Stable articulatory tasks and their variable formation: Tamil retroflex consonants

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Speech Production & Task Dynamics

- Two levels of production:
  - Articulator level
  - Task level
- *External perturbation* causes coordinated articulators to adapt configurations to achieve linguistic task (Kelso, Tuller, Vatikiotis-Bateson, & Fowler 1984)
- Current study: tongue posture for vowel production as *linguistic perturbation* of retroflex consonant production

Retroflex Consonants & Perturbation

- Retroflex consonants: tongue curled back to make contact in post-alveolar region

- High vowel /i/: domed tongue posture positioned close to palate

- Will tongue position required for /i/ act as perturbation in production of an embedded retroflex consonant?
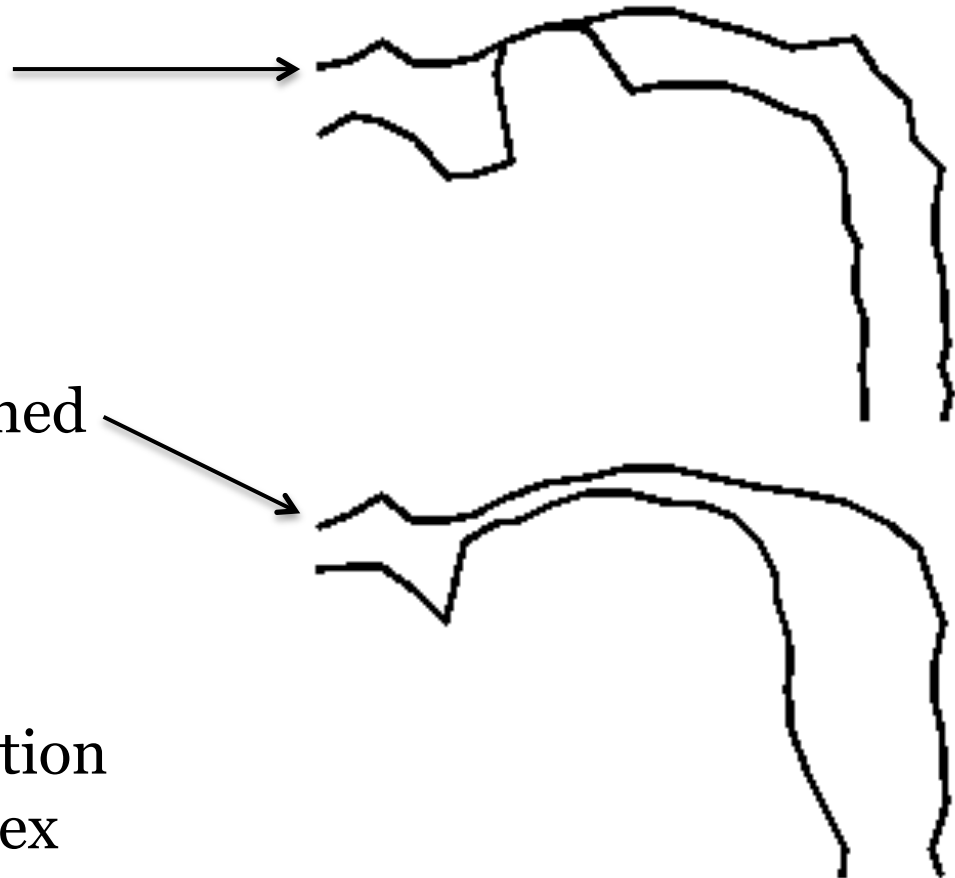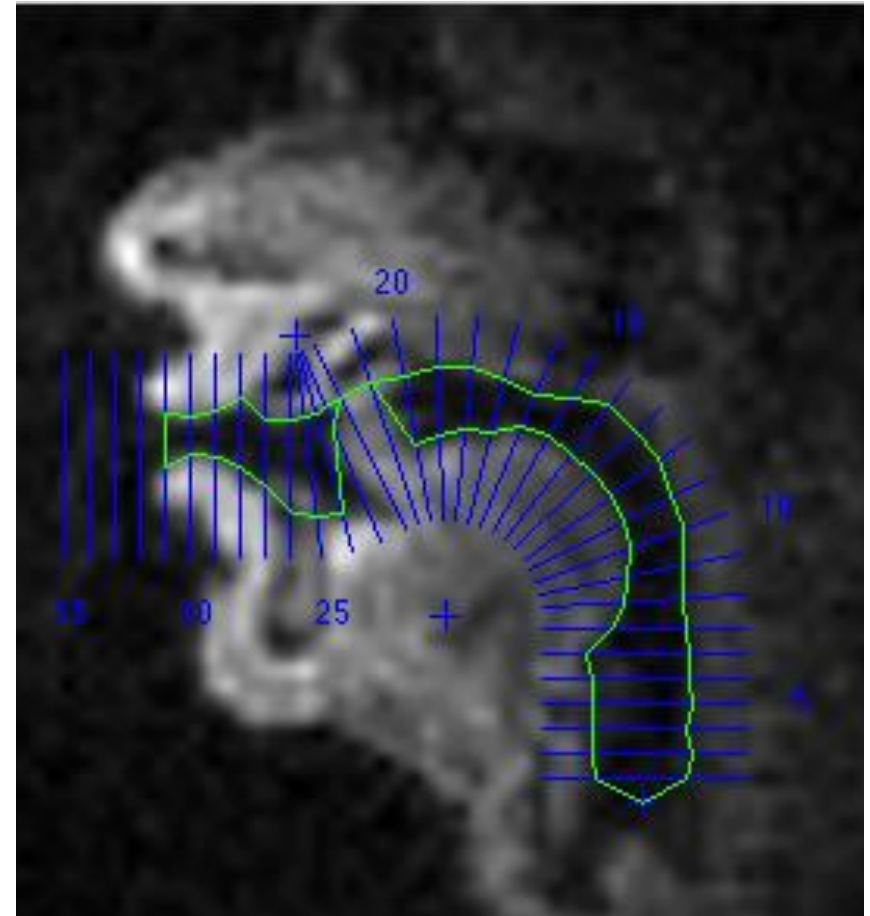
Image Acquisition/Analysis

- Real-time mid-sagittal MRI
- Isolate first frame of contact between tongue tip and palate
- Grid of ≈30 lines orthogonal to vocal tract
- Air/tissue boundaries for upper and lower surfaces of vocal tract at each gridline

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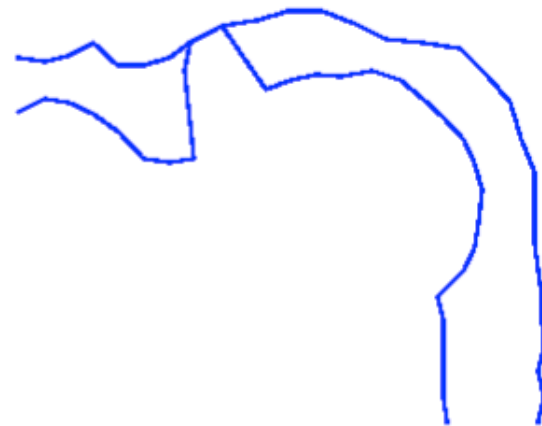
Data

- Speakers: three male, one female
- Target consonants: retroflex stop and retroflex rhotic
- Vowel contexts: /a/, /i/, and /u/
- Five repetitions of each form for speakers (exception: three repetitions for speaker 4)
- Presented in Tamil orthography

/pVɖVm/

/pVɻVm/

Hypotheses

- Two distinct levels of speech production (task and articulator):

