Constriction Location and Orientation
Contrasting Oral Constriction Gestures

- What allows oral constriction gestures to be systematically distinguished from one another?
  - shared across members of the community (parity)
  - not confusable with one another under a variety of speaking conditions.

- Anatomically distinct constricting organs
  1. lips
  2. tongue tip
  3. tongue dorsum
  4. tongue root

- Shared by all members of the community

- Decomposition of body into distinct organs is at least partially innate.

- (1)-(3) contrast in all languages for stops.
### Oral Constrictors and Locations

<table>
<thead>
<tr>
<th>Constrictor</th>
<th>Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>labial</td>
<td>bilabial, labiodental</td>
</tr>
<tr>
<td>coronal (tip)</td>
<td>labial, (inter-)dental, alveolar, post-alveolar, palatal</td>
</tr>
<tr>
<td>dorsal</td>
<td>post-alveolar, palatal, velar, uvular, pharyngeal</td>
</tr>
<tr>
<td>radical (root)</td>
<td>pharyngeal</td>
</tr>
</tbody>
</table>
Coronal Constrictor

- Coronal constrictor exhibits the most possibilities for locations
  - 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
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)

<table>
<thead>
<tr>
<th></th>
<th>apical</th>
<th>laminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>anterior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>alveolar ridge forward</td>
<td>t d n</td>
<td>t d n</td>
</tr>
<tr>
<td>non-anterior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>post-alveolar ridge</td>
<td>t d n</td>
<td>t d n</td>
</tr>
</tbody>
</table>
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).
Eastern Arrernte
Ladefoged & Maddieson (1986)

- Wubuy
- Yanyuwa
- Wangurri
Wubuy (Best et al., 2010)

TTCO = apical

TTCO = laminal

mata
alveolar

mata
dental

mata
retroflex

mata
palatal
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.

Figure III.11: Comparison of reduced /n/ (top row) and /d/ (bottom row) in Spanish (left column) and English (right column). Productions of /n/ in borsht languages are flaps, with a small amount of linguopalatal contact and a slightly curled tongue tip. English /d/ is also flapped, while Spanish /d/ is produced as an approximant at the teeth.

Turning to the results of estimated stiffness, there is no difference in the relationship between peak velocity and displacement by segment in either Spanish or English. The only difference found was based on prosodic position, such that phrase-initial position
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)

<table>
<thead>
<tr>
<th>Dental</th>
<th>French</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Alveolar</td>
<td>![French dental and alveolar chart]</td>
<td>![English dental and alveolar chart]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>t</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>![Dental row]</td>
<td>![Dental row]</td>
</tr>
<tr>
<td>UA</td>
<td>![Upper Apical row]</td>
<td>![Upper Apical row]</td>
</tr>
<tr>
<td>L</td>
<td>![Laminal row]</td>
<td>![Laminal row]</td>
</tr>
<tr>
<td>AL</td>
<td>![Apico-laminal row]</td>
<td>![Apico-laminal row]</td>
</tr>
</tbody>
</table>

A = Apical, UA = Upper Apical, L = Laminal; AL = apico-laminal

Tokens:
1
2-5
6-10
11-15
16-20
21-25
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.
Non-contrastive language differences in NON-anterior coronal stops

• “Retroflex” (=apical post-alveolar stops)
Tamil

Extreme retroflexion

CL=Palatal

[dental] [palal]
[(post)-alveolar] [palii]
[retroflex] [pali]

Rhotic:

[palii] [pali]

Nasal:

[panii] [panii]
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 ([θ]) fricatives.

(after Pétursson, 1971)
/s/-/ʃ/ contrast
/s/-/ʃ/ contrast

Area btw tongue & palate

Curvature wrt palate

Groove depth
• What are goals?
  • Constriction Location
  • palatal vs. velar dorsal constriction

• Other differences?

<table>
<thead>
<tr>
<th></th>
<th>English</th>
<th>ʃ</th>
<th>s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constrictor</td>
<td>coronal</td>
<td>coronal</td>
<td></td>
</tr>
<tr>
<td>Distance to obstacle</td>
<td>short</td>
<td>longer</td>
<td></td>
</tr>
<tr>
<td>Constriction Width</td>
<td>narrow</td>
<td>wider</td>
<td></td>
</tr>
<tr>
<td>Cross-sectional shape</td>
<td>grooved</td>
<td>domed</td>
<td></td>
</tr>
<tr>
<td>Sublingual cavity</td>
<td>absent or small</td>
<td>present, larger</td>
<td></td>
</tr>
</tbody>
</table>

• Add CD difference?
Fricatives: Oral Constriction Tasks

<table>
<thead>
<tr>
<th></th>
<th>θ</th>
<th></th>
<th>s</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>clo</td>
<td>TTCL=40</td>
<td>TTCL=24</td>
<td>TTCL=56</td>
<td>TTCL=60</td>
</tr>
<tr>
<td></td>
<td>TTCD=1.2</td>
<td>TTCD=11</td>
<td>TTCD=1.2</td>
<td>TTCD=1.2</td>
</tr>
<tr>
<td>rel</td>
<td>TTCL=24</td>
<td>TTCL=24</td>
<td>TTCL=24</td>
<td>TTCL=40</td>
</tr>
<tr>
<td></td>
<td>TTCD=11</td>
<td>TTCD=11</td>
<td>TTCD=11</td>
<td>TTCD=11</td>
</tr>
<tr>
<td>TB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TTCL=110</td>
<td>TBCL=95</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TBCD=10</td>
<td>TBCD=8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fricatives: examples
/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 meet the challenge (e.g., increased displacement of upper lip) (Kelso et al, 1983).

- **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. Houde,b,2

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 tomost 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)

<table>
<thead>
<tr>
<th>Constrictor</th>
<th>s</th>
<th>ʂ</th>
<th>ɕ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dist to Obstacle</td>
<td>coronal</td>
<td>coronal</td>
<td>coronal-dorsal</td>
</tr>
<tr>
<td></td>
<td>short</td>
<td>long</td>
<td>short</td>
</tr>
<tr>
<td>Sublingual Cavity</td>
<td>absent</td>
<td>present</td>
<td>absent</td>
</tr>
</tbody>
</table>
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.

• Ș (hissing-hushing) may be an alveolar constriction but with larger sublingual cavity (lower jaw?)