

# COM3502/4502/6502 SPEECH PROCESSING

## Lecture 7

### Articulatory Phonetics



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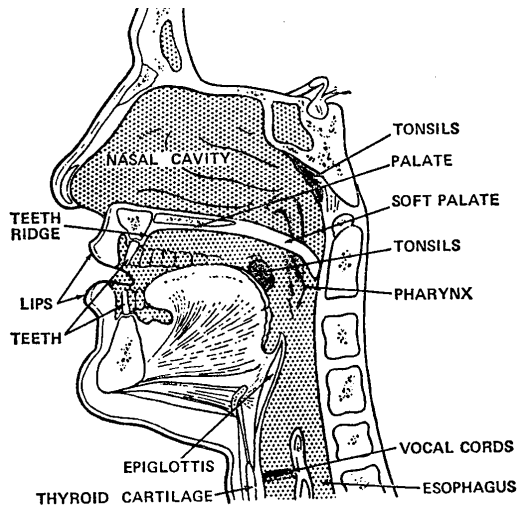
## Articulatory Phonetics

... a description of speech sounds in terms of the *physical actions* performed in their production



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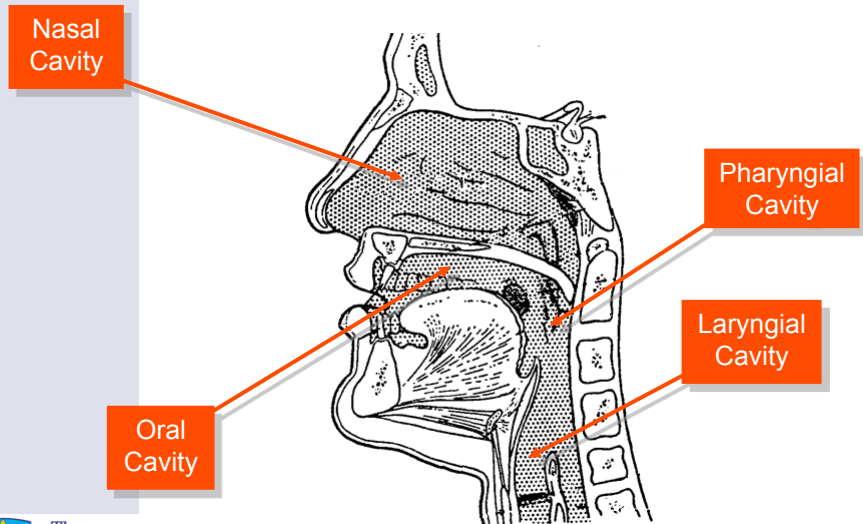
# The Vocal Tract – A Reminder



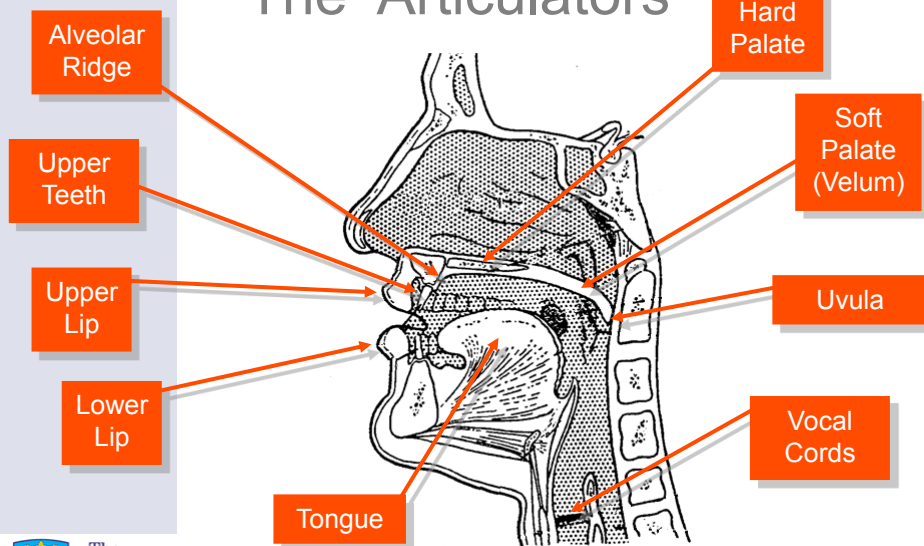
Taken from: Denes, P. B., & Pinson, E. N. (1973). *The Speech Chain: The Physics and Biology of Spoken Language*. New York: Anchor Press.



