Linguistics for CS

Lecture 2 - Phonology

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01 IPA

02 Main concepts: phones, phonemes, allophones

03 Sound Distribution

04 Computational applications in Phonology

(Isomorphic) Linguistic Levels -recap

SOUND

PHONETICS
Properties of sounds

PHONONOGY
Patterns of sounds

MORPHOLOGY
Structure of words

SYNTAX
Structure of sentence

STRUCTURE

MEANING

SEMANTICS
Meaning of words (lexical semantics), sentences and discourse (formal semantics)

PRAGMATICS
Use of language (in extra-linguistic context, intentions)

NIVELURI LINGVISTICE

SUNET

SENS

STRUCTURĂ

FONETICĂ
Proprietăți ale sunetelor

FONOLOGIE
Tipare ale sunetelor

MORFOLOGIE
Structura cuvintelor

SINTAXĂ
Structura propozițiilor

SEMANTICĂ
Sensul cuvintelor, al propozițiilor și al discursurilor

PRAGMATICĂ
Uzul limbii în contexte extra-lingvistice

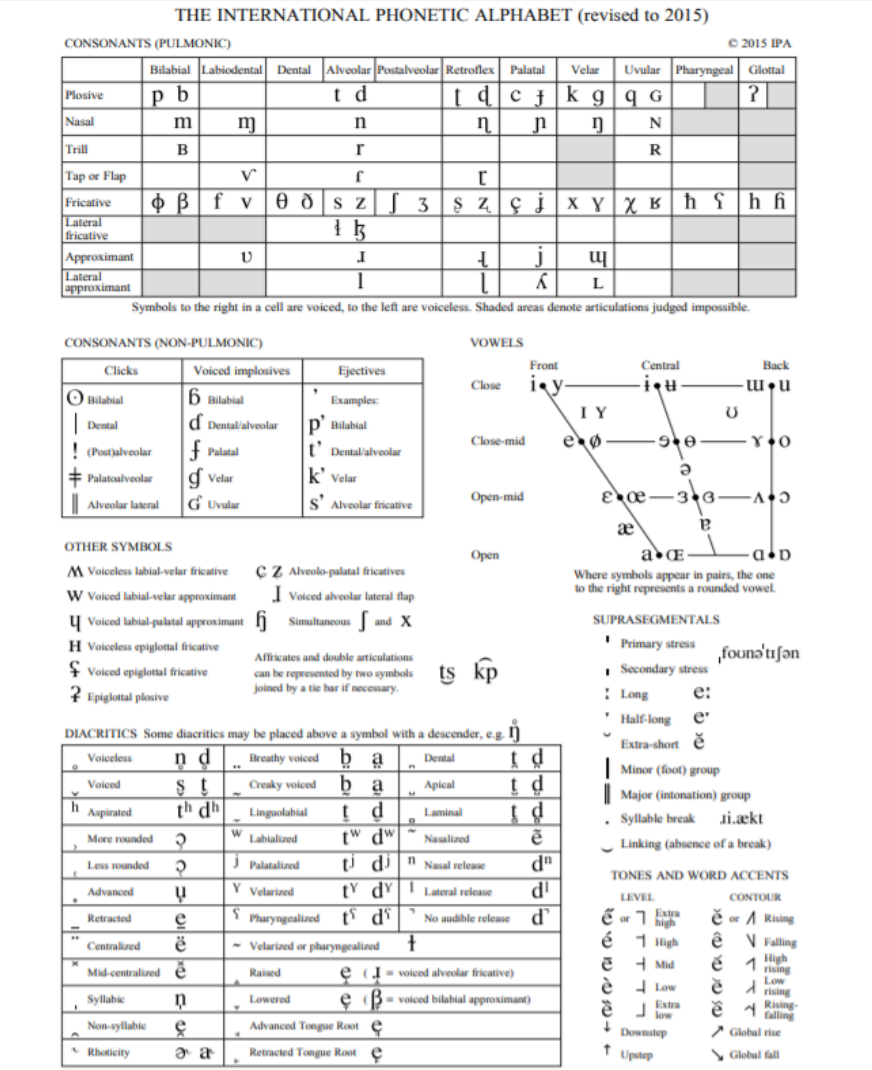
What is Phonology/Phonetics?

- Phonetics is the study of production and perception of sound in speech. Phonetics focuses on how speech is physically created and received, including study of the human vocal and auditory tracts, acoustics, and neurology.
- Phonology is the study (and use) of sound patterns to create meaning. Phonology is about different patterns of sounds in different languages, or within each language, different patterns of sounds in different positions in words etc.
- We will talk about Phonology.

International Phonetic Alphabet

- IPA is a phonetic representation of the sounds of languages, a transcription system created by the International Phonetic Association (https://www.internationalphoneticassociation.org/)
- How to write in IPA?

