LING 450/550
4 – Source Filter Theory

Articulatory Phonetics: Source

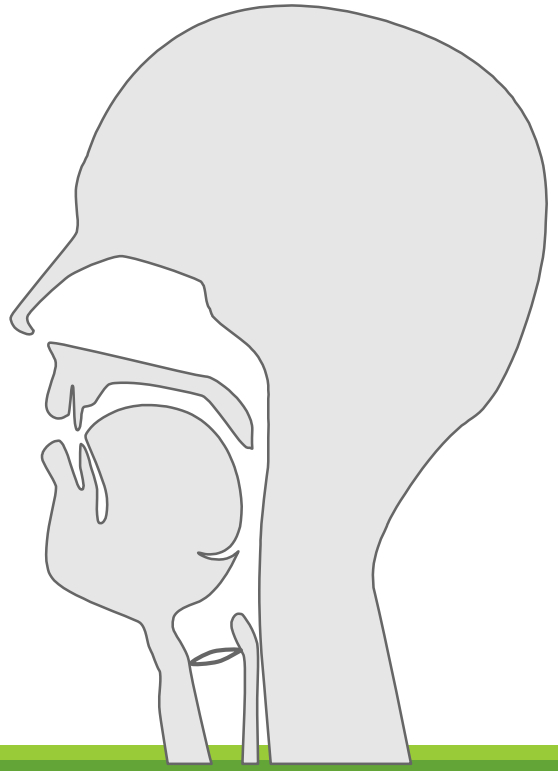
Sound is created by a *source*, which is something that moves (and generally something that vibrates).

- String, membrane, reed, vocal folds, …

Articulatory Phonetics: Filter

Sound can be changed by a *filter*, which is a tube, the shape and size of which impact how air molecules vibrate within it.

- Woodwind instruments, duck call, vocal tract, …



Articulatory Phonetics: Filter

Sound can be changed by a *filter*, which is a tube, the shape and size of which impact how air molecules vibrate within it.

- Woodwind instruments, duck call, vocal tract, …

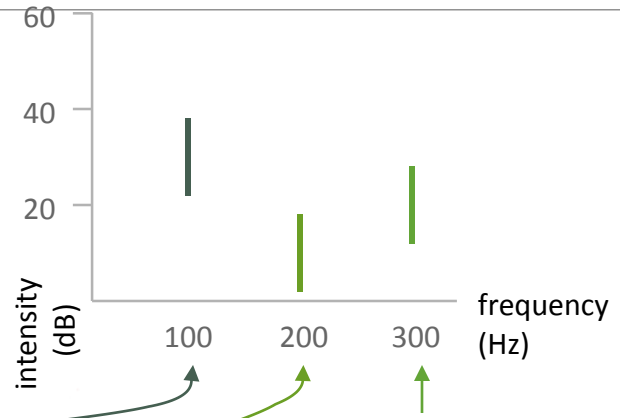
Modifications to the filter's shape and size result in different changes to the sound.

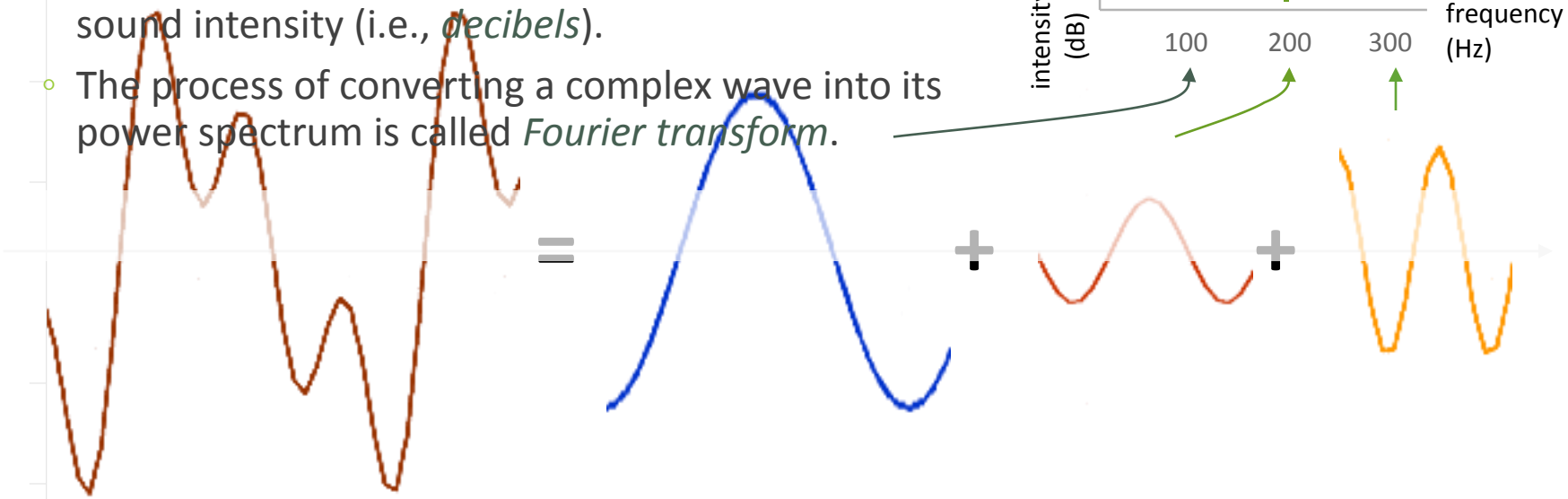
- Opening/closing holes on a woodwind instrument, moving speech articulators, …

