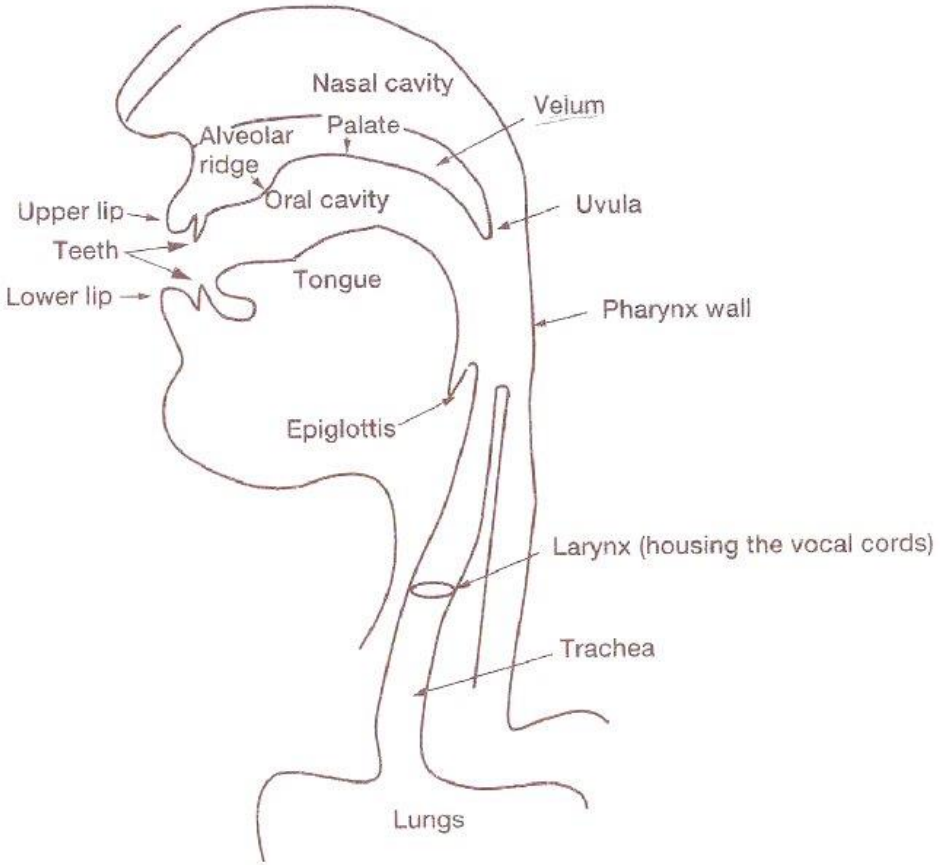
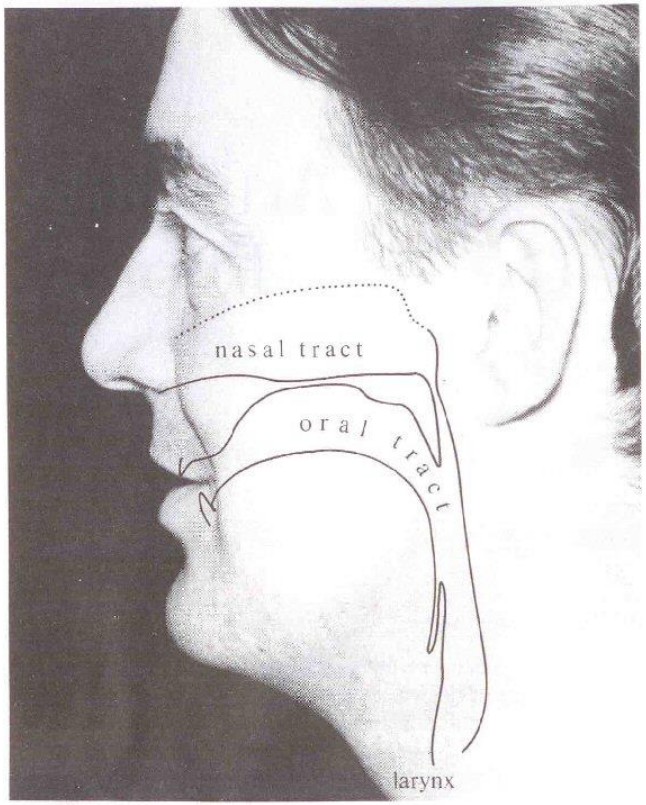
The Vocal Tract and Initiation of Speech: Anatomy and Physiology

