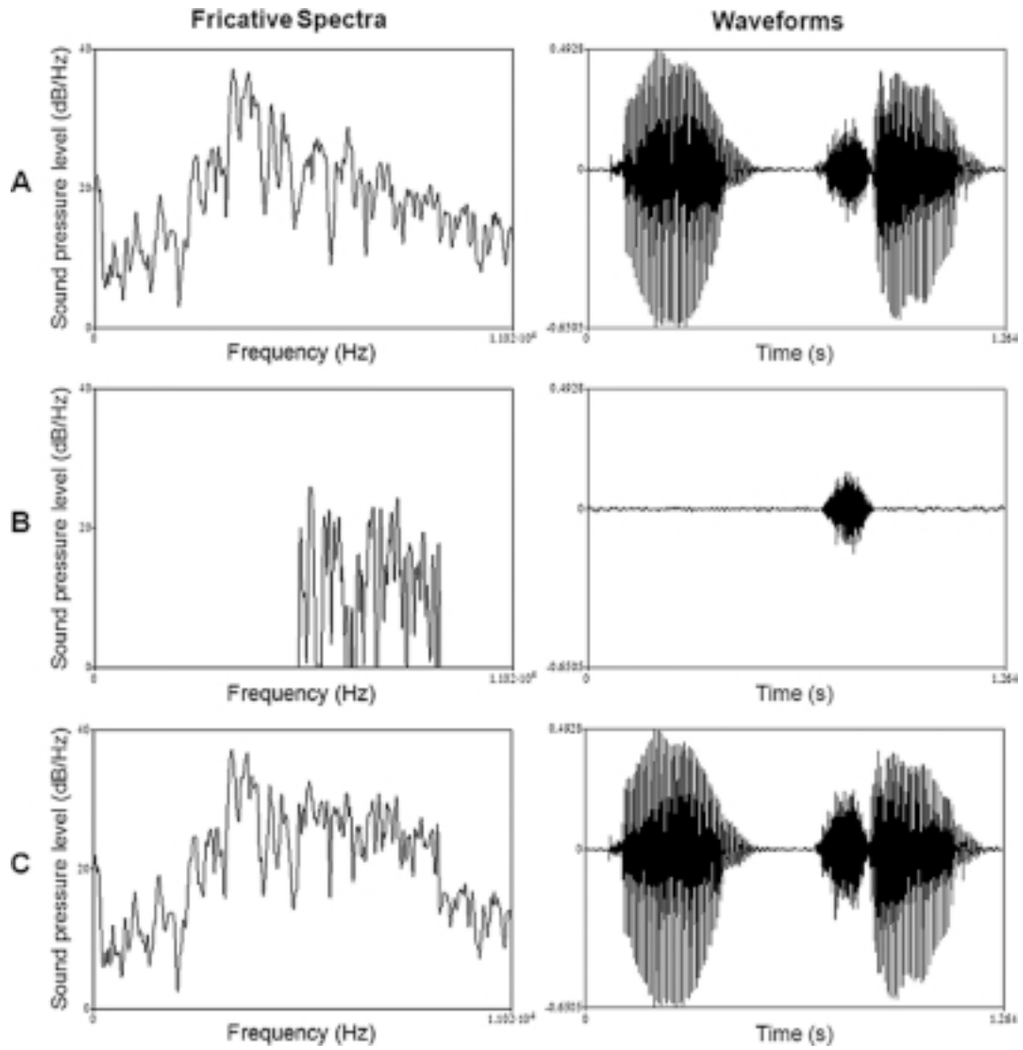
Edward F. Chang,a,1,2 Caroline A. Niziolek,b,1 Robert T. Knight,a Srikantan S. Nagarajan,c and John F. Houdeb,2

Proc Natl Acad Sci U S A. 2013 Feb 12; 110(7): 2653–2658.

