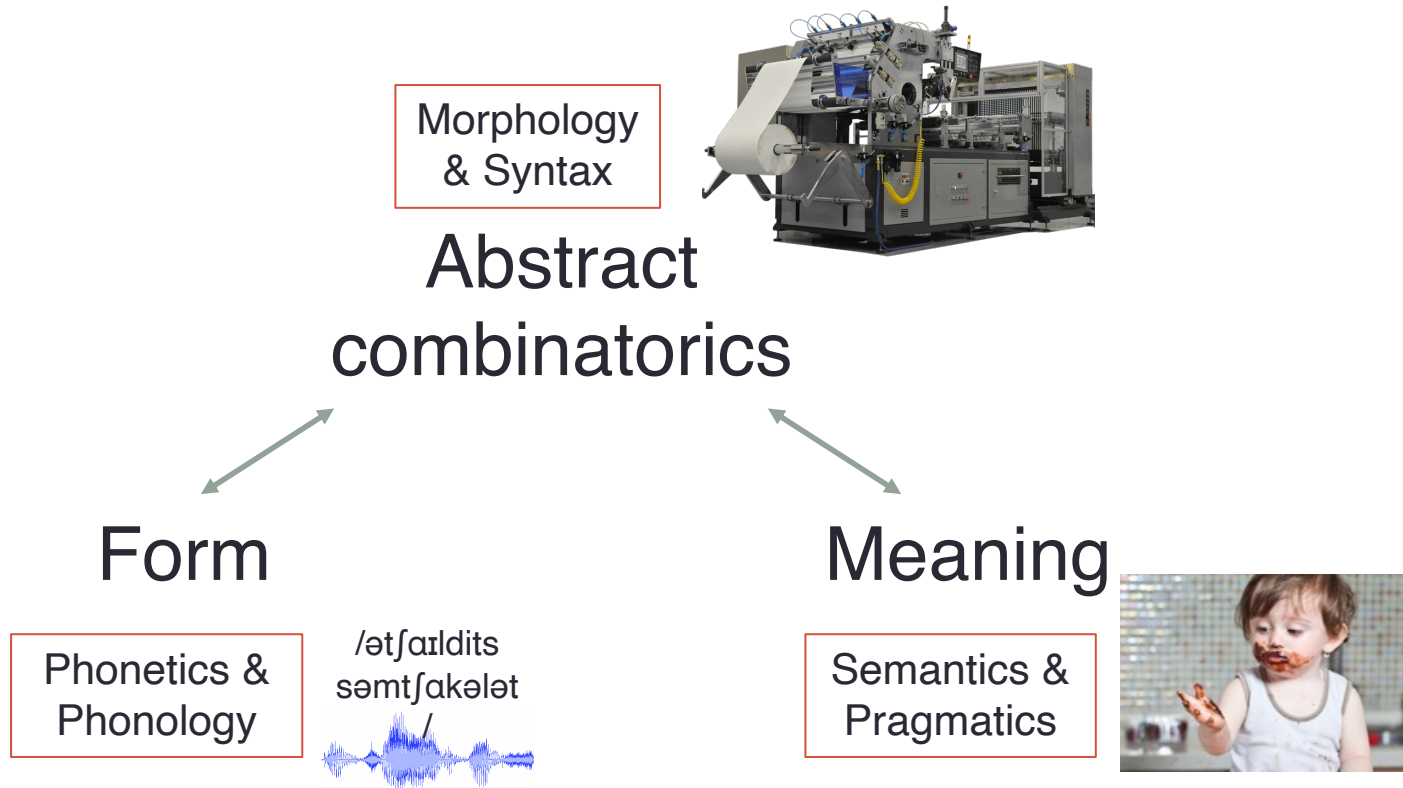


PHONETICS & PHONOLOGY

COMD570: Introduction to Language Development

Components of language



Chomsky, 1980; 1995

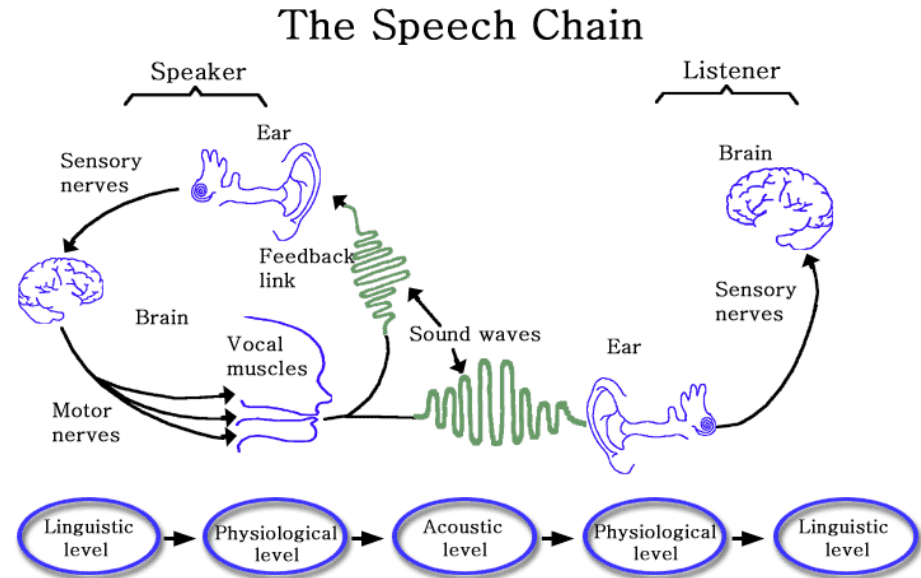
PHONETICS

Phonetics overview

- Phonetics provides a method of classification for speech sounds:
 - Consonants described with 3 principal features:
 - Place
 - Manner
 - Voicing
 - Vowels described with 3 principal features:
 - Height
 - Backness/advancement
 - Roundedness

