Week 10 Lecture: Phonetics

Linguistics 201 – Fall 2025

What we've learned so far

- We started the semester talking about words and their parts, and since then we've been moving to larger and larger elements of language:
  - **Morphology** – study of the structure of words (words)
  - **Syntax** – study of the structure of sentences (sentences)
  - **Semantics** – study of the literal meaning language (sentences + meaning)
  - **Pragmatics** – study of the implied/contextual meaning of language (discourse + meaning)
- Now we're going to jump back and look at the smallest element of language: sounds
  - **Phonetics & Phonology** – study of the sounds of language

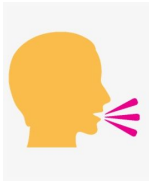
Branches of phonetics

Phonetics and Phonology

- We traditionally divide the study of the sounds of language into two fields:
  - **Phonetics** – study of speech sounds as a **physical phenomenon**
    - How do we use our vocal tract to produce sound?
    - What are the properties of sound waves?
    - How do we use our auditory system to perceive sound?
  - **Phonology** – study of how languages organize speech sounds into a **system**
    - How do we organize sounds into words?
    - What pairs of sounds contrast in language, such that replacing one with another will create a new word?
    - How do sounds change in certain contexts and over time?

Transmitting ideas through sound

Speaker (Articulation)



- Has idea
- Encodes idea in sounds, words, sentence structure
- Uses vocal tract to produce sounds: **articulation**

Air (Acoustics)

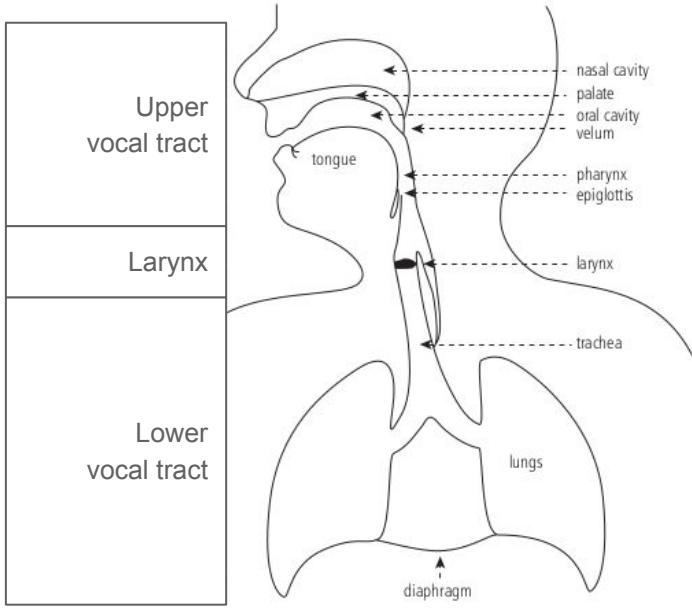
- Sound waves travel through air
- **Acoustics** is the study of the physical properties of sound waves

Listener (Perception)

- Uses auditory system to hear sounds: **perception**
- Decodes sounds into words, sentence structure
- Forms idea

Articulation: How do we make speech sounds?

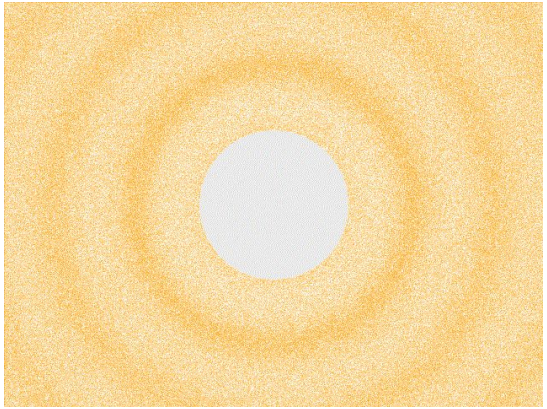
- **Articulation**: moving parts of body to produce speech sounds.
- Steps in articulation:
  - Speaker **exhales**, pushing air out of **lungs** and up the **trachea** (windpipe).
  - Air passes through **larynx** (voicebox), which contains **vocal folds** (cords), primary source of speech sounds.
  - Air passes through **upper vocal tract**, including **oral cavity** (mouth) and **nasal cavity** and leaves body.
  - Within the vocal tract, **articulators** such as the **tongue**, **lips**, **teeth**, and **soft palate** move to modify the sound coming from the larynx and produce additional sounds.



Vocal tract (Zsiga 2013)

Acoustics: What is sound?

- **Sound** is essentially a **vibration** in the air – a disturbance of **air pressure** that we can detect with our ears.
- Air consists of molecules. As we speak:
  - Our articulators push and pull on surrounding air molecules, **compressing** and **rarefying** (pulled apart) them.
  - These air molecules push and pull on their neighbors, which push and pull on their neighbors, and so on…
  - So we have waves of air pressure changes that spread outward from speaker at ~700 mph in all directions.
  - Note that it's the **waves** that travel from speaker to listener. Individual air molecules vibrate in place, but do not travel.

