Introduction to Language

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Phonetics

Phonetics, from the Greek *phōnē*, meaning sound or to speak.

- The study of making and hearing speech sounds.

- How do we articulate speech sounds?
- How do sounds differ acoustically?
- What types of sounds are used cross-linguistically?

Phonetics

Speech production

Articulatory phonetics examines the physiology of how we use our bodies to produce speech.

Physical correlates of speech sounds

Acoustic phonetics looks at the physical properties of speech sounds.

Speech perception

Perceptual acoustics examines how we interpret/perceive the sound waves of speech.

Challenges Phoneticians Face

The speech signal is continuous

We produce a continuous stream of complex, overlapping frequencies when we speak. How do hearers of a language analyze what we hear as speech sounds? How do we analyze a language phonetically and compare it to other languages?

Speech is fleeting

When we speak, words are very very short. We can pack a lot of information into only seconds of speech. Individual sounds are milliseconds long. Once they're gone, they're gone.

The articulators aren't visible

Most of the key parts of out anatomy used for producing speech (lungs, vocal cords, tongue, palate, uvula, teeth) are hidden inside our mouths.

How we tackle these challenges

Phonetic transcription

Linguists have developed several systems for writing down all the minute details of speech sounds. We call this **phonetic transcription**.

Computational analysis

Linguists have developed computational algorithms for analyzing the physical properties of the sound waves of speech sounds. We can look at the frequency, amplitude, and duration of speech sounds in great detail.

Other techniques

- Ultrasounds and palatography to 'see' inside the mouth.
- fMRI and EEG to measure brain function.

Today

1. Introduction to the sounds of the world and the **International Phonetic Alphabet**
2. The anatomy and physiology of speech
3. Articulatory properties of speech sounds, how we categorize sounds.
4. Acoustic Correlates

Inadequacy of Orthography

You say tomato, I say... tomato..?

- The **orthography** (or writing system) of English is well suited for reading and writing.
- English orthography reflects how people spoke in one area of England, hundreds of years ago.
  - English has changed and diversified since... in fact, even at the time there were major disagreements about how to spell words.
- **Problem**: Few languages' orthographies (perhaps none) have a one-to-one correlation between symbol and sound.
  - Not suitable for analyzing the sounds of the individual language, let alone all the languages of the world.

Inadequacy of Orthography

Think about the letter 'C' in English orthography.

- 'cat' /**k**æt/
- 'cent' /**s**ɛnt/
- 'cello' /**ʧ**ɛlow/
- 'ocean' /ow**ʃ**ən/
- 'cappuccino' /kæpə**ʧ**inow/
- 'indict' /ɪndajt/

Like many letters in English, 'C' is not pronounced the same way in every English word.

Inadequacy of Orthography

Think about the ways the bolded letters are pronounced in English orthography.

- pl**ea**
- s**ee**
- dec**ei**ve
- tang**y**
- k**ey**
- sk**i**
- br**ie**
- p**eo**ple
- alg**ae**

9 different ways to spell the same sound!

Inadequacy of Orthography

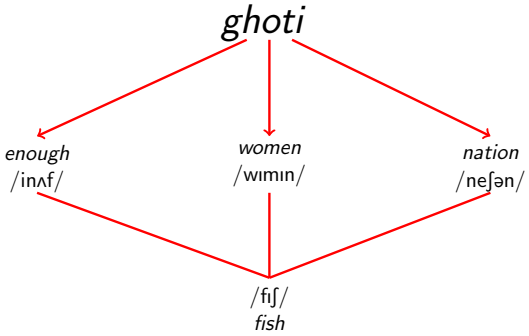
Single sounds are spelled with two symbols

- **th**in
- **th**at
- **ch**in
- **sh**in
- ac**ti**on
- **wh**at
- si**ng**
- ju**dg**e

Single symbols represent two sounds

- fa**x**
- **u**nit

Inadequacy of Orthography



Inadequacy of Orthography

We need a precise system of representation for all the sounds of all the world's languages.

