

Linguistics and Translation 香港城市大學 City University of Hong Kong

Language and its Applications **LT5903**



Jixing Li Lecture 2: Phonetics

Lecture plan

- Overview, representing speech sounds
- Articulatory phonetics
 - Consonants, Vowels, Suprasegmentals
- Acoustic phonetics
- Auditory phonetics
- Short break (15 mins)
- Group discussion on HW2

What is phonetics?

The study of the minimal units that make up language.

- Articulatory phonetics: The study of the production of speech sounds.
- Acoustic phonetics: The study of the transmission and the physical properties of speech sounds.
- Auditory phonetics: The study of the perception of speech sounds.

Types of speech sounds

- Segments: discrete units of the speech stream
 - **Consonants:** Constriction in the vocal tracts that impedes airflow, e.g., p, t, k, m, n, l, r
 - Vowels: Allow air to flow freely through the oral cavity. e.g.,
 - monophthongs: e.g., a, o, e, i, u
 - diphthongs: e.g., ai, oi, ei, au
- Syllable structure
 - food [fud]
 - awe [ɔ]
 - button [`bʌtn]
 - knives [naivz]
 - naive [na'iv]



Types of speech sounds

- Suprasegmentals: larger properties of speech, often apply to entire strings of consonants and vowels
 - Length: beat vs bead
 - **Stress:** perfect / record / subject
 - Tone: mā, má, mǎ, mà
 - tone languages: Mandarin Chinese, Cantonese, Vietnamese, Thai, Bantu languages, many North and South American Indian Languages, etc.

Intonation

- **pitch accent:** change in pitch in the middle of an utterance MARY kissed Peter. / Mary kissed PETER. / Mary KISSED Peter.
- phrase tone: occur at the end of a phrase; affect the overall meaning, group words into phrases:
 - sentence-final intonation: You got an A on the test.
 - question intonation: You got an A on the test?
 - What's that in the road ahead? vs What's that in the road? A head?

Representing speech sounds

- The English spelling system (orthography) is not a good phonetic alphabet:
 - see, sea, scene
 - chater, character
 - special, apple
 - exit,
 - know, doubt

The International Phonetic Alphabet (IPA)

- Applicable to all spoken languages
- one-to-one correspondence between sounds and symbols
- Organized by place and manner of articulation
- Shading indicates voicing

Full chart is on the back cover of your textbook

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Articulation: Consonants

Voicing:

Whether the vocal folds are vibrating?



Soft palate

Voiceless vs voiced consonants

a. [f] $\underline{f}at$ c. [θ] $\underline{th}igh$ e. [s] \underline{sip} g. [\int] dilu \underline{tion} [v] $\underline{v}at$ [δ] $\underline{th}y$ [z] \underline{zip} [z] delu \underline{sion} b. [t] richd. [p] patf. [t] $\underline{t}ab$ h. [k] $\underline{k}ill$ [d] ridge[b] $\underline{b}at$ [d] $\underline{d}ab$ [g] gill

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retr	Retroflex Pa		atal	Velar		Uvular		Pharyngeal		Glottal	
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Nasal	m	ŋ		n			η		ŋ	ŋ			Ν				
Trill	В			r									R				
Tap or Flap		\mathbf{V}		ſ			r										
Fricative	φβ	f v	θð	S Z	$\int 3$	Ş	Z	Ç	j	хγ	-	χ	R	ħ	ſ	h	ĥ
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Approximant		υ		r			ŀ		j	u	I						
Lateral approximant				1			l		λ	L							

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

Articulation: Consonants

Place of Articulation:

Where in the vocal tract is the constriction made?

- bilabial: pat, bat, mat, with
- labiodental: fat, vat
- interdental: thigh, thy
- alveolar: tab, dab, sip, zip, nose, lab, red
- post-alveolar: leash, measure, church, judge
- palatal: yes
- velar: kill, gill, sing
- glottal: high



Place of articulation

	Bilabial	Labiodental	Dental Alveolar	Postalveolar	Retroflex		Pala	ıtal	Velar	Uvular		Pharyngeal		Glo	ttal
Plosive	рb		t d		t	q	С	J	k g	q	G			2	
Nasal	m	m	n			η		ŋ	ŋ		Ν				
Trill	В		r								R				
Tap or Flap		\mathbf{V}	ſ			r									
Fricative	φβ	f v	$\theta \delta s z$	∫ 3	Ş	Z	Ç	j	хγ	χ	R	ħ	ſ	h	ĥ
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Symbols to the right in a cell are voiced, to the left are voiceless. Shaded areas denote articulations judged impossible.

