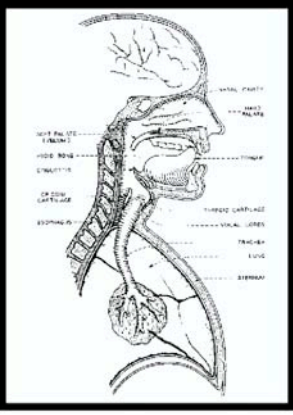
Week 2: Vocal fold vibration and Source-filter Theory



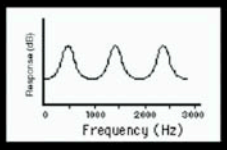
Sources

- **Frication**
  - Aperiodic (Noise or Transient)
  - Created by turbulence due to blowing air through a small constriction
  - Present in fricatives like /s/ and /z/
  - Present at the start of plosives like /b/ and /p/
- **Aspiration**
  - Aperiodic (Noise)
  - Created by turbulence due to blowing air through vocal folds
  - Present in voiceless consonants like /p/ and /k/
  - Used for whispered speech
- **Voicing**
  - Periodic (i.e., harmonic)
  - Created by vibration of the vocal folds
  - Present in all vowels and voiced consonants like /b/, /n/, and /z/

Filter

- The vocal tract is a *complex resonator* (i.e., multiple resonances)
  - Can be thought of as a tube
    - One end closed (vocal folds)
    - One end open (mouth)

  - Multiple resonant frequencies
    - Resonances are called *formants*
    - Resonant frequencies are called *formant frequencies*



Sources and filters are independent

Original

Original

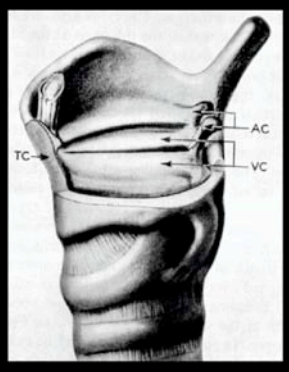
Mixture w/ noise

Music

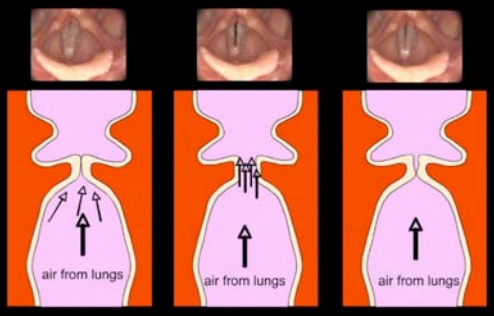
Mixture

The phonetic information mostly depends on the filter, but the source is important because it puts energy into the system

The Larynx

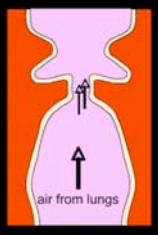


Vocal Fold Vibration (i.e., Voicing)



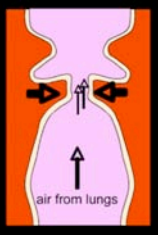
- **Voicing is a series of opening and closing of the vocal folds**
  - Vocal folds are placed together (*adduction*)
  - Vocal folds get blown apart by air from the lungs
  - Vocal folds snap back together due to the *elasticity of the vocal folds* and the *Bernoulli effect*

The Bernoulli Effect



- Airflow increases when the vocal folds are blown open.

The Bernoulli Effect



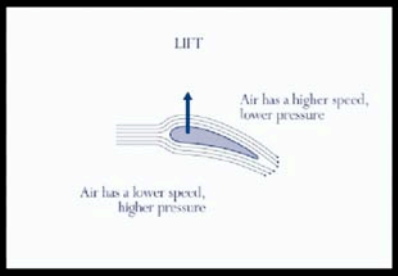
- Airflow increases when the vocal folds are blown open.
- The increase in airflow causes drop in pressure perpendicular to the airflow, which is the *Bernoulli Effect*

The Bernoulli Effect

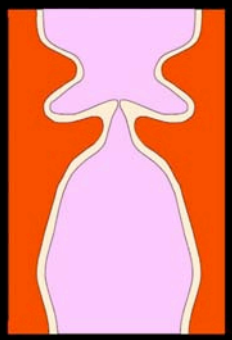
- Airflow increases when the vocal folds are blown open.
- The increase in airflow causes drop in pressure perpendicular to the airflow, which is the *Bernoulli Effect*
- The drop in pressure causes the vocal folds to snap back together.