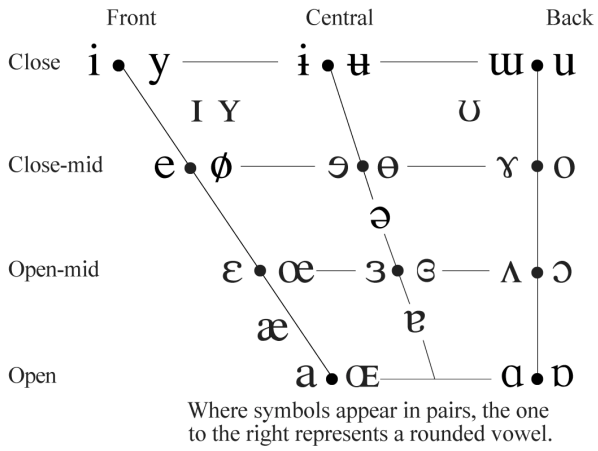
- **Solution**: **The International Phonetic Alphabet**
  - A system developed to describe and record all the sounds of spoken human languages.
  - Based on the Roman orthography (like English)
  - Contains a wide array of symbols and diacritics to represent over 800 speech sounds.
  - Lots of symbols are used in English **BUT** there are key differences.
  - The IPA provides precise information about speech sounds.
  - **One symbol for one sound**
  - IPA symbols are enclosed in [ ] square brackets to distinguish them from orthography.

Consonants of the IPA

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k g	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			r					ʀ		
Tap or Flap		ⱱ		ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

Where symbols appear in pairs, the one to the right represents a voiced consonant. Shaded areas denote articulations judged impossible.

Vowels of the IPA



Where symbols appear in pairs, the one to the right represents a rounded vowel.

The Anatomy and Physiology of Speech

Become aware of your articulators!

1. Breath in, then breath out though your mouth.
   - Feel the air flow out of your lungs, through your throat and out your mouth.
2. Say the word *tea* [ti] out loud, a couple times.
3. Go to say the *tea* but stop right before you pronounce the [t] sound.
   - Feel where your tongue is.
4. Now say *key* [ki], *fee*, [fi], *she* [ʃi], *these* [ðiz], and *bee* [bi].
   - Be aware of where your tongue, lips, and teeth are.

The basics of speaking

To speak, we follow these three basic steps:

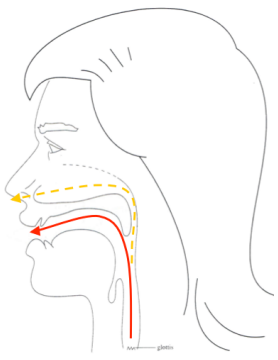
1. Force air out of your **lungs**.**
2. Send that air between your **vocal cords** (folds) in your **larynx** located at the bottom of your throat.
   - Depending on the sound you make, your vocal cords will vary in position and may vibrate.
3. Use your **primary articulators** (**tongue** and **lips**) to manipulate the shape of your **vocal tract** to change the speech sound you make.

** - All English sounds are made by forcing air out of your lungs. The outward movement of air from the lungs is called a **pulmonic egressive airstream mechanism**.

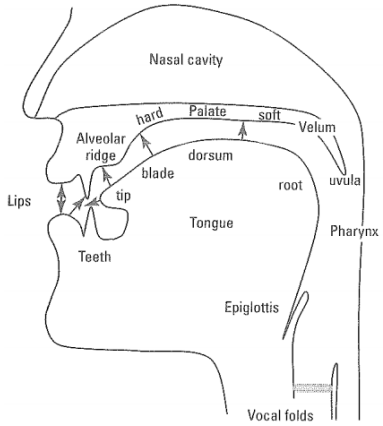
The Vocal Tract

In many ways, our vocal tract is like a trumpet or saxophone.

- There is a source of airflow and vibration at one end, the sound is manipulated by the shape of the instrument, and finally the sound leaves through the other end.