Outline

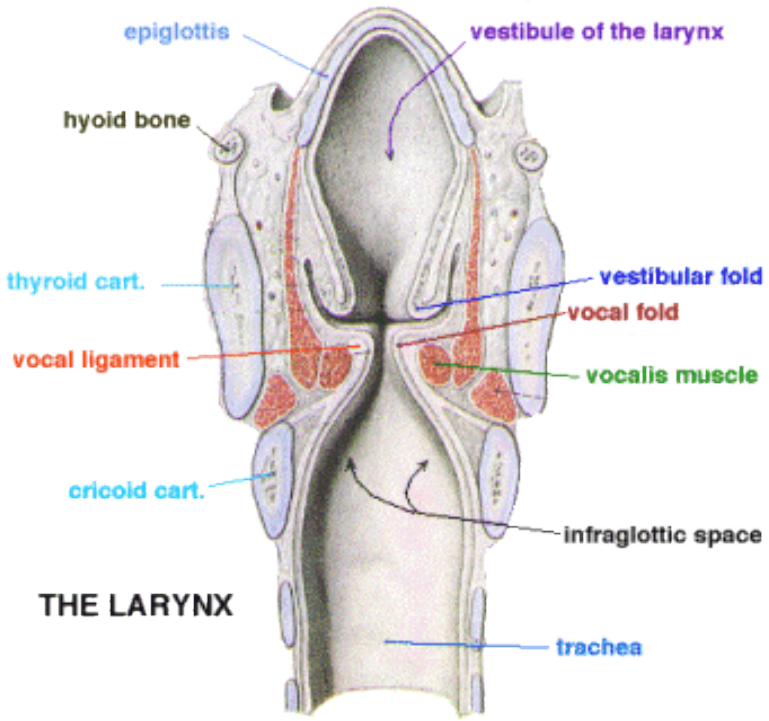
- The vocal tract and articulatory organs
- The airstream mechanisms
- Anatomy of the larynx
- Vocal folds - anatomy
- The state of the vocal folds
- Velum position
- Places of articulation
- Manners of articulation
- The articulation of vowels
- Classification of speech sounds
- Consonants vs. Vowels
- Suprasegmental features