Application to Fricatives (Casserly, 2011)



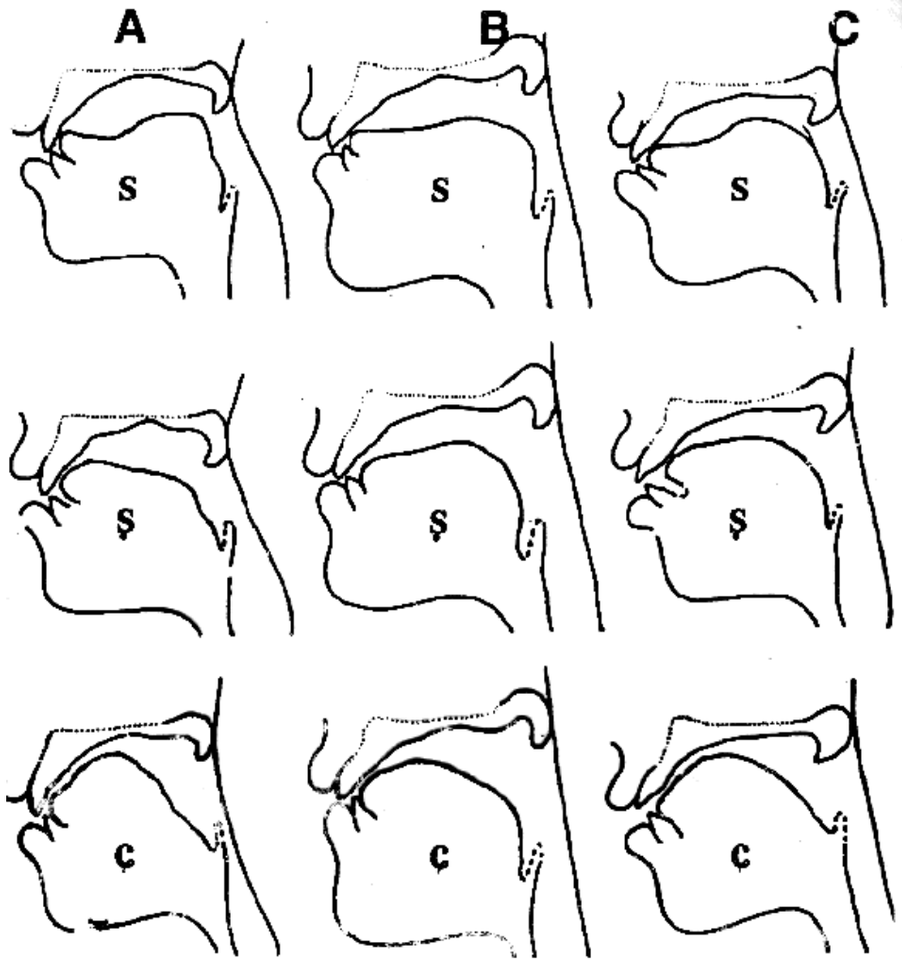
(A) Final trial of baseline, without acoustic alteration. Speaker produces a vowel-[ʃ]-vowel nonword. (B) Production is recorded and the voiceless fricative is automatically excised from the file (vertical lines). (C) Power spectrum is computed from the fricative and its frequency bandwidth (schematic cutoffs shown by vertical lines) is noted. (D) Synthetic fricative containing turbulent noise starting at the topmost edge of the observed frequency bandwidth is created. (E) High-frequency fricative noise is played over headphones to the speaker during production of their next fricative. That natural production starts the cycle over at (A).



