Lecture 9: International Phonetic Alphabet

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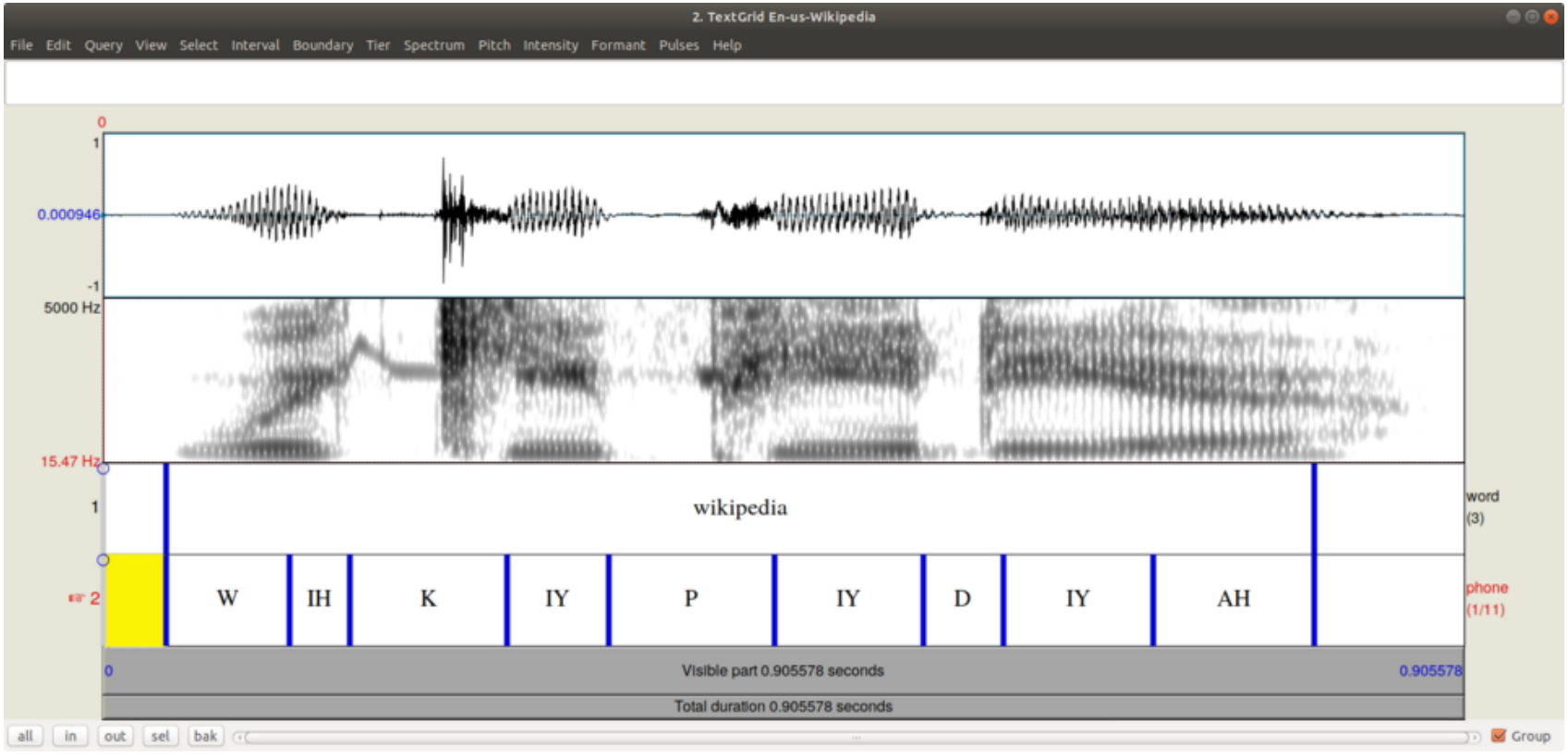
ECE 537: Speech Processing

Outline

Distinctive Features: Segmental vs. Suprasegmental

- A **distinctive feature** is a feature that can be computed (by a machine or human listener) from the waveform of a word that, in the language in which the word is spoken, distinguishes it from some other word.
- A segmental feature is time-aligned with many other features.
- A bundle of many segmental distinctive features that can be produced together is called a **phoneme**.
- A suprasegmental feature is not time-aligned with any single phoneme. Examples include Chinese tones.

Example phonemes



The labeled segments are phonemes of English because, if you changed any of them (e.g. [W] $\rightarrow$ [Y]), the result would be a different (possibly nonsense) word.

