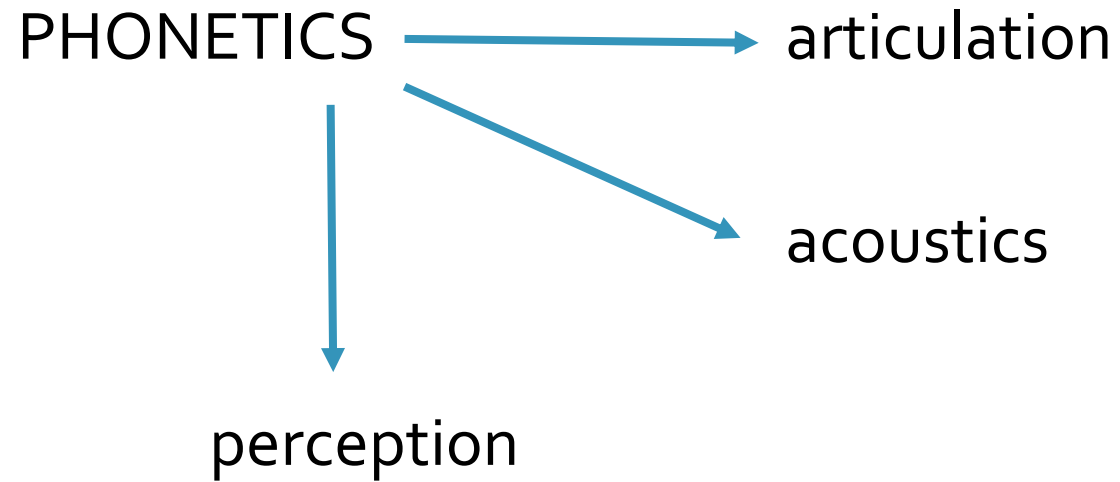


Methods of phonetic investigation

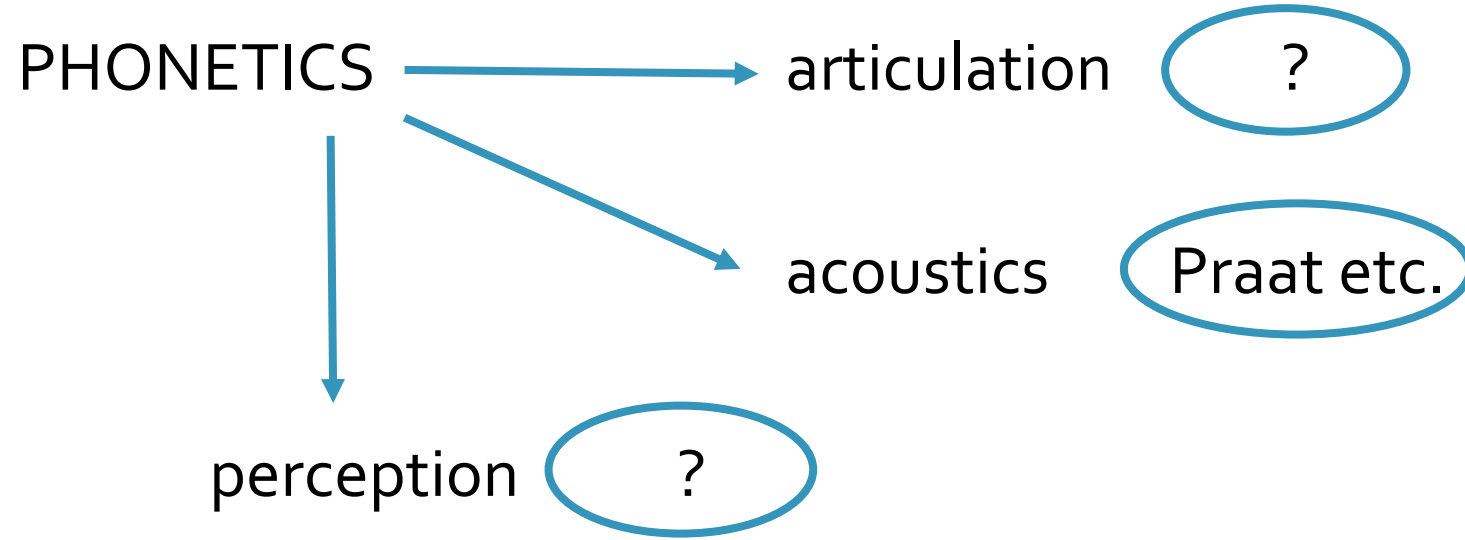
Inna Sieber

innasieber@gmail.com

What can we study?



