Advanced Phonetics and Phonology

1302741

Lecture (2)

PHONETICS
Phonetics

- Scientific study of *spoken language*
- Basic conditions and constraints of human speech production and perception
- How are speech sounds produced and perceived?
  - anatomy and physiology
  - speech production, phonation, articulation
  - speech acoustics, speech signal
  - speech perception
- Articulatory Phonetics, Acoustic Phonetics, Auditory-Perceptual Phonetics, Neurophonetics
Phoneticians

- What do phoneticians actually do?
  - They *observe* how people say things
  - They *describe* spoken language at the level of pronunciation
  - They *measure* pronunciation events
  - They *model* pronunciation behavior
  - They *explain* the communicative contribution of pronunciation patterns
  - They construct *theories*, *hypotheses* and *models* of phonetic events – and they test them experimentally
Speech production organs
Speech production organs

- Nasal Cavity
- Oral Cavity
- Pharynx
- Larynx: vocal folds in it
- Trachea: the windpipe
- Lung: supply airstream
Speech production organs

- hyoid bone
- thyrohyoid membrane
- median thyrohyoid ligament
- lateral thyrohyoid ligament
- superior cornu of thyroid cartilage
- superior laryngeal nerve and artery
- oblique line
- cricothyroid muscle
- inferior cornu of thyroid cartilage
- cricothyroid joint
- cricoid cartilage
- trachea
- laryngeal incisure
- thyroid cartilage
- median cricothyroid ligament
- conus elasticus
Speech production organs

The larynx: in situ

larynx
thyroid gland
trachea
Speech production organs

- nasal cavity
- nasopharynx
- uvula
- tonsil
- oropharynx
- laryngopharynx
- tongue
- epiglottis
- glottis
- vocal cords
- trachea
- esophagus
Speech production organs

- hard palate
- soft palate
- uvula
- pharynx
- tongue root
- epiglottis
- alveolar ridge
- tongue tip
- tongue blade
- tongue body
- larynx
Speech production organs
Articulatory phonetics

- Humans produce different kinds of sounds, not all related to language (e.g., *coughing*, *burping*).

- Major aspects of speech production:
  - airstreams mechanism
  - state of the vocal cords
  - state of the velum
  - place of the obstruction of airstream
  - manner of the airflow between articulators
Airstream Mechanism

- All sounds are made with some movements of airstream
- The basic source of power is the lungs
- The air goes up the windpipe (trachea) and into the larynx and out of the body through the vocal tract (i.e. mouth or nose) ‘pulmonic egressive’ (= from the lungs outwards)
Airstream Mechanism

- Pulmonic egressive- all human languages
- Pulmonic ingressive- not found
- Velaric egressive- not found
- Velaric ingressive- e.g, Zulu
- Glottalic egressive- e.g, Navajo
- Glottalic ingressive- e.g, Sindhi
The larynx

- Hyoid bone
- Thyroid cartilage
- Cricoid cartilage
- Trachea
- Epiglottis
- False vocal cords
- Vocal ligament
- Vocal cords
- Tracheal cartilage
- Vocal Cords
- The Larynx
- The Trachea
The vocal cords

- Their outer edges are attached to muscle in the larynx while their inner edges are free.

- If the back end of the vocal folds are held apart, a triangular space opens up between them.

- The space is called glottis.
Glottis

- 1 – vocal fold
- 2 – vestibular fold
- 3 – glottis
- 4 – aryepiglottic folds
- 5 – epiglottis

(you only need to know ‘glottis’ and ‘vocal fold’)

Copyright 1997 The Anatomy Project
State of the vocal cords

- Adjustments of the glottis is very crucial in speech production. 3 positions

- 1) **Open glottis**, i.e. the folds are apart
  - normal breathing
  - *voiceless* sounds
    - [ssssssssssss] and [fffffff]
State of the vocal cords cont.

- 2) **Narrow glottis**: i.e. held gently together
- The air from the lungs forces its way through them causing the folds to **vibrate**.
  - Voiced sounds
    - [zzzzzzzz], [vvvvvvvvv] and [i]
  - Try it yourself!

- Some consonants are voiced, but **ALL vowels** are voiced.
State of the vocal cords cont.