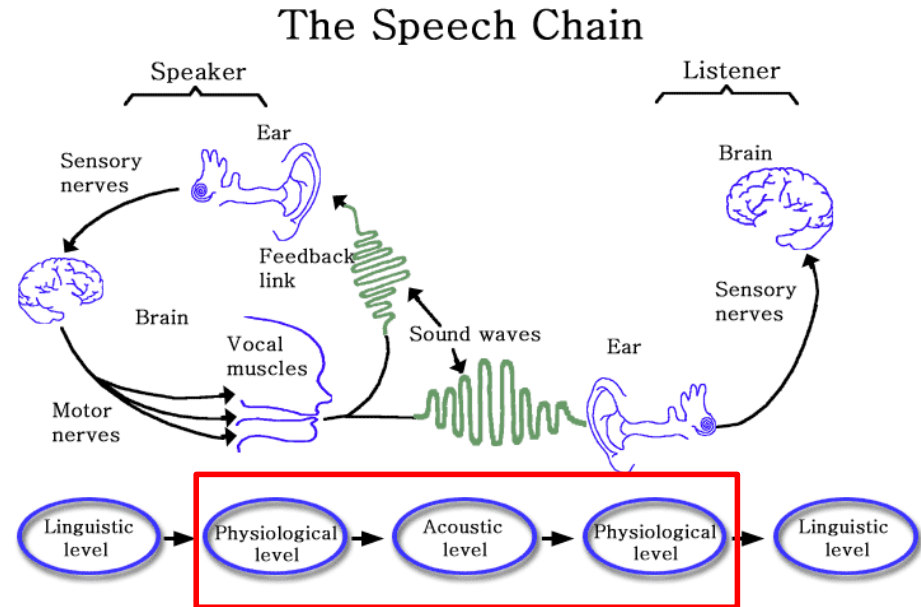
Phonetics vs. Phonology

- Phonetics deals with **physical & physiological** properties of sounds
- Phonology deals with **psychological** properties of sounds



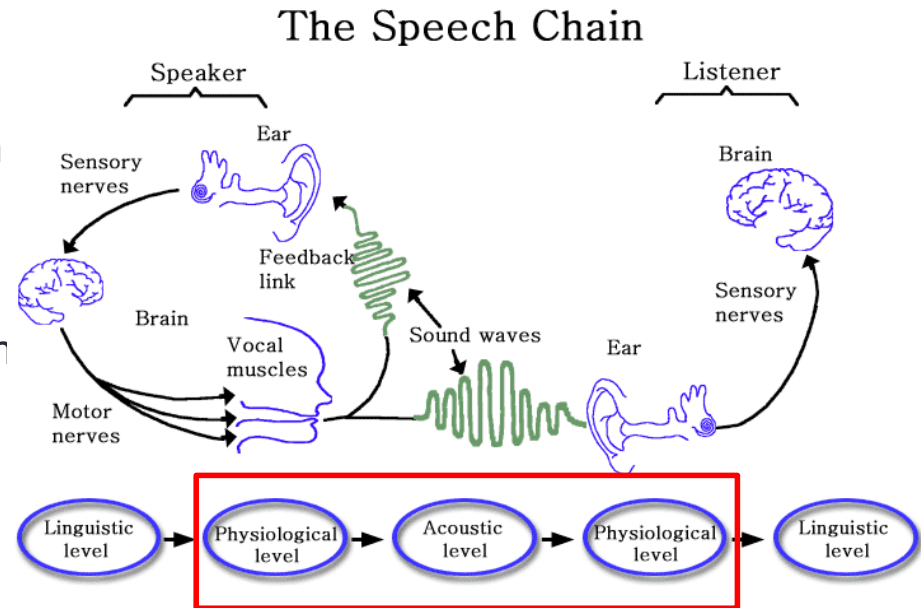
Three types of phonetics

- Articulatory
- Acoustic
- Auditory



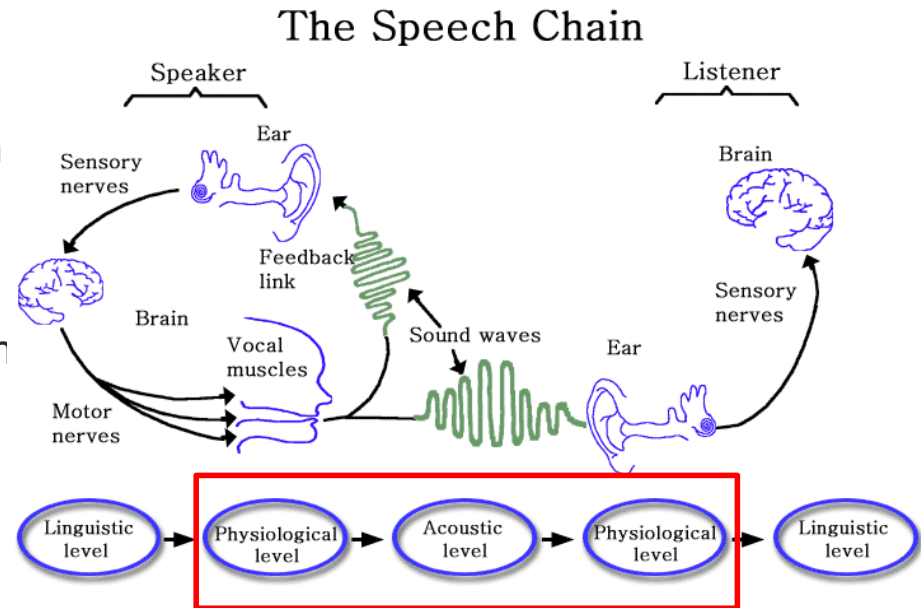
Three types of phonetics

- **Articulatory phonetics**
 - The study of speech production
 - Physiological properties of speech production
- **Acoustic phonetics**
 - The study of the physics of speech
 - What speech *is*, from mouth to ears
- **Auditory phonetics**
 - The study of speech perception
 - Physiological processes involved in hearing