# The Resonant Cavities

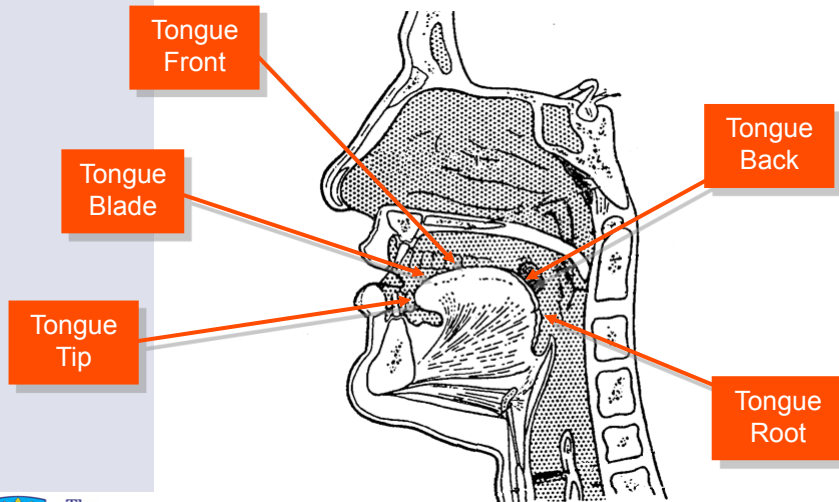


## The 'Articulators'



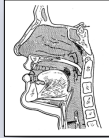
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## The Tongue



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# Articulatory Phonetics



Speech sounds are classified in 'articulatory phonetics' as follows ...

- vowels & consonants (*i.e. all sounds*)
  - where the air stream comes from
  - whether air is going in or out
- consonants
  - whether the vocal cords are vibrating: 'voice'
  - where the constriction is: the 'place' of articulation
  - how the sound is made: the 'manner' of articulation
- vowels
  - the position of the tongue
  - the shape of the lips

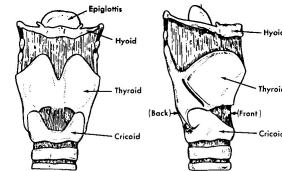
# Voice, Place, Manner

# Voice

- Covered in Lecture 3

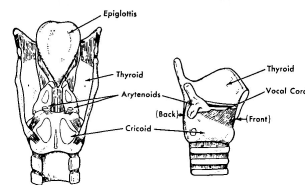
- **‘Degree of voicing’**

- voiced
- voiceless



- **‘Voice quality’**

- modal (*normal*)
- creaky
- falsetto
- breathy



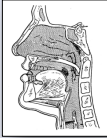
Human Larynx



# Voice, **Place**, Manner



## 'Place' of Articulation



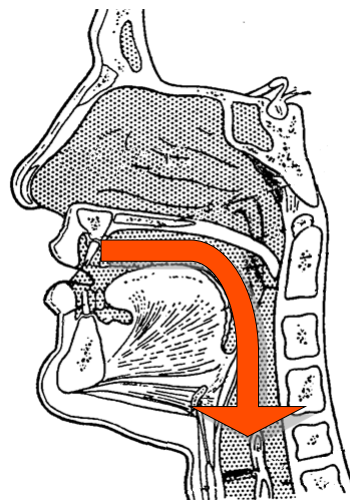
- Articulation refers to the **constriction** of the vocal tract during speech production
- Articulation involves the movement of an **'active articulator'** (e.g. *the tongue*) towards a **'passive articulator'** (e.g. *the top of the mouth*)
- The **'place'** of articulation refers to the physical location of the constriction in the vocal tract



## 'Place' of Articulation



- Bilabial
- Labiodental
- Dental
- Alveolar
- Postalveolar
- Retroflex
- Palatal
- Velar
- Uvular
- Pharyngeal
- Glottal