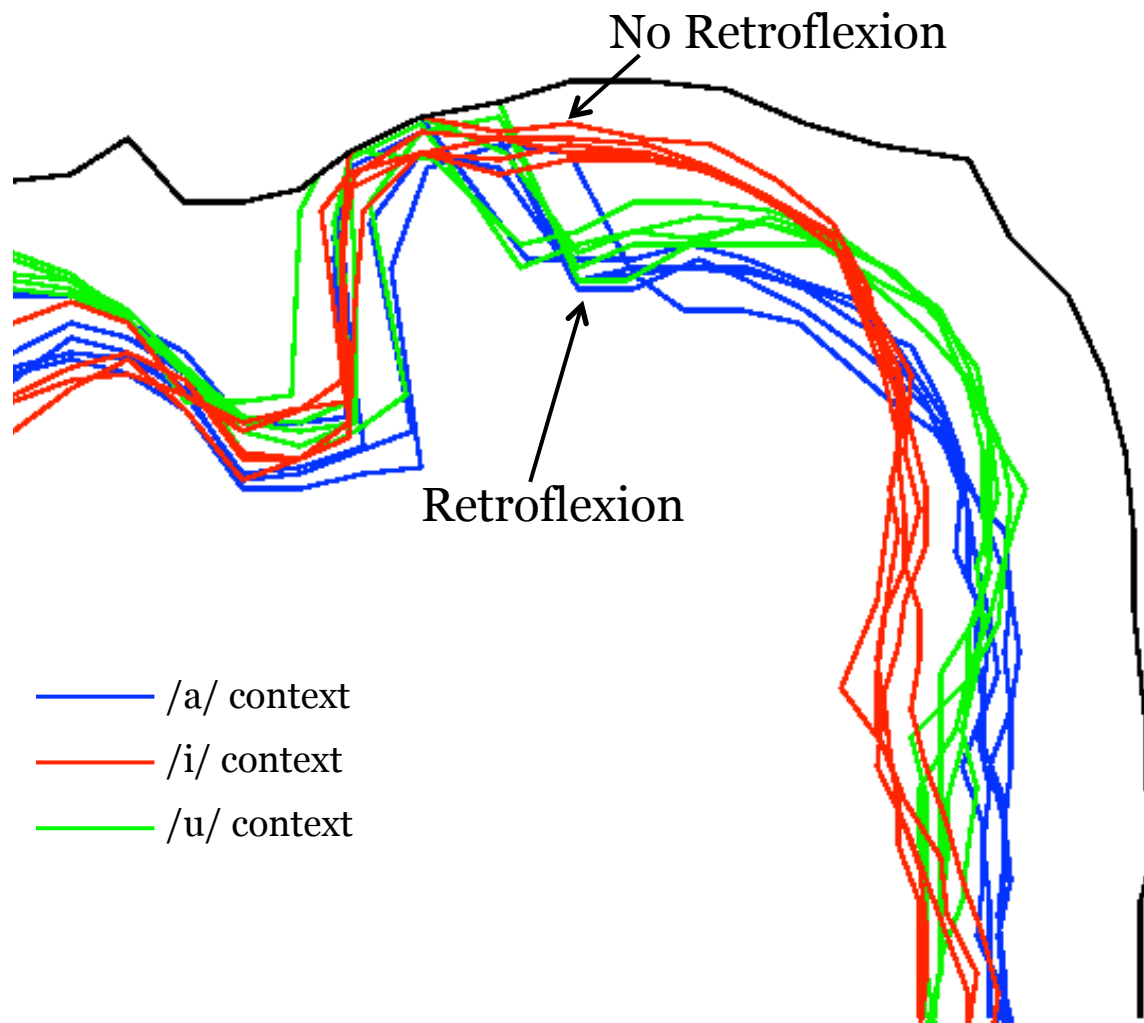> Unvarying linguistic task with variability of configuration to achieve it when perturbations are introduced

- Direct link between task and articulatory configuration:

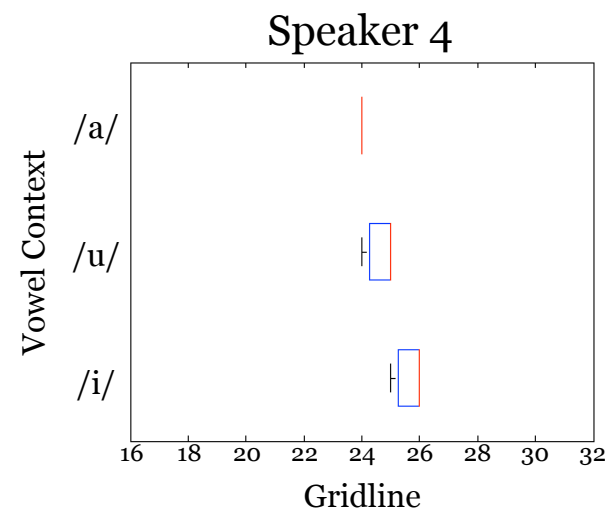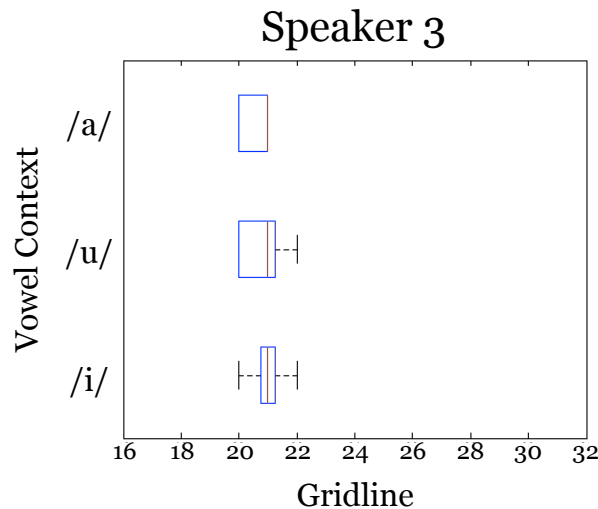> Unvarying configuration employed for a given linguistic task

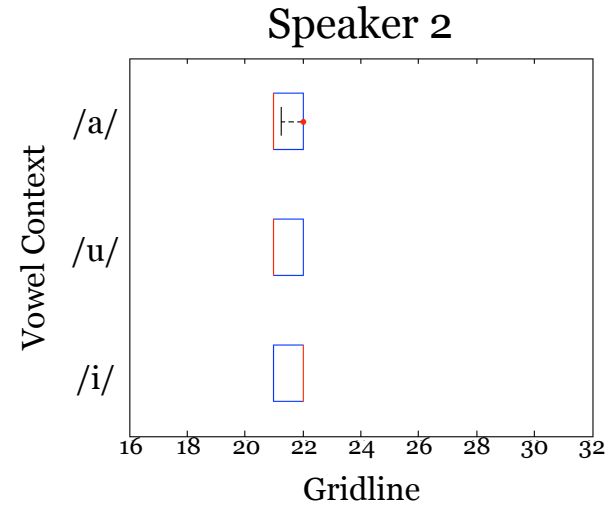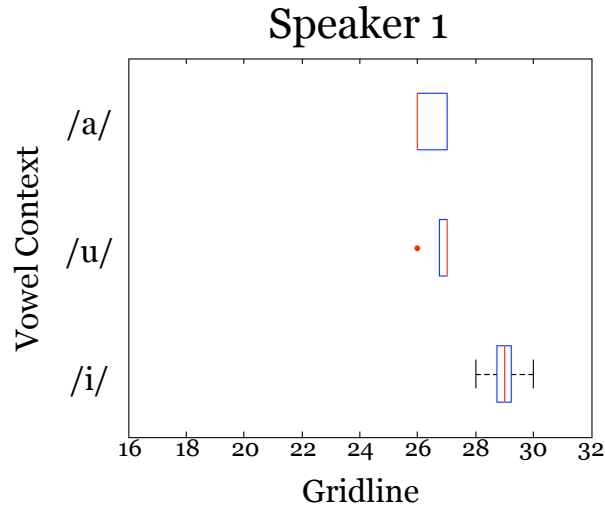/a/ context