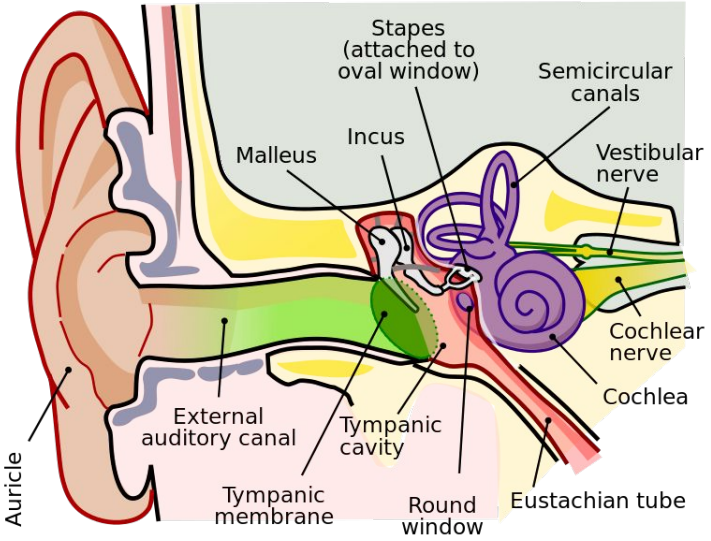


Pressure waves in the air

Ripples on a pond surface
(both images Wikimedia Commons)

Perception: How do we hear sounds?

- Sound waves are channeled by the outer ear through the ear canal to the **eardrum**, causing it to vibrate.
- These vibrations are transmitted by the ossicles and tympanic cavity to the **inner ear**.
- The **inner ear** is full of fluid and regulates balance as well as being essential to hearing.
- In the inner ear, vibrations pass through the fluid into the spiral-shaped **cochlea**, where they cause movements in a series of tiny **hairs** – different hairs for different pitches.
- The hairs connect to nerves, which send neural impulses to the brain, where sounds are decoded into language. Perception therefore involves both **ear** and **brain**.



Branches of phonetics

- Because the transmission of speech sounds involves these three physical processes, we can split phonetics into three branches:
    - **Articulatory phonetics** – study of how we move our vocal tract to produce speech sounds
    - **Acoustic phonetics** – study of the physical properties of sound waves
    - **Perceptual phonetics** – study of how we perceive speech sounds using our auditory system and brain
- We can also talk about the **phonetics of signed languages** – they follow the same processes, but with articulation of visual gestures, optical transmission, and visual perception.
- In this class, we'll focus on **articulatory phonetics**, but if you'd like to know more about acoustics or perception, take a phonetics class!

Segments: Vowels and consonants

Segments and suprasegmentals

- The sounds represented by IPA symbols called **segments** or **phones**
  - **Segment** – discrete, individual unit of sound, for example a consonant, vowel, or glide
  - We can divide the speech stream cleanly into segments: *cats* = [k], [æ], [t], [s]
- But some sounds occur above the level of the segment, affecting multiple segments at once.
  - We call these **prosodic** sounds or **suprasegmentals**
  - For example, stress. Say out loud *fantastic!* Which is the stressed syllable.
    - *fanTAStic* – stressed syllables tend to be louder, longer, more clearly enunciated, and pronounced with a change in pitch – which affects *all* of the sounds in the syllable
    - Stress is a **prosodic** or **suprasegmental** phenomenon: it affects multiple segments.

Segments

- We'll focus on sound **segments** in this class.
- Say these words out loud and try breaking them down into segments. What segments do they have, and how many does each word have? What letters do they correspond to? Does one letter always correspond to one sound?
    - *banana*
    - *ship*
    - *peak*
    - *knock*
    - *rough*

Vowels and consonants

- We can divide segments into the following major categories:
  - **Vowels** like [a, e, i, o, u…]
  - **Consonants** like [p, t, k, b, d, g, m, n, f, s, v, z, r…]
  - **Glides** like the *y* in *yes* (phonetic symbol: [j]) and the [w] in *wait* form an intermediate category – they resemble vowels in some ways and consonants in other ways

Vowels and consonants

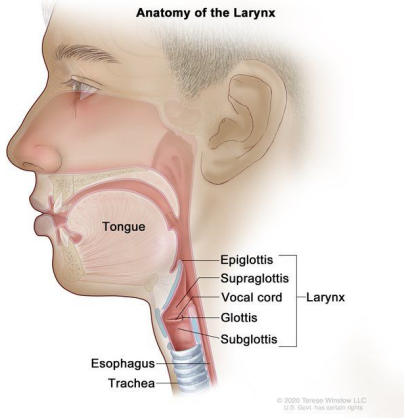
- The way we **articulate** vowels and consonants differs in two important ways.
  - **Airflow** – when we speak, we exhale, forcing air to flow outward through our **vocal tract**
    - With consonants, we block this airflow completely or partially. With vowels, we don't
  - **Voicing** – when we cause our vocal cords to vibrate during speech.
    - Vowels are usually voiced. Consonants may be voiced or voiceless.