## 'Place' of Articulation

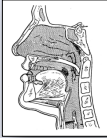
Place of Articulation	Active Articulator	Passive Articulator	Example Sounds
<b>Bilabial</b>	upper and lower lips	<i>none</i>	[p b m]
<b>Labiodental</b>	lower lip	upper front teeth	[f v]
<b>Dental</b>	tongue tip	upper front teeth	[θ ð]
<b>Alveolar</b>	tongue tip or blade	alveolar ridge	[t d n l s z]
<b>Postalveolar</b>	tongue tip or blade	rear of alveolar ridge	[ɹ ʃ]
<b>Retroflex</b>	tongue tip	hard palate	[ʈ ɖ ɳ]
<b>Palatal</b>	tongue front	hard palate	[j ɲ]
<b>Velar</b>	tongue back	soft palate	[k g ŋ]
<b>Uvular</b>	tongue back	uvula	[q ɢ]
<b>Pharyngeal</b>	tongue root	rear wall of pharynx	[ħ]
<b>Glottal</b>	vocal folds	<i>none</i>	[h ʔ]



Voice, Place, **Manner**



## 'Manner' of Articulation



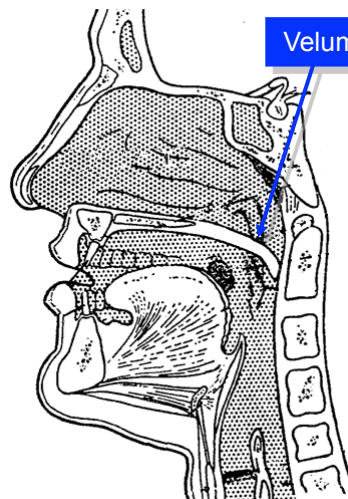
- The '**manner**' of articulation refers to the way in which the airstream is modified by the primary and secondary articulators
- Degrees of '**stricture**' ...
  - **closure**: articulators in firm contact ('**stops**')
  - **narrowing**: articulators close together but not touching ('**fricatives**')
  - **approximation**: wide gap between articulators ('**approximants**')



## 'Manner' of Articulation

### **Stops:**

- complete blockage of the airstream
- can be produced at many different places of articulation
- stops made with a velic closure are called '**oral stops**'
- stops made without a velic closure (*and with airflow through the nasal cavity*) are called '**nasal stops**'

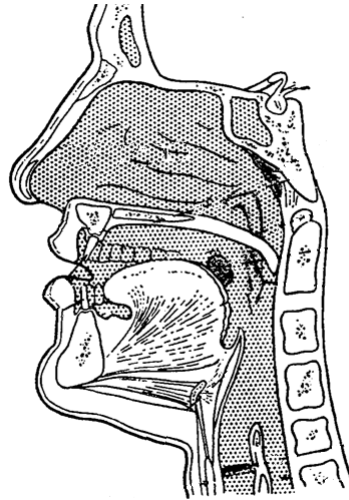




## 'Manner' of Articulation

### Oral Stops:

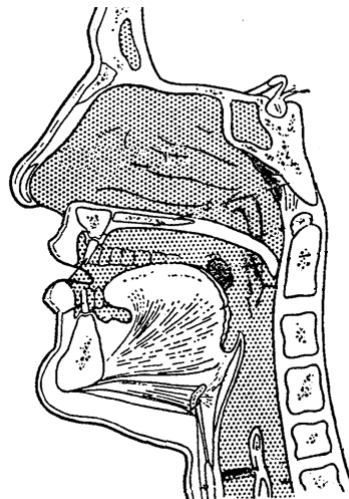
- air pressure rises rapidly in the vocal tract during closure
- the compressed air bursts out of the vocal tract with a small explosive noise when the closure is released
- such sounds are called '**plosives**', e.g. [p t k b d g]
- slower release sounds are called '**affricates**', e.g. [tʃ dʒ]



## 'Manner' of Articulation

### Fricatives:

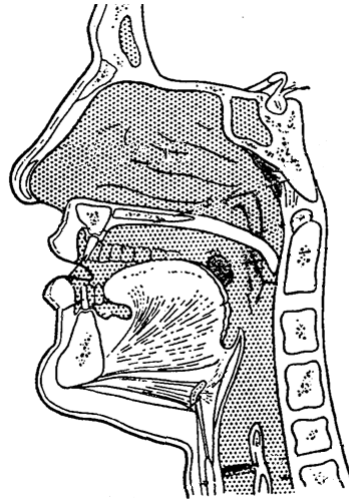
- sound is produced with a very narrow opening between the active and passive articulators
- the resulting airflow is **turbulent** and hence noisy
- air for a '**median fricative**' flows through a narrow channel in the centre of the cavity, e.g. [s]
- airflow for a '**lateral fricative**' escapes through a narrow space at the sides of the tongue, e.g. [ɬ]