Three types of phonetics

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Differences between sounds & letters

- Same sound, different letters:
 - [f]: fat, phat, laugh
 - [i]: he, believe, seize, sea, caesar, see, people, amoeba, key, machine
- Same letter, different sounds:
 - a: dame [e], dad [æ], father [ɑ]
 - c+h: character [k], charge [tʃ], charade [ʃ]

Differences between sounds & letters

- Silent letters:
 - psychology, gnat, knight, lamb, heir, debt
- Multiple letters, one sound:
 - add [d], pocket [k], peat [i], song [ŋ], sharp [ʃ], thin [θ]
- One letter, multiple sounds:
 - taxi [ks], exam [gz], use [ju]

The relation between sound and writing

- Writing systems (partially) reflect phonetics and/or phonology of speech
 - Different for different languages
 - Not all languages have writing systems
- Transparency between orthographic form (written form) and phonetic form affects rates of dyslexia (citation)

International Phonetic Alphabet (IPA)

- 1-to-1 mapping between symbol and sound
 - Universal, cross-linguistic alphabet for depicting speech sounds

	Bilabial	Labiodental	Dental	Alveolar	Post-alveolar [= palatoalveolar]	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive [= stop]	p b		t d			ʈ ɖ	c ɟ	k ɡ	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								
[Central] approximant		ʋ	ɹ			ɻ	j	ɰ			
Lateral approximant			l			ɭ	ʎ	ʟ			

Articulatory phonetics

- Speech sounds can be precisely described by using a set of universal distinctive features, based on articulatory vocal tract configurations:
 - Voicing (laryngeal)
 - Manner of articulation (vocal tract)
 - Place of articulation (vocal tract)

Pitch

- Rate of vibration in the vocal folds/chords is the **Fundamental Frequency** (F_0)
 - Fundamental frequency determines the **pitch** of a person's voice
 - Pitch is perception of how 'high' or 'low' a sound is
- Pitch in speech affected by size and shape of larynx
 - Men typically have lower F_0 than women
- Pitch can be modulated by tension of vocal folds, intensity of air from lungs

Intonation

- **Intonation:** the use of pitch in discourse
- Used for:
 - Statements vs. questions
 - Emotional content
 - Nuances of meaning
- E.g.:
 - I said I would clean the dishes tonight.
 - I said I would clean the dishes tonight?

Tones

- **Tone:** pitch contour on a vowel
 - Used to distinguish words in some languages

STANDARD CHINESE ma			
Chinese Character	Tone symbol	Tone description	English gloss
媽	˥ 55	high level	'mother'
麻	˨˨˨ 35	high rising	'hemp'
馬	˨˨˨ 214	low falling	'horse'
罵	˥˥ 51	high falling	'scold'

Voicing

- The vocal fold vibration creates distinction of **voicing**
 - If producing a speech sound with vibration: **voiced**
 - If producing a speech sound without vibration: **voiceless**
- Vowels and consonants with lots of energy are usually voiced
- Other consonants can be voiced or voiceless

Linguistic parameters

- Motion & configuration of vocal tract gives us two main parameters (in addition to voicing) used to create speech sounds:
 - Manner of articulation
 - Place of articulation
- There are also two additional parameters we will discuss:
 - Nasality
 - Lip-Rounding

Manner of Articulation

- **Manner** of articulation refers to **how** a speech sound is articulated in the vocal tract
 - Technically, nasality is a type of manner distinction
- The key distinction in manner is the **degree of closure** of the vocal tract while producing a given speech sound

Manner: Stricture & Aperture

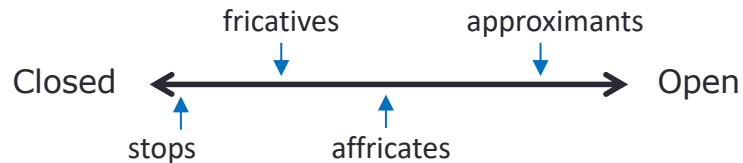
- Think of a continuum of closure, going from complete closure to wide open
 - A given speech sound will fall somewhere on this continuum

Closed ←————→ Open

- Two separate continua for consonants and vowels
 - Consonants: **stricture**
 - Vowels: **aperture**