	Vowels	**Consonants**
Obstruction of airflow	No obstruction in vocal tract; air flows freely	Total or partial obstruction in vocal tract, blocking or restricting airflow
Voicing	Usually voiced	May or may not be voiced

Larynx and voicing

Voicing and the larynx

- **Larynx** is the **primary source** of speech sounds.
- It contains:
  - **vocal folds** (vocal cords): two sheets of muscle that can be brought together or pulled apart
  - **glottis**: opening between the vocal folds through which air passes
  - other structures of muscle, cartilage, and ligament that support and move the vocal folds



(back of throat)

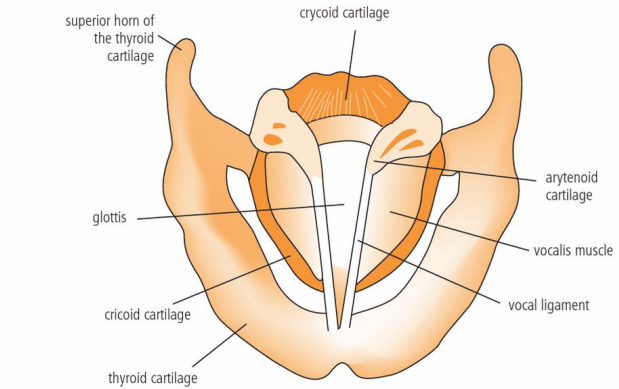


Figure 5.3 Structures of the larynx, viewed from above.

(front of throat)

(Zsiga 2013)

Voicing and the larynx

- By moving the vocal folds in different ways, we can produce different speech sounds.
- If we bring them close together and breathe out, they'll start **vibrating** due to Bernoulli's effect
    - This vibration is called **voicing** and is used in vowels [a, e, i, o, u] and certain consonants like [z, v, b, d, g, m, n, l, r]
- If we move them apart, they'll stop vibrating:
    - This is called **voicelessness**; voiceless consonants include [s, f, p, t, k, h]

Vocal folds open (breathing)

Vocal folds close (voicing)

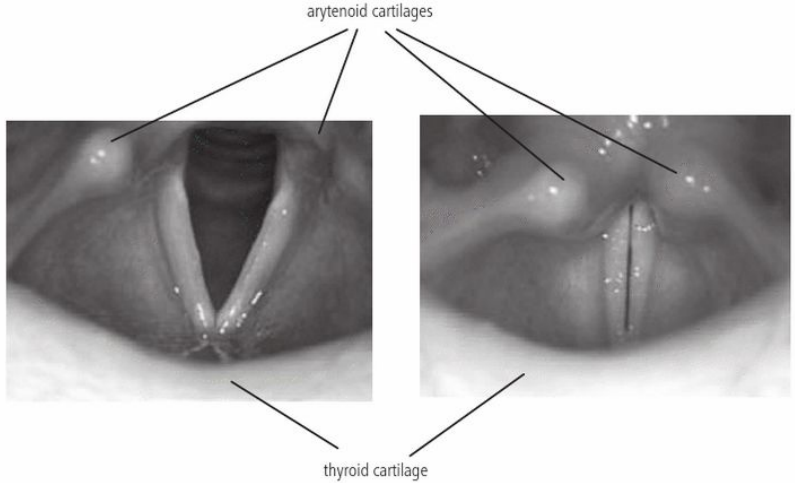
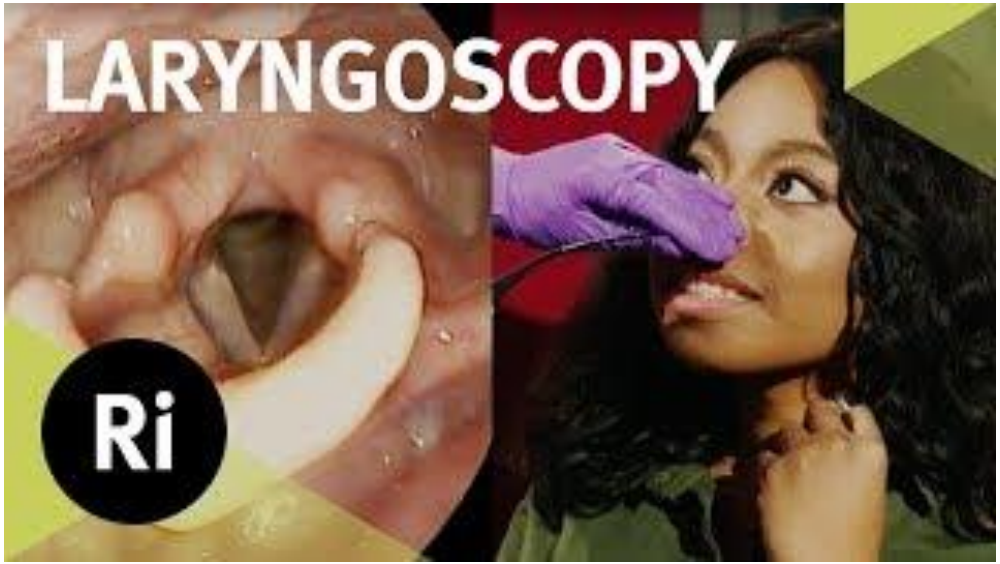


Figure 5.4 Photos of the glottis, taken via endoscope. Left: Vocal folds abducted for breathing. Right: vocal folds adducted for a sustained note. Source: http://www.voicedoctor.net/media/photo/normal/normalfemale.html.