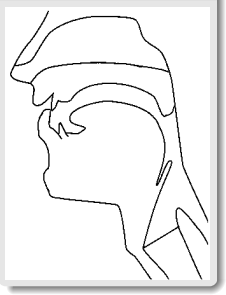


The Vocal Tract

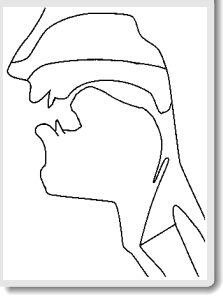


Manipulating the vocal tract

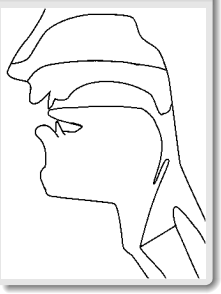
[f] (*fee*)



[ʃ] (*she*)



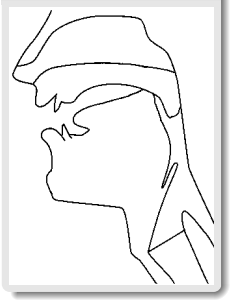
[θ] (*thought*)



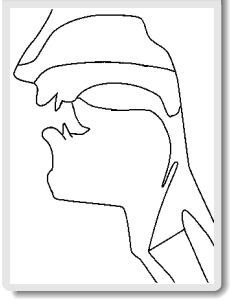
Sagittal section: A diagram of the head as though cut in two from front to back.

Manipulating the vocal tract

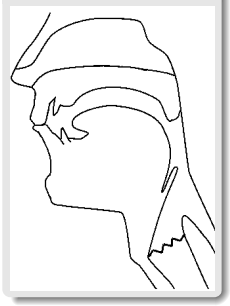
[k] (*key*)



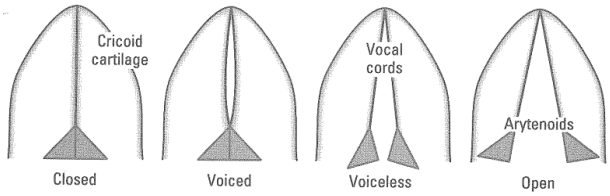
[t] (*tea*)



[b] (*bee*)



States of the Glottis



- Your vocal cords come together completely and block airflow from lungs
- A glottal stop [ʔ]
- *uh-oh*

- Voiced sounds vs. voiceless sounds.
- Say the word *zoo* but hold the [z] sound, now [s] (*see*).
- **Voiced sounds**: vocal cords come together tightly, but air flows between then, causing them to vibrate.
- **Voiceless sounds**: Vocal cords are more open, no vibration.

- Vocal cords are open but still and stiff
- Turbulance in airflow creates noise
- [h] *ham*

Articulatory Properties of Sounds

Two Major Types of Sounds

Sounds in the worlds languages are divided into two major classes.

- **Consonants** are sounds made with complete or partial obstruction of the oral tract (i.e., the flow of air is either stopped completely or limited)
  - [p, t, k, b, d, g, f, v, s, z, m, n, ŋ, θ, ð, ʃ, ʒ, ʧ, ʤ, h, l, ɹ, j, w]
- **Vowels** are sounds made with very little obstruction in the oral tract (i.e., the air passes rather freely)
  - [i, u, e, o, æ, ʌ, aj, oj, ɪ, ɛ, ʊ, ɑ, ə, aw]

The Consonants of Canadian English

Sound	Initial Ex.	Final Ex.
[p]	pat	rap
[t]	tack	sat
[k]	cat	lack
[b]	bat	slab
[d]	duel	rude
[g]	gum	rug
[f]	face	poof
[v]	vow	rove
[s]	salad	race
[z]	zoo	raise
[m]	mute	clam
[n]	now	pan
[ŋ]	...	sang

Sound	Initial Ex.	Final Ex.
[θ]	think	breath
[ð]	though	breathe
[ʃ]	ship	clash
[ʒ]	Jacque	beige
[ʧ]	chip	rich
[ʤ]	Joe	badge
[h]	ham	...
[ʔ]	uh-uh	
[l]	luck	call
[ɹ]	run	car
[j]	you	...
[w]	water	...