Phonemes vs. Allophones

- Phonemes are language-dependent. A sound substitution that changes meaning in one language might not change meaning in another language.
  - "beat" and "bit" differ in English, but not in Japanese or Spanish.
  - "ka" and "kha" differ in Hindi, but not in English.
  - "tu" and "tout" differ in French, but not in English.
- If two segments are acoustically different but can be used interchangeably without changing the meaning of any word, they are called allophones.
- Two sounds might be phonemes in one language but allophones in another language.

Outline

Phones vs. Phonemes

- A language's phoneme inventory is described by listing, from an international phone inventory, the phones that match the prototypical production of each phoneme, e.g., `https://phoible.org/`.
- **Phonemes** are language-dependent; **Phones** are language-independent.
- **Distinctive features** are language-dependent; **Articulatory features** are language-independent.
- Notation: [ɑ] is a phoneme, /ɑ/ is a phone.

The International Phonetic Alphabet

Ladefoged describes two criteria for deciding which symbols should exist in the IPA:

- If two sounds are different phonemes in any known language, then they should be different phones in the IPA.
- Two sounds are different phones only if distinguished by a change in at least one articulatory feature.

The top level: Consonants vs. Vowels

- Vowels are produced with minimal or no vocal tract constriction. Consonants are produced with full or partial closure.
- The boundary between “consonant” and “vowel” is a little fuzzy: What’s considered a [w] in one language might be exactly the same vocal tract shape as the [u] in another language. It depends partly on rhythm and syllable structure of the language.

Outline

IPA: The Pulmonic Consonants

	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			

Symbols to the right in a cell are voiced, to the left are voiceless. Shaded areas denote articulations judged impossible.

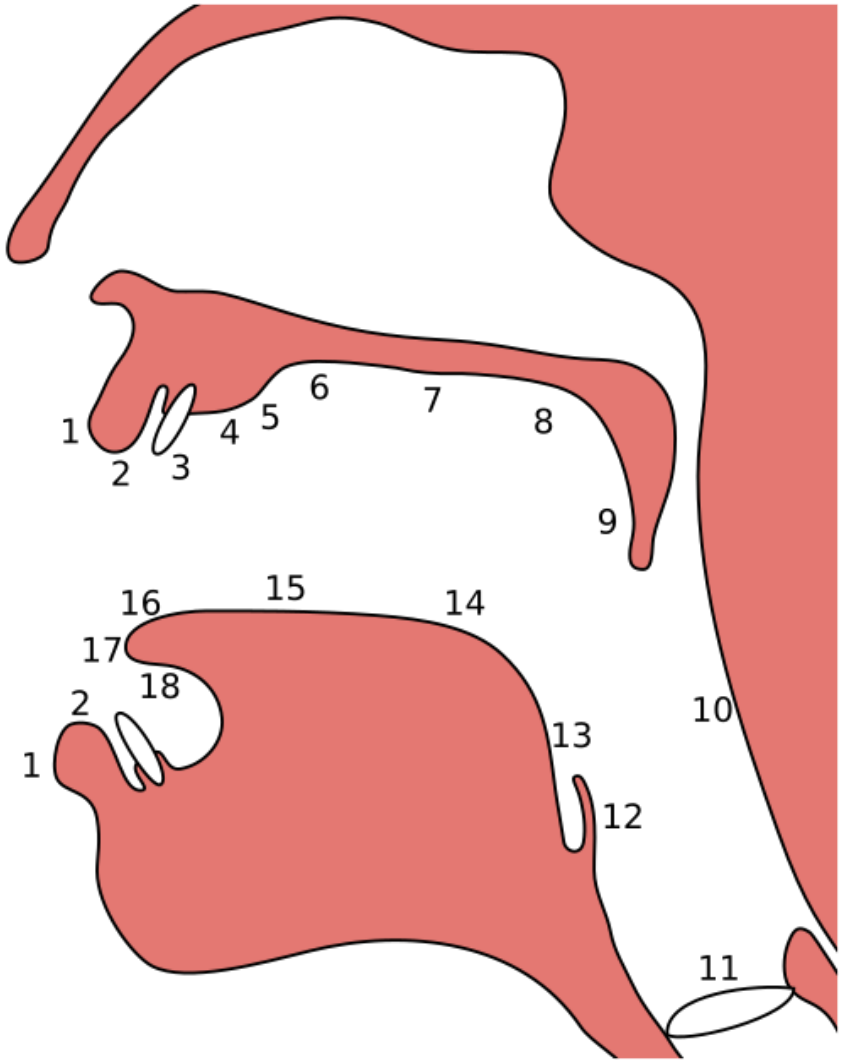
Articulatory features that distinguish consonants

- **Pulmonic** means it involves air leaving your lungs. We'll see non-pulmonic consonants later.
- **Manner of articulation** is the row index
- **Place of articulation** is the column index
- **Voicing** distinguishes first from second in each cell