(Zsiga 2013)

Larynx in action

- This video shows the larynx of an opera singer during breathing and **phonation** (production of speech sounds).
- Try to identify the vocal folds and the glottis.
- How do the vocal folds move when the singer breathes, sings, talks, and laughs?



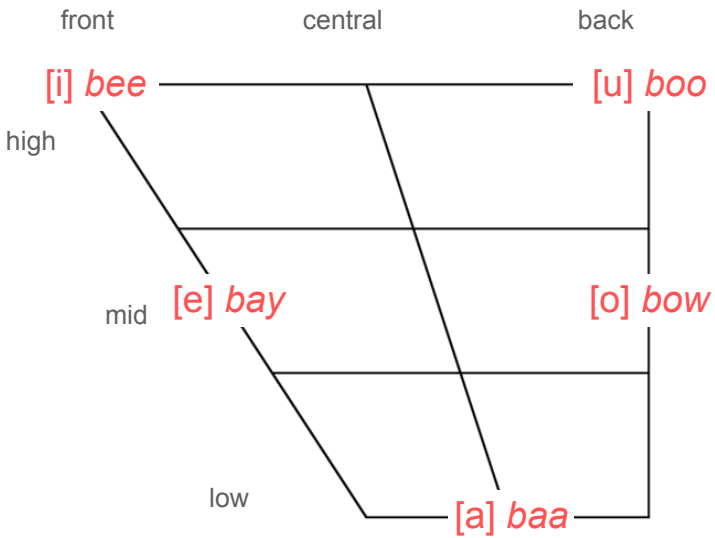
Vowel articulation

Vowel articulation

- We've seen that vowels are articulated with:
  - **Constant airflow** (no obstruction)
  - **Voicing** (vibration of vocal folds)
- Let’s explore **vowels** a bit more and see how they’re **articulated** – how the vocal tract moves to produce them.
- We’ll come back to consonants next week.

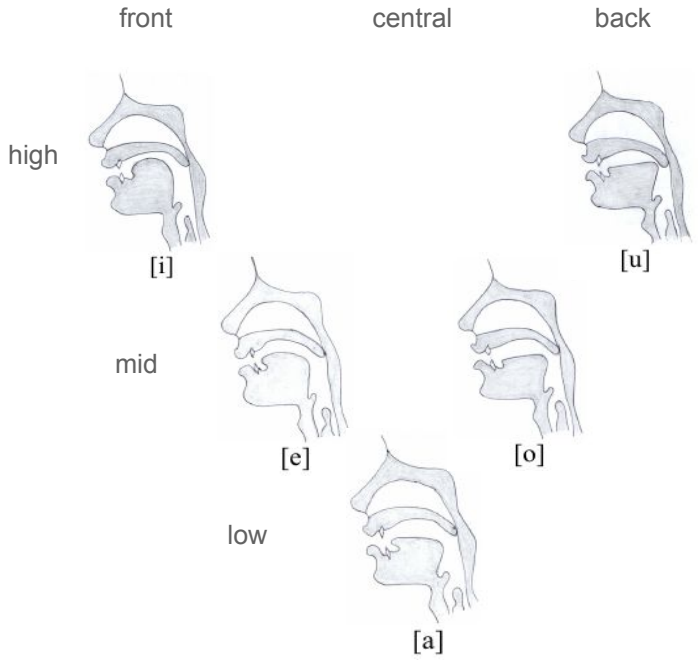
Cardinal vowels

- When discussing vowels, it's useful to establish a few simple vowels – **cardinal vowels** – and build up from there.
- We'll start with the 5 cardinal vowels on the chart:
  - These are the 5 vowels of Spanish, and many other languages have a similar 5-vowel system.
  - I've given English key words to show roughly how these vowels sound.
- Note that the International Phonetic Alphabet's symbols for vowels don't always match our English names for them.



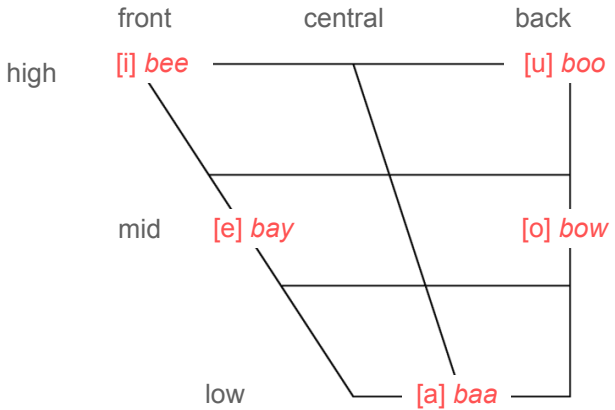
Vowel Features

- Different vowel qualities can be primarily be distinguished based on **three features**:
  - **Tongue height**
    How high is the tongue in the mouth?
  - **Tongue backness**
    Is tongue further forward or back in mouth?
  - **Lip roundedness**
    Are the lips rounded or unrounded?