Power Spectra (Review)

A *power spectrum* (plural *spectra*) is a graph showing the different frequencies of sine wave components that make up a complex wave, and the different magnitudes of each contributing component wave.

- Spectral magnitudes are usually given in units of sound intensity (i.e., *decibels*).
- The process of converting a complex wave into its power spectrum is called *Fourier transform*.





The Sound of the Larynx

Remember that the pressure waves generated by vibrating vocal folds are complex waves.

In modal-voiced sounds, the vocal folds tend to blow open smoothly and then snap shut, giving the wave a sawtooth-like pattern.

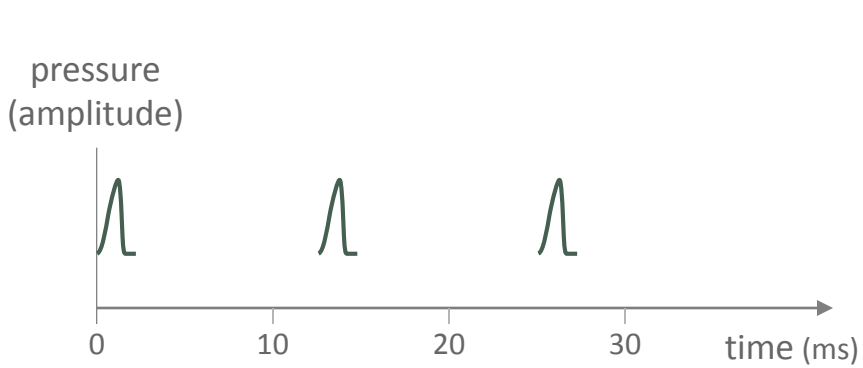
- *Bernoulli's principle* (simplified): an increase in a fluid's velocity means a decrease in its pressure.
- Air from the lungs pushes the vocal folds open. Open vocal folds mean less friction, so the air has higher velocity and thus lower pressure. Lower pressure between the vocal folds causes them to snap shut. Air from the lungs pushes the vocal folds open, etc.

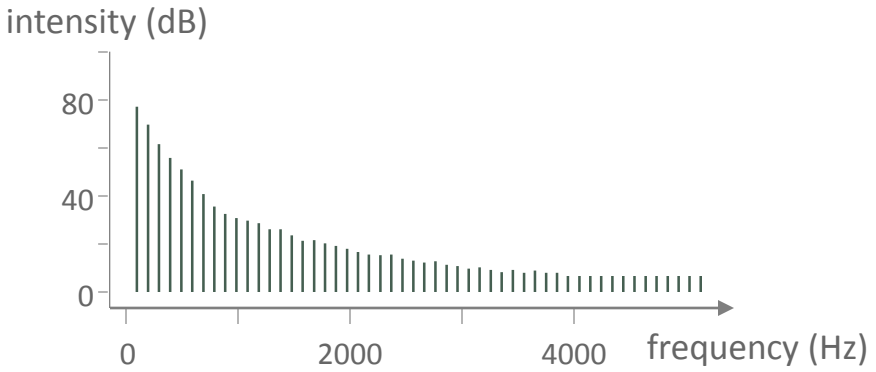
http://www.youtube.com/watch?v=P-xNXrELCmU

The Sound of the Larynx

Remember that the pressure waves generated by vibrating vocal folds are complex waves.