1. Physical Phonetic Keyboards,
2. Installed (http://inkey.freehostia.com/),
3. online (https://ipa.typeit.org/)



THE INTERNATIONAL PHONETIC ALPHABET (revised to 2015)

CONSONANTS (PULMONIC) © 2015 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			

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

CONSONANTS (NON-PULMONIC)

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

OTHER SYMBOLS

ʍ Voiceless labial-velar fricative
ɕ ʑ Alveolo-palatal fricatives
w Voiced labial-velar approximant
ɺ Voiced alveolar lateral flap
ɥ Voiced labial-palatal approximant
ʡ Simultaneous ʃ and x
ʜ Voiceless epiglottal fricative
ʢ Voiced epiglottal fricative
ʡ Epiglottal plosive

Affricates and double articulations can be represented by two symbols joined by a tie bar if necessary. ʦ k͡p

DIACRITICS Some diacritics may be placed above a symbol with a descender, e.g. n̥

◌̥ 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 (ɹ̝ = voiced alveolar fricative)		
◌̩ Syllabic	n̩	◌̞ Lowered	e̞ (β̞ = voiced bilabial approximant)		
◌̯ Non-syllabic	e̯	◌̘ Advanced Tongue Root	e̘		
◌˞ Rhoticity	ə˞ a˞	◌̙ Retracted Tongue Root	e̙		

VOWELS

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

SUPRASEGMENTALS

ˈ Primary stress ˌfoʊnəˈtɪʃən
ˌ Secondary stress
ː Long eː
ˑ Half-long eˑ
˘ Extra-short ĕ
| Minor (foot) group
‖ Major (intonation) group
. Syllable break ɹi.ækt
‿ Linking (absence of a break)

TONES AND WORD ACCENTS

LEVEL		CONTOUR	
e̋ or ˥	Extra high	ě or ˧˥	Rising
é ˦	High	ê ˥˩	Falling
ē ˧	Mid	e᷄ ˦˥	High rising
è ˨	Low	e᷅ ˩˧	Low rising
ȅ ˩	Extra low	e᷈ ˥˦˥	Rising-falling
↓	Downstep	↗	Global rise
↑	Upstep	↘	Global fall

Why do we need IPA?

- Every language has a set of sounds and its own system of arranging the sounds in patterns and its own way of writing.
- English is not a phonetic language: one cannot predict the pronunciation of a sound by its writing.

- In that, Romanian is “more phonetic”.
- Why languages do not have phonetic writing systems? Because spoken language evolves way faster than written language.
- Linguists need an international writing system to represent the sound of all languages...IPA.

Use of IPA

- A nice tutorial for using IPA at:
- https://www.youtube.com/watch?v=ETGdhiILtCE
- Example of English text written in IPA:

```
Please call Stella.  Ask her to bring these things with her from the store:  Six spoons of fresh
snow peas, five thick slabs of blue cheese, and maybe a snack for her brother Bob.  We also need a
small plastic snake and a big toy frog for the kids.  She can scoop these things into three red
bags, and we will go meet her Wednesday at the train station.

The text in IPA:
------------------
pliz kɔl ˈstɛlə. æsk hər tɪ brɪŋ ðiz θɪŋz wɪθ hər frəm ðə stɔr: sɪks spunz əv frɛʃ snoʊ piz, faɪv
θɪk slæbz əv blu ʧiz, ənd ˈmeɪbi ə snæk fər hər ˈbrəðər bɑb. wi ˈɔlsoʊ nid ə smɔl ˈplæstɪk sneɪk ənd
ə bɪg tɔɪ frɑg fər ðə kɪdz. ʃi kən skup ðiz θɪŋz ˈɪntu θri rɛd bægz, ənd wi wɪl goʊ mit hər
ˈwɛnzˌdeɪ æt ðə treɪn ˈsteɪʃən.
```

Sounds - phonemes, phones, allophones

- A phoneme is a mental representation of a sound. It is the smallest unit that distinguishes meaning between sounds in a given language. When we swap a phoneme, we change the word.
- A phone is the phonetic representation of a phoneme (the actual sound).
- Notational conventions:
  - Phones, the actual sound part that you can hear, are marked with brackets ([]) and
  - Phonemes, the mental representation of the sound, are marked with slashes (/ /).
- Example:
  - the phonemic representation of the word *water* is: /wɑtəɹ/
  - the actual phonetic representation of the word water for many Americans is: [wɑrɚ]

Sounds - phonemes, phones, allophones

- Allophones are different ways to pronounce the same phoneme while keeping the same meaning (from Greek *allos*-other).
- They are predictable depending on their environment and who is speaking.