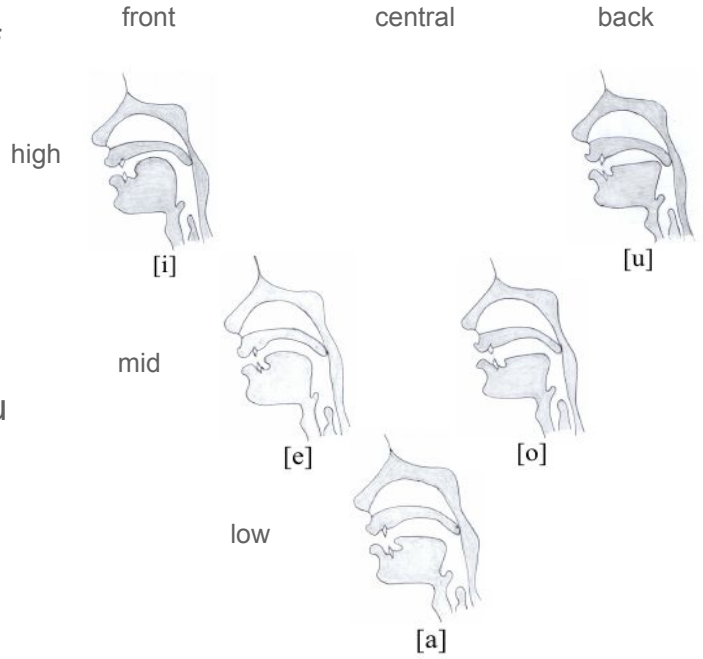
Vowels in a real-time MRI

- This video is produced by an **MRI** (magnetic resonance imaging) scanner, a machine used to see inside the body.
- Watch how the tongue and lips move as these people sing [a, e, i, o, u].



Vowel Features

- In different vowel qualities, we can distinguish various levels of **tongue height**:
  - **High, mid, low**
- And we can distinguish various levels of **tongue backness**:
  - **Front, central, back**
- Arranging them by tongue position, they form a triangle, so you often see vowels arranged in a **vowel triangle/trapezoid**.



Lip rounding

- The third vowel feature is **lip rounding**:
  - **rounded** vs. **unrounded** (spread)
- Here are our five vowels as pronounced by a speaker of Italian.
- How does his mouth shape change for each vowel? Which ones are rounded/unrounded?
- Note that he's exaggerating a bit for the purposes of demonstration since in the video he’s trying to teach Italian pronunciation.

[i]

[e]

[a]

[o]

[u]

Podcast Italiano: Le vocali dell’italiano standard
https://www.youtube.com/watch?v=UL9Czh_LG34

Lip rounding

- [o, u] are **rounded**; [i, e, a] are **unrounded**
- This follows a crosslinguistic tendency:
  - Back vowels tend to be rounded
  - Front and low vowels tend to be unrounded
- Front rounded vowels exist but are less common:
  - German *schön* [ʃøːn] 'beautiful'
  - French *tu* [ty] 'you'
- As are back unrounded vowels:
  - Japanese *kuzu* [kɯzɯ] 'kudzu vine'


[i]


[e]


[a]