In modal-voiced sounds, the vocal folds tend to blow open smoothly and then snap shut, giving the wave a sawtooth-like pattern.





Fundamental Frequency (f_0) (Review)

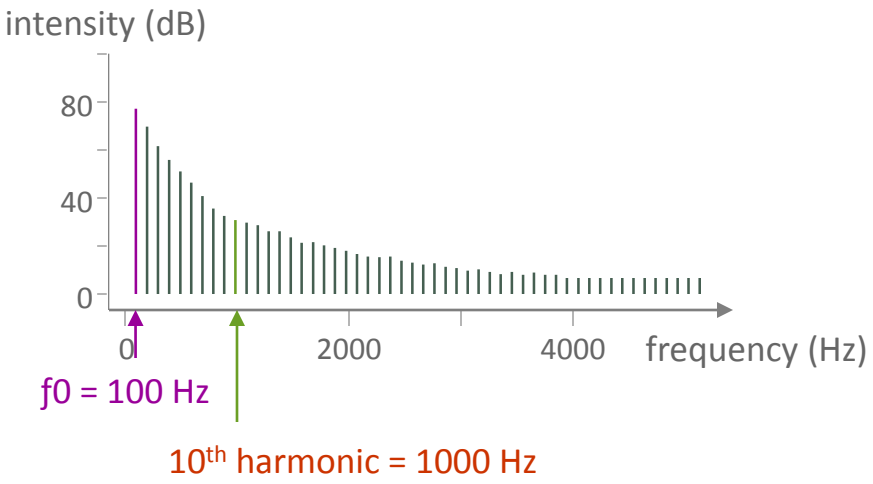
Articulatorily, the *fundamental frequency* is the rate of vibration of the vocal folds.

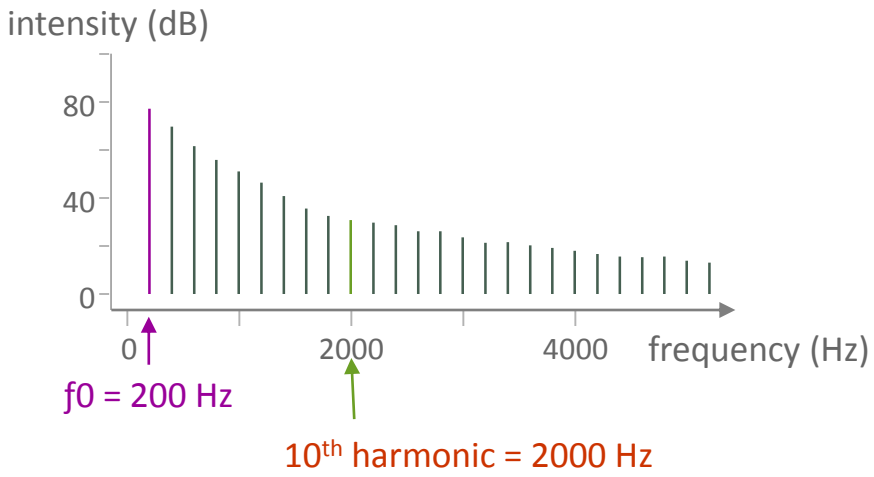
Acoustically, the *fundamental frequency* is the frequency of the complex wave.

The Effect of f_0 on the Power Spectrum

Recall that the component waves of a complex wave are integer multiples of the fundamental frequency; thus, the peaks on a power spectrum are evenly spaced.

Changing the fundamental frequency of the voice changes the width of the space between the harmonics on the power spectrum.

