

# Speech recognition and synthesis

## 1 Speaking and hearing

- The soundchain
- Phonetics and Phonology
- Speech
- Source-filter model of speech production
- Hearing
- Speech sounds
- Dutch consonants
- Dutch vowels
- Assignment
- Bibliography

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# The soundchain

From idea to sound to perception to idea to sound...



# Phonetics and Phonology

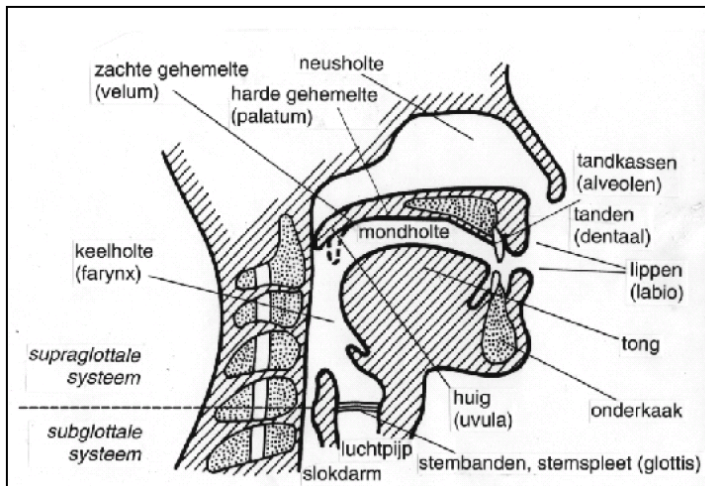
- **Phonetics:**
  - Physics of speaking, sound, and hearing  
Production, signal characteristics, differences...
  - analysis speech signal
- **Phonology:** sound systems
  - Vowel and consonant system: **Phones & Phonemes**
  - Allowed combinations:
  - Sound changes: **Assimilation** and **Coarticulation**
  - **Prosody**

Phonetic reps: [a]

Phonological reps: /a/



# The parts involved in speaking



# Source-filter model of speech production

Each speech sound has a source of sound which is filtered by the vocal tract

- The source can be glottal vibrations, airflow noise from a constriction, or a trill
- In general, the source sound has a flat (pink) spectrum
- The filter is the complete oral and/or nasal cavities or the part following a constriction
- It can in general be assumed that source and filter act independently



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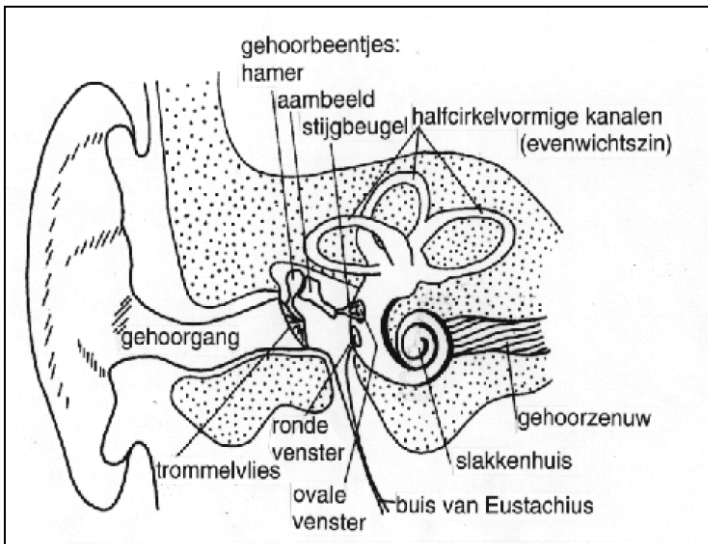
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# The ear



# Basic speech sounds

## Two categories

### 1 Vowels

Hardly any constriction in the vocal tract

### 2 Consonants

Constriction in the vocal tract

## Classification

- **Manner of articulation** (sound source)  
Fricative, plosive, nasal, ...
- **Place of articulation** (filter shape)  
Constriction at the lips, teeth, **alveolar ridge**, **palate**, ...
- **Voicing**  
Vibrating **vocal folds** or not

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### • Voicing

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# Manner of articulation

- **Plosive:** p, t, k  
Complete closure, pressure building up, release
- **Fricative:** f, s  
Almost complete closure
- **Liquids:** r, l  
Air escapes laterally from the tongue
- **Nasals:** m, n  
Air escapes through the nose
- **Approximants:** w, j  
Constriction without turbulence