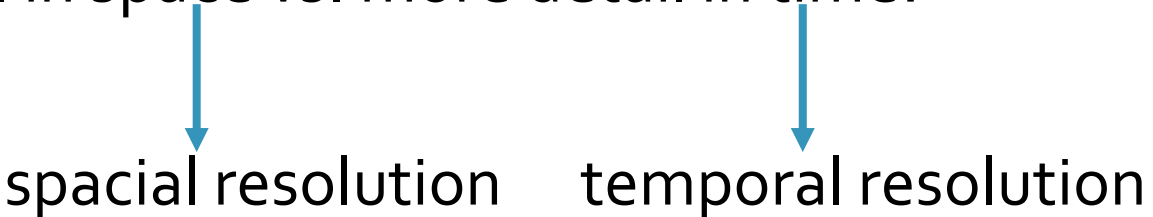
How can we study?



Searching for the balance

- Safe and comfortable, less knowledge vs.
unsafe and uncomfortable, more knowledge?
- Special purpose vs. universal?
- More detail in space vs. more detail in time?

Searching for the balance

- Safe and comfortable, less knowledge vs.
unsafe and uncomfortable, more knowledge?
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spacial resolution temporal resolution

Searching for the balance

- More detail in space vs. more detail in time?

spacial resolution

X-ray

temporal resolution

Electropalatography

- Comparable to other techniques? audio, ultrasound...

Types of techniques

```
graph TD; A[Types of techniques] --> B[imaging tools]; A --> C[point-tracking tools]; A --> D[no spacial information];
```

imaging tools

- endoscopy
- x-ray film
- ultrasound (UTI)
- electropalatography (EPG)
- magnetic resonance imaging (MRI)

point-tracking tools

- Optotrak
- electromagnetic articulometers (EMA)

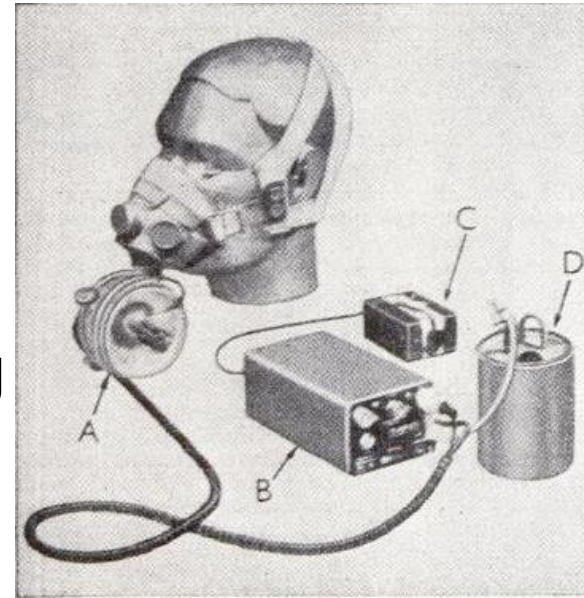
no spacial information

- electromyographs (EMG)
- airflow meters
- electroglottographs (EGG)

Techniques

- Measuring muscle activation: **electromyography** (EMG)
- Measuring airflow and air pressure during speech: **pneumotachograph**
(a speech airflow meter)

An airtight mask on the mouth/nose
attached to sensors that detect airflow



DETAILS OF THE IMP—(a) the flowmeter;
(b) the integrating and sampling unit; (c) the
90V dry battery; (d) the aluminium sample tin.