Manner: consonants

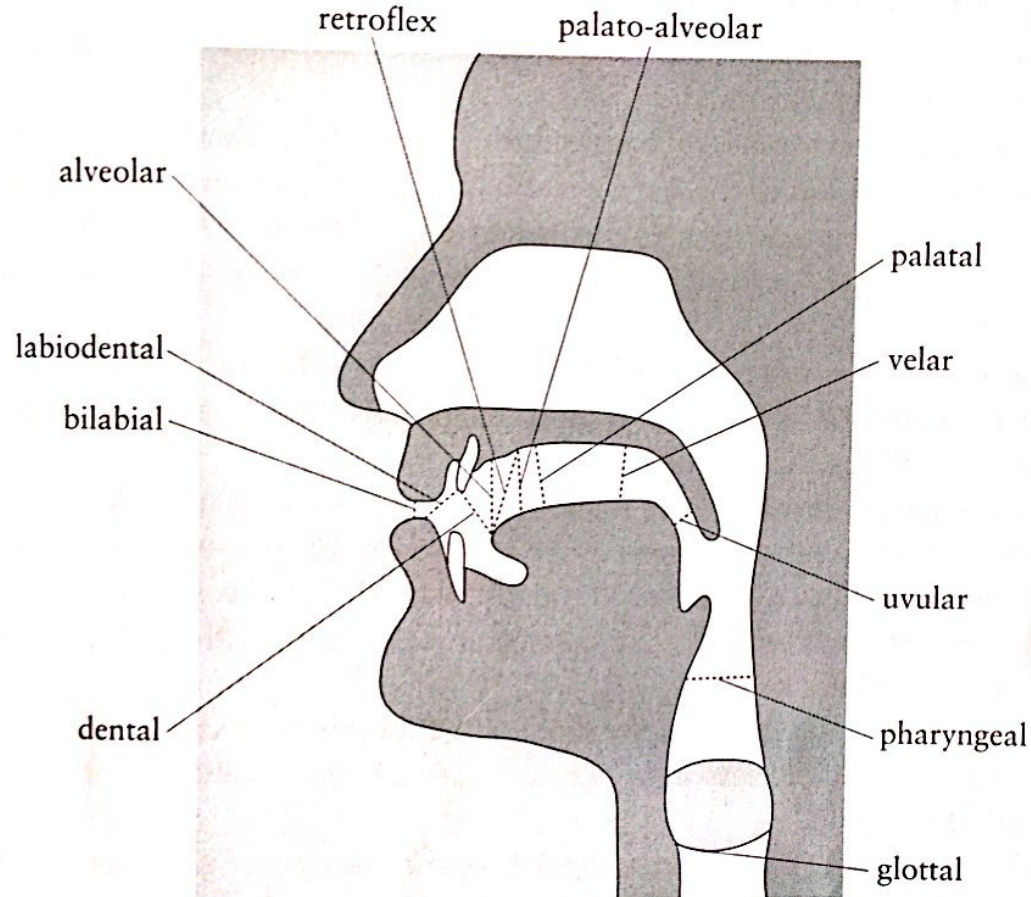
- Consonants are classified according to four degrees of stricture:
 1. Complete closure: **stops**
 2. Partial closure: **fricatives**
 3. Complete closure -> partial release of closure: **affricates**
 4. Limited closure: **approximants**



Place of Articulation

- **Place of articulation** refers to the location of stricture (closure) in the vocal tract
 - I.e. – *where* is the consonant produced? (vs. how, manner)

Places of articulation in the vocal tract



English IPA consonant chart

* First of each pair is voiceless, second is voiced; ** All English nasals, liquids and glides are voiced

		Place of articulation							
		Bilabial	Labio-dental	Dental	Alveolar	Post-alveolar	Palatal	Velar	Glottal
Manner of articulation	Stop	p b			t, d			k, g	ʔ
	Fricative		f, v	θ, ð	s, z	ʃ, ʒ			
	Affricate					tʃ, dʒ			
	Nasal	m			n			ŋ	
	Liquid				l / ɹ				
	Glide	w					j	(w)	

Full IPA consonant chart

	Bilabial	Labiodental	Dental	Alveolar	Post-alveolar [= palatoalveolar]	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive [= stop]	p b			t d		ʈ ɖ	c ɟ	k ɡ	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							
[Central] approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

Variation in Speech Sounds Due to Context

- Variability in the production of sounds is common
 - Some variability occurs due to differences among individuals
 - Other variability occurs within individuals
 - Interestingly, some variability occurs due to phonetic **context**

Stops and Aspiration

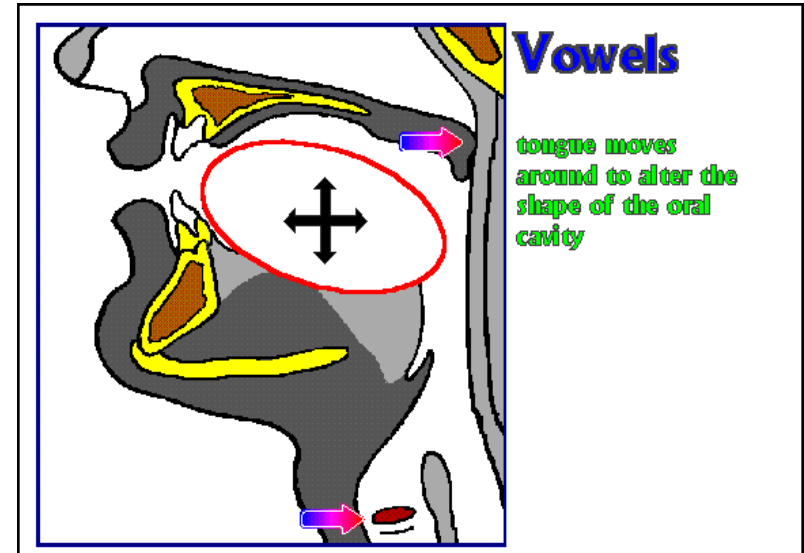
- In English, voiceless stops ([p, t, k]) can be **aspirated**
- Aspiration: puff of air following the release of a stop consonant
 - Voiceless stops appear **with** aspiration in certain positions:
 - pie, tie, chi – [p^h, t^h, k^h]
 - And **without** in other positions:
 - spy, sty, sky – [p, t, k]

Variation due to context

- Historically had been analyzed as purely ‘mechanical’ transformations
 - Changes occur due to necessity of articulation
- As we shall see, this type of analysis doesn’t work
 - Not all languages pattern the same way
 - If purely mechanical, then all languages should be the same
- We’ll discuss this more in **phonology**

Vowels

- Vowels: produced with much freer flow of air through the vocal tract than consonants
- Different configurations of vocal tract create different **resonating chambers**
 - Akin to musical instruments with different sizes and shapes
 - These different configurations lead to different **vowel quality**