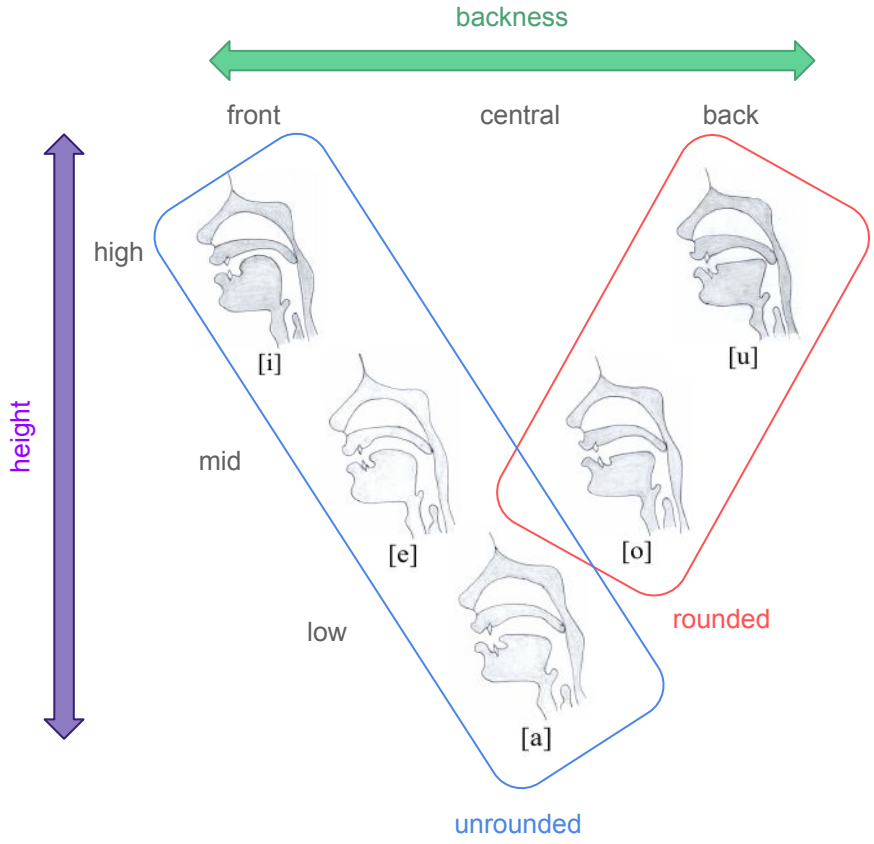

[o]


[u]

Image source: *Podcast Italiano*: Le vocali dell'italiano standard
https://www.youtube.com/watch?v=UL9Czh_LG34

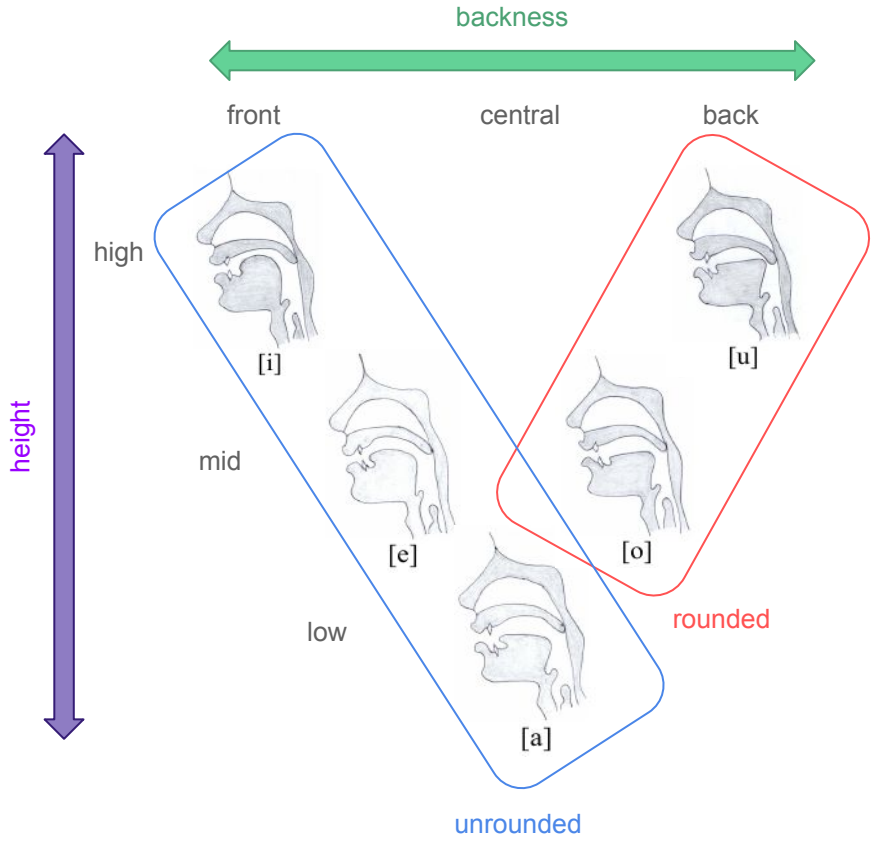
Vowel Features

- So these are the three **articulatory features** we use to distinguish different vowel **qualities**:
  - **Tongue height**
    How high is the tongue in the mouth?
  - **Tongue backness**
    Is tongue further forward or back in mouth?
  - **Lip roundedness**
    Are the lips rounded or unrounded?



Vowel Features

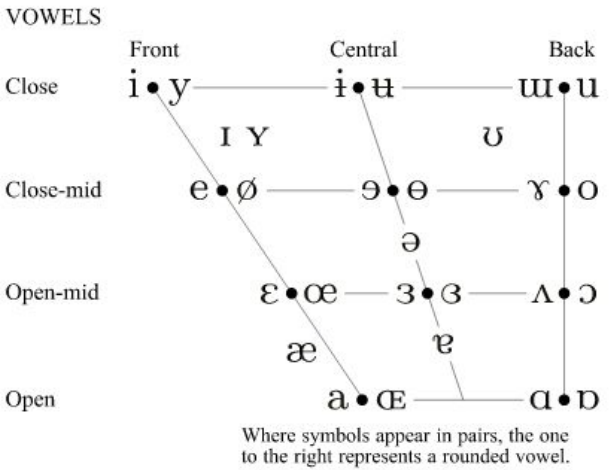
- When we describe vowels, we typically do so in terms of *height - backness - roundedness*:
  - [i] = high front unrounded vowel
  - [e] = mid front unrounded vowel
  - [a] = low central unrounded vowel
  - [o] = mid back rounded vowel
  - [u] = high back rounded vowel