Sound Distribution

- Sound Distribution is the phonetic context (environment) in which a sound (phone) occurs.
- There are three types of **Sound Distribution:**

1. **Contrastive Distribution:** two different phones occur in the same environment and result in semantic contrast;
2. **Complementary Distribution:** a phoneme takes a slightly different form (allophone), depending on the environment in which it appears.
3. **Free Variation:** two different phones appear in a word (same environment), without changing its meaning.

Contrastive Distribution - Minimal pairs

How can we tell what are the phonemes in a particular language?

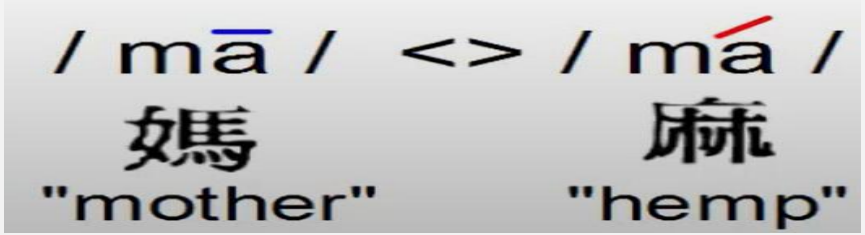
- The sound distribution tells us whether two or more sounds (phones) are allophones of the same phoneme or different phonemes.
- The Minimal pairs test is used to discover the phonemes in unknown languages.
- Minimal pairs are pairs of words or phrases in a particular language, that:
  - have the same number of phones,
  - differ in only one phonological (not orthographical) element, which is in the same position,
  - have distinct meanings.
- The phonological elements may be: phonemes, tonemes or chronemes.

Minimal pairs -examples

- phonemes (sounds) as in (feel, meal) or (know, go) in English

Minimal pairs -examples

- tonemes as in Asian languages (ma, ma)



Minimal pairs -examples

- chronemes (length in time) as in German (ban, bahn)

Complementary Distribution

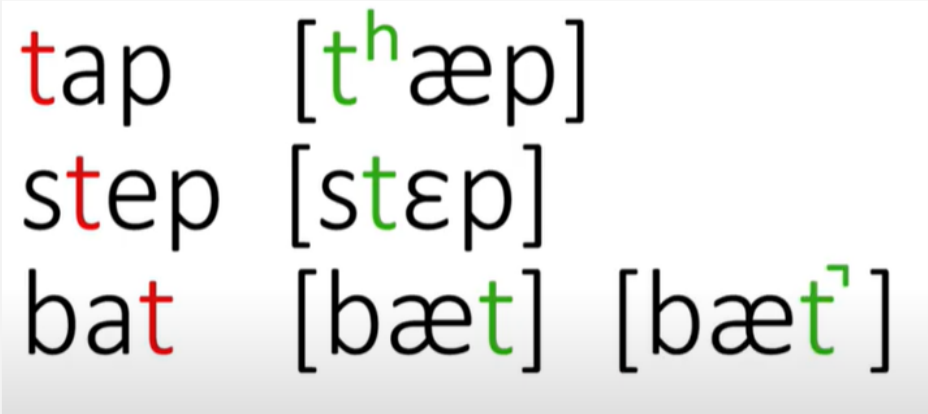
- Complementary distribution is a relation between variants of the same phoneme (allophones), which appear in distinct sound environments

- Example:

- aspirated t: word initial, followed by a vowel

- standard t: preceded by an s

- unrealised t: word final



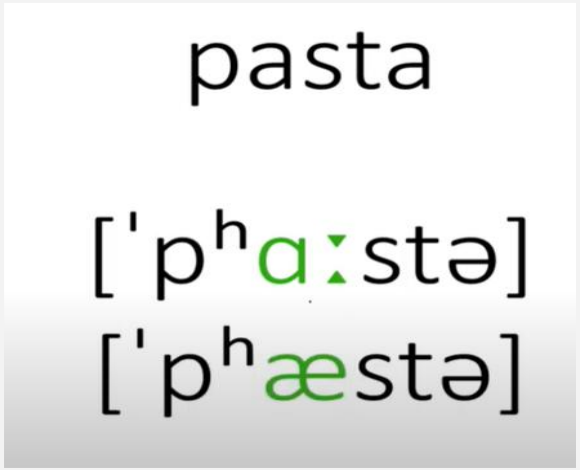
Complementary Distribution

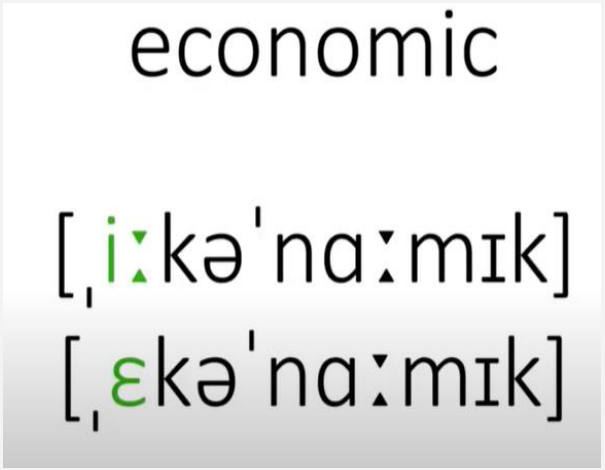
the three variants of the sound t occur in three different sound environments:

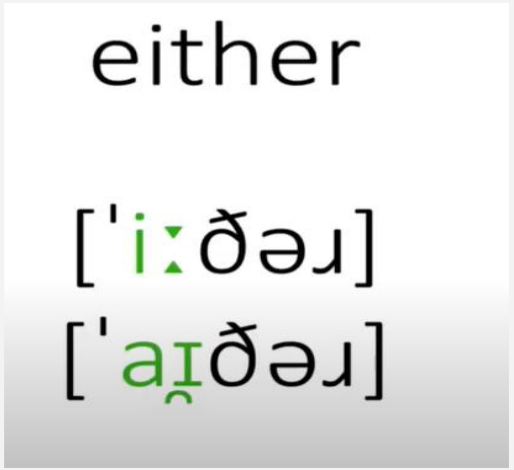
tap	[tʰæp]	#_æ
step	[stɛp]	s_ɛ
bat	[bæt]	æ_#

Free Variation

- Free variation is the situation when two sounds appear in a word (same environment), without changing its meaning, like in:







Exercises

- JAPANESE
- Consider the sounds [t] and [tʃ] in Japanese and determine whether they are allophones of the same phoneme or represent two different phonemes. If allophones, state the complementary distribution and the rule; if phonemes, state the contrast.

1. tatami	mat
2. tegami	letter
3. tʃitʃi	father
4. shita	under
5. tʃizu	map
6. koto	fact
7. utʃi	house
8. te	hand
9. degutʃi	exit

Exercises

- FRENCH
- Which vowels belong to different phonemes? How many vowel phonemes do you have?

1.	[vo]	veal	2.	[vø]	wishes
3.	[vu]	you (pl)	4.	[vy]	seen
5.	[li]	bed	6.	[ly]	read
7.	[ble]	wheat	8.	[blø]	blue

Exercises

- Korean
- Consider the distribution of [r] and [l] in the following Korean words:
- rubi ‘ruby’
- mul ‘water’
- kir-i ‘road (nom.)’
- pal ‘arm’
- saram ‘person’
- scul ‘Seoul’
- irum-i ‘name (nom.)’
- ilgop ‘seven’
- ratio ‘radio’
- ibalsa ‘barber’
- Do [r] and [l] occur in any minimal pairs? Do they have a contrastive distribution? Do [r] and [l] have a complementary distribution? Are [r] and [l] allophones of one or two phonemes? If so, state the rule.

- æ

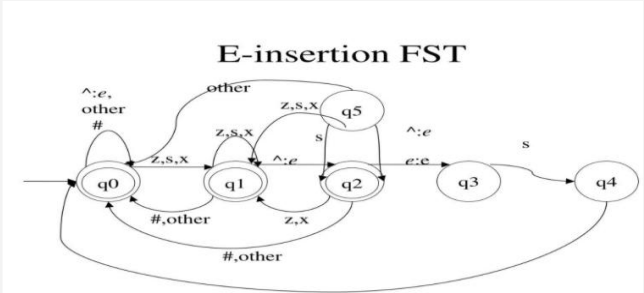
Computational applications of Phonetics

- Phonetics:
  - speech recognition/ production/ agents (Siri, Alexa, ...)
  - accent prediction in a word
  - accent classification by native language (resources: http://accent.gmu.edu/,https://www.kaggle.com/rtatman/speech-accent-archive), etc.;
  - Automatic syllabification –Romanian example, non-trivial because, for instance, the hiatus-diphthong ambiguity

sequence	hiatus		diphthong	
ai	*ha-i-nă*	(heinous)	*hai-nă*	(coat)
iu	*pi-u-li-ță*	(screw nut)	*piu-re*	(purée)
oa	*bo-ar*	(bull herder)	*oa-meni*	(humans)

Computational applications of Phonology

- Automatically discovering the phonemes in an unknown language;
- Comparing the phonetics of two or more languages;
- Measuring the phonetic distance between them;
- Phonetic space modelling;
- Automatically processing the phonetic patterns in a language by FSAs or FSTs (finite state automata or transducers)



THANKS

Questions?

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