- 9 subjects imitate shift
- 6 counter it (compensate)
- 5 showed no change

Three-way contrasts among sibilants

Chinese (after Ladefoged and Wu, 1984)



s

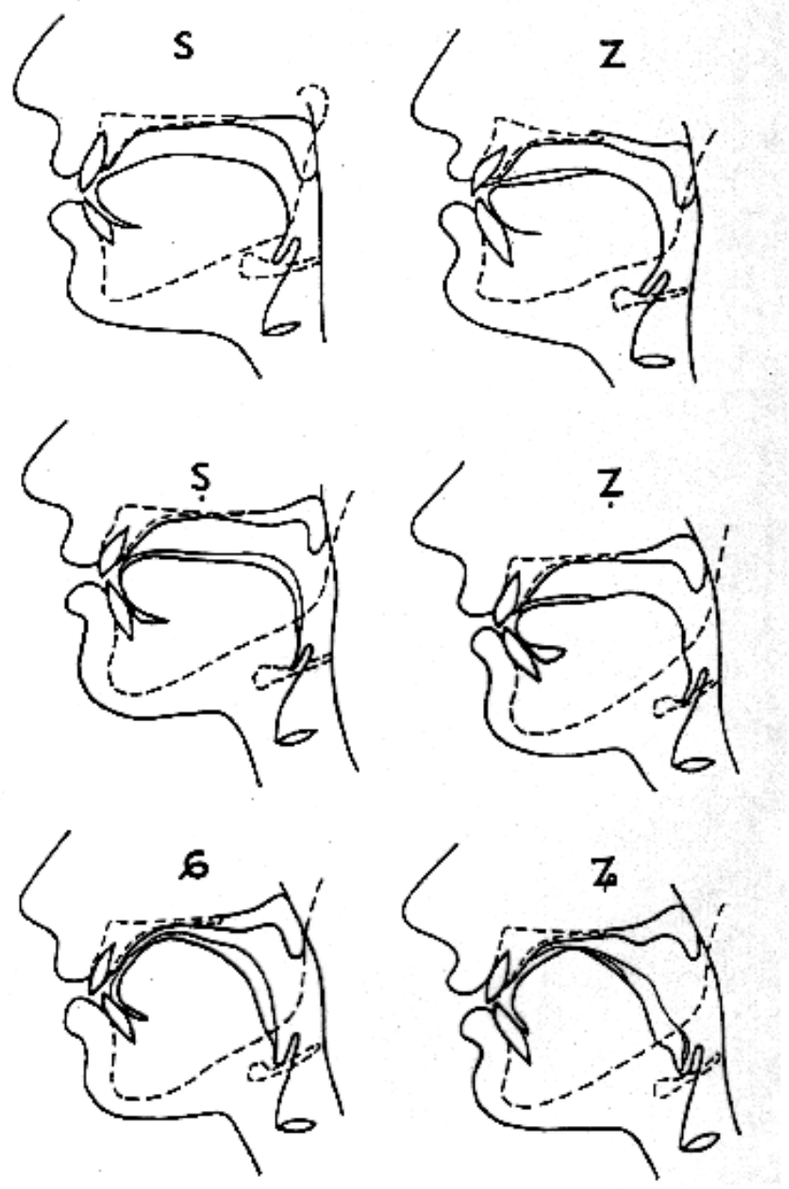
ʂ

ɕ

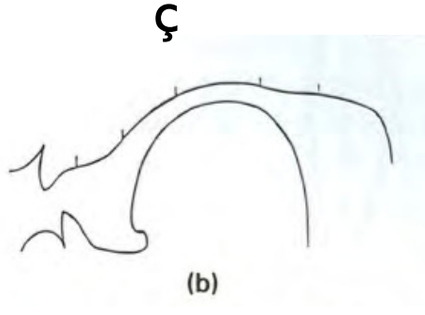
Chinese	s	ʂ	ɕ
Constrictor	coronal	coronal	coronal-dorsal
Dist to Obstacle	short	long	short
Sublingual Cavity	absent	present	absent

Three-way contrasts among sibilants

Polish (after Ladefoged & Maddieson)



Compare coronal-dorsal sibilants
to dorsal palatal non-sibilants (Recasens, 1990)



Four-way contrasts among sibilants

- In Ubykh, there may be a minimal contrast between two fricatives as a function of sublingual cavity.
- ŝ (hissing-hushing) may be an alveolar constriction but with larger sublingual cavity (lower jaw?)