Three Key Properties of English Consonants

1. Voicing
   - What is the state of the glottis? Voiced? Voiceless?
2. Place of Articulation
   - Where in the mouth do you obstruct the airflow?
3. Manner of Articulation
   - How much do you obstruct the airflow? Completely? Partially? Both? Through your mouth? Through your nose?

Voicing

The consonants of English are either voiced or voiceless.

- **Voiced**: Vocal cords vibrate.
  - [b, d, g, v, ð, z, ʒ, ʤ, m, n, ŋ, j, w]
- **Voiceless**: Vocal cords do not vibrate.
  - [p, t, k, f, θ, s, ʃ, ʧ, h, ʔ]

Places of Articulation

The consonants of English are pronounced in seven different places in the mouth.

- **Bilabials**: both lips together [p, b, m, w]
- **Labiodentals**: lower lip and upper teeth [f, v]
- **Interdental**: tongue tip between teeth [θ, ð]
- **Alveolars**: tongue tip and alveolar ridge [t, d, n, s, z, l ,r]
- **Palatal**: tongue blade and hard palate [ʃ, ʒ, ʧ, ʤ]
- **Velar**: tongue dorsum and soft palate [k, g]
- **Uvular**: tongue and uvula (no English sounds)
- **Glottal**: vocal cords [h, ʔ]

X-ray video

Manners of Articulation

The consonants of English are use six different manners

- **Stops**: airstream from the mouth is completely stopped and then released in a single burst. Also called **plosives**. [p, t, k, b, d, g, ʔ]
- **Fricatives**: airstream is partially obstructed causing frication/turbulence in the airstream. [f, v, θ, ð, s, z, ʃ, ʒ, h]
- **Affricates**: a combination of a stop followed by a fricative. [ʧ, ʤ]
- **Nasals**: Complete closure in the mouth. Airflow escapes through nose. [m, n, ŋ]
- **Approximants**: More vowel-like consonants.
  - **Liquids**: Some constriction/obstruction, but not enough to create frication/turbulence. [l, ɹ][a]
  - **Glides**: Very little constriction/obstruction. [j, w]

[a] [l] is a lateral liquid, [ɹ] is a retroflex liquid.

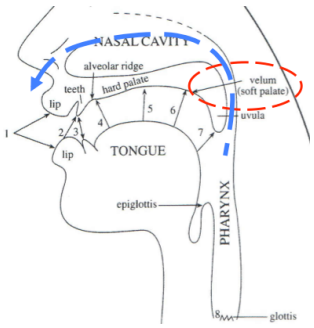
Physiology of nasals

Nasalization

You can easily tell if a sound is nasal or not.

- Try to continuously make the sound [m] as in *math*, but plug your nose.

To produce nasal sounds, we make a full closure in the oral cavity and lower our velum to allow air to escape through the nose.



Linguists usually think of nasals as a type of **stop** because the airflow through the oral cavity is completely stopped.

A note on voiceless stops

In English, the voiceless stops ([p, t, k]) cause the vocal cords to stay open longer in certain contexts. When this happens, the result is **aspiration**

- Aspiration is the slight puff of air that is the result of keeping the vocal cords open longer.
- [p, t, k] are all aspirated in **stressed, syllable-initial position** (e.g., *pin*, *tall*, *apart*)

Compare the p-sound in:

- *pin* [pʰɪn] (ASPIRATED)
- *spin* [spɪn] (UNASPIRATED)

Can't hear the difference? Put your hand in from of your mouth and say the two words. You can feel the puff of air!