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# Place of articulation

p, t, k are different

- **Labial:** b  
Both lips (bilabial)  
Lower lip and the upper teeth (labiodental)
- **Dental:** d  
Tongue against the upper teeth
- **Alveolar:** s  
Tongue against or close to the superior alveolar ridge
- **Palatal:** j  
Body of the tongue raised against the hard palate
- **Velar:** k  
Back part of the tongue (the dorsum) against the soft palate
- **Uvular:** huig-r  
Back of the tongue against or near the uvula
- **Glottal:** h  
Consonants articulated with the glottis  
dental+alveolarl = coronal  
velar+uvular = dorsal



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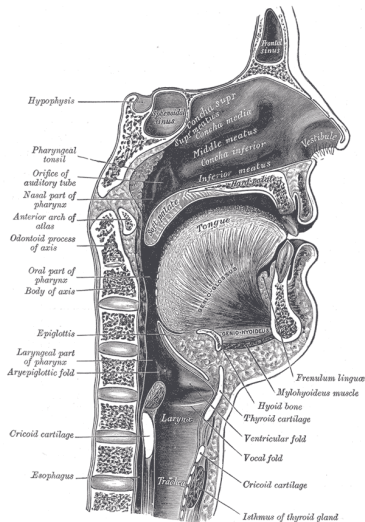
velar+uvular = dorsal



## Voicing

Are the **vocal folds** vibrating?

- Voiced: b, d, g
- Voiceless: p, t, k



# Dutch consonants

Plosive	p	b	t	d			k	g
	<u>p</u> aal	<u>b</u> aal	<u>t</u> aal	<u>d</u> op			<u>k</u> ok	<u>g</u> oal
Fricative	f	v	s	z	ʃ	ʒ	x	ɣ
	<u>f</u> iets	<u>v</u> ies	<u>s</u> ier	<u>z</u> ier	<u>s</u> jaal	<u>r</u> ouge	<u>a</u> cht	<u>g</u> e
Nasal		m		n		ŋ		ŋ
		<u>m</u> aar		<u>n</u> aar		or <u>a</u> nje		ri <u>n</u> g
Liquid				l				
				<u>l</u> euk				
				ɹ				
Affricate				ter <u>ʃ</u>				
		ʋ				j		
		<u>w</u> eeke				jeuk		



# Dutch consonants

Plosive	p <u>paal</u>	b <u>baal</u>	t <u>taal</u>	d <u>dop</u>			k <u>kok</u>	g <u>goal</u>
Fricative	f <u>fiets</u>	v <u>vies</u>	s <u>sier</u>	z <u>zier</u>	ʃ <u>sjaal</u>	ʒ <u>rouge</u>	x <u>acht</u>	ɣ <u>gele</u>
Nasal		m <u>maar</u>		n <u>naar</u>		ɲ <u>oranje</u>		ŋ <u>ring</u>
Liquid				l <u>leuk</u>				
				ɹ <u>ter</u>				
Affricate		ʋ <u>week</u>				j <u>jeuk</u>		



# Dutch consonants

Plosive	p pa <u>al</u>	b ba <u>al</u>	t ta <u>al</u>	d do <u>p</u>			k ko <u>k</u>	g go <u>al</u>
Fricative	f fi <u>ets</u>	v vi <u>es</u>	s si <u>er</u>	z zi <u>er</u>	ʃ sja <u>al</u>	ʒ rou <u>ge</u>	x a <u>cht</u>	ɣ ge <u>le</u>
Nasal		m ma <u>ar</u>		n na <u>ar</u>		ɲ oran <u>je</u>		ŋ ri <u>ng</u>
Liquid				l le <u>uk</u> r ter <u> </u>				
Affricate		ʋ we <u>ek</u>				j je <u>uk</u>		



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Nasal		m maar		n naar		ɲ oranje		ŋ ring
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dax jonəs en meɪfəs