Articulation: Consonants

Manner of Articulation:

How the airstream is constricted in the vocal tract?

- stop/plosive: pat, bat, tab, dab, kill, gill
- fricative: fat, vat, thigh, thy, sip, zip, ship, measure, high
- affricate: church, judge
- nasal: mat, nose
- approximant:
 - liquid: lateral: lab, retroflex: red
 - glide: with, yes



Manner of articulation

	Bilabi	al	Labiodental	Dental Alveolar Postalveola			Retroflex Palat		atal	Velar		Uvular		Pharyngeal		Glottal	
Plosive	p ł	3			t d		t	d	C	J	k	g	q	G			2
Nasal	n	n	ŋ		n			η		ŋ		ŋ		N			
Trill	F	B			r									R			
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Symbols to the right in a cell are voiced, to the left are voiceless. Shaded areas denote articulations judged impossible.

Investigating consonant articulation Palatography: X-Ray, real-time fMRI:



Practice

What consonant sound could be produced with this articulation of the vocal tract?

Voicing? Place? Manner?

Play with the <u>Interactive Sagittal</u> <u>Section</u>.



Articulation: Vowels

Two types:

- monophthong: single vowel: but, beet, bit, bet, bat, boot
- diphthong: two vowels in sequence: bite, bout, boy, boat, bait

Most audible sounds in speech

- Always voiced; No constriction in the vocal tract
- \rightarrow the three descriptors for consonants are not helpful

How to describe vowels?

- Tongue height: raising/lowering the body of the tongue
- **Tongue advancement:** advancing/retracting the body of the tongue
- Lip rounding: rounding/spreading lips
- **Tenseness:** making movements with tense/lax gestures

Articulation: Vowels

Tongue advancement



Articulation: Vowels



Acoustic phonetics



@Jixing Li

Simple sound waves Amplitude Frequency $y(t) = 1.0 sin(100 2\pi t)$ $y(t) = 1.0 sin(100 2\pi t)$ $y(t) = 1.0 sin(200 \ 2\pi t)$ $y(t) = 0.5 sin(200 2\pi t)$

Complex sound waves

- fundamental frequency (pitch/f0): the lowest frequency of a periodic waveform
- harmonics: multiples of the fundamental frequency



 $y(t) = 1.0 \sin(100 \ 2\pi \ t) + 0.6 \sin(200 \ 2\pi \ t) + 0.45 \sin(300 \ 2\pi \ t) + 0.3 \sin(400 \ 2\pi \ t) + ...$

Spectrogram

• Three acoustic dimensions: frequency, time, amplitude



Spectrogram: Vowels

In the production of vowels, the filtering effect of the vocal tract produces amplitude at certain frequencies

Frequency (Hz)



Spectrogram: Stops

d: F2 : 1700-1800 Hz g: "velar pinch" b: lowered F1 and F2



voice bar

@Jixing Li

Spectrogram: Fricatives

Aperiodic sounds



Auditory phonetics

- What are the most fundamental units listeners extract from the speech signal?
 - general auditory approach: We hear sounds
 - motor theory of speech: We hear gestures

Motor theory of speech perception

Phonemes related to both acoustics and articulation





Time (ms)

these relations are more invariant

Motor theory of speech perception

- General audition and learning cannot account for uniqueness of human ability to perceive speech
- Speech-specific linguistic module is needed

acoustic signal \rightarrow intended articulatory gestures

General auditory approach

- acoustic events are the objects of perception
- no special speech-module, perception uses the same perceptual systems and learning mechanisms that other animals have



- context dependence of acoustics is tractable: listeners make use of multiple cues can interpret cues with acoustic context
 - birds can be trained to recognize consonants, and can then correctly recognize them in novel vowel contexts

Time (ms)

McGurk Effect: Evidence for motor theory?



Motor theory: gestures are specified visually and acoustically General auditory theory: general mechanisms of perception allow visual cue-phoneme mappings

Mirror neurons: Evidence for motor theory?



motor neurons activate when a monkey eats banana

subset of the same motor neurons activate when a monkey watches another monkey eating a banana

mechanism for understanding actions/gestures?

Evidence from neuroscience

against motor theory:

- people with lesions of motor cortex exhibit normal discrimination
- activity in auditory cortex during perception is far more robust than in other areas

for motor theory:

 activity in motor cortex associated with perception disruption of motor cortex (through TMS) influences perception