- 3) Closed glottis, i.e. vocal folds are firmly pressed together.
- Airstream is stopped completely
  - Glottal stop
    - The [t] in American English in words like ‘button’
    - Arabic
Other glottal configurations

- Other less common configurations:
  - When vocal cords open only at one end (*creaky voice*); e.g. (*Hausa*)
  - When the vocal cords are apart; but force of air may still cause some vibration (*breathy voice*), or (*murmured*); e.g. (*Hindi*)
Other glottal configurations

*Figure A4.2*  Simplified model of the larynx
Other glottal configurations

- Vocal folds wide apart
- Arytenoids wide apart

Glottal setting: voiceless

- Vocal folds in normal vibration
- Arytenoids pressed together

Glottal setting: voice
Other glottal configurations

Vocal folds together but not vibrating

Arytenoids pressed together

Pulmonic airstream is blocked

Glottal setting: glottal stop

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Front portion of vocal folds in slow vibration

Rear portion of vocal folds in rapid vibration

Arytenoids pressed together

Glottal setting: creaky voice
Other glottal configurations

Glottal setting: whisper
- Vocal folds together but not vibrating
- Gap between arytenoids

Glottal setting: breathy voice
- Vocal folds in rapid vibration
- Gap between arytenoids
Other glottal configurations

Listen to the audio recording and then try to imitate different glottal settings for this sentence in English:

*Jack and Jill went up the hill to fetch a pail of water.*

1. Voice.
2. Whisper.
3. Breathy voice.
4. Creaky voice.
The Velum

- Velum (*soft palate*): muscular flap at the back of the roof of the mouth
- When velum is raised; air flows into the oral tract resulting in *oral sounds*
- when velum is lowered, air flows into both mouth & nose resulting in *nasal sounds* as [m, n]
The Oral Tract

- The air passages above the larynx are known as the oral / vocal tract.
- The shape of the vocal tract is very important in the production of speech.
- Made up of:
  - Oral cavity (mouth and pharynx)
  - Nasal cavity
- The parts of the vocal tract that are used to form sounds are called articulators.
- Upper and lower surface
The Oral Tract (Tongue)

Oral-nasal process

- Oral sounds: The soft palate is raised so there is a velic closure.
- Nasal sounds: The soft palate is lowered so air escapes from nose.

[From: Dan Jurafsky slide]

VICTOR GAO, Teaching English Consonants Zhejiang Education Institute
The Oral Tract

Contains:

- *Active articulators*: lower lip & tongue
- *Passive articulators*: upper surfaces of the oral tract (non-mobile parts) upper lip, teeth, pharynx wall & roof of the mouth which includes:
  - *Alveolar ridge*: behind upper teeth
  - *Hard palate*: bony structure
  - *Soft palate or velum*: at the back of the mouth
The Oral Tract

- **Tongue** - five areas:
  1) *Tip* at the very front
  2) *Blade* below the alveolar ridge
  3) *Front* below the hard palate
  4) *Back* below the soft palate
  5) *Root* towards the rear wall of the pharynx
The Oral Tract

1. Bilabial
2. Labiodental
3. Dental and interdental
4. Alveolar
5. Postalveolar
   (a) retroflex
   (b) palato-alveolar
6. Palatal
7. Velar
8. Uvular
9. Pharyngeal
Articulators in action
Articulation of consonants

- **Places of articulation**: which active articulator is making the articulation, and what part of the upper vocal tract is involved.
  - Bilabial, labiodental, dental, alveolar, Retroflex, Paloto-Alveolar, Palatal, Velar, etc.

- **Manners of articulation**: the ways in which consonants are produced. The articulators may close off the oral tract, or may narrow the space considerably.
  - Oral stop, nasal stop, fricative, approximant, lateral approximant, tap/flap, affricate, etc.
**Places of articulation: labial**

- **Bilabial**: made with two lips
  \((\text{pie, buy, my})\)

- **Labiodental**: lower lip and
  Upper front teeth \((\text{fie, vie})\).
Places of articulation: dorsal

- **Palatal**: front of the tongue and hard palate (*you*).

- **Velar**: back of the tongue and the soft palate (*hack, hag, hang*).
Manners of articulation

- **Stop**: complete closure of articulators, so no air escapes through mouth

- **Oral stop**: In addition to the articulatory closure in the mouth, the soft palate is raised so that the nasal cavity is blocked off, no air escapes through nose. Air pressure builds up behind closure, explodes when released.
  - *pie*, *buy* (bilabial closure), *tie*, *dye* (alveolar closure), *kye*, *guy* (velar closure).