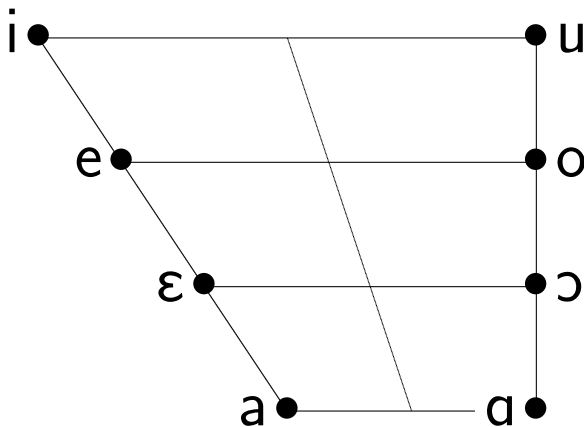
# Vowels

## Place of articulation

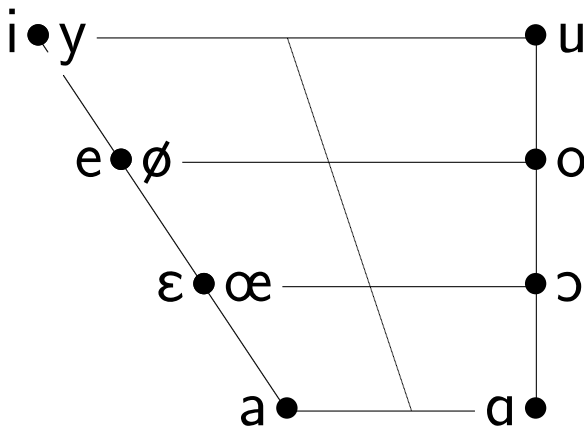
- Position tongue blade
  - Front-back: /i/, /u/
  - High-low (closed-open): /u/ - /a/
- Lips spreading/rounding: /i/, /y/



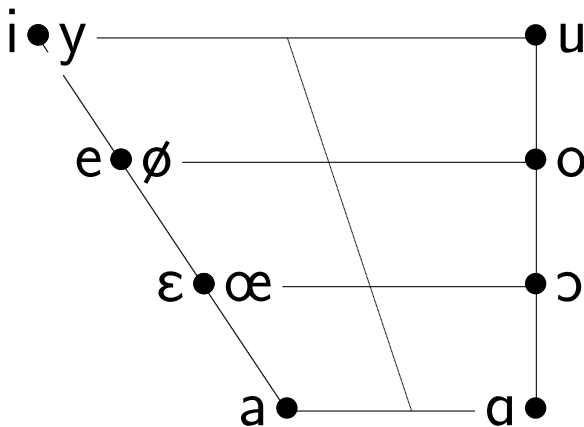
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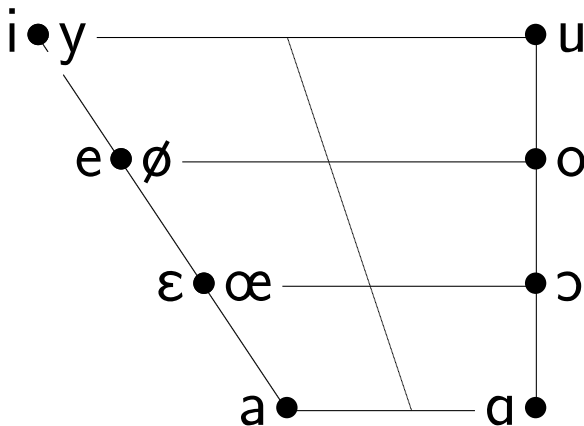
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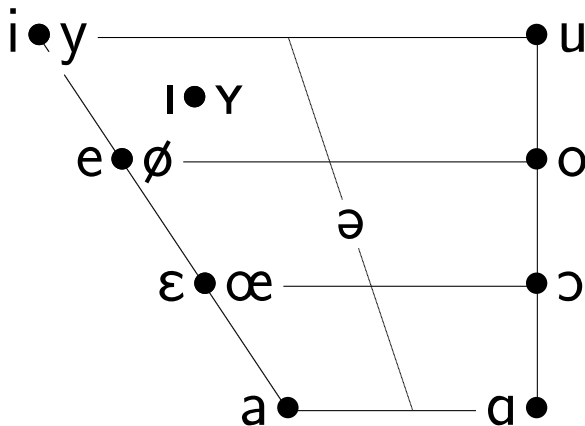


Any vowels we forget?