American English vowels

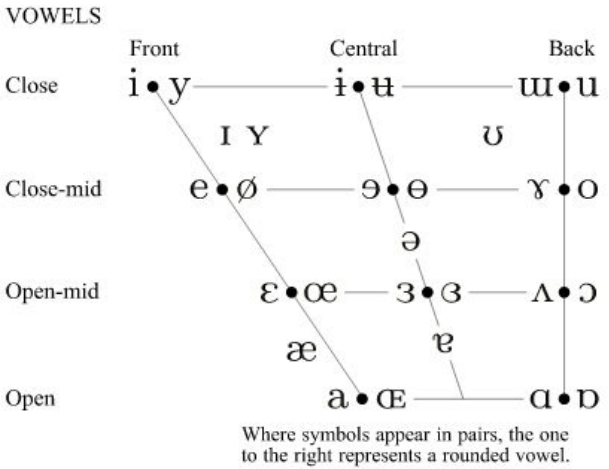
Beyond the cardinal vowels

- Of course, there are more than five vowels.
- IPA chart uses **28 cardinal vowels** to try to represent all of the world's languages – though no language uses them all.
- Note that:
  - IPA chart uses terms close/open instead of high/low, but most phoneticians use terms high/low
  - IPA chart distinguishes 4 levels of height instead of 3
  - IPA chart includes some vowels between these levels. We can use terms like near high, near front, etc.
  - [ə] *schwa* is in the center of the chart and is the mid central vowel



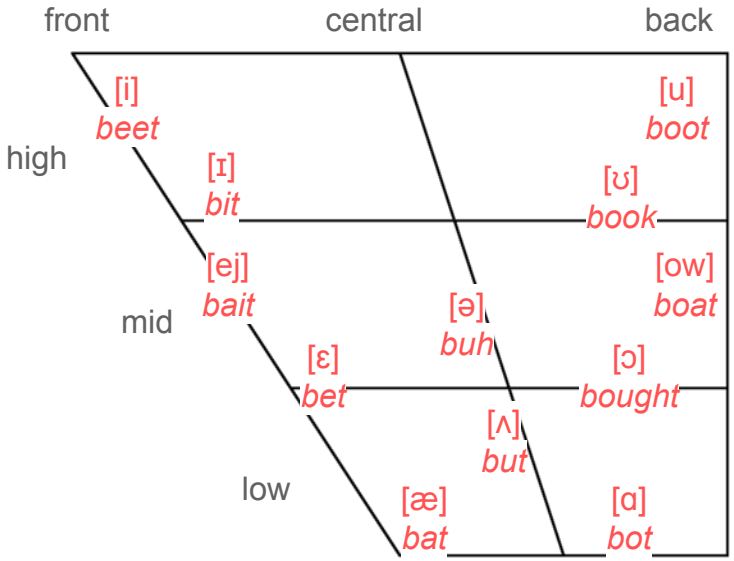
Beyond the cardinal vowels

- How do we figure out what sound these symbols represent?
- We use our five cardinal vowels as a starting point:
  - How do we pronounce [y]?
    - Start with [i] and make it rounded.
  - How do we pronounce [ɛ]?
    - Tongue about halfway between [e] and [a].
  - How do we pronounce [ɨ]?
    - Tongue about halfway between [i] and [u].



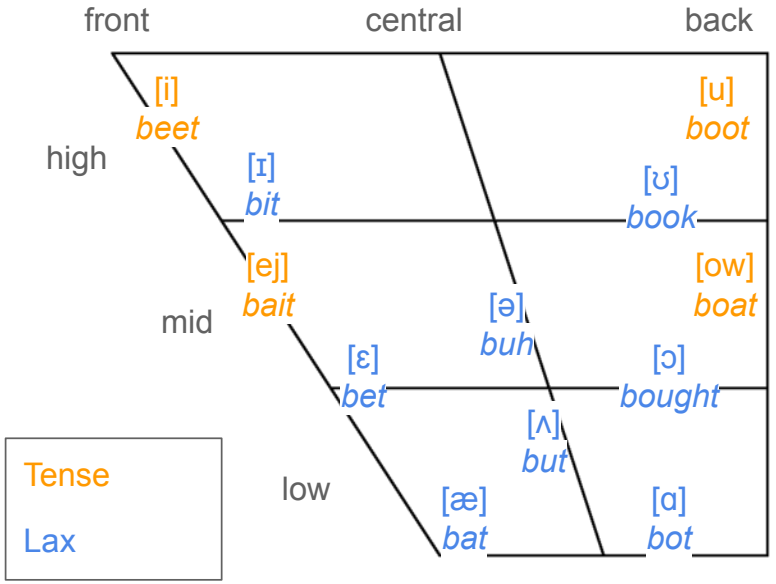
American English vowels

- American English has around **12-14** vowels.
- Exact number and pronunciation varies by region – English accents tend to differ in terms of vowels.
- A few notes about American English vowels:
  - There is a 5-way height contrast
  - Speakers tend to diphthongize some of these vowels, especially the *bait* and *boat* vowels, but also to a certain degree *beet* and *boot*
  - Some American English speakers don't differentiate [ə] and [ʌ], and some don’t differentiate [ɑ] and [ɔ].