1958

2018



Techniques

- Measuring vocal fold closure: **electroglottography** (EGG)

A collar around the throat with electrodes on it

Measures the electrical resistance between them

Electricity passes through flesh much more easily than through air

😊 non-invasive

😊 easy-to-use

😊 shows the degree of closure

😊 high temporal resolution

no information about:

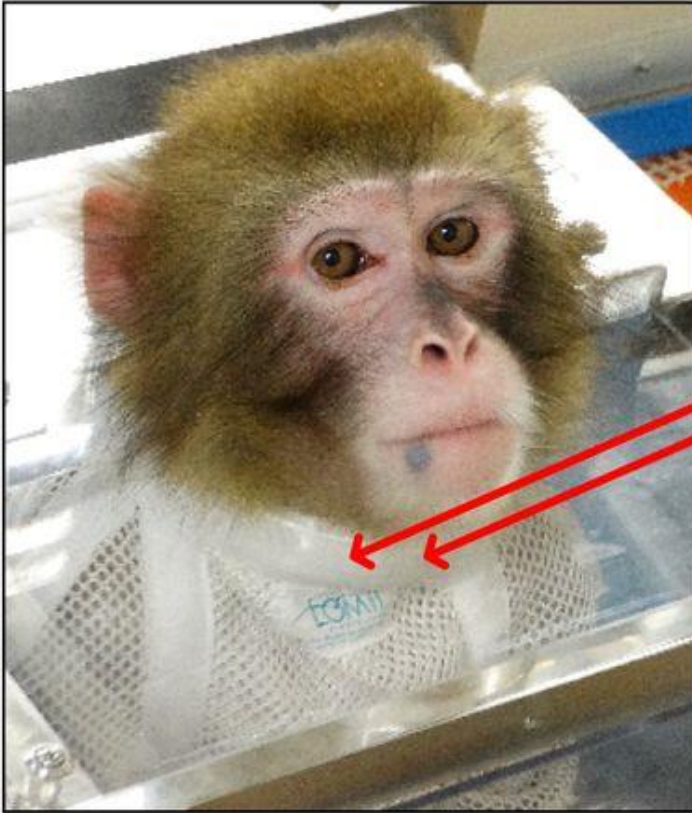
😞 degree of opening