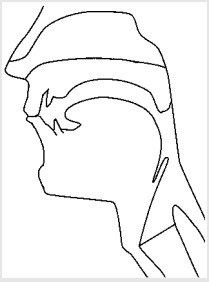
The Consonants of Canadian English

		Bilab.	Labden.	Intden.	Alv.	Pal.	Vel.	Glot.
Stops	vls	p			t		k	ʔ
	vcd	b			d		g	
Fricatives	vls		f	θ	s	ʃ		h
	vcd		v	ð	z	ʒ		
Affricates	vls					ʧ		
	vcd					ʤ		
Nasal	vcd	m			n		ŋ	
Approximants								
Glides	vcd	w				j		
Liquids								
Lateral	vcd				l			
Retroflex	vcd				ɹ			

Note: 'vls' = voiceless, 'vcd' = voiced

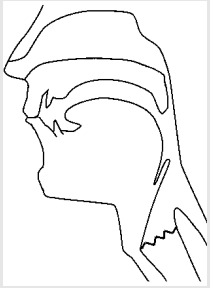
Practice With Sagittal Sections

[p] (**p**ack)



voiceless
bilabial
stop

[m] (**m**at)



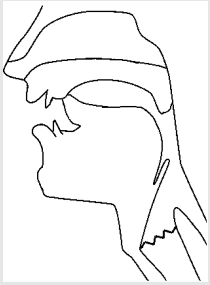
voiced
bilabial
nasal

[ŋ] (ra**ng**)

voiced
velar
nasal

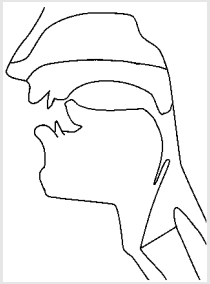
Practice With Sagittal Sections

[d] (**d**oll)



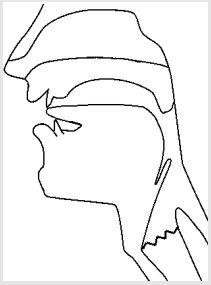
voiced
alveolar
stop

[s] (**s**ip)



voiceless
alveolar
fricative

[ð] (**th**y)



voiced
interdental
fricative

The Vowels of Canadian English

Sound	Example
[i]	bead
[u]	booed
[e]	bait
[o]	boat
[æ]	bad
[ʌ]	but
[aj]	buys
[ɔj]	boy
[aw]	bowed

Sound	Example
[ɪ]	bid
[ʊ]	book
[ɛ]	bed
[ɑ]	bought
[ə]	b**a**nana

In this class, we are using the vowels of Canadian English, which differ from the textbook! Unless otherwise told to, follow these slides.

Four Key Properties of English Vowel

1. Tongue position
   - How high/low is the tongue?
   - How far foward/back is the tongue?
2. Lip Rounding
   - Are the lips rounded or spread?
3. Rigidity of the tongue
   - Is your tongue tense or lax?
4. Static or dynamic?
   - Do the articulators remain stationary during articulation of the vowel or do they move?

Tongue Height

There are three levels of tongue height:

- **High vowels**:
  - [i] (beet), [ɪ] (bit), [u] (boot), [ʊ] (book)
- **Mid vowels**:
  - [e] (bait), [ɛ] (bet), [o] (boat), [ʌ] (but), [ə] (the)
- **Low vowels**:
  - [æ] (bat), [ɑ] (bought)

**Say [i], [e], and [æ] to yourself a few times. Feel how your jaw drops and your tongue gets lower.

Tongue Backness

There are three levels of tongue backness:

- **Front vowels**:
  - [i] (beet), [ɪ] (bit), [e] (bait), [ɛ] (bet), [æ] (bat),
- **Central vowels**:
  - [ʌ] (but), [ə] (the)
- **Back vowels**:
  - [u] (boot), [ʊ] (book), [o] (boat), [ɑ] (bought)

Lip Rounding

In English, some vowels are produced with the lips rounded others are not.

- **Rounded**:
  - [u] (boot), [ʊ] (book), [o] (boat)
- **Unrounded** (=lips spread):
  - [i] (beet), [ɪ] (bit), [e] (bait), [ɛ] (bet), [æ] (bat), [ʌ] (but), [ə] (the), [ɑ] (bought)

Other languages have vowels that are produced in the same position as unrounded vowels in English, but the lips are rounded.