Tense and lax vowels

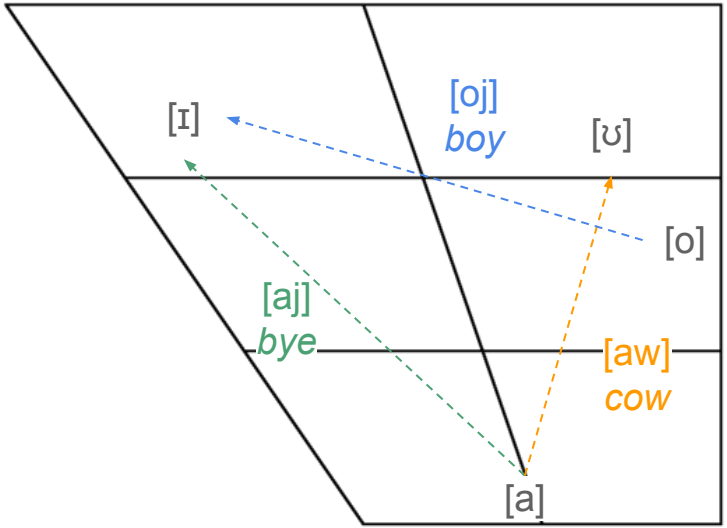
- 5 height differences is a bit unwieldy.
- A common solution is to divide the vowels into:
  - **Tense vowels**: [i], [u], [eɪ̯], [oʊ̯]
    a bit higher and more peripheral,
    tend to be diphthongized in American Eng.
  - **Lax vowels**: the rest
    tongue a bit more relaxed,
    cannot end a word in American Eng.



Diphthongs and glides

- A **diphthong** is two vowel sounds that are combined into a single sound.
- A diphthong consists of:
  - **vowel + glide** or **glide + vowel**
- A glide (semi-vowel) is a vowel-like sound produced by moving your tongue while saying a vowel.
  - By combining a glide with a vowel, we get a **diphthong**.
- There also exist **triphthongs**: glide + vowel + glide
  - For example, *yay, wow, way*

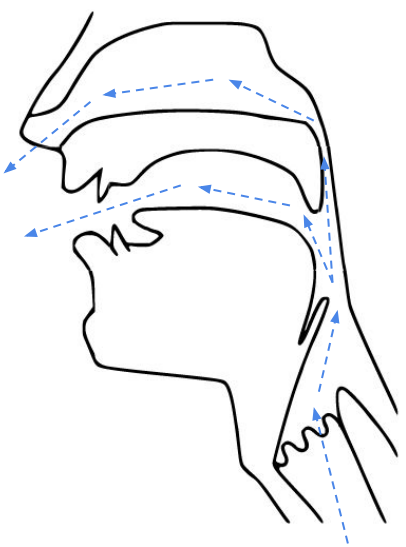
Major diphthongs of American English



Vowels beyond English

Vowel features beyond English

- Across languages, vowels always differ by height, backness, and rounding – but they can also differ by other features
- Some languages feature **nasal vowels** in addition to the **oral vowels** we've been talking about so far:
    - **Nasal vowels** are articulated by lowering the **velum** (soft palate) at the back of the mouth, allowing air to flow through both the nose and the mouth.
    - Portuguese *bom* [bõ] 'good', *bem* [bẽ] 'well', *um* [ũ] 'one'
- Some languages contrast **long** and **short** vowels:
    - Japanese [obasan] 'aunt' vs. [oba:san] 'grandmother'



Nasal vowel: [ã]

Vowel features beyond English

- In **tone languages** like Mandarin, Cantonese, Vietnamese, Thai, and Punjabi, vowels are distinguished by differences in **pitch**:
  - Mandarin distinguishes four tones + neutral. All of these are considered to be different words:
    - Tone 1 (high level): *mā* 'mother'
    - Tone 2 (rising): *má* 'hemp'
    - Tone 3 (falling-rising): *mǎ* 'horse'
    - Tone 4 (falling): *mà* 'scold'
    - Neutral tone: *ma* (question marker)

Wrap-up

- In these slides, we learned about the **larynx** and **vowels**:
- The **larynx** is an organ in the throat:
  - It contains the **vocal folds** and the **glottis** (opening between the vocal folds)
  - When the vocal folds **vibrate**, it is called **voicing**
- Vowels are a type of sound segment characterized by **unobstructed airflow** and **voicing**.
- Different vowel qualities can be described using the following three **features**:
  - **tongue height** (high/close, mid, low/open)
  - **tongue backness** (front, central, back)
  - **lip rounding** (rounded, unrounded)