


Acoustics of Speech and Hearing

Lecture 8
Source-Filter Model
of Speech Production

Overview

- Properties of vowel sounds
- Source-Filter model
- Source: Larynx Excitation Signal
- Filter: Vocal Tract System
- Relationship between Acoustic and Phonetic descriptions of vowels.

Properties of vowel sounds -1

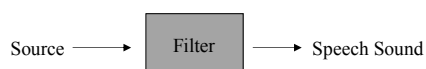
- Have pitch
 - are *periodic* signals
- Can produce same vowel on different pitches
 - fundamental frequency set independently of vowel quality
- Can produce same vowel on different voice qualities
 - voice quality set independently of vowel quality 

Properties of vowel sounds - 2

- Have different timbres
 - have differences in harmonic amplitudes
- Can produce same pitch on different vowels
 - vowel quality set independently
- Vowel quality depends on tongue position
 - front-back, close-open
- Vowel quality also depends on position of other articulators
 - lip rounding, jaw position, velum height

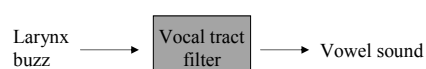
Source-Filter Model

- Many speech sounds can be understood as arising from two **independent** components:
 - a *source* of sound generated in the vocal tract
 - a *filter* which shapes the sound spectrum



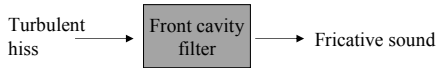
Source-Filter Model

- Vowel sounds
 - source is 'buzz' generated by vocal fold vibration in larynx
 - filter is resonant cavity comprising the vocal tract tube extending from larynx to lips



Source-Filter Model

- Fricative sounds
 - source is ‘hiss’ generated by turbulence as air forced through constriction
 - filter is resonant cavity comprising the vocal tract tube extending from constriction to lips

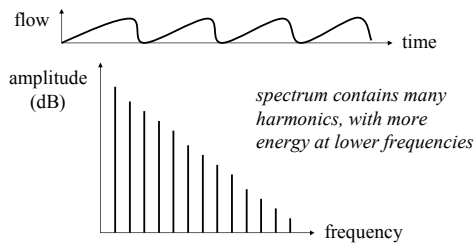


Vowel sounds: Source

- Source
 - Vocal fold vibration in larynx
 - Air blown between two elastic membranes
 - Periodic buzz
 - Intensity set by lung pressure
 - Repetition frequency set by vocal fold tension
 - Quality affected by degree of approximation of vocal folds (among other things)

Vowel Sounds: Source

- Source Signal and Spectrum



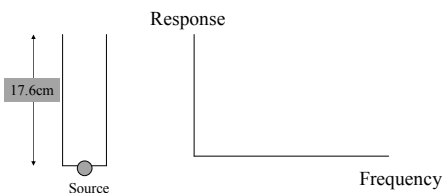
Vowel Sounds: Source

- Typical character of source
 - Fundamental frequency range for men
 - typically 100-200Hz
 - Fundamental frequency range for women
 - typically 150-300Hz
 - Slope of spectrum
 - typically 6dB fall every doubling in frequency



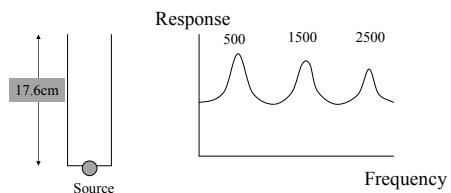
Vowel Sounds: Filter

- Frequency Response of an open tube of 17.6cm in length



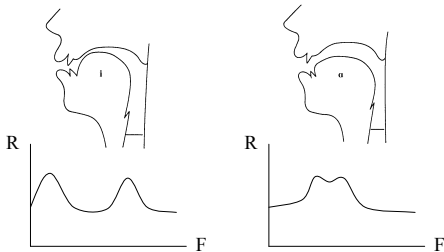
Vowel Sounds: Filter

- Frequency Response of an open tube of 17.6cm in length



Vowel Sounds: Filter

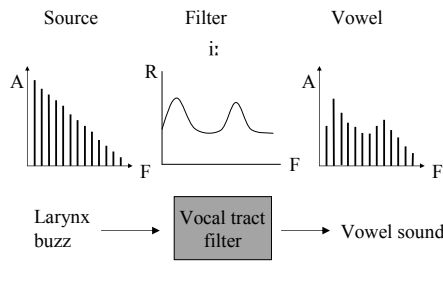
- Vocal tract filter frequency response



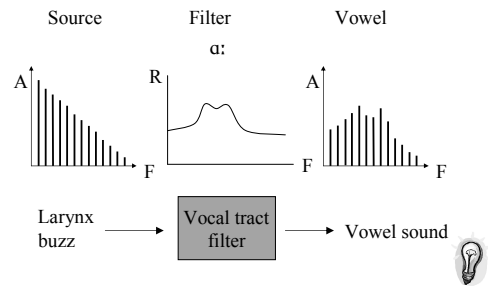
Vowel Sounds: Filter

- Characteristics of Vocal Tract Filter
 - typically made up of a small number of resonant peaks
 - peaks in response called *formants*
 - formant frequencies depend on position of articulators (affect shape of tube)
 - frequency of first 2 or 3 peaks most important for setting phonetic quality

Vowel Sounds: Output

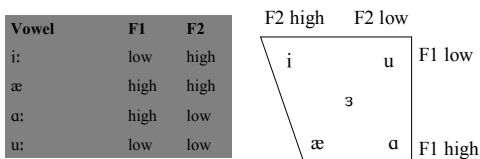


Vowel Sounds: Output



Vowel Phonetics

- Can roughly relate formant frequencies to position on Vowel Quadrilateral



Formant Frequencies

- First formant frequency: F1
 - frequency roughly related to ‘openness’ of vowel
 - frequency high when pharyngeal cavity small
- Second formant frequency: F2
 - frequency roughly related to ‘frontness’ of vowel
 - frequency high when front cavity small