- **Nasal stop**: oral closure, but soft palate is lowered, air escapes through nose.
  - *my* (bilabial closure), *nigh* (alveolar closure), *sang* (velar closure).
Oro-nasal process

- Oral sounds: The soft palate is raised so there is a velic closure.
- Nasal sounds: The soft palate is lowered so air escapes from nose.
**Manners of articulation**

- **Fricative**: Close approximation of two articulators, resulting in turbulent airflow between them, producing a hissing sound.
Manners of articulation

- **Approximant**: One articulator is close to another, but without the vocal tract being narrowed to such an extent that a turbulent airstream is produced.
  - *yes* (approximation in the palatal area), *we* (approximation between the lips and in the velar region), *raw* (approximation in the alveolar region).
Manners of articulation

- **Lateral approximant**: Obstruction of airstream along center of oral tract, with opening around one or both sides of the tongue.
  - *lie, laugh* (alveolar lateral)
Manners of articulation

- **Tap or flap**
  - Tongue makes a single tap against the alveolar ridge
    - *pity, butter*

- **Affricate**
  - A combination of a stop immediately followed by a fricative
    - *church, judge*
Interpreting the articulation timing diagrams

Figure B2.4 Articulation timing diagram showing the stages of a stop

<p>| PA | = passive articulator |
| AA | = active articulator |</p>
<table>
<thead>
<tr>
<th>VF</th>
<th>= vocal folds</th>
</tr>
</thead>
<tbody>
<tr>
<td>_____</td>
<td>= vocal folds apart as for voiceless (p. 32)</td>
</tr>
<tr>
<td>_____</td>
<td>= vocal folds vibrating as for voiced (p. 33)</td>
</tr>
<tr>
<td>_____</td>
<td>= vocal folds together as for glottal stop (pp. 33–4)</td>
</tr>
</tbody>
</table>
Interpreting the articulation timing diagrams

Aspiration

Aspiration occurs when fortis plosives /p t k/ are initial in a stressed syllable, and takes the form of a delay in the onset of voicing, an effect often compared to a little puff of air. The link with stress is significant; in competitor aspiration is heard on the /p/, but much less so on the unstressed /k/ or the two /t/s; compare competent. In initial clusters with /s/, e.g. stool, spool, school, aspiration is absent.
## Place of articulation

<table>
<thead>
<tr>
<th>Place of articulation</th>
<th>Active articulator</th>
<th>Passive articulator</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>bilabial</td>
<td>lower lip</td>
<td>upper lip</td>
<td>bat</td>
</tr>
<tr>
<td>labiodental</td>
<td>lower lip</td>
<td>upper teeth</td>
<td>fish</td>
</tr>
<tr>
<td>dental</td>
<td>tongue tip or blade</td>
<td>upper teeth</td>
<td>moth</td>
</tr>
<tr>
<td>alveolar</td>
<td>tongue tip or blade</td>
<td>alveolar ridge</td>
<td>dog</td>
</tr>
<tr>
<td>retroflex</td>
<td>curled tongue tip</td>
<td>area immediately</td>
<td>Malayalam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>behind alveolar</td>
<td>[kuṭṭi] ‘child’</td>
</tr>
<tr>
<td>palato-alveolar (or</td>
<td>tongue blade</td>
<td>area immediately</td>
<td>shark</td>
</tr>
<tr>
<td>alveo-palatal)</td>
<td></td>
<td>behind alveolar</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ridge</td>
<td></td>
</tr>
<tr>
<td>palatal</td>
<td>tongue front</td>
<td>hard palate</td>
<td>yak</td>
</tr>
<tr>
<td>velar</td>
<td>tongue back</td>
<td>velum</td>
<td>goat</td>
</tr>
<tr>
<td>uvular</td>
<td>tongue back</td>
<td>uvula</td>
<td>Fr. rat ‘rat’</td>
</tr>
<tr>
<td>pharyngeal</td>
<td>tongue root</td>
<td>pharynx wall</td>
<td>Ar. [ʕamm] ‘uncle’</td>
</tr>
<tr>
<td>glottal</td>
<td>vocal cords</td>
<td>vocal cords</td>
<td>hare</td>
</tr>
</tbody>
</table>
Articulation of vowels

- Position of the “highest” point of the arch of the tongue:
  - Front vs. back
  - high vs. low
- Shape of the lips:
  - Rounded vs. unrounded
[i] vs. [u]

(From a lecture given by Rochelle Newman)
[æ] vs. [ɑ]

(From a lecture given by Rochelle Newman)
Articulation – the vocal tract

Vocal tract geometry (tongue position) of some English vowels
Vowel chart

- **Cardinal vowels**: A set of reference vowels evenly spaced between the two most extreme tongue body positions: high front [i] and low back [a]. The cardinal vowels demarcate the articulatory vowel space. Other vowels are placed on the (quadrilateral) vowel chart using these cardinal vowels as landmarks.