Phonetic Parameters for Vowels

- Three main parameters:
 - Tongue **height**
 - How high/low the tongue is in the oral tract
 - Tongue **backness**
 - How forward/back the tongue is in the oral tract
 - Lip **roundedness**
 - Whether the lips are rounded or not
- Additional parameters:
 - **Tenseness**
 - Whether the tongue root is tense or lax
 - **Nasality**
 - Whether velum is raised/closed (oral) or lowered/open (nasal)

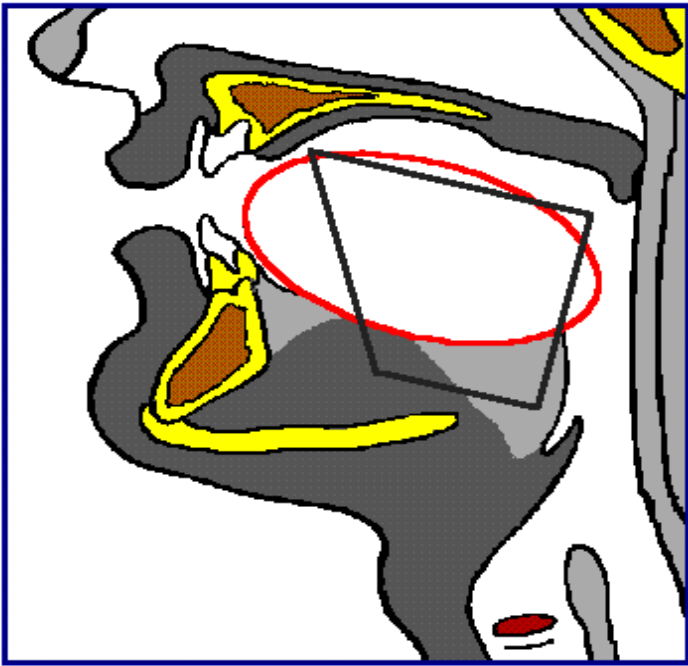
English Vowel Chart

	Front	Central	Back
High	[i] <i>h<u>ee</u>d</i> [ɪ] <i>h<u>i</u>d</i>		[u] <i>wh<u>o</u>'d</i> [ʊ] <i>h<u>oo</u>d</i>
Mid	[e] --- [ɛ] <i>h<u>ea</u>d</i>	[ə] <i>ah<u>o</u>y,</i> [ʌ] <i>H<u>u</u>d</i>	[o] --- ([ɔ] <i>ca<u>u</u>ght</i>)
Low	[æ] <i>h<u>a</u>d</i>		[ɑ] <i>h<u>o</u>t</i>

Height/backness

Vowels

stylised oral cavity coordinates to mark tongue height



	Front	Central	Back
Hig h	[i] <i>h<u>ee</u>d</i> [ɪ] <i>h<u>i</u>d</i>		[u] <i>wh<u>o</u>'d</i> [ʊ] <i>h<u>oo</u>d</i>
Mid	[e] --- [ɛ] <i>h<u>ea</u>d</i>	[ə] <i>gh<u>o</u>y</i> , [ʌ] <i>H<u>u</u>d</i>	[o] --- ([ɔ] <i>ca<u>u</u>ght</i>)
Low	[æ] <i>h<u>a</u>d</i>		[ɑ] <i>h<u>o</u>t</i>

Diphthongs

- All vowels discussed so far are **monophthongs**
 - Articulation of the vowel is constant throughout duration of vowel
- **Diphthongs** have shift in articulation during production
 - Represented with two vowel symbols pushed together



Monophthong



Diphthong

English Diphthongs

- [aɪ], as in *high, rye, ally*
- [aʊ], as in *how, pow, allow*
- [ɔɪ], as in *ahoy, Roy, alloy*

- [eɪ], as in *bay, ray, eh?*
- [oʊ], as in *boat, wrote, oh...*

English Vowel Chart

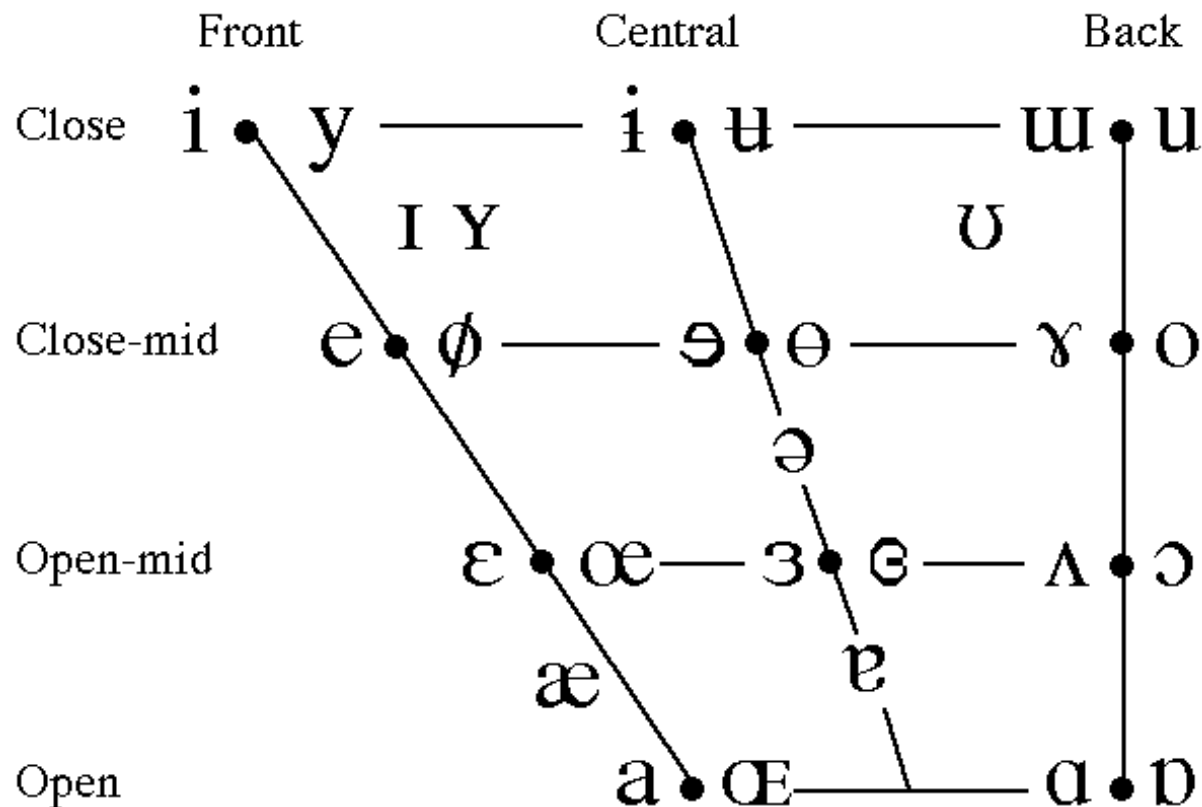
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Low	[æ] <i>h<u>a</u>d</i>		[ɑ] <i>h<u>o</u>t</i>