The vocal tract and articulatory organs





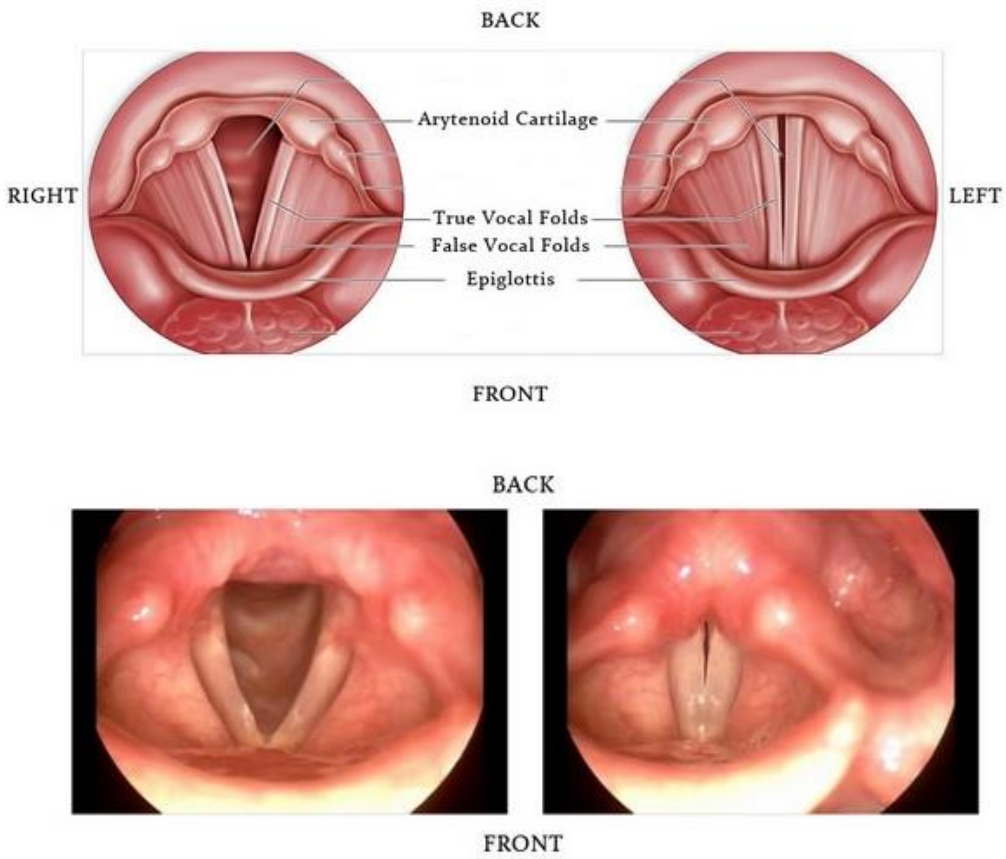
Anatomy of the larynx



Cross-section of the larynx – rear view.

- positioned in the front of the neck
- separates the respiratory (breathing) and digestive (swallowing) tracts
- plays a critical role in normal breathing, swallowing, and speaking -> damage to the larynx or its tissues can result in problems with any or all of these functions
- made up mainly of two cartilages: *thyroid cartilage* and *cricoid cartilage*
- **epiglottis:** on the top portion of this structure; protects the larynx during swallowing and prevents aspiration (breathing in) of food

Vocal folds



- **VF** are two muscular tissues:
  - at the front joined together to the *thyroid* cartilage
  - at the back separated by attachment to processes on the *arytenoid* cartilages
- due to activity of *arytenoid* cartilages **VF** can take different position and modify the passage of the airflow
- the tension of the VF is controlled by *thyroarytenoid* muscles (inside the folds)
- *glottis* - the gap between the vocal folds
- "false vocal folds" - fleshy structures above the vocal folds

Classification of speech sounds (1)

Consonantal sounds can be described by referring to the following features:

- Airstream mechanism
- The state of the vocal cords
- Velum position
- Place of articulation
- Manner of articulation

Consonants – usually **3** dimensions: voicing, place and manner of articulation

Vowels – the *height* of the tongue body, the *front-back position* of the tongue and the degree of *lip rounding*

Classification of speech sounds (2)

obstruents: noticeably restricted airflow, the articulators are in complete closure or close approximation	*stricture type*	***stops:*** complete closure of two articulators + velic closure
		fricatives: narrowing of two articulators + a turbulent airstream
		affricates: sequence of a plosive+fricative (involving a specific transition)
sonorants: free passage of the airflow through the vocal tract; no restriction in the oral tract or nasal tract opened	*consonants*	***nasals:*** complete closure of two articulators + soft palate lowered
		liquids ***a)lateral approximants:*** the obstruction is located centrally and the air passes out at the side ***b) trills:*** articulator set in vibration by the airstream
		glides (approximants): approximation of two articulators with no turbulent airstream
	vowels	***oral:*** free passage of the airflow through the vocal tract, nasal tract blocked off
		nasal: free passage of the airflow through the vocal tract: nasal tract opened

Articulation of English consonants: an overview

b	buy	
d	die	
g	guy	
p	pie	
t	tie	
k	kite	
w	why	
j ('y')	—	
l	lie	
r	rye	
m	my	ram
n	nigh	ran
ŋ		rang
f	fie	
θ	thigh	
s	sigh	
ʃ	shy	mission
h	high	
v	vie	
ð	thy	
z	Zion	mizzen
ʒ		vision
tʃ	chime	
dʒ	jive	

Audio demonstration of BBC English vowels (and consonants):
http://www.teachingenglish.org.uk/article/phonemic-chart
http://www.phonetics.ucla.edu/vowels/chapter6/soundsvowels.html

The airstream mechanisms

Airstream mechanism	Airflow initiator	Airflow direction	language
Pulmonic egressive	**lungs**	**outwards**	**Most languages, for many it is the sole AM**
Velaric ingressive	velum	inwards	Zulu (S. Africa)
Glottalic egressive	glottis	outwards	Navajo (N. America)
Glottalic ingressive	glottis	inwards	Sindhi (India)

