Laryngeal Gestures and States of the Glottis
Vocal Fold Vibration and Laryngeal Gestures

• Requires two sets of conditions to be met:

  • aerodynamic conditions
    pressure below the glottis must be greater than pressure above the glottis.

  • laryngeal conditions
    Vocal folds must be narrowed, Vocal folds cannot be too stiff.

• Laryngeal gestures will not always have expected consequences if their aerodynamic conditions are not met.

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Expected Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocal Fold Adduction</td>
<td>Voicing</td>
</tr>
<tr>
<td>Vocal Fold Abduction</td>
<td>Voicelessness</td>
</tr>
</tbody>
</table>
Muscular Control of Abduction/Adduction

• Separation of vocal folds by rocking of arytenoid cartilages with respect to cricoid cartilage.

• Rocking caused by action of posterior crico-arytenoid (PCA) muscles.

• In speech, vocal folds re-adduct immediately after maximum glottal opening is reached.

• Re-adduction is accomplished by action of inter-arytenoid (INT) and lateral crico-thyroid (LCA) muscles.
Investigation of abduction *in situ*

- electromyography (EMG)

- measures muscle activation by means of electrical potentials in the relevant muscle.
Fibroscopy
Transillumination
Transillumination

- Abducted vocal folds can still vibrate (murmur).
Consequences of Basic **Abduction** Gesture

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voicelessness</td>
<td>oral airflow is reduced by stop or fricative gesture</td>
</tr>
<tr>
<td>Murmur</td>
<td>when oral airflow is unimpeded and rapid</td>
</tr>
</tbody>
</table>
Consequences of Adduction Gesture

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voicing</td>
<td>with sufficient airflow and tension</td>
</tr>
<tr>
<td>Voicelessness</td>
<td>when oral airflow is reduced, e.g. θ ʒ</td>
</tr>
<tr>
<td>State</td>
<td>Symbol</td>
</tr>
<tr>
<td>--------------</td>
<td>--------</td>
</tr>
<tr>
<td>Voiceless</td>
<td>ṃ</td>
</tr>
<tr>
<td>Murmur</td>
<td>a</td>
</tr>
<tr>
<td>Voice</td>
<td>a</td>
</tr>
<tr>
<td>Laryngealized</td>
<td>ä</td>
</tr>
<tr>
<td>Closed</td>
<td>?</td>
</tr>
</tbody>
</table>
Timing and Scaling of Basic Abduction Gesture

• Abduction gesture may exhibit:
  
  • different patterns of coordination with respect to oral closure gestures

  • different magnitudes of opening

• These variations can lead to four stops in some languages that contrast in phonation type (e.g., Hindi, Gujarati)
voiceless unaspirated stop \[p\]
- Adduction complete at stop release
- voicelessness during closure
- voicing begins at release
- Voice Onset Time is short.

(2) voiceless aspirated stop \[p^h\]
- Adduction begins at stop release
- voicelessness during closure
- voicing is delayed after release
- Voice Onset Time is long.

(3) voiced aspirated stop \[b^h\]
- Abduction begins at stop release
- voicing during closure
- breathy voice after release
Gujarati

[ɖ] vs. [ɖʰ]

[t] vs. [ʈʰ]
Korean (older dialect 1970s)

- Korean contrasts 3 stops, in word-initial position, all voiceless
  - voiceless aspirated [pʰul] “grass” (long VOT)
  - voiceless unaspirated [pul] “fire” (short VOT)
  - stiffened vocal folds [p*ul] “horn” (even shorter VOT)
    - Vocalis muscle contracts (also raises f0)
    - Vocal folds too stiff to vibrate

- Contemporary Korean
  - Formerly unaspirated is now aspirated; contrasts with aspirated by having low f0
• Creaky voice

• Constriction of the Ventricular folds (false vocal folds)

• Action of aryepiglottal muscles?
Intrinsic Muscles of Larynx
Lateral Dissection

- Aryepiglottic muscle
- Oblique and transverse arytenoid muscles
- Thyroepiglottic muscle
- Thyroarytenoid muscle
- Posterior cricoarytenoid muscle
- Lateral cricoarytenoid muscle
- Cricothyroid muscle (cut away)
- Epiglottis
- Aryepiglottic fold
- Cuneiform tubercle
- Corniculate tubercle
- Aryepiglottic muscle
- Oblique arytenoid muscle
- Transverse arytenoid muscle
- Posterior cricoarytenoid muscle
- Cricoid cartilage

Posterior view
Vocal Fry

- Social meaning
Hausa

jiibi [ III ]
'day after tomorrow'

giibii [ HL ]
'gap from loss of tooth'

[dʒiːbiː]

[giːbiː]
Creaky Voice

- **Mazatec** (Oaxaca)
- **Mpi** (Thailand)
- Possible Trilling of aryepiglottal system (John Esling)  
  See IPA Phonetics app
Muscles that control $f_0$ (tone)

- Increasing **longitudinal tension**

- Crico-thyroid muscle increases angle between thyroid and arytenoid cartilages.

Statement: BEV loves Bob.

Question: Bev loves Bob?
Longitudinal Tension
Pitch Lowering

- Decrease in vertical tension produced by lowering entire larynx.
- Action of the sterno-hyoid muscles
Example:

H and L in Japanese

Sugito & Hirose (1978)
• Most basic elements of phonological tone representation are H, L

• Contrastive tones are controlled by discretely different mechanisms
  • CT vs SH
  • H, L are not points on a continuum

• What about languages with more than two contrastive tones?
Cantonese Tones

- Four pitch levels
- Nissenbaum (2010) hypothesized they are produced with a 2x2 combination of:
  - Larynx Height ("register")
  - Stretching (CT)

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Cine-MRI evidence: extreme tones

Male speaker age 20

Upper and Lower extreme tones

**UPPER register, HIGH tone**
- High Larynx
- Stretched folds

**LOWER register, LOW tone**
- Low Larynx
- Short folds
• In running speech, the f0 of the two middle tones are not distinct, but they are produced with distinct gesture combinations.

Mid tones

/u³/  UPPER mid-tone

/vocal fold length = 17.7 mm
/posterior vertical dist. from top = 127.7 mm

High Larynx
Short folds

/u⁶/  LOWER mid-tone

/vocal fold length = 19.7 mm
/posterior vertical dist. from top = 132 mm

Low Larynx
Stretched folds

• Difference in vocal fold length between tones 3 and 6 for this subject is 2 mm (i.e. vocal folds are 11% longer at onset of tone 6 than at onset of tone 3)
• Difference in vertical position is 4.3 mm (i.e. larynx lowers by nearly 1/2 cm for tone 6)
Cine-MRI

- not real-time

- utterance has to be repeated multiple times; each time is used to image the next temporal snippet.