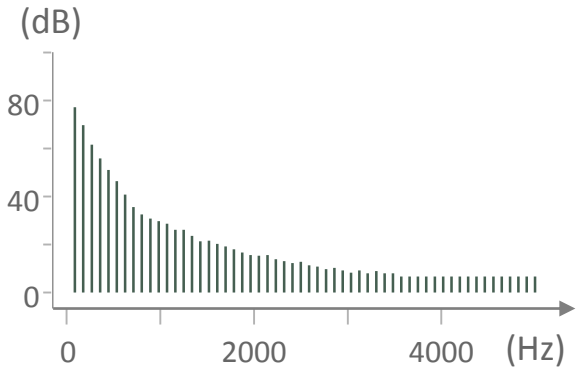




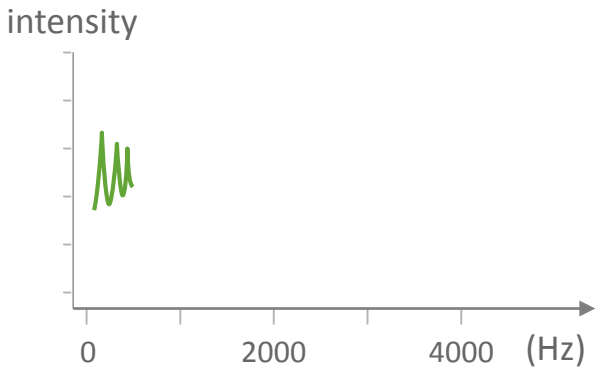
The Vocal Tract as Resonator

As the “sawtooth” wave passes out through the vocal tract, the shape of the vocal tract acts as a set of *resonators*.

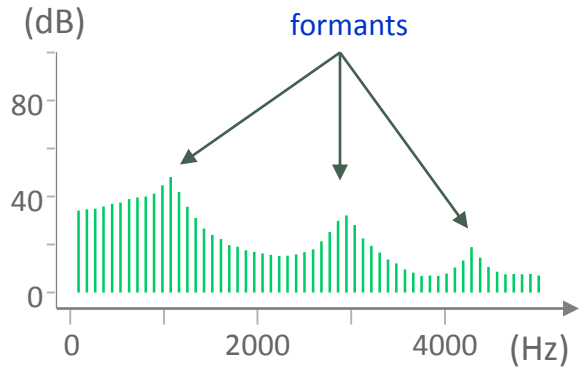
- The resonator *reinforces* certain component frequencies (so they increase in intensity) and *attenuates* other component frequencies (so they decrease in intensity).
- This creates broad peaks of higher energy at the frequencies where the filter graph peaked. These broad peaks are called *formants*.



vocal fold power spectrum (source)



vocal tract frequency curve (filter)



resulting power spectrum

Acoustic Phonetics: Source-Filter Theory

The separation of the speech signal into the source wave of the vocal folds and the vocal tract resonators is called the *source-filter theory* of speech production.

- The *source* is determined by fundamental frequency and phonation type.
- The *filter* is determined by the size and shape of the vocal tract (including the position of the articulators).

Formants and Formant Frequencies

The frequencies that are most strongly reinforced by the resonator are called *formants*.

- Formants are typically the tallest bars on a power spectrum.
- As the shape of the vocal tract changes (through lip, tongue, jaw, and velum movements), the *formant frequencies* also change.

In the analysis of speech, formants are a very important means of distinguishing sounds from one another.

- The first three formants (labeled F_1, F_2, F_3) are the most important formants for understanding the speech signal we hear.

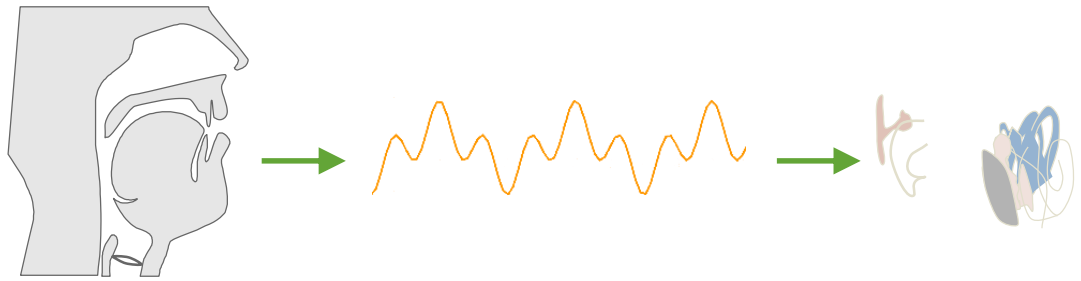
http://corpus.linguistics.berkeley.edu/acip/course/chapter8/speechbird/