The Bernoulli Effect

Airplane Wing



Balancing of forces causes cycle to repeat



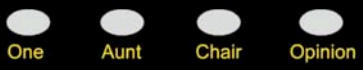
Modal Voice Vs. Aspiration

- **Vocal fold vibration depends on the separation of the vocal folds**
  - When vocal folds are in the best position to vibrate, this is called ***modal voice***
  - When vocal folds are further apart
    - Vibration does not occur
    - The vocal folds create turbulence, producing ***aspiration noise***

Pitch

- **Stretching the vocal folds**
  - Decreases the vibration period, increases pitch frequency
  - Increases the pitch
- **Pitch can provide prosodic information**
  - Can make a sentence into a question
- **Pitch can be used in tone languages to make different phonemes**

Mandarin tones



Voice Quality

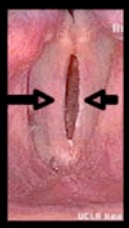
The stiffness of the vocal folds affects the duration of the *open phase* of the vibration

- **Voices with a short open phase are *creaky***
- **Voices with a long open phase are *breathy***

Voice Quality

Creaky Voice
- More tension
- Lower pitch
- Irregular pitch (diplophonia)
- Short open phase

Breathy Voice
- Less tension
- Incomplete closure (air passes)
- Longer open phase



Falsetto Voice
- High pitch
- More tension
- Vibration only at edges of vocal folds

Pathological Voice Quality

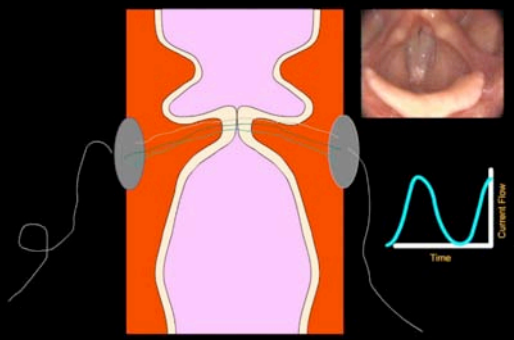
Asymmetries or stiffness of vocal folds
- Polyps
- Damage due to smoking

Cause difficulties in producing regular phonation
- Irregular pitch
- Too much air passing
- Low amplitude

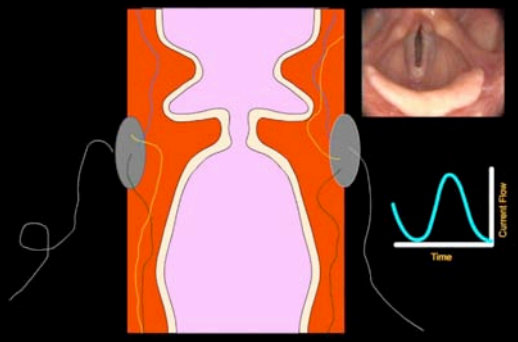
How can we measure vocal fold vibration? -- Laryngograph

- Non-invasive means of monitoring vocal fold contact
- Two surface electrodes at thyroid cartilage
- High frequency electrical current
- Monitor resistance to current flow (impedance)
- Slightly less impedance when vocal folds shut.

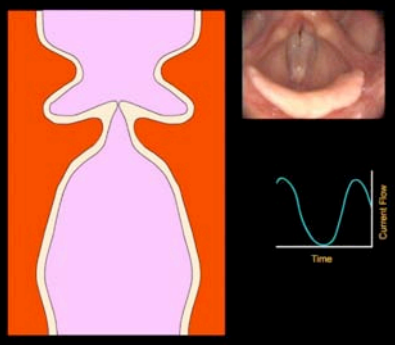
When vocal folds are shut, current flows easily



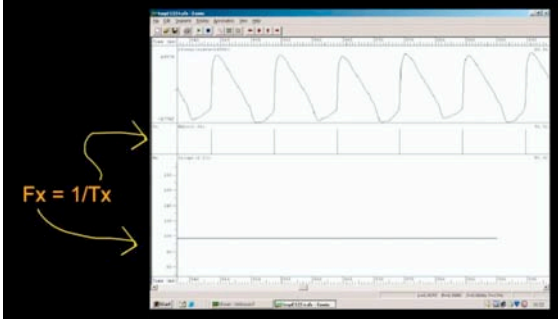
When vocal folds are open, current must flow using a longer path



The laryngograph thus measures how the vocal folds open and close over time



Laryngograph is useful for pitch analysis



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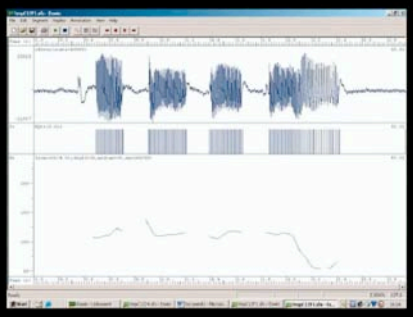

Summary

- Source-filter theory
- Vocal fold vibration cycle
- Pitch and voice quality
- Voice pathology
- Laryngograph

Today's lab: Laryngographic analysis of vocal fold vibration