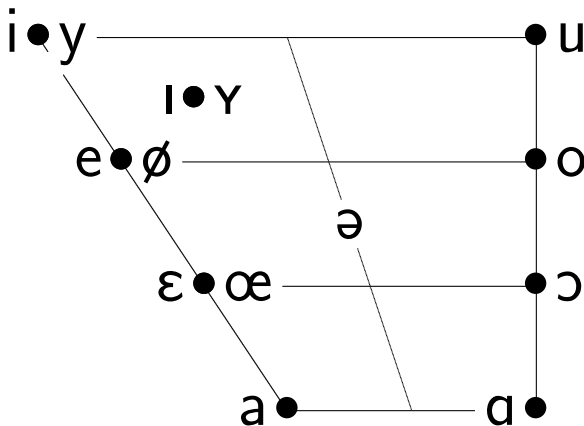
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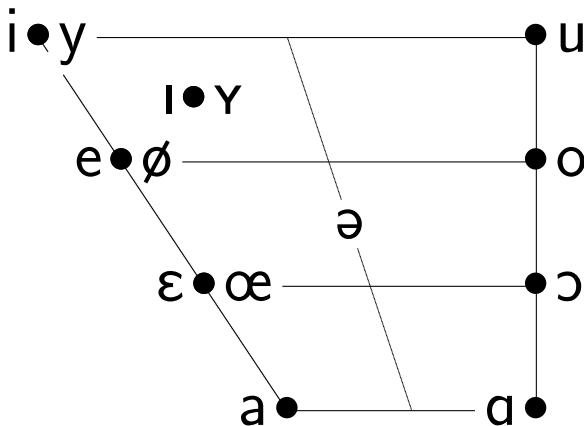
# Dutch vowels



Speak aloud: /au/



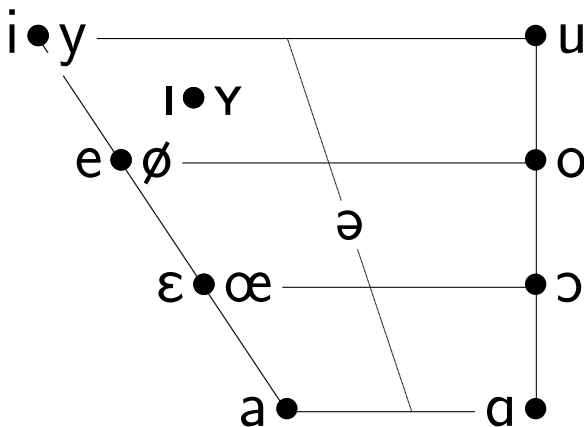
# Dutch vowels



Speak aloud: /œy/



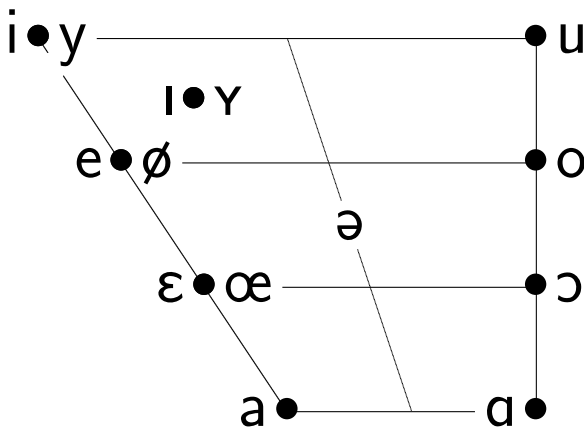
# Dutch vowels



Speak aloud: /ɛi/



# Dutch vowels



Speak aloud: /ɑu/ /œy/ /ɛi/



# Assignment- Week 1a Introduction to praat

## See BlackBoard for full description

- Download and install praat <http://www.praat.org/>.
- Create a sine tone in noise
- Edit
- Inspect the spectrogram
- Record your own whistle and study the spectrogram



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# Assignment- Week 1b Phonemes in Speech

## See BlackBoard for full description

- Record a sentence
  - Try to determine the position of individual words, are there pauses?
  - Try to determine the position of selected individual phonemes
  - Listen to individual phoneme segments. Do identical phonemes sound the same?
  - Are phonemes altered or reduced in running speech?



# Assignment- Week 1b Phonemes in Speech

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# Further Reading

Peter Ladefoged & Ian Maddieson, *The sounds of the world's languages*, Blackwell, 1996

Peter Ladefoged, *Vowels and consonants*.





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