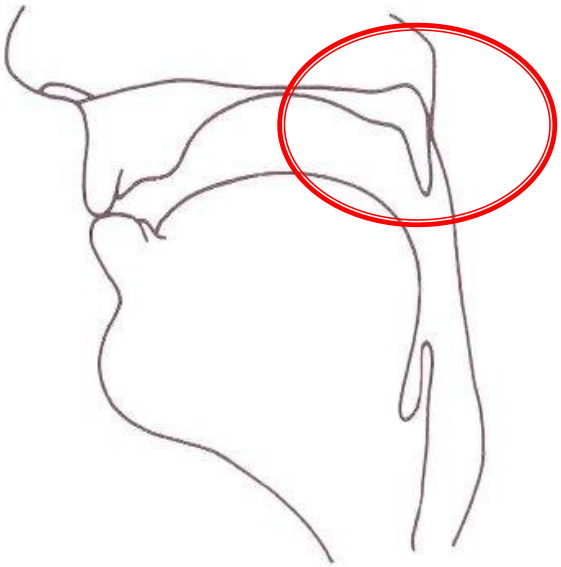
The state of the vocal folds

Voiceless sounds: /p/, /t/, /k/, /f/, /s/, /ɕ/, /ʃ/, /x/, /ts/, /tɕ/, /tʃ/

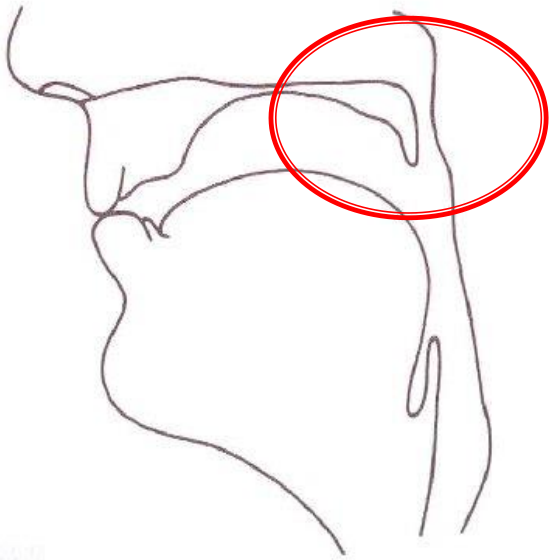
Voiced sounds: all vowels, sonorants and /b/, /d/, /g/, /v/, /z/, /ʑ/, /ʒ/, /dz/, /dʑ/, /dʒ/ …

If you want to see the larynx in action go to:
https://www.youtube.com/watch?v=iYpDwhpILkQ&list=PLB78D43E66A2CCBD8

Velum position



oral sound /b/



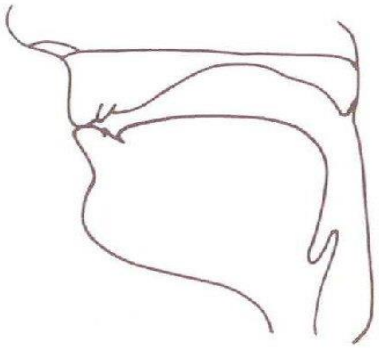
nasal sound /m/

Place of articulation (1)

Lips	• Labial articulations
Tongue tip and blade	• Coronal articulations
The back of the tongue	• Dorsal articulations

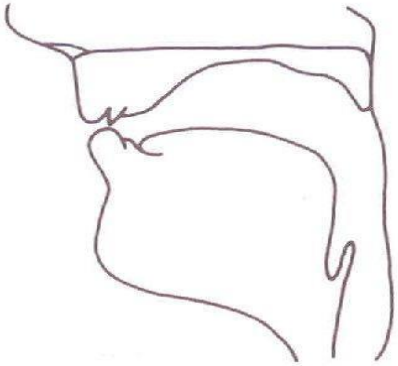
Places of articulation (2): Labial articulations

- **bilabial** (lower and upper lip)



/b/ e.g. *buy*
/p/ e.g. *pie*
/m/ e.g. *most*

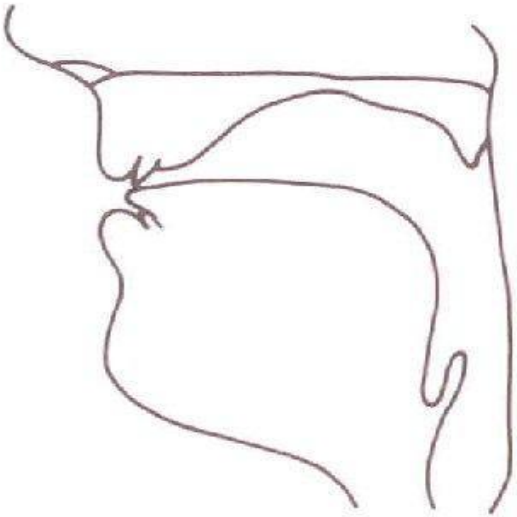
- **labiodental** (lower lip and upper teeth)