- **French**: *ceux* 'those' [sø] ([ø] = rounded [e])
- **German**: *süss* 'sweet' [sys] ([y] = rounded [i])

Tongue rigidity

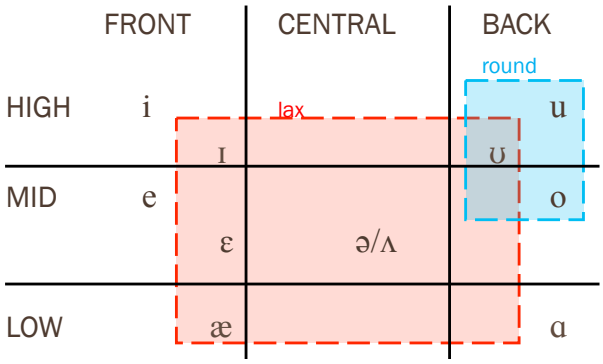
Some vowels are produced with more tension in the muscles of the tongue some with less.

- **Tense** vowels: [i, u, e, o, ɑ]
- **Lax** vowels: [ɪ, ʊ, ɛ, æ, ʌ, ə]

The tense/lax distinction is often hard for non-native speakers to hear. Here are some **minimal pairs** that make only a tense/lax distinction.

- seen [sin] vs. sin [sɪn]
- suit [sut] vs. soot [sʊt]
- late [let] vs. let [lɛt]

The Static Vowels of Canadian English



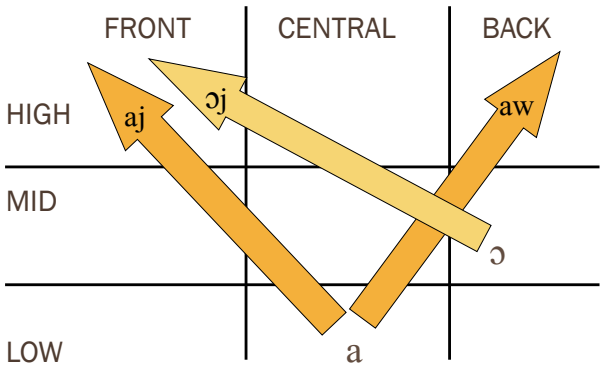
Diphthongs: The dynamic vowels

In addition to the static vowels, Canadian English also has three DYNAMIC vowels!

- Linguists call static vowel **monophthongs** and dynamic vowels **diphthongs**.
- Diphthongs are "moving vowels" because the tongue is in one position at the start of the vowel and moves to another position by the end of the vowel.
  - Try saying *I*, *ow!* and *oi!*
  - These are the three diphthongs and we transcribe them as [aj, aw, ɔj]*

*-Note that we differ from the text book here!

Diphthongs: The dynamic vowels



A note on nasal vowels

Vowels can also be nasalized and many languages of the world have nasal vowels (e.g., French, Portuguese, Khoekhoe).

In English, nasalization **does not distinguish** vowels but it does occur predictably in certain environments.

- When a vowel is before a nasal consonant, it's usually nasalized.
- 'ban' [bæ̃n]

A note on [ə] and [ʌ]

For many speakers of English, [ə] and [ʌ] sound *very* similar.

- 'the' vs. 'hut' [ðə] vs. [hʌt]

How to distinguish [ə] and [ʌ]

- [ə] occurs in unstressed syllables (e.g., 'Canada' [kʰæ.nə.də]) and function words like 'the'
- [ʌ] occurs in stressed syllables (e.g., 'putting' [pʰʌ.tɪŋ])

Tips for transcription

- Try to ignore spelling!
- Try to sound out how many sounds there are in the word.
- Use the examples in these slides/your handout to compare sounds. Does X sound like Y?