Diphthongs

- [aɪ] high, [aʊ] how, [ɔɪ] ahoy, [eɪ], hayed, [oʊ] home

	Front	Central	Back
High	[ɪ]		[ʊ]
Mid	[e]		[o] [ɔ]
Low			[ɑ]

Full IPA Vowel Chart



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

Vowels Summary

- Speech sounds sometimes undergo transformations due to phonetic context
- Three main parameters for vowels:
 - **Height**
 - **Backness**
 - **Roundedness**
- Additional parameters:
 - Nasality
 - Tenseness
- Monophthongs vs. Diphthongs

“high back round vowel”

Consonants Summary

- Three main parameters for consonants:
 - **Voicing**
 - **Place of articulation** “voiced alveolar stop”
 - **Manner of articulation**

General phonetics Summary

- We now have enough machinery to describe the properties of consonants and vowels
 - These parameters as discussed so far are ‘shorthand’ for the physical properties of speech sounds
 - This allows us to transcribe words from various languages into IPA
 - It also allows us to demonstrate the transformations that we have observed

Phonology

Phonology overview

- Goal of phonology:
 - Characterize a speaker's knowledge of speech
 - **Phonemic inventory:** what speech sounds are used in the language
 - **Phonological rules:** how sounds change depending on context
 - **Phonotactic constraints:** which sounds are allowed to be near each other

Speech sounds and phonology

- Phonological knowledge is **tacit**: the rules are acquired and used without awareness
- **Phoneme**: the mental representation of a speech sound
- **Phonemic inventory**: the set of phonemes in a language
- I.e., what building blocks of speech are available to speakers of a language?

Minimal Pairs

- Consider two words of English: *time* and *dime*
 - The 'ime' part of each is the same
 - The only different part: [t] vs. [d]
 - If a speaker produces 'ime' with [t], you get *time*, if [d], *dime*
 - Speaker has **control** over which sound to use
 - [t] and [d] **contrast** at the beginning of words
- A linguist establishes the phonemes of a language by looking for these kinds of *minimal pairs*

Sounds that do not contrast

- We can identify speech sounds that are different, but do *not* contrast

English stops

- Voiceless stops are sometimes **aspirated**:
 - [p^haɪ] ‘pie’ [t^haɪm] ‘time’ [k^heɪt] ‘Kate’
- Voiceless stop are sometimes *not* aspirated:
 - [spɑɪ] ‘spie’ [stɪm] ‘steam’ [skɛɪt] ‘skate’
- Voiced stops are *never* aspirated:
 - [bɑɪ] ‘buy’ [daɪm] ‘dime’ [gɛɪt] ‘gate’

Aspiration: the strong burst of air that comes out at the release of a stop consonant

English stops & minimal pairs

- Can find minimal pairs between voiceless and voiced stops:
 - [p^haɪ] ‘pie’ vs. [bɑɪ] ‘buy’
 - [t^haɪm] ‘time’ vs. [dɑɪm] ‘dime’
 - [k^heɪt] ‘Kate’ vs. [gɛɪt] ‘gate’
- Suggests that the voiceless & voiced stops are all separate phonemes of English

Lack of contrast for aspiration in English

- No minimal pairs between voiceless stops and aspirated voiceless stops
 - No new word if you switch [p] for [p^h]
 - Almost impossible to swap out one for the other

Lack of contrast for aspiration in English

- Aspirated and unaspirated voiceless stops:
phonetically different sounds, but lack a
phonemic contrast
 - Therefore **allophones** of the same phoneme in English
 - Belong to the same phoneme

Context & Complementary Distribution

- As a native speaker of English, you have no choice (without phonology classes) but to aspirate at the beginning of words, and not to aspirate elsewhere
- **Context** determines which sound you get
- Instead of *contrastive distribution*, these sounds have **complementary distribution**

Oral stops in Thai

- Same types of stops are phonetically present in Thai:

Aspirated

Voiceless

[p^haa] ‘to split’

[t^ham] ‘to do’

[k^hat] ‘to interrupt’

Unaspirated

Voiceless

[paa] ‘forest’

[tam] ‘to pound’

[kat] ‘to bite’

Voiced

[baa] ‘shoulder’

[dam] ‘black’

n/a

Thai contrasts for voicing AND aspiration

- You can find minimal pairs for voicing:
 - [p^haa] vs. [b^{aa}]
 - [t^ham] vs. [d^{am}]
- Unlike English, you can **also** find minimal pairs for aspiration:
 - [p^haa] vs. [p^{aa}]
 - [t^ham] vs. [t^{am}]
 - [k^hat] vs. [k^{at}]