/v/ e.g. *vehicle*
/f/ e.g. *fortune*

Places of articulation (3): Coronal articulations

- **dental** (tip of the tongue and upper teeth)

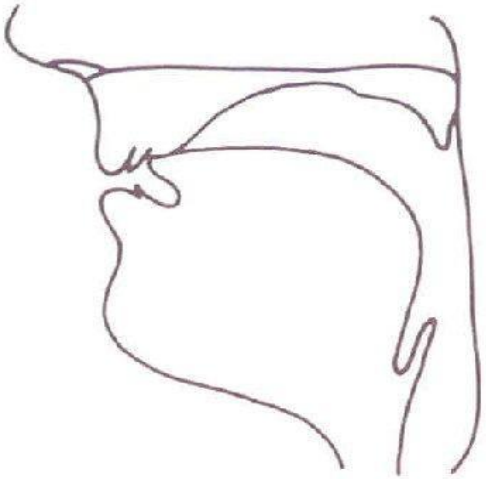


/θ/, e.g. *th*igh

/ð/, e.g. *th*y

Places of articulation (4): Coronal articulations

- **alveolar** (tongue tip/blade and alveolar ridge)



/t/ e.g. *tiger*
/d/ e.g. *dog*
/s/ e.g. *snake*
/z/ e.g. *zebra*

/ɾ/ e.g. *better, ladder*
/ɹ/ e.g. *red*
/l/ e.g. *love*
/n/ e.g. *nose*

- **retroflex** (tip of the tongue (curled up and back) and the back of the alveolar ridge)
  EN (optionally):

/ʂ/ e.g. *try*
/ʐ/ e.g. *dry*

Places of articulation (5): Coronal articulations

- **palato-alveolar** (tongue blade and the back of the alveolar ridge)

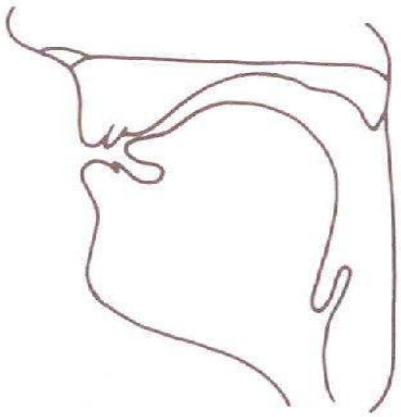
  /ʃ/ e.g. *shrew*

  /ʒ/ e.g. *measure*

  /tʃ/ e.g. *chimpanzee*

  /dʒ/ e.g. *lodger*

- **alveolo-palatal** (the blade and the center of the tongue and the front of the hard palate), e.g. <u>in Polish</u>:



  /ɕ/ e.g. *śnieg*

  /ʑ/ e.g. *ziarno, zwieźle*

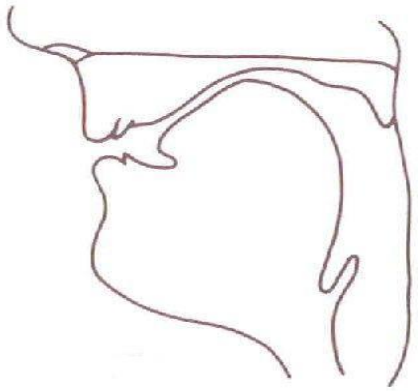
  /tɕ/ e.g. *ćma, ciemno, pięć*

  /dʑ/ e.g. *dźwięk, przedziwny*

  /ɲ/ e.g. *niania, mięsień*

Places of articulation (6): Coronal articulations

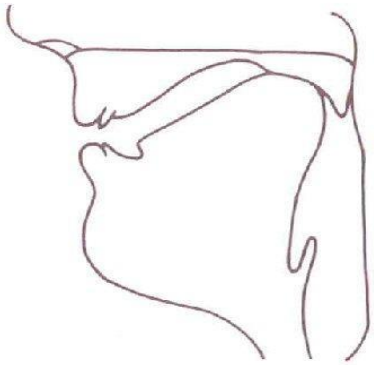
- **palatal** (the center of the tongue and (the back of) the hard palate)



/j/ e.g. *y*outh

Places of articulation (7): Dorsal articulations

- **velar** (tongue back and soft palate)