/i/ context

/u/ context

/a/ context

/i/ context

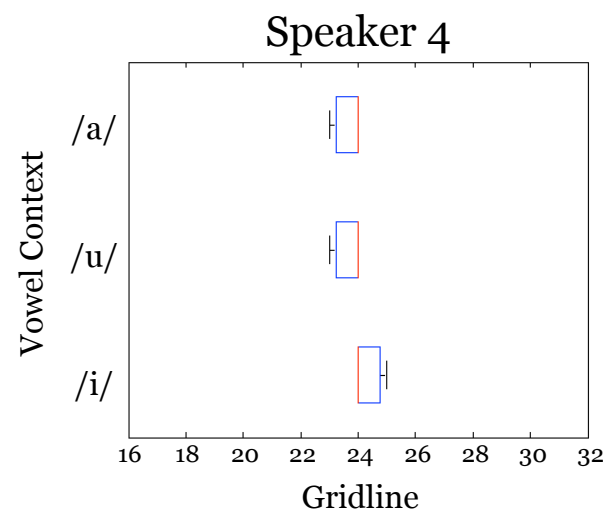/u/ context
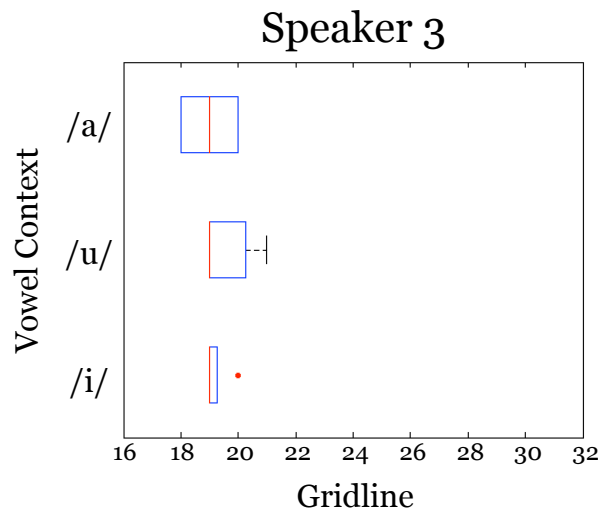
No Retroflexion
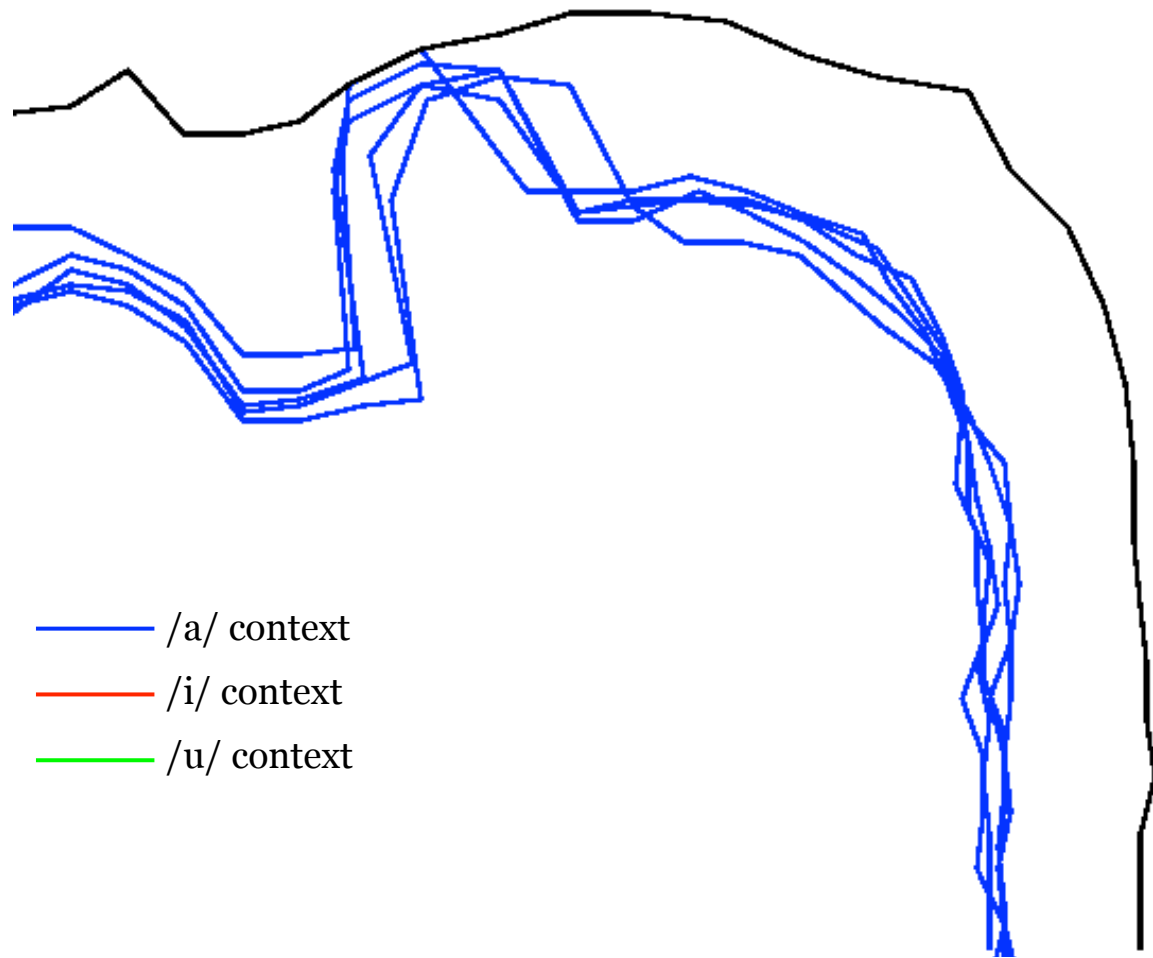
Retroflexion

/a/ context
/i/ context
/u/ context
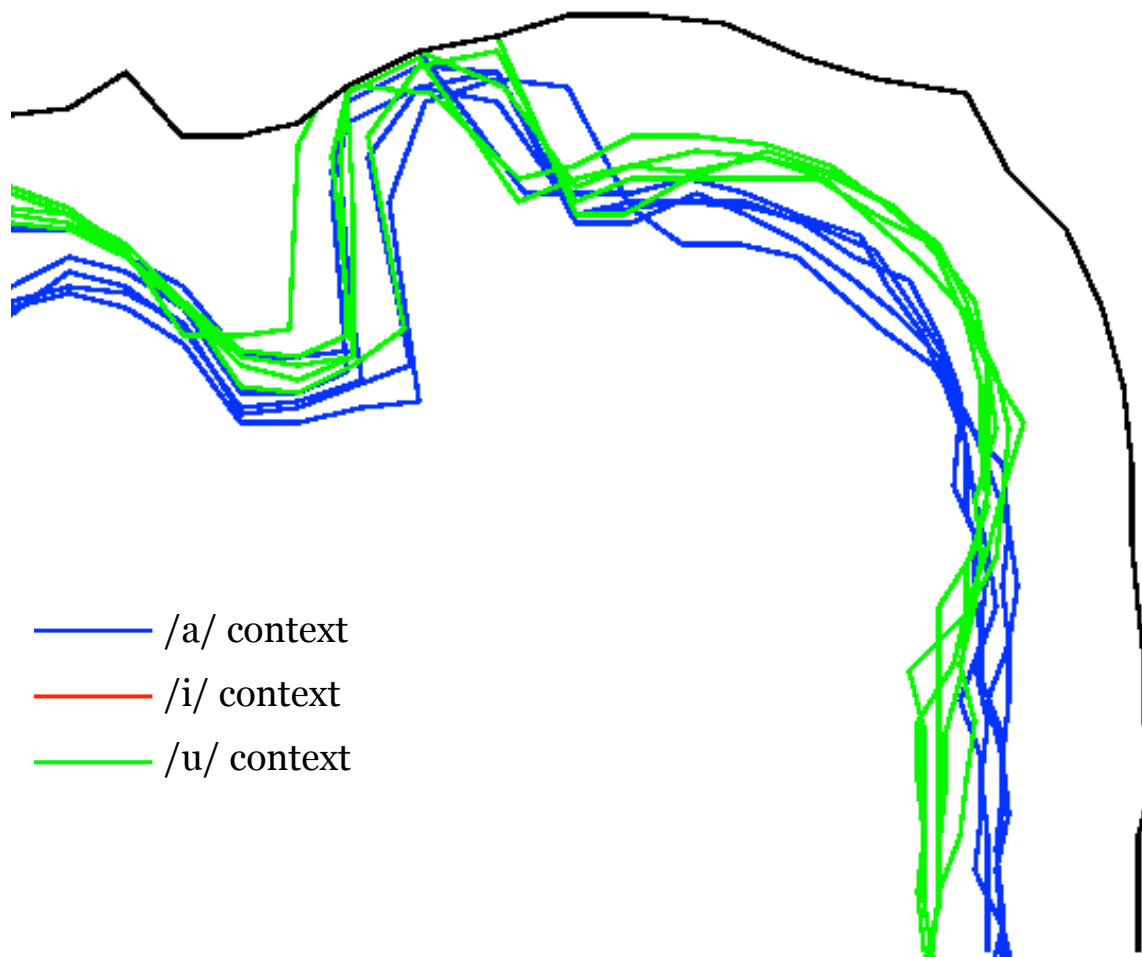
Measuring the Task: Constriction Location