Manner of articulation

- **sonorant** (there is no air pressure drop between larynx and lips) vs. **obstruent** (there is a constriction between larynx and lips)
- **continuant** (sound continues throughout closure) vs. **discontinuant** (there is a discontinuity)

	[-sonorant]	[+sonorant]
[-continuant]	Plosive	Nasal, Trill, Tap
[+continuant]	Fricative	Approximant, Vowel



https://en.wikipedia.org/wiki/Place_of_articulation

Places of articulation (**Bold**=the articulator, Non-bold=the place)

- **2=Lips**: 2=Bilabial, 3=Labiodental
- **17=Tip:** 3=Dental, 4=Alveolar, 5=Postalveolar, 6=Retroflex
- **14=Body:** 7=Palatal, 8=Velar, 9=Uvular, 10=Pharyngeal

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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			

Symbols to the right in a cell are voiced, to the left are voiceless. Shaded areas denote articulations judged impossible.

Diacritics

◌̥	Voiceless	n̥	d̥	◌̤	Breathy voiced	b̤	a̤	◌̪	Dental	t̪	d̪
◌̬	Voiced	s̬	t̬	◌̰	Creaky voiced	b̰	a̰	◌̺	Apical	t̺	d̺
◌ʰ	Aspirated	tʰ	dʰ	◌̼	Linguolabial	t̼	d̼	◌̻	Laminal	t̻	d̻
◌̹	More rounded	ɔ̹		◌ʷ	Labialized	tʷ	dʷ	◌̃	Nasalized		ẽ
◌̜	Less rounded	ɔ̜		◌ʲ	Palatalized	tʲ	dʲ	◌ⁿ	Nasal release		dⁿ
◌̟	Advanced	u̟		◌ˠ	Velarized	tˠ	dˠ	◌ˡ	Lateral release		dˡ
◌̠	Retracted	e̠		◌ˤ	Pharyngealized	tˤ	dˤ	◌̚	No audible release		d̚
◌̈	Centralized	ë		~	Velarized or pharyngealized			ɫ			
◌̽	Mid-centralized	e̽		◌̝	Raised	e̝	(ɪ̝ = voiced alveolar fricative)				
◌̩	Syllabic	n̩		◌̞	Lowered	e̞	(β̞ = voiced bilabial approximant)				
◌̯	Non-syllabic	e̯		◌̘	Advanced Tongue Root	e̘					
◌˞	Rhoticity	ɚ	a˞	◌̙	Retracted Tongue Root	e̙					

Non-Pulmonic Consonants

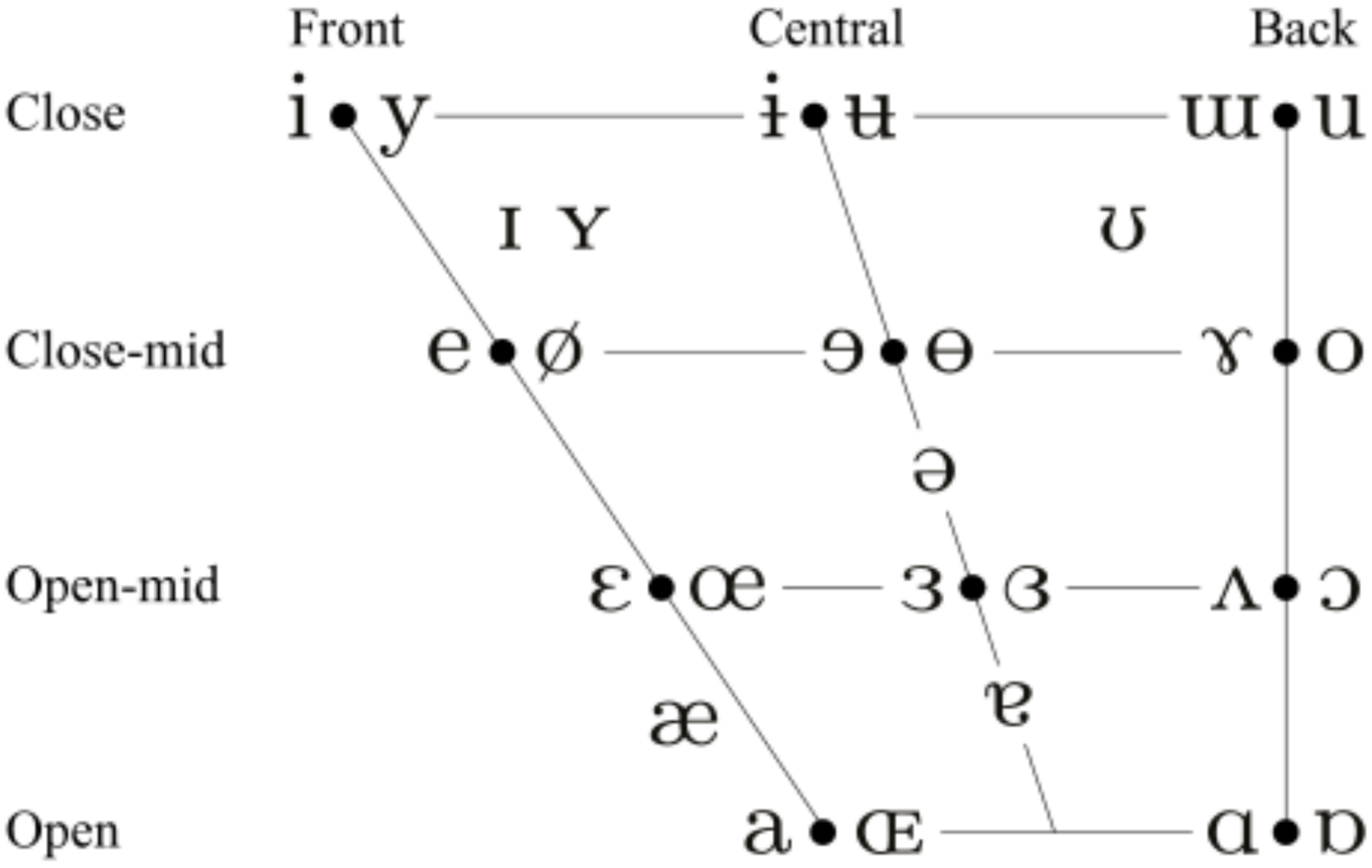
Clicks	Voiced implosives	Ejectives
ʘ Bilabial	ɓ Bilabial	’ Examples:
ǀ Dental	ɗ Dental/alveolar	pʼ Bilabial
ǃ (Post)alveolar	ʄ Palatal	tʼ Dental/alveolar
ǂ Palatoalveolar	ɠ Velar	kʼ Velar
ǁ Alveolar lateral	ʛ Uvular	sʼ Alveolar fricative