## 'Manner' of Articulation

### Approximants:

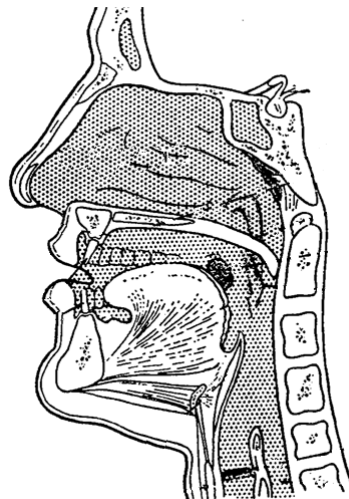
- sonorants do not have a stricture narrow enough to cause turbulence
- 'lateral approximants' have complete closure on the midline, e.g. [l]
- 'median approximants' have no complete closure and are also called 'semi-vowels' or 'glides', e.g. [w v j]



## 'Manner' of Articulation

### Taps and trills:

- closure in a 'tap' or 'flap' is much shorter than for a plosive hence there is no build up of air pressure, e.g. [ɾ]
- a 'trill' or 'roll' consists of a series of rapid tap-like closures, e.g. [r]



# Voice, Place, Manner

I  
P  
A

Manner

Place

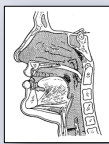
CONSONANTS (PULMONIC)																	
	Bilabial		Labiodental		Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal				
Plosive	p	b				t	d		ʈ	ɖ	c	ɟ	k	g	q	ʁ	ʔ
Nasal		m		ɱ			n			ɲ	ɳ		ɴ				
Trill							ʀ								ʀ		
Tap or Flap							ɾ		ɽ								
Fricative	ɸ	β	f	v	θ	ð	s	z	ʃ	ʒ	ʂ	ʐ	x	χ	ʁ	ħ	ʕ
Lateral fricative							ɬ	ɮ									
Approximant				ʋ			ɹ		ɻ	j	ɰ						
Lateral approximant							l		ɭ	ʎ	ʟ						

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

Voice



# Voice, Place, Manner



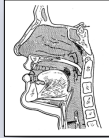
• Voice, Place, Manner (**VPM**) labels are the standard method of specifying consonants

• For example ...

- [p] → voiceless bilabial plosive
- [g] → voiced velar plosive
- [s] → voiceless alveolar fricative
- [tʃ] → voiceless postalveolar affricate
- [n] → voiced alveolar nasal
- [t] → voiceless alveolar plosive
- [l] → voiced alveolar lateral-approximant



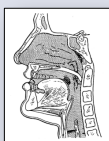
## Exercise 1



What are the VPM labels for the following consonants?

- [k] → voiceless velar plosive
- [θ] → ?
- [m] → ?
- [b] → ?
- [h] → ?
- [ʃ] → ?
- [ʔ] → ?

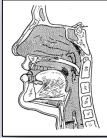
## Exercise 1



What are the VPM labels for the following consonants?

- [k] → voiceless velar plosive
- [θ] → voiceless dental fricative
- [m] → voiced bilabial nasal
- [b] → voiced bilabial plosive
- [h] → voiceless glottal fricative
- [ʃ] → voiceless postalveolar fricative
- [ʔ] → glottal stop

## Exercise 2



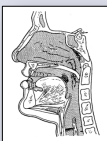
What consonants have the following VPM labels?

- voiced alveolar nasal → [n]
- voiced alveolar fricative → ?
- voiceless labiodental fricative → ?
- voiced bilabial plosive → ?
- voiced postalveolar fricative → ?
- voiceless alveolar plosive → ?
- voiced velar nasal → ?



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## Exercise 2



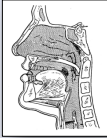
What consonants have the following VPM labels?

- voiced alveolar nasal → [n]
- voiced alveolar fricative → [z]
- voiceless labiodental fricative → [f]
- voiced bilabial plosive → [b]
- voiced postalveolar fricative → [ʒ]
- voiceless alveolar plosive → [t]
- voiced velar nasal → [ŋ]



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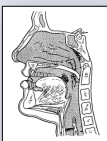
## Vowels



- Vowels are articulated by ...
  - raising the front or the back of the tongue towards the roof of the oral cavity
  - shaping the lips
  - ... thereby changing the **'vowel quality'**
- Vowel quality is governed by ...
  - **'vowel height'**: *high / low*
  - **'vowel location'**: *front / back*
  - **'lip position'**: *rounded / unrounded*