Retroflex Stop

Speaker 1
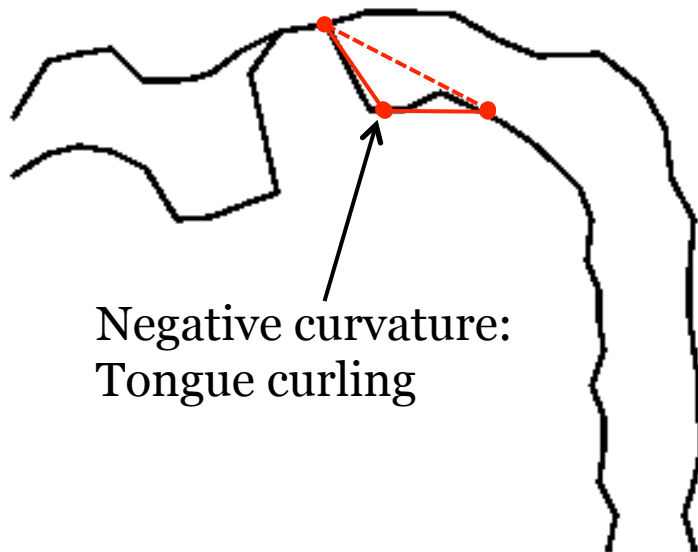
Speaker 2

Speaker 3

Speaker 4

Measuring the Task: Constriction Location

Retroflex Rhotic
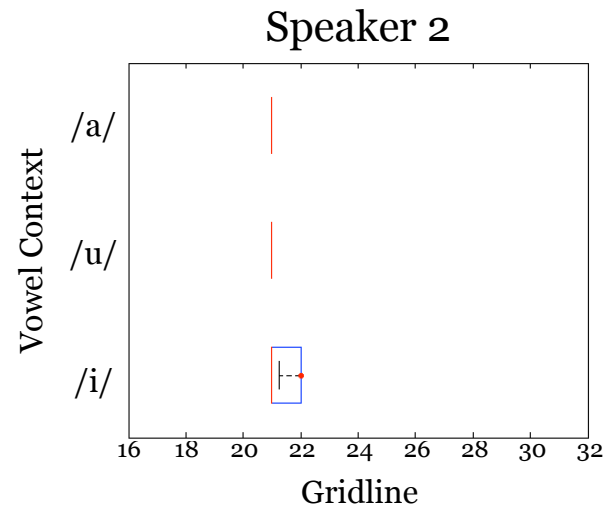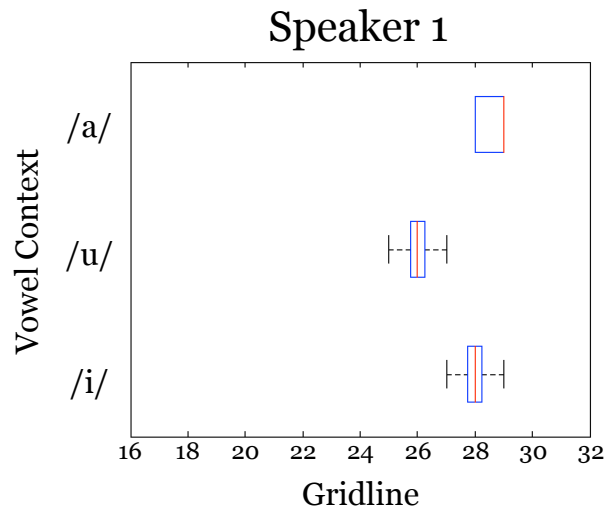
Measuring Articulator Configuration: Tongue Shaping

Negative curvature:
Tongue curling
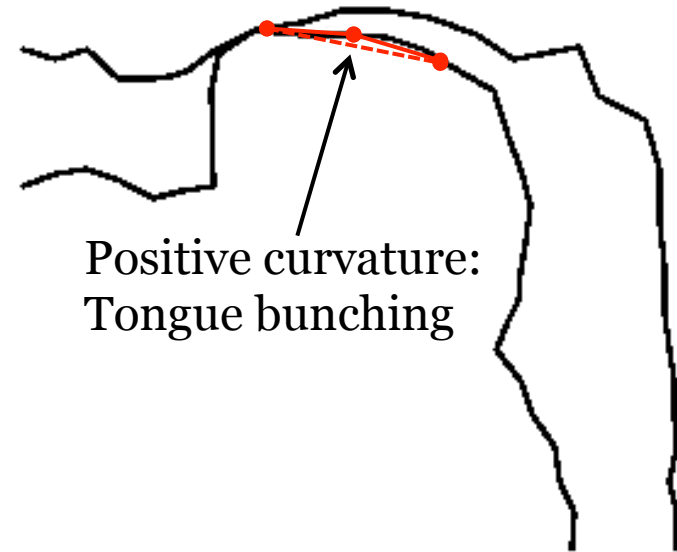
Positive curvature:
Tongue bunching

Retroflex stop /ɖ/ in /a/ vowel context

Retroflex stop /ɖ/ in /i/ vowel context

Measuring Articulator Configuration: Tongue Shaping
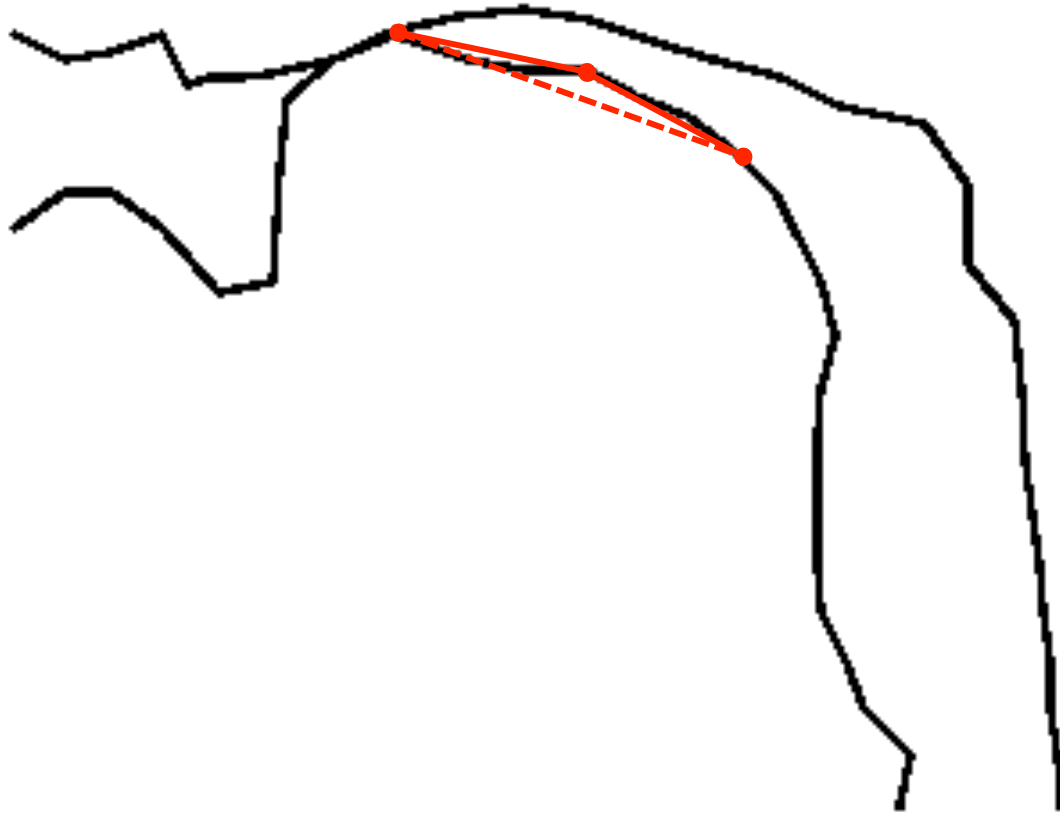
Measuring Articulator Configuration: Tongue Shaping

