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>
Abduction/Adduction Gestures

- 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).

Japanese: Transillumination

```
t  e  t  e  s  e  s  e
h  e  h  e
```

```
  d  e  d  e
z  e  z  e
```

```
n  e  n  e  n  e
```
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. ( \text{\textcopyright} )</td>
</tr>
</tbody>
</table>
### States of the Glottis

<table>
<thead>
<tr>
<th>State</th>
<th>Symbol</th>
<th>Description</th>
<th>Gestures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voiceless</td>
<td>ṃ</td>
<td>open turbulent source</td>
<td>abduction</td>
</tr>
<tr>
<td>Murmur</td>
<td>ñ̤</td>
<td>breathy voice</td>
<td>abduction medial compression</td>
</tr>
<tr>
<td>Voice</td>
<td>a</td>
<td>modal voice</td>
<td>adduction medial compression</td>
</tr>
<tr>
<td>Laryngealized</td>
<td>ñ̴̴̴̰</td>
<td>creaky voice</td>
<td>adduction aryepiglottal constriction</td>
</tr>
<tr>
<td>Closed</td>
<td>?</td>
<td>no source</td>
<td>ventricular constriction</td>
</tr>
</tbody>
</table>
Breathy Voice (murmur)

- Medial compression without Adduction of the arytenoids

From: John Esling, IPA Phonetics app
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)
1) **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** [pʰ]
   - Adduction begins at stop release
   - voicelessness during closure
   - voicing is delayed after release
   - Voice Onset Time is long.

3) **voiced aspirated stop** [bʰ]
   - Abduction begins at stop release
   - voicing during closure
   - breathy voice after release
Gujarati

[d] vs. [dʰ]

[t] vs. [tʰ]
- Creaky voice
- Constriction of the aryepiglottal folds (false vocal folds)
- Action of aryepiglottal muscles
Intrinsic Muscles of Larynx
Lateral Dissection

- Aryepiglottic muscle
- Oblique and transverse arytenoid muscles
- Posterior cricoarytenoid muscle
- Lateral cricoarytenoid muscle
- Thyroarytenoid muscle
- Thyroplastic muscle
- Cricothyroid muscle (cut away)
- Epiglottis

Creaky Voice

From: John Esling, IPA Phonetics app
Hausa

jiibi [HHL] 'day after tomorrow'

giibii [HHL] 'gap from loss of tooth'

[dʒiːbiː]  [giːbiː]
Creaky Voice

- Mazatec (Oaxaca)
- Mpi (Thailand)
Vocal Fry

- Social meaning
Muscles that control f0 (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)
Pitch Gestures and Phonological Tones

- 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)

Cine-MRI evidence: extreme tones

Male speaker age 20

Upper and Lower extreme tones

UPPER register, HIGH tone

Low Larynx
Stretched folds

LOWER register, LOW tone

High Larynx
Short folds
Mid tones

- In running speech, the f0 of the two middle tones are not distinct, but they are produced with distinct gesture combinations.

**Mid tones**

/\text{u}^3/ \text{UPPER mid-tone} \quad /\text{u}^6/ \text{LOWER mid-tone}

- 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.