For example, let's transcribe 'shook':

- Try to sound it out. Do you hear three different sounds?
  - First sound: same first sound in 'ship', so [ʃ]
  - Second sound: same vowel as in 'book', so [ʊ]
  - Third sound: same last sound in 'lack', so [k]
- So we get [ʃʊk]

Transcription practice

Suprasegmental features of language

Languages also manipulates the **amount of airflow** and the **frequency at which the vocal cords vibrate** to mark meaning differences.

- We call these suprasegmental, because they happen over top of the properties of the individual sounds (segments).

Suprasegmental features: Stess

Stress (in English at least) is realized as an increase in airflow and possibly an increase in pitch and vowel length.

- We use stress to distinguish between noun/verb pairs:
  - PERmit (noun), perMIT (verb)
  - CONflict (noun), conFLICT (verb)
- In other languages, stress is predictable (e.g., always falls on the first syllable of a word)

Suprasegmental features: Pitch

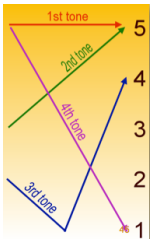
As we'll see in a second, the rate at which are vocal cords vibrate determines the pitch of a sound.

- In English, the pitch of a sound doesn't effect the meaning of an individual word, but the way that pitch changes across a sentence (=**intonation**) can alter the meaning of the sentence.
  - That's a cat. (falling intonation, a statement)
  - That's a cat? (rising intonation, a question)

Suprasegmental features: Pitch

Other languages do use pitch to change the meaning of individual words. We call these **tone** languages.

- For instance, there are four tones in Mandarin:
  1. High level tone: mā, 'mother'
  2. High rising tone: má, 'hemp'
  3. Low falling tone: mǎ, 'horse'
  4. High falling tone: mà, 'scold'



Acoustic Properties of Sounds

Three Dimensions of Sound

1. Frequency
2. Time/duration
3. Amplitude

What happens acoustically when we speak?

1. We create a sound source using one or both of the following mechanisms:
   - **Periodic** vibration of the vocal cords
   - **Non-periodic** turbulent noise resulting from airflow through a narrow constriction.
2. We filter the periodic or non-periodic sound source with the vocal tract which shape the frequencies and amplitude of the signal into a particular speech sound.

Fundamental frequency

Most of the sounds of English are *voiced* sounds:

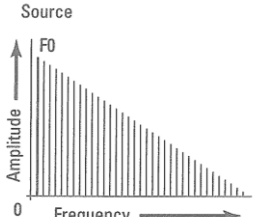
- The sound source is the periodic vibration of the vocal cords... they open and close rapidly at a steady rate.
- The rate of vibration is what we perceive as pitch! The faster the vibration, the higher the pitch
- For vocal cords to vibrate when we send air past them
  - **Bernoulli Principle**
- The rate of vibration depends on three things:
  - **Length** (shorter vocal cords vibrate faster)
  - **Mass** (thinner vocal cords vibrate faster)
  - **Tension** (tighter vocal cords vibrate faster)

The length and mass of an individual's vocal cords are constant. People with a low voice have longer heavier vocal cords. We can only manipulate the tension of our vocal cords to change our pitch.

Fundamental frequency

Definition: The rate/frequency at which the vocal cords vibrate determines the **fundamental frequency** (or F0) of your voice.

- But vocal cords also generate other frequencies, called **harmonics** which are multiples of the fundamental frequency.
  - If the fundamental frequency of my voice is 100Hz (i.e., my vocal cords vibrate 100 times per second), then I'll also produce 200Hz, 300Hz, 400Hz, 500Hz etc.



Digression into music

Have you ever wondered why two different musical instruments can play the same note but sound so different?

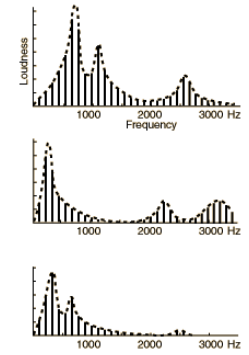
- Violin vs. a trumpet!