Negative curvature:
Tongue curling

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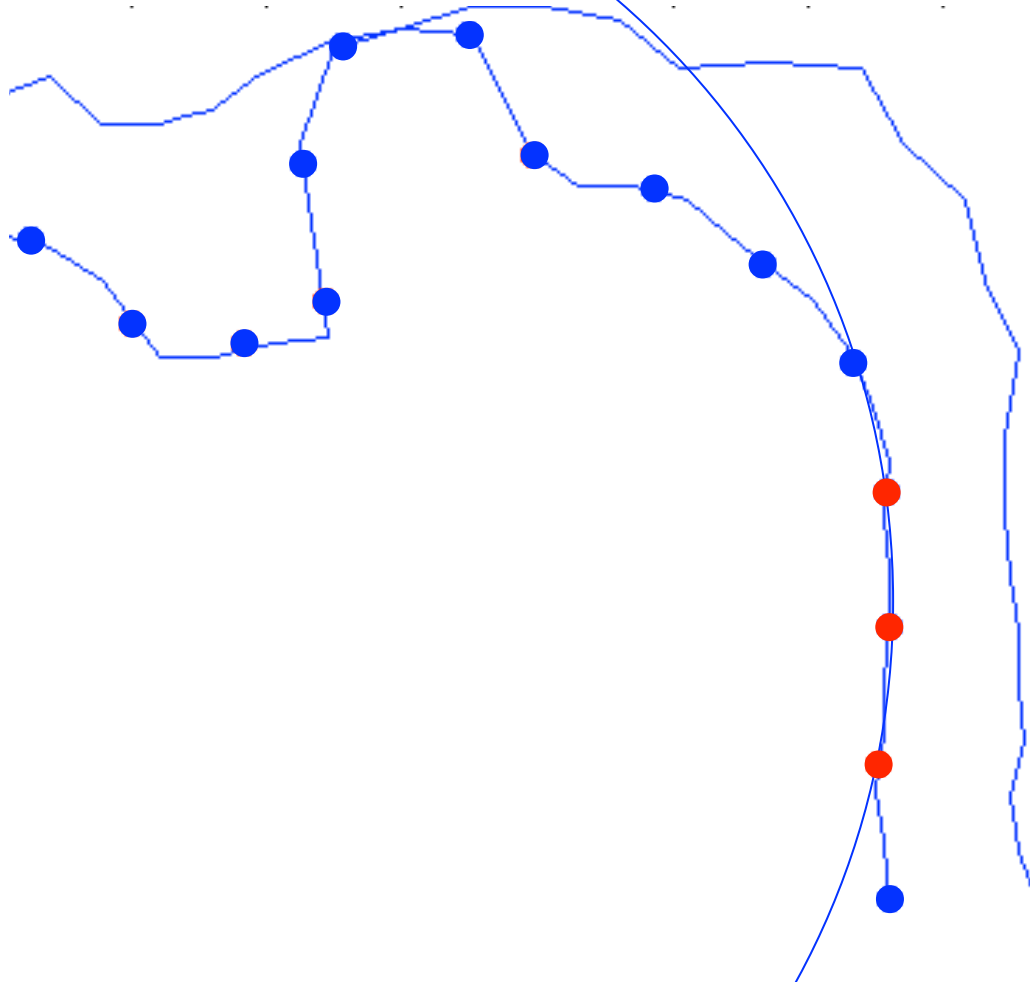
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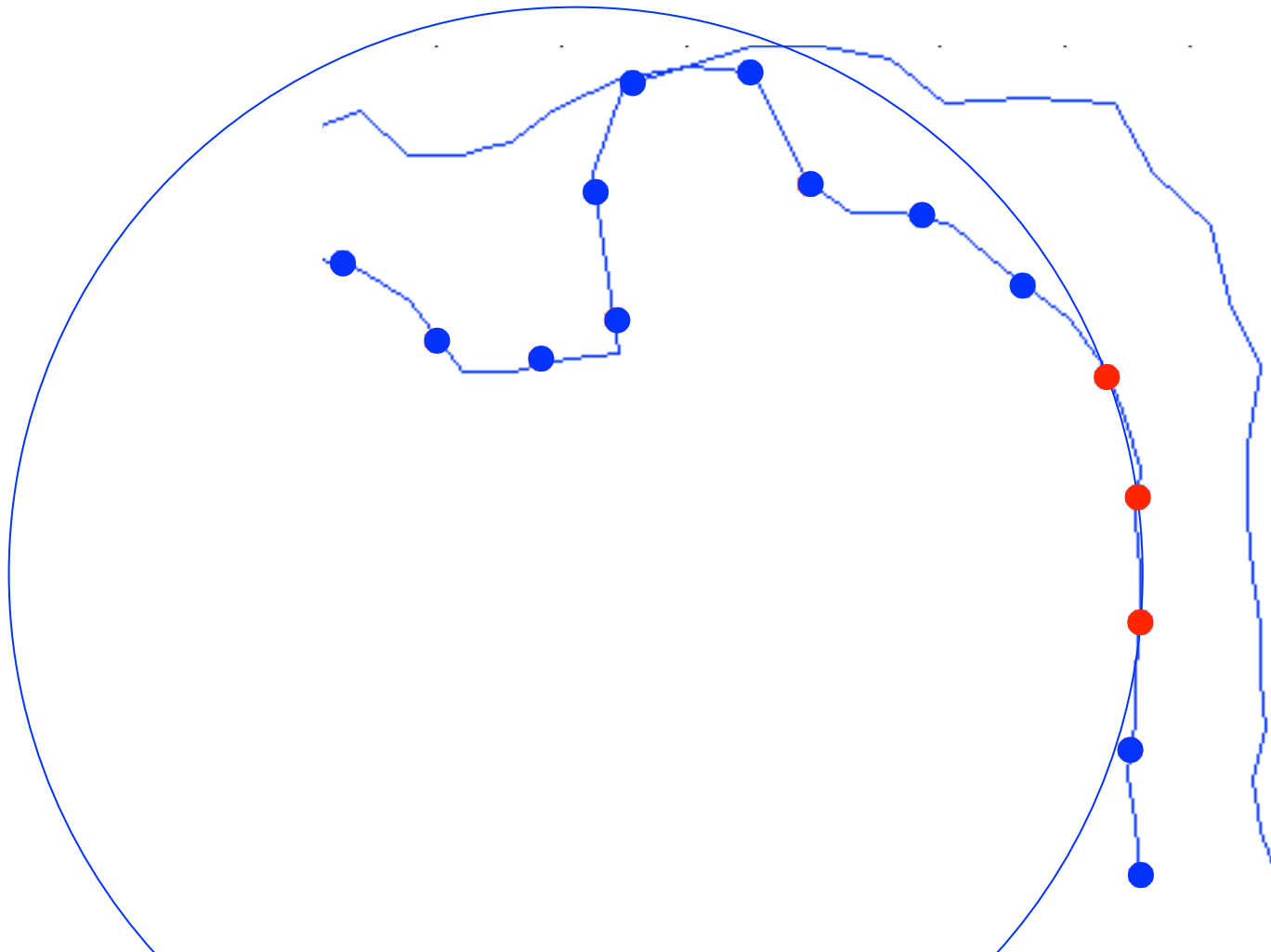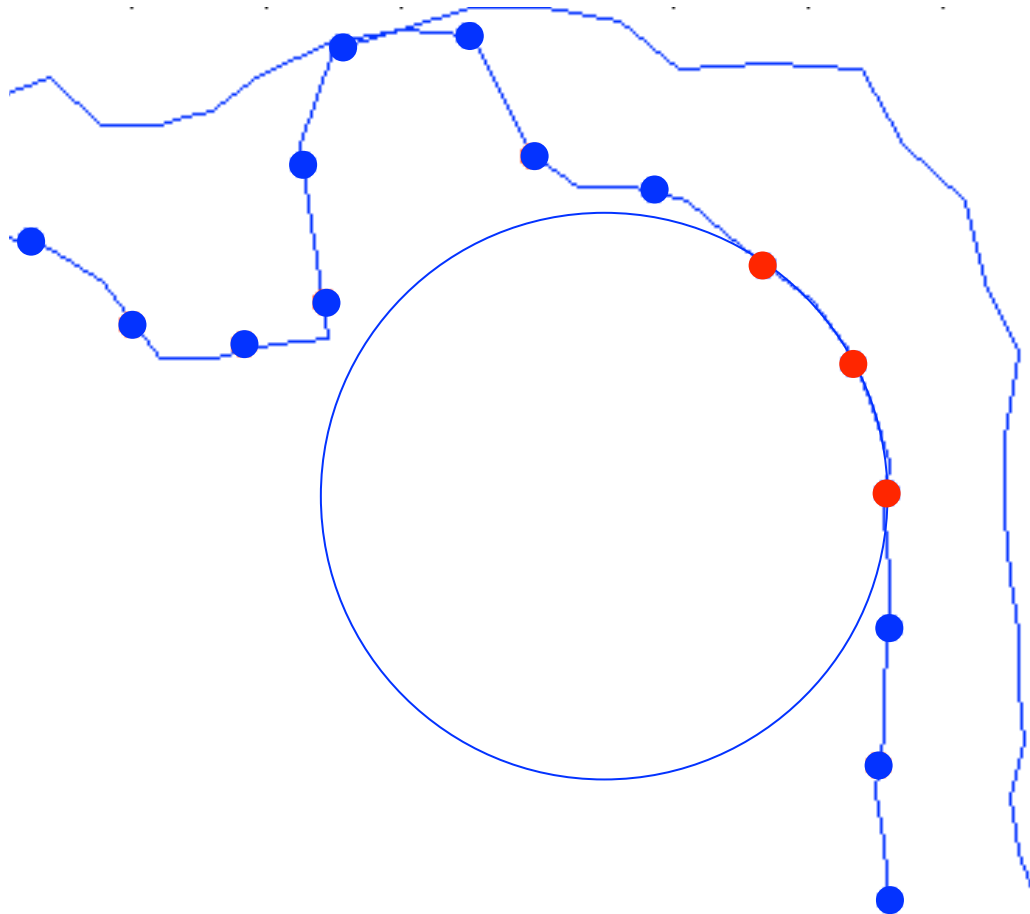