The consonants of American English

- Plosives/Stops: [p^h,b,t^h,d,k^h,g]
- Nasals: [m,n,ŋ]
- Fricatives: [f,v,θ,ð,s,z,ʃ,ʒ]
- Affricates: [tʃ,dʒ]
- Approximants: [w,l,ɻ,j]

Outline

IPA: The Vowels



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

Articulatory features that distinguish vowels

- **Height** is the row index: Close=high, Open=low
- **Fronting** is the column index
- **Rounding** distinguishes left from right symbol in each pair

The vowels of American English

- Front: [i,ɪ,e,ɛ,æ] (beat, bit, bait, bet, bat)
- Back: [u,ʊ,o,ʌ,ɑ] (boot, book, boat, but, bot)
- Reduced: [ə] (about)
- Diphthongs: [ɑɪ,ɔɪ,au] (bite, boy, bout)
- Retroflex: [ɝ] (bird)

Outline

How to write IPA symbols on a computer

- All IPA symbols are part of unicode, so you can enter them in a Word document or unicode text file by looking up the symbol from a menu (or `https://en.wikipedia.org/wiki/International_Phonetic_Alphabet`) and copying it.
- In LaTeX, you should use `https://en.wikipedia.org/wiki/TIPA_(software)`.
- You will still often see older ASCII-based phonetic codes including ARPABET for American English. Please avoid using ARPABET if you don't have to; however, it's worth being able to read it.

American English consonants in ARPABET

- Plosives/Stops: P,B,T,D,K,G
- Nasals: M,N,NG
- Fricatives: F,V,TH,DH,S,Z,SH,ZH
- Affricates: CH,JH
- Approximants: W,L,R,Y

American English vowels in ARPABET

- Front: IY,IH,EY,EH,AE
- Back: UW,UH,OW,AH,AA
- Reduced: AX
- Diphthongs: AY,OY,AW
- Retroflex: ER

Outline

Example

Write “The quick brown fox jumped over the lazy dog” in IPA.

Outline

Summary

	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			

Close
Close-mid
Open-mid
Open

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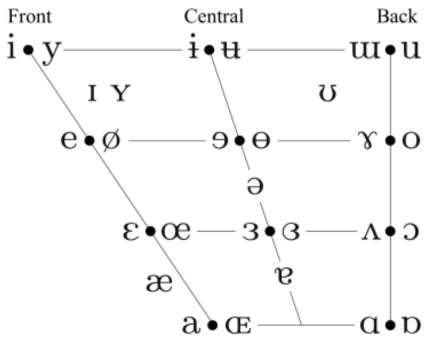

Where symbols appear in pairs, the one to the right represents a rounded vowel.