

Acoustics of Speech and Hearing

Lecture 2-1
Voice

Term Plan

- Source
 - Voice & intonation (Weeks 1-2)
- Filter
 - Steady state (vowels & fricatives) (Weeks 3-4)
 - Dynamic (approximants & stops) (Weeks 5-6)
- Hearing
 - Vowel & consonant perception (Week 7)
 - Loudness, pitch & timbre (Weeks 8-10)

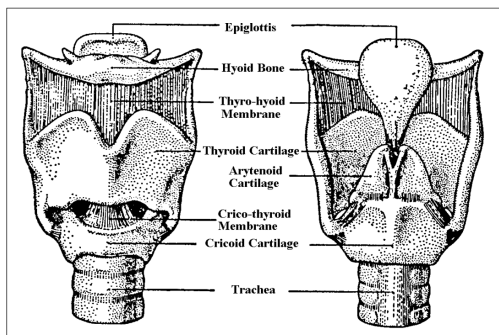
Voice Overview

- Functional anatomy of larynx
- Use of Laryngograph
- Measures of voice quality
- Four basic voice qualities
 - Modal, breathy, creaky, falsetto
- Some pathologies

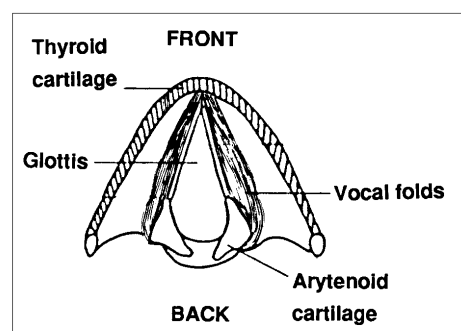
Basic Anatomy

- Know these parts related to the Larynx:
 - Trachea, Pharynx
 - Thyroid cartilage (Adam's apple)
 - Arytenoid cartilages
 - Vocal folds
 - Glottis
 - Vocalis (Thyro-arytenoid) muscle
 - False vocal folds

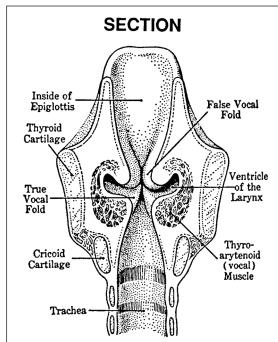
Anatomy 1



Anatomy 2



Anatomy 3



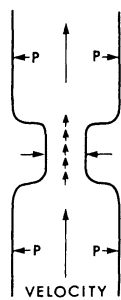
Basic Functions

- Arytenoids rotate to draw vocal folds together across top of trachea
- They control degree of closure and amount of lateral compression
- Arytenoids and Thyroid together can adjust longitudinal tension of vocal folds
- Vocal folds themselves contain muscles which can control their flexibility

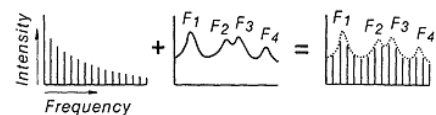


Voice Qualities - Basic Cycle

- Vocal folds approximated and tensed
- Increased sub-glottal pressure
- Vocal folds blown apart
- Increased air flow - decreased pressure
 - Bernoulli effect
- Vocal folds snap together
- Cycle repeats



Source-Filter Reminder



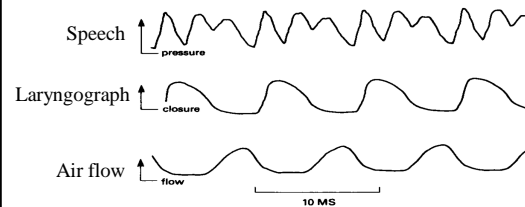
- Larynx vibration is sole source of sound in vowel production
- Larynx 'buzz' gets shaped by resonances in vocal tract
- Vowel spectrum depends on **both** source spectrum and filter
- Source spectrum changes with settings of larynx muscles and lung pressure

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.