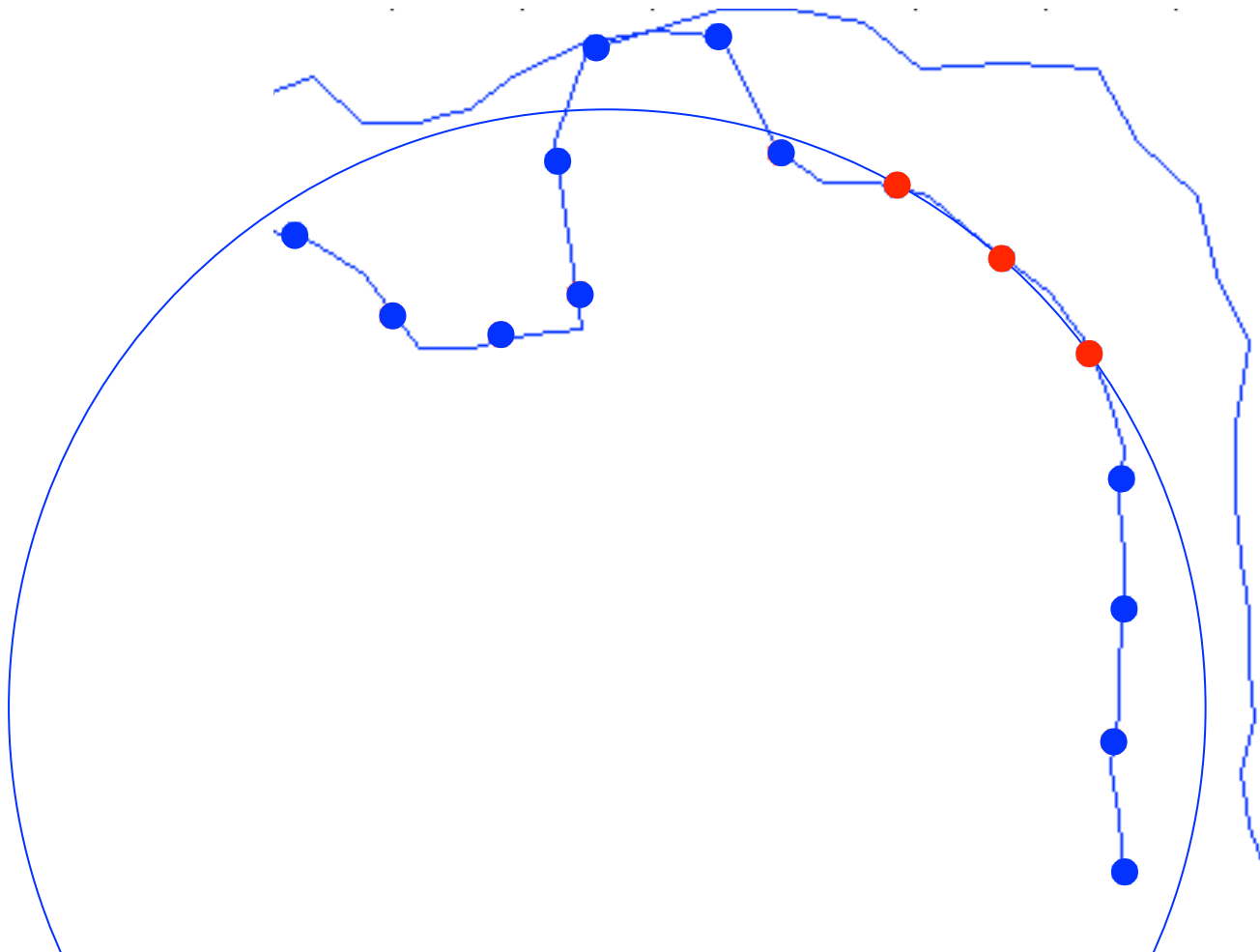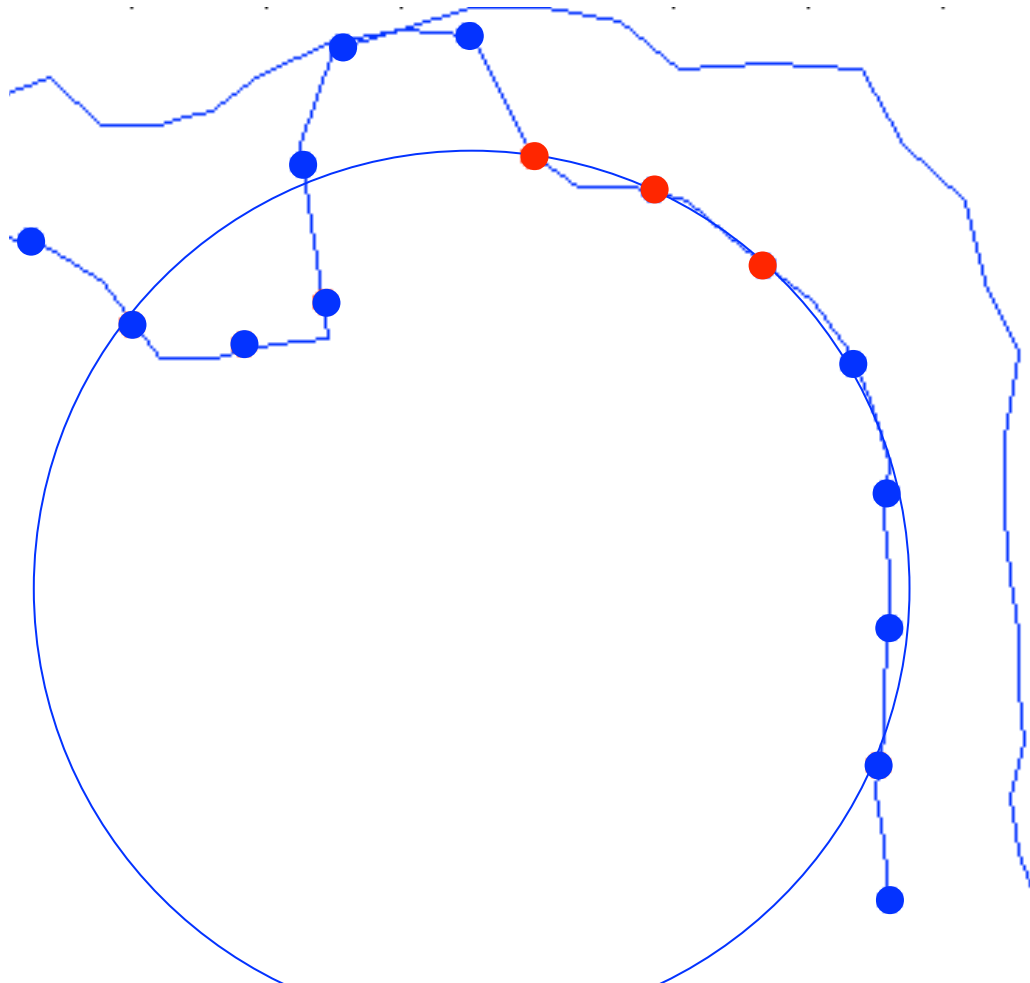
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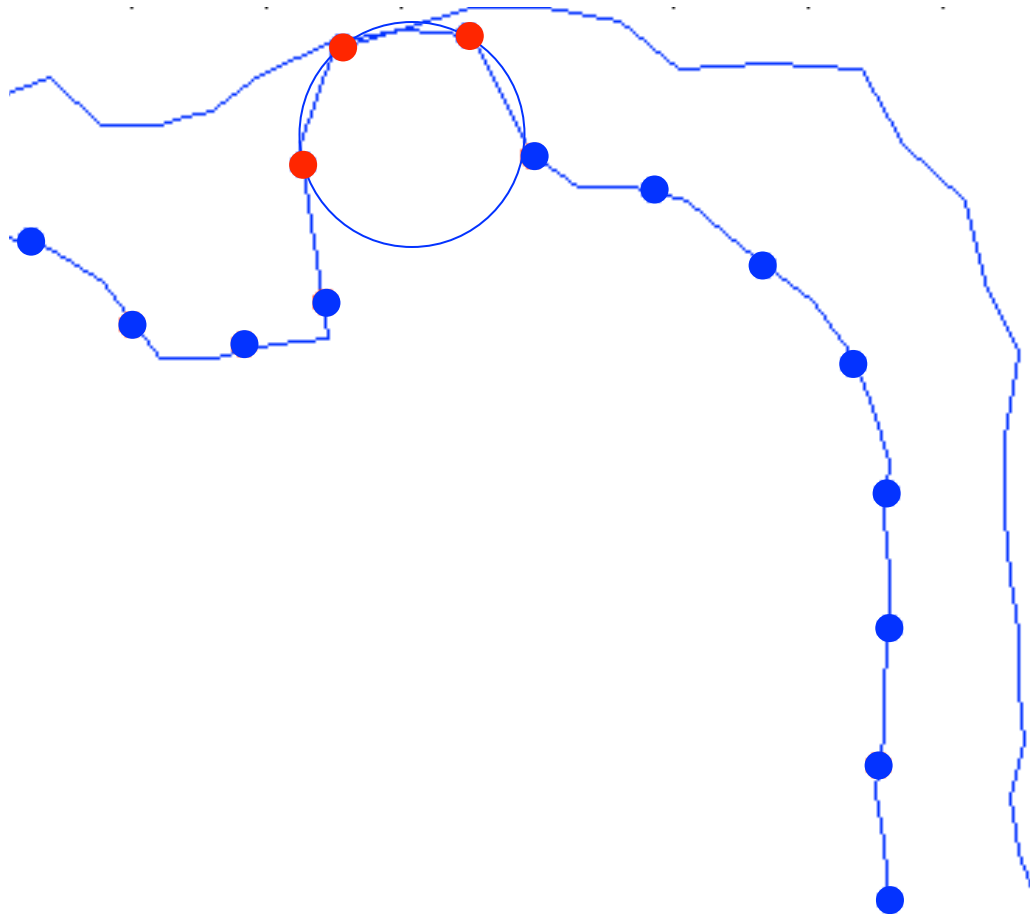
Measuring Articulator Configuration: Tongue Shaping