The Speech Cycle: Vowels

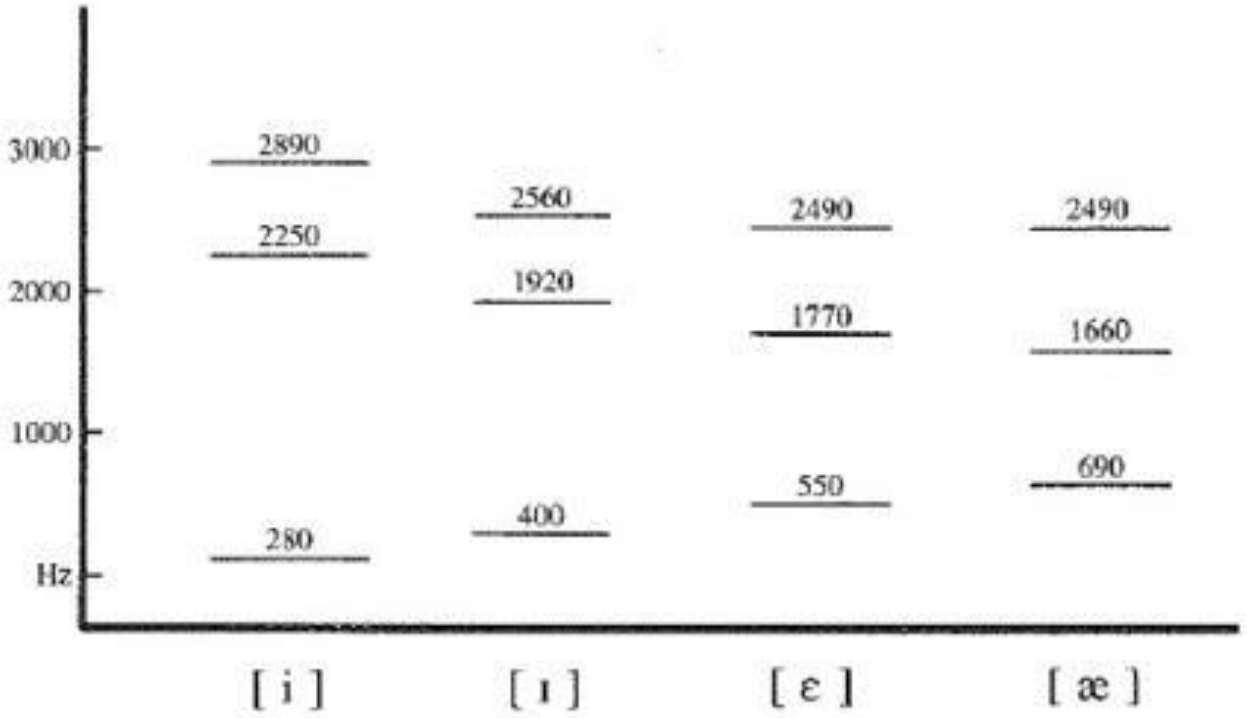
Articulatorily, we change the shape of the vocal tract to produce different vowel sounds.

Acoustically, these different vocal tract configurations reinforce different harmonics, and thus result in different formant frequencies.

Auditorily, we perceive these complex waves with different power spectra as different vowel qualities.



American English Vowel Formants (fig. from textbook)