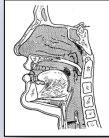
## Vowel Height



- The **'height'** of a vowel refers to the relationship between the highest point of the tongue and the roof of the oral cavity
- A **'close'** or **'high'** vowel (*such as [i] or [u]*) is produced when the tongue is raised close to the roof
- An **'open'** or **'low'** vowel (*such as [æ] or [ɑ]*) is produced when there is a wide gap between the highest point of the tongue and the roof of the oral cavity
- Vowels can also be **'mid'** ([ə]), **'half-close'** ([e]) or **'half-open'** ([ʌ])



# Vowel Location

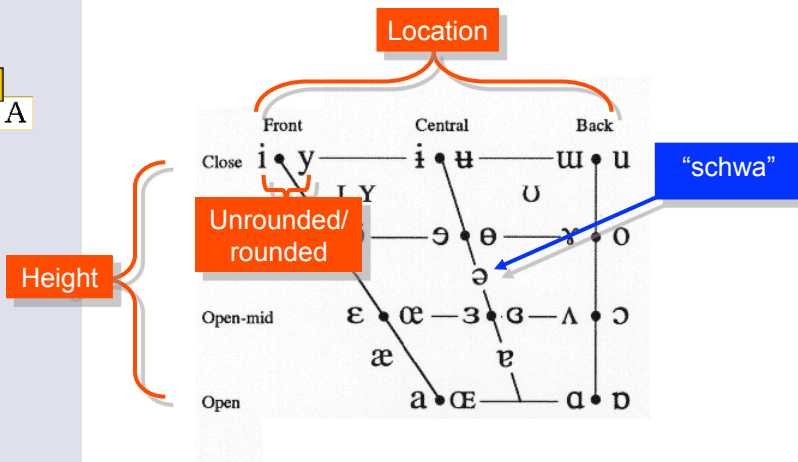


- The **'location'** of a vowel refers to the part of the tongue which is highest
- A **'front vowel'** (such as [i]) is produced by raising the front part of the tongue towards the hard palate
- A **'back vowel'** (such as [u]) is produced by raising the back part of the tongue towards the soft palate
- A **'central vowel'** is produced by raising the central part of the tongue towards the junction of the hard and soft palates
- The mid-central vowel [ə] is called **"schwa"**

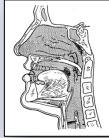


# Vowels

I  
P  
A

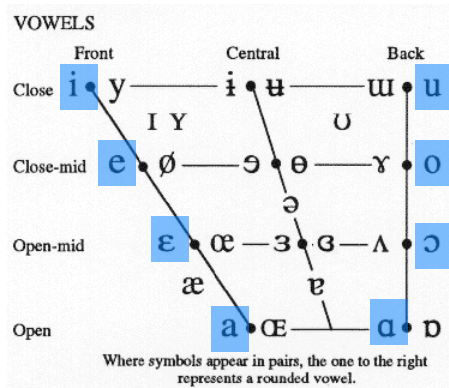


# Vowels



- Many languages make a distinction between ...
  - rounded and unrounded vowels
  - long and short vowels
  - oral and nasalised vowels
  - monophthongs and diphthongs (*vowel glides*)
- Vowel quality can be indicated by ...
  - placing a dot on the ‘**vowel quadrilateral**’
  - ... or ...
  - relating it to a set of language-independent ‘**cardinal vowels**’

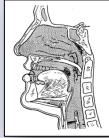
# The Vowel Quadrilateral



The Cardinal Vowels



## Vowel Instability



- Vowels appear to carry less information than consonants, e.g. ...  
[ən əpəl ə də kəps ðə dəktə əwə]
- Vowels seem to act as a **carrier signal** that is **modulated** by the consonants
- For these reasons, vowel quality is very variable and can drift over time (*hence giving rise to different historical and contemporary accents*) ...
  - Chaucer: “house” → [hu:s]
  - Shakespeare: “house” → [hoos]
  - Modern day: “house” → [haus]
- This is why a non-phonetic writing system can have an advantage; people can communicate despite having very different accents

## This lecture has covered ...

- The articulators
- Consonants
  - voice, place, manner (VPM)
- Vowels
  - vowel quality
  - vowel height (*open-close*)
  - vowel location (*front-back*)
  - rounded/unrounded
  - the neutral vowel ‘schwa’
  - the vowel quadrilateral
  - cardinal vowels

# Any Questions ?



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# Next time ...

## Acoustic Phonetics



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