- The vowel chart:

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

Daniel Jones (1881-1967)
Speech Sound Classification

We classify consonants according to:
- Voicing
- Place of articulation
- Manner of articulation

Vowels according to:
- part of the tongue used
- Position of the tongue
- Lip rounding
Consonants vs. vowels

- **Consonants**: there is obstruction in the oral tract

- **Vowels**: no hindrance to the outflow of air

- **Liquids & nasals**: the air flows out freely

- **Glides** don’t form nuclei of syllables, but occur on the edges of syllables

- **Vowel**: produced with open approximation and is a syllable nuclei (excluding glides, syllabic liquids & nasals)
IPA = International Phonetic Association

- aim: universal phonetic alphabet, capable of describing all speech sounds of all languages
- aim: universal classification systems for all speech sounds
- founded in Paris in 1886
- last revision: Kiel 1989 (alphabet 1995/96)
Phonetic transcription - IPA

'hou tʃuʰ ˈnɔː əɪm ˈmæd | ˈsed əˈlɪs ||
 ju ˈmæs² bi | ˈsed ðəˈkæt | ɔː ju ˈwʊdŋt əv ˈkʌm hɪə ||
 əˈlɪs ˈdɪŋt θɪŋk ˈdæt ˈpruːv ɪt ə ˈtɔːl³ || ˈhauˈeva | ʃi ˈwent ˈən | ðə ˈhau tʃuʰ ˈnɔː
dət ˈjʊə: ˈmæd ||
 tə ˈbɛŋ ˈwɪd | ˈsed ðəˈkæt | ə ˈdɔːg nɔt ˈmæd || ˈjuː ˈɡraːnt ˈdæt ||
aɪ ˈsæpəʊz ˈsəʊ | ˈsed əˈlɪs ||
ˈwel ðən | ə ˈkæt went ˈən | ə ˈsiː | ə ˈdɔːg ˈgraʊlz wen ðəs əˈŋri | ən ˈwæg əs ə ˈteɪl wen ðəs ˈplɪːzd || ˈnaʊ əi ˈgraʊl wen əɪm ˈplɪːzd | ən ˈwæg ˈmæɹi ˈteɪl wen əɪm əˈŋri || ˈðəːfə ɾ⁴ aim ˈmæd ||
 əi kɔːl ɪt ˈprəːrɪŋ | nɔt ˈgraʊlɪŋ | ˈsed əˈlɪs ||
ˈkɔːl ɪt wɒʃu¹ ˈlaɪk | ˈsed ðə ˈkæt ||
‘How do you know I’m mad?’ said Alice.
‘You must be,’ said the cat, ‘or you wouldn’t have come here.’
Alice didn’t think that proved it at all. However, she went on, ‘And how do you know that you’re mad?’
‘To begin with,’ said the cat, ‘a dog’s not mad. You grant that?’
‘I suppose so,’ said Alice.
‘Well, then,’ the cat went on, ‘you see a dog growls when it’s angry, and wags its tail when it’s pleased. Now I growl when I’m pleased, and wag my tail when I’m angry. Therefore I’m mad.’
‘I call it purring, not growling,’ said Alice.
‘Call it what you like,’ said the cat.
THE INTERNATIONAL PHONETIC ALPHABET (revised to 2005)

CONSONANTS (PULMONIC) © 2005 IPA

<table>
<thead>
<tr>
<th>Articulator</th>
<th>Bilabial</th>
<th>Labiodental</th>
<th>Dental</th>
<th>Alveolar</th>
<th>Postalveolar</th>
<th>Retroflex</th>
<th>Palatal</th>
<th>Velar</th>
<th>Uvular</th>
<th>Pharyngeal</th>
<th>Glottal</th>
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<tbody>
<tr>
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<td>p</td>
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<td>t</td>
<td>d</td>
<td>t̠</td>
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<td>Tap or Flap</td>
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<td>Fricative</td>
<td>φ</td>
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<td>θ̑</td>
<td>s̑</td>
<td>ʃ</td>
<td>j̑</td>
<td>ξ̑</td>
<td>χ̑</td>
<td>ʁ</td>
<td>h̑</td>
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<td>Approximant</td>
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</tbody>
</table>