Three-way contrast in Thai

- Thai has a three-way contrast for stops:

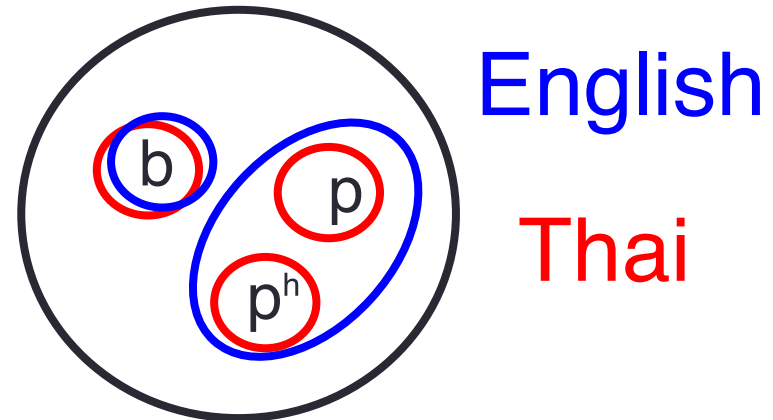
[p^haa] vs [paa] vs [baa]
'to split' 'forest' 'shoulder'

- Speaker of Thai can choose between unaspirated and aspirated stops
- A speaker of English cannot

Phonetic and Phonemic inventories

- Both English and Thai have the same *phonetic* inventory
- But they must have different *phonemic* inventories
- The two languages use these sounds in different ways to express contrast

- Phonemes are abstract **categories** that contain multiple possible phonetic realizations



Phonological Rules

- **Underlying representations:** sequences of phonemes
- **Surface representations:** sequences of segments
- Phonological rules:
 1. Take as input underlying phonemic representations
 2. Apply **changes** to **targets** containing the relevant **contexts**
 3. Output segmental surface representations (pronunciations)

Underlying Representation	/paɪ/
Aspiration Rule	p ^h aɪ
Surface Representation	[p ^h aɪ]

Thai vs. English

- The difference between Thai & English regarding voiceless stops is twofold:
 - They have **different phonemic inventories**
 - English: /p/ and /b/
 - Thai: /p/, /p^h/ and /b/
 - They have **different phonological rules**
 - English has aspiration rule (among others)
 - Thai does NOT have aspiration rule (but does have other rules)

Phonological Knowledge

- So far, we've discussed two types of **phonological knowledge**:
 1. Sound inventories
 - Speakers of a language know tacitly what sounds exist in their language
 2. Phonological rules
 - Speakers of a language know how sounds change depending on context

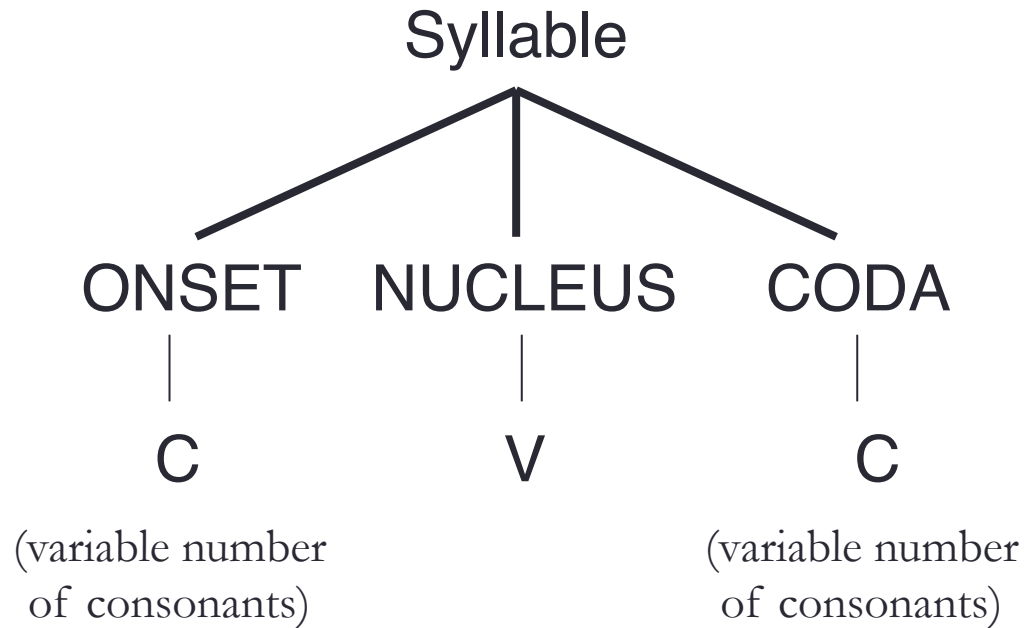
Syllables

- **Syllable**: a structured grouping of phonemes
- How many syllables in the following words?
 - *test, syntax, linguistics, phonology, antidisestablishmentarianism*
- Speakers can readily judge the number and boundaries of syllables

Syllables

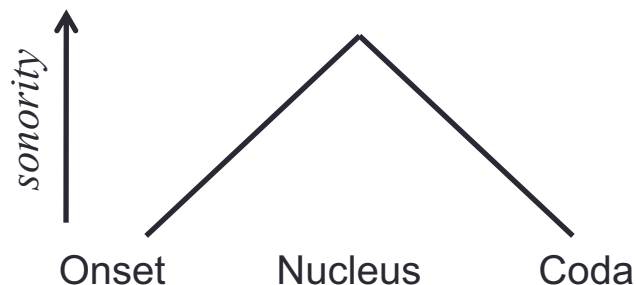
- A few important notions regarding the syllable:
 - The structure of syllables
 - The sonority hierarchy
 - Syllable types across languages
 - Onset vs Coda