- Musicians call this the **timbre** [tæmbəɹ] of an instrument.
  - It's what makes a trumpet sound like a trumpet.
- Different timbres are the result of the shape and material of an instrument.
  - Different shapes and materials cause certain harmonic frequencies to be amplified while other harmonic frequencies are reduced.
- This is because of the natural tendency of a body to vibrate at certain frequencies (**resonance**).

Vowels as instruments with different timbres

Essentially, every vowel has it's own timbre and that's why they sound different!

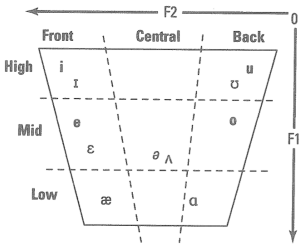
- The shape of your vocal tract determines which frequencies will be amplified and which will be reduced.
  - Changing the shape, changes the pattern
- Here we have [ɑ], [i] and [u]
- We call each of these peaks a **formant** (F1, F2, F3)



The acoustic properties of vowels

We can classify all the vowels of English using F1 and F2:

- **High** vowels have **low** F1 values
- **Low** vowels have **high** F1 values.
- **Back** vowels have **low** F2 values
- **Front** vowels have **high** F2 values.



The acoustics of fricatives and stops

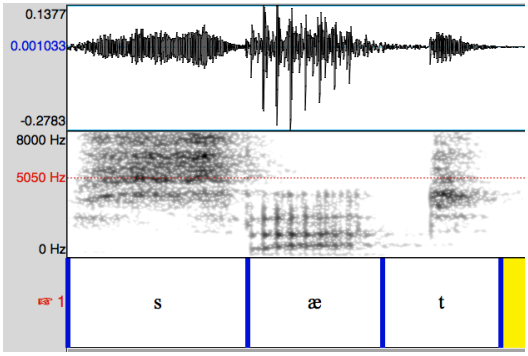
The turbulent airflow of **fricatives** causes non-periodic sound.

- Produce all kinds of frequencies (**noise**)
- Can differentiate fricatives from one another by:
  - **Frequency range and centre of sonic energy**
    - [s] has a wider range and higher centre than [f]
  - **Duration**
    - [s] is longer than [f]
  - **Voicing**
    - Voicing adds a periodic sound to the mix: [f] vs. [v], [s] vs. [z]

Stops cause:

- a closure in oral tract (thus momentary silence).
- then when released cause a short burst of noise.
- Stops interact with the formants of surrounding vowels as well.

The acoustics of fricatives and stops

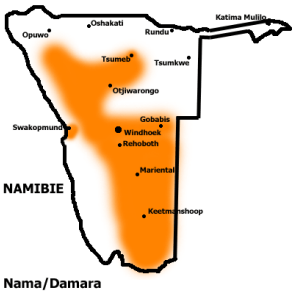


Linguistic Diversity

The sounds of English are made with a **pulmonic egressive** airstream but other languages use other airstream mechanisms

- Glottalic ingressive airstream (=**implosives**)
  - The glottis is closed and lowered, creating a vacuum in the oral tract, which is then released, which causes air to rush into the oral tract to fill the vacuum.
- Glottalic egressive airstream (=**ejectives**)
  - The glottis is closed and raised, increasing pressure in the oral tract, which is then released, pushing the air out of the mouth.
- Velaric ingressive airstream (=**clicks**)
  - Using the dorsum of the tongue against the velum, a vacuum is created inside the mouth and when released, air is sucked in.

Linguistic Diversity



Khoekhoe (Khoe Family)

- National language of Namibia. Also spoken in Botswana and South Africa.
- Has four **click** sounds.
  - A dental click [|]
  - An alveolar click [!]
  - A palatal click [ǂ]
  - A lateral click [ǁ]

Ticket out the door

Try to transcribe your name!

For Tuesday...

1. Read chapter 3 (if you haven't already) and chapter 4.
2. Complete assignment 2
   - I'll post it on blackboard tomorrow