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

CONSONANTS (NON-PULMONIC)

<table>
<thead>
<tr>
<th>Articulator</th>
<th>Clicks</th>
<th>Voiced imlossives</th>
<th>Ejectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilabial</td>
<td>b̌</td>
<td>b̌</td>
<td></td>
</tr>
<tr>
<td>Dental</td>
<td>ď</td>
<td>ď</td>
<td></td>
</tr>
<tr>
<td>Alveolar</td>
<td>ǧ</td>
<td>ǧ</td>
<td></td>
</tr>
<tr>
<td>Velar</td>
<td>ǩ</td>
<td>ǩ</td>
<td></td>
</tr>
</tbody>
</table>

OTHER SYMBOLS

<table>
<thead>
<tr>
<th>Articulator</th>
<th>Voiced labial-velar approximant</th>
<th>Voiced labial-velar approximant</th>
<th>Alveo-palatal fricative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilabial</td>
<td>b̌</td>
<td>b̌</td>
<td>b̌</td>
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<tr>
<td>Dental</td>
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<tr>
<td>Alveolar</td>
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<tr>
<td>Velar</td>
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</tr>
</tbody>
</table>

DIACRITICS

Diacritics may be placed above a symbol with a descender, e.g. ʃ

VOWELS

<table>
<thead>
<tr>
<th>Front</th>
<th>Central</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close</td>
<td>i</td>
<td>y</td>
</tr>
<tr>
<td>Close-mid</td>
<td>e</td>
<td>œ</td>
</tr>
<tr>
<td>Open-mid</td>
<td>ɛ̃</td>
<td>ɔ̃</td>
</tr>
<tr>
<td>Open</td>
<td>æ̃</td>
<td>ɶ̃</td>
</tr>
</tbody>
</table>

SUPRASEGMENTALS

<table>
<thead>
<tr>
<th>Primary stress</th>
<th>Secondary stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long</td>
<td>Short</td>
</tr>
<tr>
<td>Extra-long</td>
<td>Extra-short</td>
</tr>
<tr>
<td>Minor (foot)</td>
<td></td>
</tr>
<tr>
<td>Major (intonation)</td>
<td></td>
</tr>
<tr>
<td>Syllable break</td>
<td></td>
</tr>
<tr>
<td>Linking (absence of a break)</td>
<td></td>
</tr>
</tbody>
</table>

TONES AND WORD ACCENTS

<table>
<thead>
<tr>
<th>Extra high</th>
<th>High</th>
<th>Mid</th>
<th>Low</th>
<th>Extra low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rising</td>
<td></td>
<td></td>
<td></td>
<td>Falling</td>
</tr>
</tbody>
</table>

CHARACTER LEVEL

<table>
<thead>
<tr>
<th>Extra high</th>
<th>High</th>
<th>Mid</th>
<th>Low</th>
<th>Extra low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rising</td>
<td></td>
<td></td>
<td></td>
<td>Falling</td>
</tr>
</tbody>
</table>

Downstep | Ustep | Global rise | Global fall |
|--------|-------|-------------|-------------|
Applications of phonetics

- Understanding the mechanisms of speech, i.e. the processes of production and perception, is indispensable for work on
  - foreign language teaching and learning
  - pronunciation dictionaries
  - speech pathology and disorders, clinical phonetics
  - forensic phonetics
  - speech technology (automatic speech recognition, speech synthesis, speech-to-speech translation, dialog systems)
**Sounds in other languages**

- There are about 7,000 languages in the world today. Over half of them (52 percent) are spoken by fewer than 10,000 people; over a quarter of them (28 percent) are spoken by fewer than 1,000 people; at least 10 percent of them are spoken by fewer than 100 people.

- There are about 600 consonants in different languages. The 10 most widely spoken languages use about 100 different consonants of which only 22 occur in English.
Sounds in other languages

- Unfamiliar sounds: **Clicks** occur in words in several African languages, such as Zulu, Nama, and Xhosa. Clicks also occur in interjections or non-linguistic gestures in many languages, for example, *tsk-tsk*, an interjection expressing disapproval in English.
That's all Folks!

/ ði end əv lektʃə tuː /