Syllable structure



Sonority Hierarchy

- “Best” nucleus:
 - Most sonorous sounds (vowels)
- “Best onset”:
 - Least sonorous sounds (oral stops)



- “Good” complex onsets increase in sonority slope
- “Good” complex codas decrease in sonority slope

Phonotactics

- **Phonotactics:** the constraints governing possible phoneme sequences
- Phonotactic constraints vary by position within the syllable
- Cross-linguistic patterns reveal general principles governing syllable shape

Phonotactics across languages

- CV syllables (e.g. /ka/) occur in all languages
 - Unmarked or 'universal' syllable
 - The only syllable structure allowed in some languages (e.g. Hawaiian)
 - Commonly found exclusively in earlier stages of language acquisition

Phonotactics across languages

- In many languages, onsets are obligatory
 - e.g. Arabic, Karok, Tagalog
 - No language with forbidden onsets
- In many languages, codas are forbidden
 - e.g. Hawaiian, Samoan, Zulu
 - No language with obligatory codas

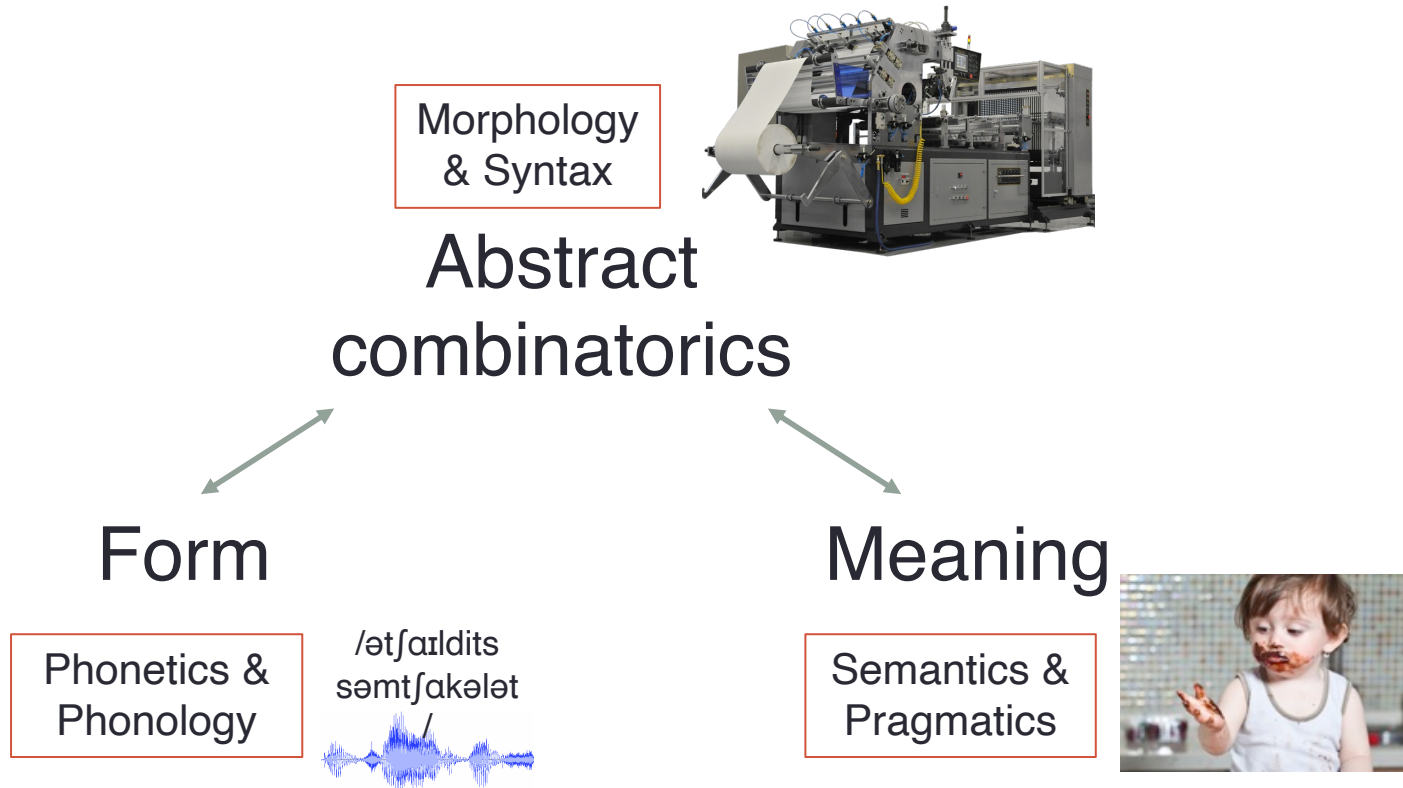
Syllable typology & phonotactics

- [CVC] = a frequent maximal syllable size allowed.
- Varying degree of complexity in onset and coda position
 - e.g. English *kit* [kɪt], *clip* [klɪp], *kilt* [kɪlt]; *texts* [tɛksts], *strengths* [stɹɛŋkθs])
- Varying restrictions on the types of consonant clusters allowed
 - e.g., English *brick* [brɪk], *blick* [blɪk], **bnick* *[bnɪk];
apt [æpt], *act* [ækt], *[ætp], *[ætk] (but *Atkins* is possible [æt.kɪns])

Recap

- Phonetics
 - Physical instantiation of sounds
 - (Main) consonant parameters: place, manner, voicing
 - (Main) vowel parameters: height, backness, rounding
- Phonology
 - Psychological representation of sounds and sound structure
 - Underlying and surface representations
 - Phonological rules
 - Syllable structure

Components of language



Chomsky, 1980; 1995