- Curvature score = $\dfrac{100}{radius}$

- Negative curvature: circle lies outside tongue contour

  $\boxed{\text{Tongue Curling}}$

- Positive curvature: circle lies within tongue contour

  $\boxed{\text{Tongue Bunching}}$

- Record *minimum* curvature score along tongue blade

Curvature Score: -4.14

Retroflex stop /ɖ/ in /a/ vowel context

Curvature Score: 1.05
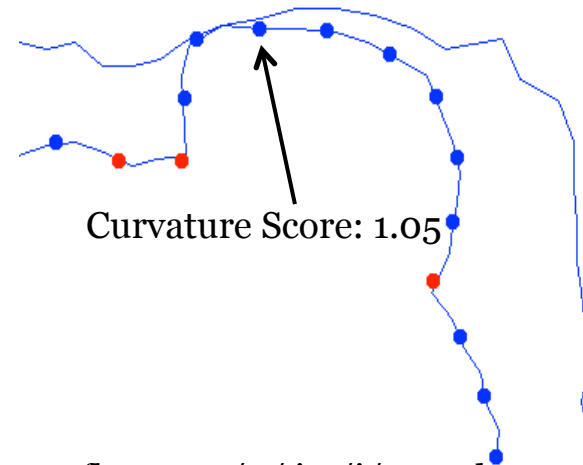
Retroflex stop /ɖ/ in /i/ vowel context

Results: Tongue Shaping

- Back vowel contexts: substantial negative curvature scores along tongue blade

  Tongue Curling

- High front vowel context: less extreme negative curvature OR positive curvature along tongue blade

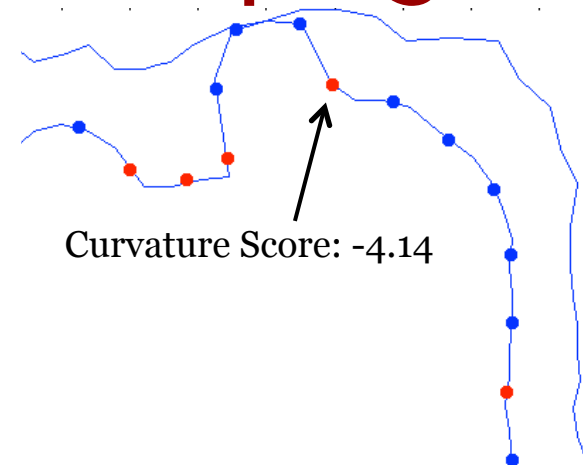 Tongue Bunching

Retroflex Stop

■ /a/ Context   ■ /u/ Context   ■ /i/ Context

Subject 1: -8.29, -5.63, -0.632
Subject 2: -0.45, -0.91, 0.28
Subject 3: -3.74, -4.52, 0.89
Subject 4: -2.2, -2.13, -1.43

X-axis: -10, -8, -6, -4, -2, 0, 2, 4

Mean Minimum Curvature Score

Curling | Bunching

Results: Tongue Shaping

- Back vowel contexts: substantial negative curvature scores along tongue blade

  ┌─────────────────────────┐
  │ Tongue Curling   │
  └─────────────────────────┘

- High front vowel context: less extreme negative curvature OR positive curvature along tongue blade