/k/ e.g. *hack*

/g/ e.g. *hug, ghost*

/ŋ/ e.g. *hang*

/w/ e.g. *want*

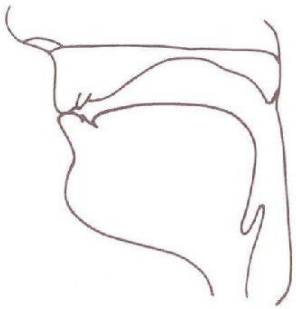
- **uvular** (tongue back and uvula), e.g. French *„rat"*
- **pharyngeal** (tongue root and pharynx wall)
- **glottal** (vocal cords are the active and passive articulator), e.g. ***home, house***

Manner of articulation (1)

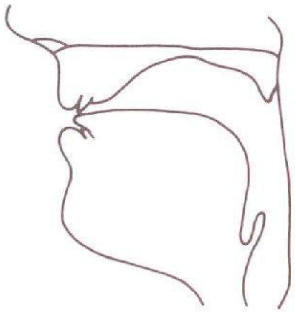
It refers to the *vertical relationship* (i.e. the distance) between the active and passive articulators.

Stops – complete closure of the articulators, the airstream can not escape through the mouth

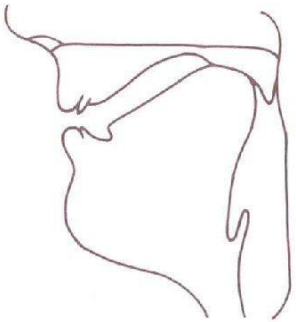
- Oral stops



Bilabial
/p/, /b/



Alveolar
/t/, /d/



Velar
/k/, /g/

- Nasal stops (-> nasals): **/m/, /n/** and **/ŋ/**

Manner of articulation (2)

Fricatives – close approximation of two articulators, the airstream is partially obstructed and turbulent airflow is produced.
(examples from English)

labiodental /f/, /v/
dental /θ/, /ð/
alveolar /s/, /z/
palato-alveolar /ʃ/, /ʒ/
glottal /h/

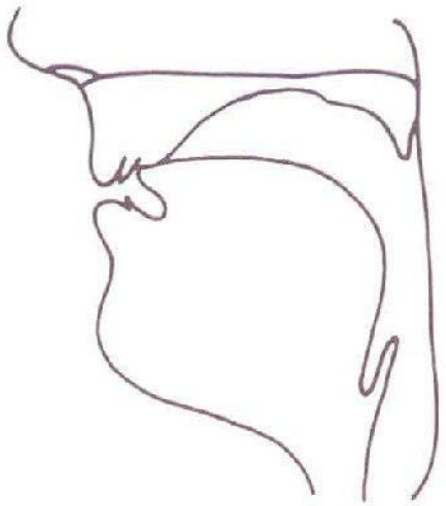
Affricates - involve more than one manner of articulation:
a combination of a stop followed by a fricative of the same place of articulation
(examples from Polish & English)

Polish:
dental /ts/, /dz/
alveolar /tʃ/, /dʒ/
alveolo-palatal /tɕ/, /dʑ/

English:
palato-alveolar /tʃ/, /dʒ/

Manner of articulation (3)

Liquids – the articulators approach each other, but to such an extent that there is a free passage of air through the oral tract



Alveolar
/l/ , /r/, /ɾ/, /ɹ/

lateral /l/ – produced with a central obstruction – the air passes out at the side, e.g. *love*

trill /r/ – articulator set in vibration by the airstream

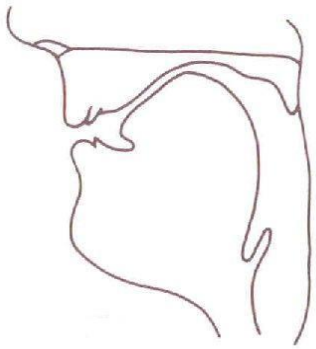
tap/flap /ɾ/ – a single movement in a trill, tongue hits the roof of the mouth, e.g. *better, ladder*

approximant /ɹ/ – approximation of two articulators with no turbulent airstream, e.g. *red*

Manner of articulation (4)

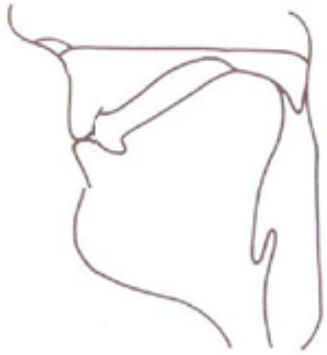
Glides

- the articulators are wide apart and the air flows unhindered
- the position of the articulators is unstable
- like consonants they do not form the nuclei of syllables