In-Class Transcription #2

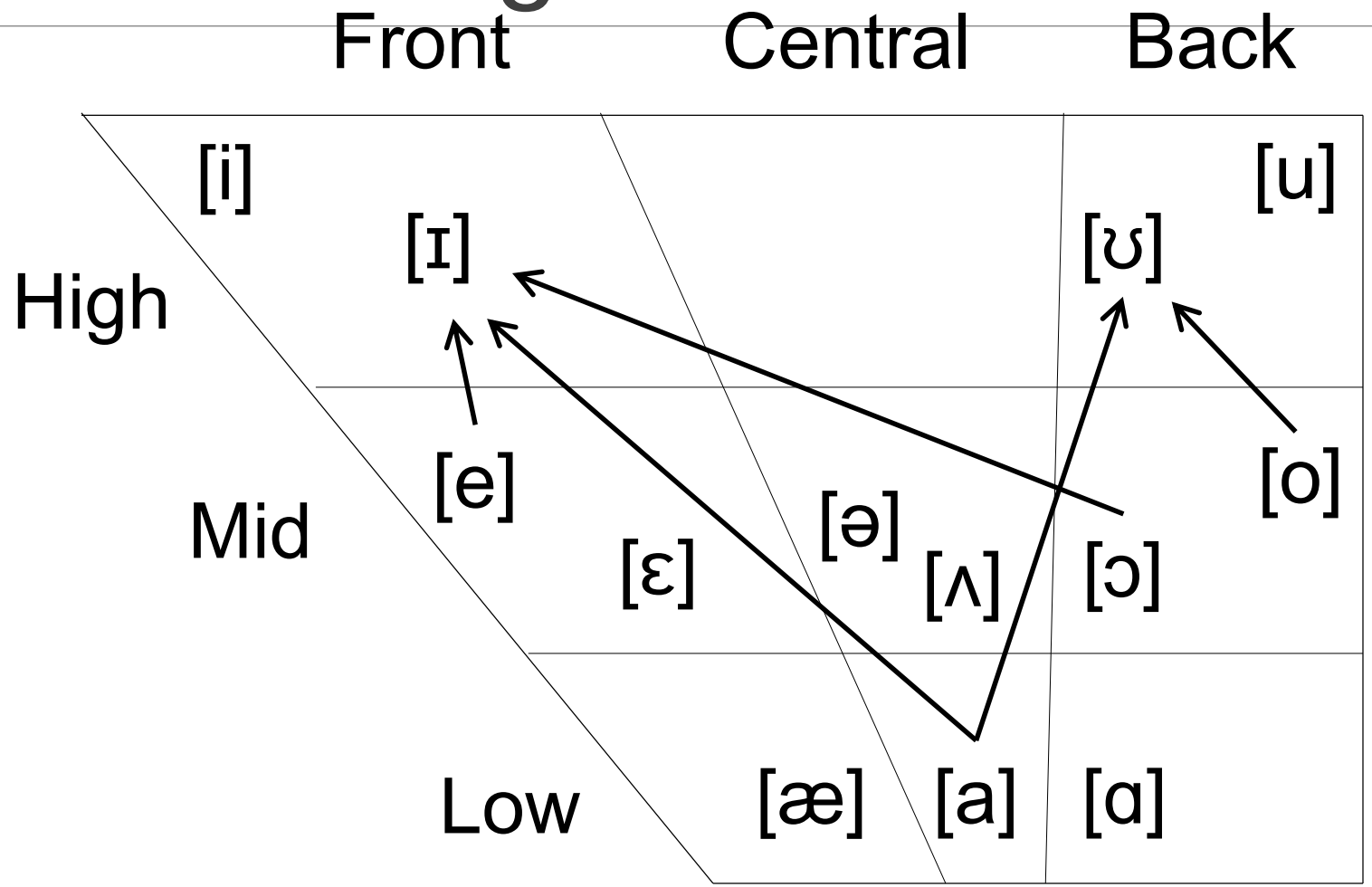
AMERICAN ENGLISH

adapted from slides by Richard Wright, Dan McCloy, and Valerie Freeman

American English Consonants

	Bilabial	Labio-dental	Dental	Alveolar	Palato-alveolar	Palatal	Velar	Glottal
Stop	p b			t d			k g	ʔ
Nasal	m			n			ŋ	
Tap				ɾ				
Fricative		f v	θ ð	s z	ʃ ʒ			h
Affricate					ʧ ʤ			
Approximant	w			ɹ		j		
Lateral				l				

American English Vowels



American English: Vowel Contrasts

11.		‘above’	[əˈbʌv]	19.		‘booed’	[ˈbud]
12.		‘bad’	[ˈbæd]	20.		‘bough’	[ˈbaʊ]
13.		‘bayed’	[ˈbeɪd]	21.		‘boy’	[ˈbɔɪ]
14.		‘bead’	[ˈbid]	22.		‘bud’	[ˈbʌd]
15.		‘bed’	[ˈbɛd]	23.		‘buy’	[ˈbaɪ]
16.		‘bid’	[ˈbɪd]	24.		‘good’	[ˈgʊd]
17.		‘bird’	[ˈbɚd]/[ˈbɻd]	25.		‘pod’	[ˈpʰɑd]
18.		‘bode’	[ˈboʊd]				

Praat

Praat is free software for analysis of waveforms and spectrograms (and it's handy for just playing sound files, as you might want to do for your project).

http://www.fon.hum.uva.nl/praat/

Reminders

Please bring a pencil and an IPA chart or your textbook for in-class transcription exercises

Download Praat

Do HW 3

Read Ladefoged & Johnson chapter 8

Transcriptions up