Laryngograph Waveform

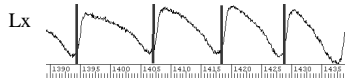


- Graph current flow against time: Lx waveform
- Vertical axis = current flow, analogous to degree of contact



VQ Measures: Jitter

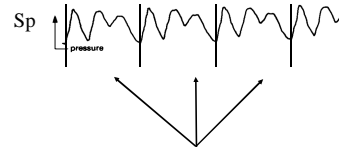
- **Jitter**: cycle to cycle variation in pitch period



How much do individual pitch cycle durations vary from local average?

VQ Measures: Shimmer

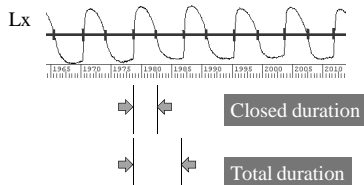
- **Shimmer**: cycle to cycle variation in speech amplitude



How much do individual pitch cycle amplitudes vary from local average?

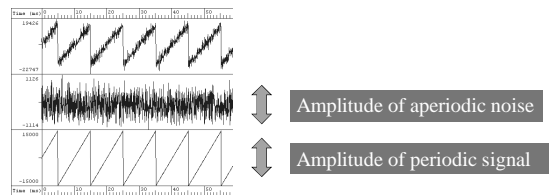
VQ Measures: Closed Quotient

- **Closed Quotient**: average % time closed in each cycle

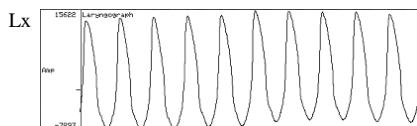


VQ Measures: HNR

- **Harmonic-to-Noise Ratio (HNR)**: measure of signal periodicity. Ratio of amplitudes of periodic and aperiodic signal components

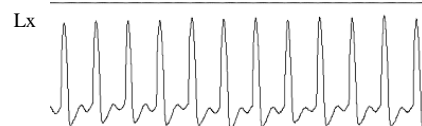


Voice Qualities - Modal



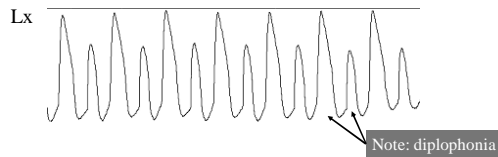
Moderate tension	Medium Fx
Complete approximation	High HNR
Regular cycles	Low jitter & shimmer
Sharp closures	High energy
Good medial compression	Long closed phase

Voice Qualities - Breathy



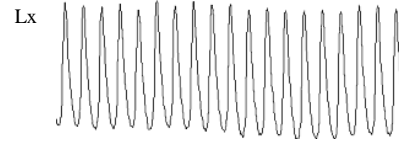
Moderate tension	Medium Fx
Incomplete approximation	Low HNR & increased shimmer
Regular cycles	Low jitter
Weak closures	Low energy
Weak medial compression	Short closed phase

Voice Qualities - Creaky



Often low tension	Low Fx
Complete approximation	Low HNR (irregular)
Irregular cycles	High jitter & shimmer
Sharp closures	High energy
Strong medial compression	Long closed phase

Voice Qualities - Falsetto



High tension	High Fx
Complete approximation	High HNR
Regular cycles	Low jitter & shimmer
Weak closures	Low energy
Strong medial compression	Equal open/closed phases

Pathology (Organic)

- Inflammation
 - increased vocal fold mass, change in mucosa
 - increased vibrational mass affects Fx
- Nodules & Polyps
 - growths on folds
 - affect degree of closure & regularity
- Neuromuscular control
 - e.g. spastic dysphonia
- Damage
 - accidents, cancer, smoking, mis-use

Summary

- Normal voicing cycle
- Laryngograph waveforms for measurement
- Quality measures: jitter, shimmer, closed-quotient, HNR
- Voice qualities: modal, breathy, creaky, falsetto
- Some pathologies

Lab Experiment

- Use Laryngograph
- Study Lx waveform shape for different voice qualities
- Relate shape to larynx settings
- Measure Jitter, Shimmer, Closed Quotient, and Harmonic-to-Noise Ratio for each quality.