/j/

yacht, young



/w/

we, want

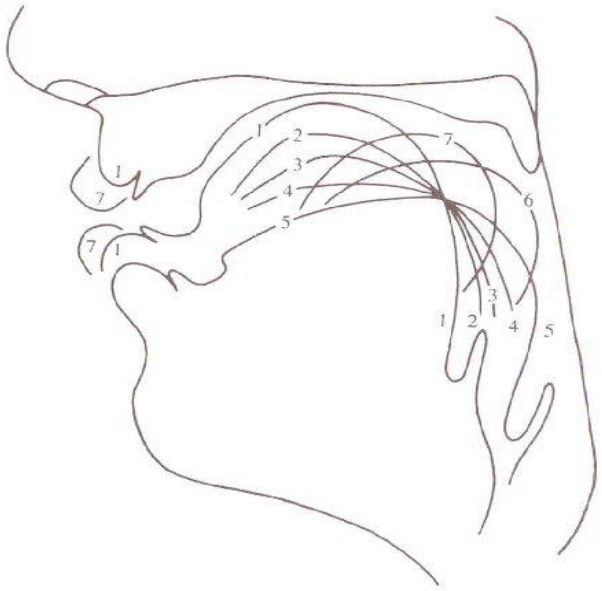
Glides and liquids are classified as ***approximants.***
Together with nasals and vowels they belong to ***sonorants.***

The articulation of vowels (1)

Open approximation – the articulators do not come very close together; an unobstructed passage for the airstream in the oral cavity

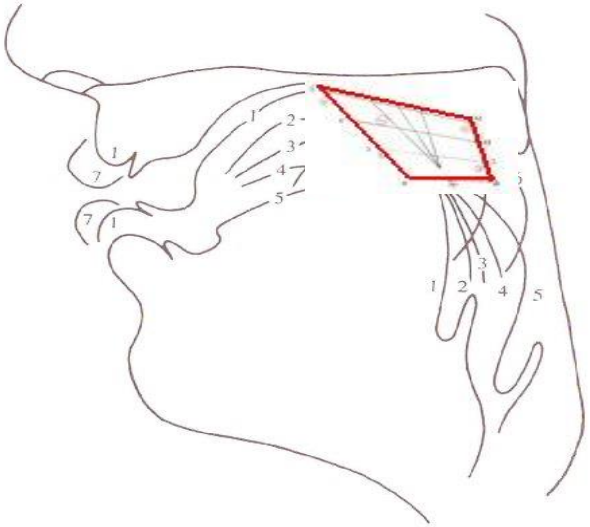
Classification of vowels:

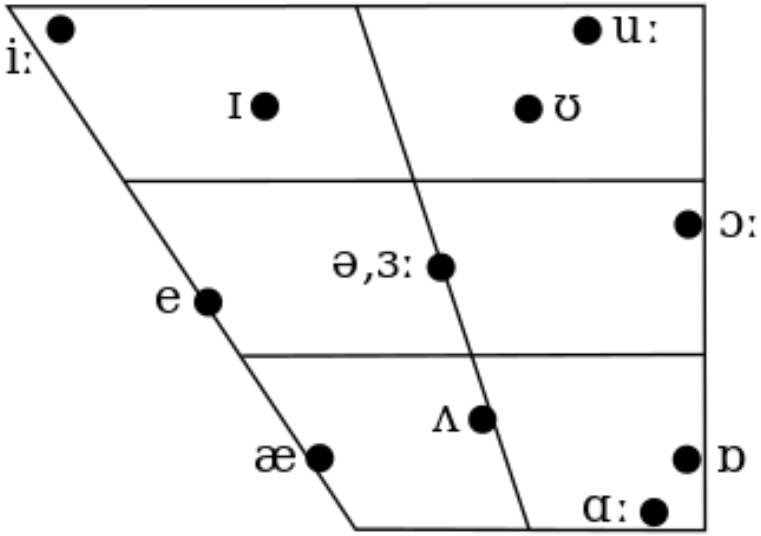
- Vertical position of the body of the tongue -> **front** and **back** vowels
- Horizontal position of the body of the tongue -> **high, mid** and **low** vowels
- Lip rounding -> **rounded** and **unrounded** vowels