  ┌─────────────────────────┐
  │ Tongue Bunching   │
  └─────────────────────────┘

Retroflex Rhotic

■ /a/ Context ■ /u/ Context ■ /i/ Context

Subject 1: -4.26, -3.37, -0.91
Subject 2: -1.82, -0.68, 0.32
Subject 3: -4.02, -4.22, 0.65
Subject 4: -2.85, -1.82, -0.09

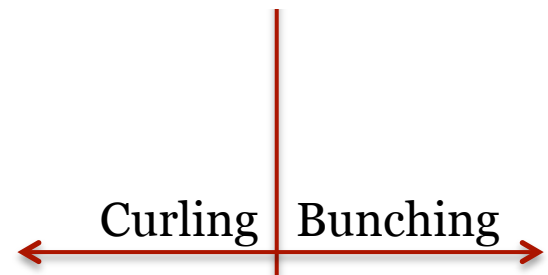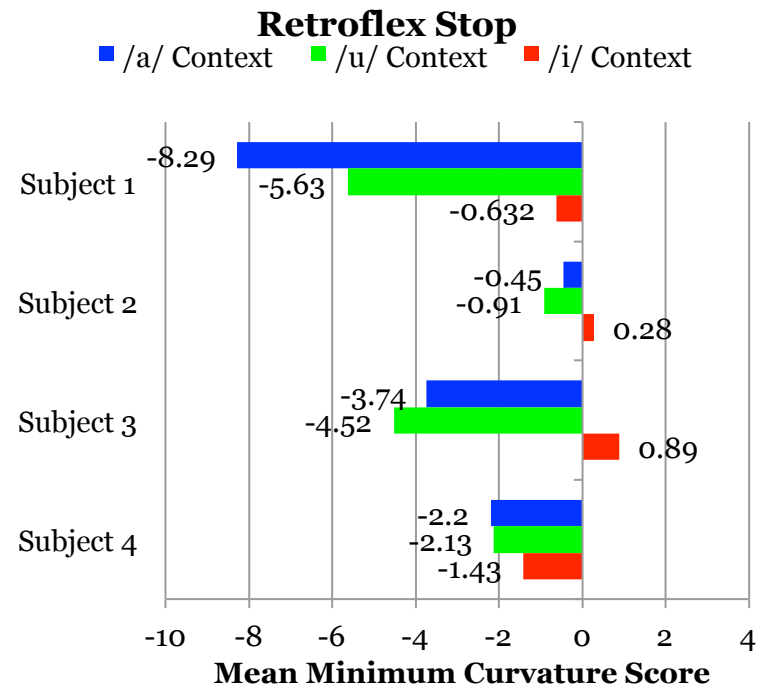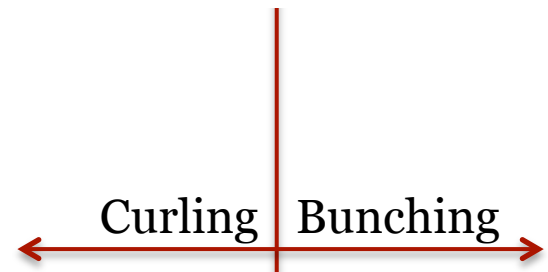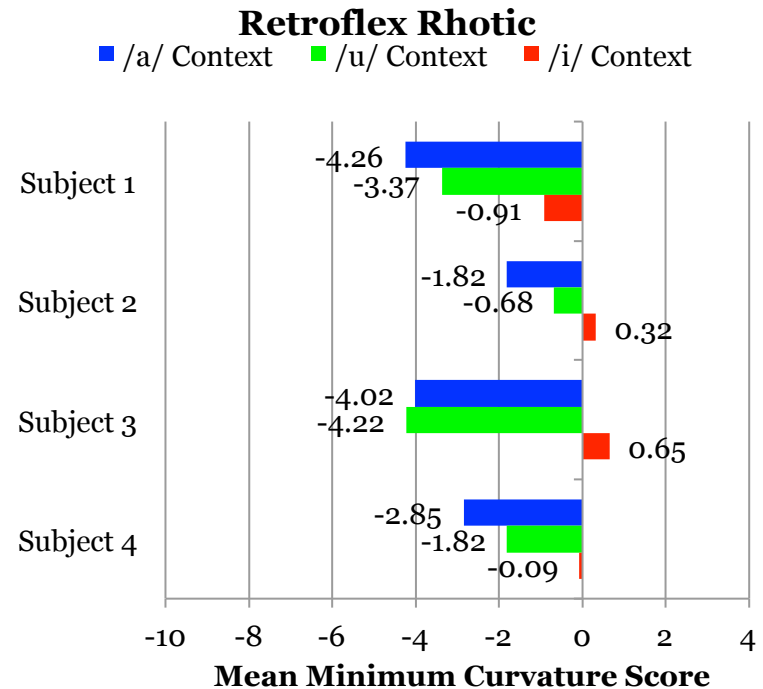**Mean Minimum Curvature Score**

Curling | Bunching
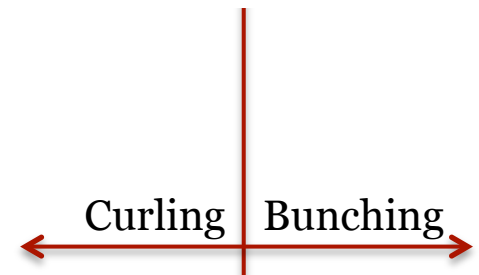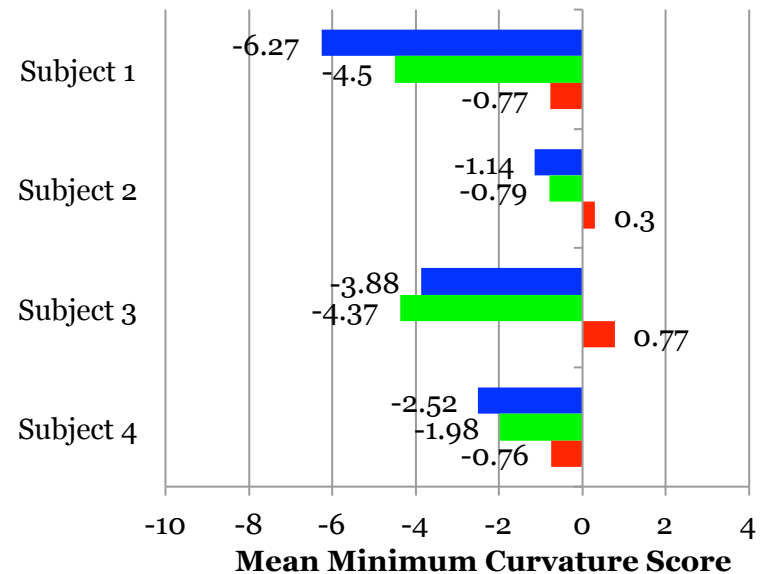
Results: Tongue Shaping

- Back vowel contexts: substantial negative curvature scores along tongue blade

  Tongue Curling

- High front vowel context: less extreme negative curvature OR positive curvature along tongue blade

  Tongue Bunching

Retroflex Stop & Rhotic

■ /a/ Context ■ /u/ Context ■ /i/ Context

Subject 1: -6.27, -4.5, -0.77
Subject 2: -1.14, -0.79, 0.3
Subject 3: -3.88, -4.37, 0.77
Subject 4: -2.52, -1.98, -0.76

Mean Minimum Curvature Score

Curling ← | → Bunching

Conclusion

- Tamil retroflex consonants specified for stable post-alveolar constriction *task*

- *Articulatory configuration* for achieving task varies with vowel context

  - Back vowels: tongue may curl back to make palatal contact

  - High front vowel: tongue is prevented from curling back and instead bunches

- Tongue posture necessary for retroflex's surrounding vowel context acts as *linguistic perturbation* to determine the configuration/maneuvering of articulators to achieve linguistic task