1) heed, 2) hid , 3) head, 4) had, 5) father, 6) good, 7) food

The articulation of vowels (2)





Audio demonstration of BBC English vowels (and consonants):
http://www.teachingenglish.org.uk/article/phonemic-chart
Videos of vowel articulation:
http://www.phonetics.ucla.edu/vowels/chapter11/chapter11.html
http://www.rose-medical.com/vowel-sounds.html

The articulation of vowels (3)

Audio examples from British English and American English

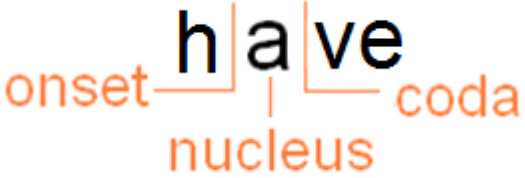
	b__d	IPA		b__d	IPA
1	bead	iː	11	booed	uː
2	bid	ɪ	12	bud	ʌ
3	bayed	eɪ	13	bird	ɜː
4	bed	ɛ	14	bide	aɪ
5	bad	æ	15	bowed	aʊ
6	bard	ɑː	16	Boyd	ɔɪ
7	bod(y)	ɒ	17	beer	ɪə
8	bawd	ɔː	18	bare	ɛə
9	budd(hist)	ʊ	19	byre	aə
10	bode	əʊ	20	boor	ʊə

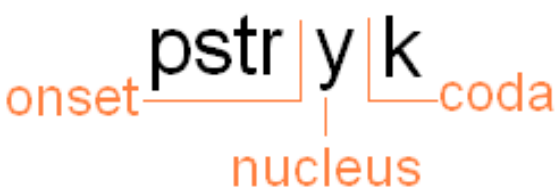
	b__d	IPA		b__d	IPA
1	bead	iː	9	bode	oʊ
2	bid	ɪ	10	booed	uː
3	bayed	eɪ	11	bud	ʌ
4	bed	ɛ	12	bird	ɜ˞ː
5	bad	æ	13	bide	aɪ
6	bod(y)	ɑː	14	bowed	aʊ
7	bawd	ɔː	15	Boyd	ɔɪ
8	budd(hist)	ʊ			

Consonants vs. vowels

The distinction between ***vowels*** and ***consonants*** is primary in the analysis and description of speech.

- Vowels:
  - articulated with an <u>open approximation</u>
  - syllabic (nucleus)
- Consonants:
  - articulated with some kind of an <u>obstruction</u>
  - non-syllabic* (onset, coda)





*Nasals and liquids (/m/, /n/, /ŋ/, /r/, /l/) may be syllabic in unstressed syllables (Roach, 2004)

Suprasegmental features (1)

These features are superimposed on units larger than a single speech unit (phoneme) -> syllables, phrases, sentences.

They include:

- variation in stress
- variation in pitch
- (variation in length)

Analysis and description – in relation to other items in the same utterance – relative values are linguistically significant.

Suprasegmental features (2)

- Variation in stress
  - increased activity of respiratory and laryngeal muscles
- functions
  - Grammatical e.g. (En) in**s'ult** (verb) vs. **'in**sult (noun)
  - Lexical e.g. (Pl) **j'a**jem vs. ja **j'em**
  - Grouping e.g. (Pl) do **d'o**mu
  - Demarcative e.g. (Pl) nieda**l'e**ko, po**j'u**trze
  - Cumulative
  - Emphasis (focus) or contrastive emphasis

British English		American English
	*(an)insult* *(to) insult* *(a) pervert* *(to) pervert* *(an) overflow* *(to) overflow*	
*I want a **red** pen, not a **black** one*		

Tables and audio examples downloaded from: http://www.phonetics.ucla.edu/course/chapter1.1/chapter1.1.htm#four

Suprasegmental features (3)

- Variation in pitch
  - laryngeal activity
  - *intonation* – patterns of distinctive changes in pitch
  - domain: phrases, sentences
  - convey semantic, evidential and regulative information

British English		American English
	*This is my father* *Is this your father?* *This is a cat* *This is a cat?*	

Tables and audio examples downloaded from:
http://www.phonetics.ucla.edu/course/chapter1.1/chapter1.1.htm#four

Thank you for your attention!

I used tables, audio examples and graphs from the book „A course in phonetics" available at: http://www.phonetics.ucla.edu/course/contents.html and „Vowels and consonants" available at: http://www.phonetics.ucla.edu/vowels/contents.html