😞 the location of the opening

😞 the larynx as a whole

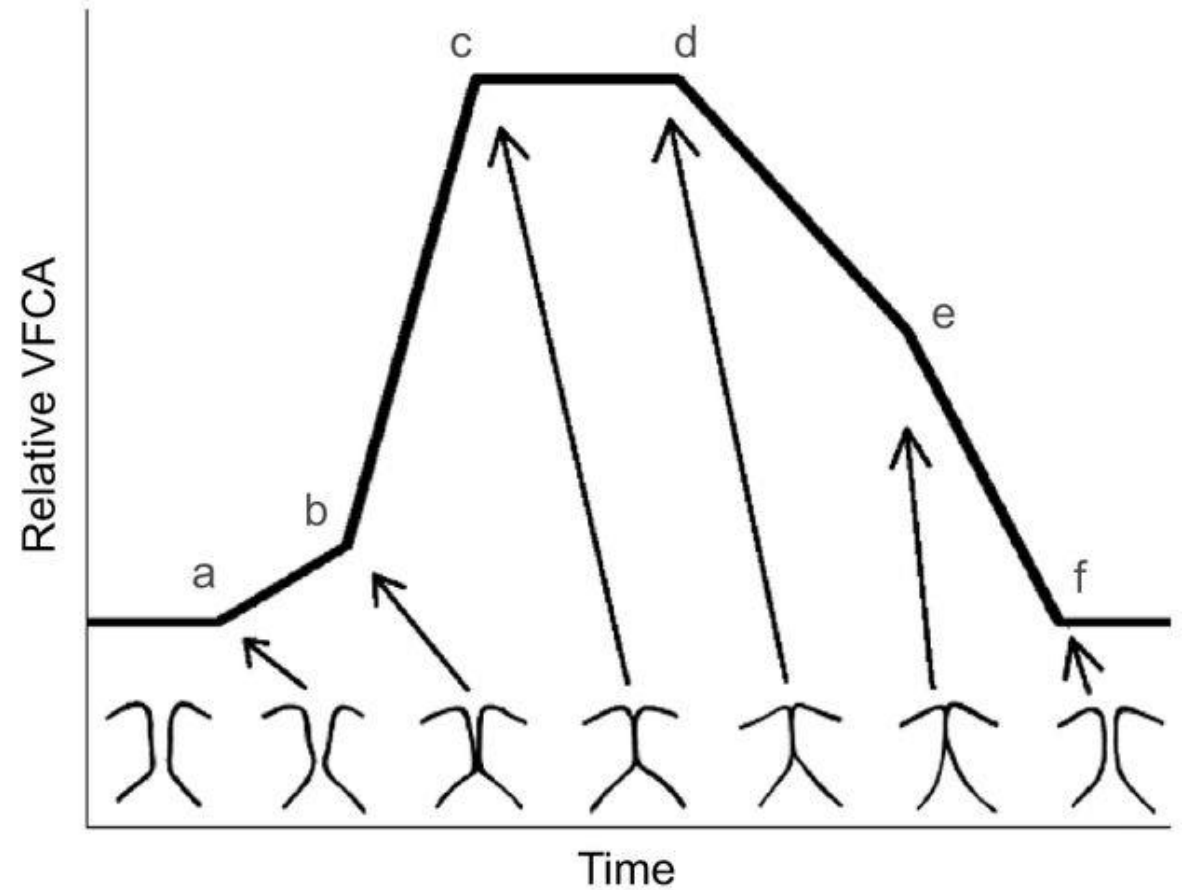
Electroglottography

A



EGG
electrodes
embedded
in collar

B



Techniques

Endoscopy

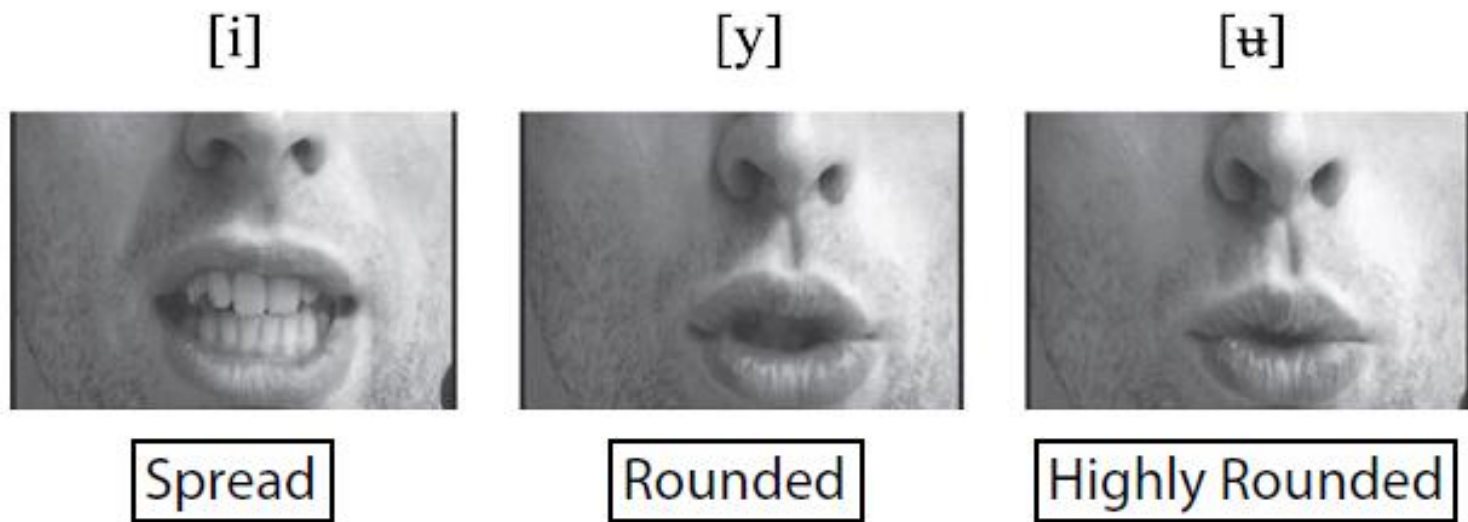
- 😊 dynamics
- 😊 shows the degree of opening
- 😊 high temporal resolution
- 😞 vertical variation can't be observed
- 😞 requires anesthetization and medical supervision

Video!



Techniques

- **Video:** moving articulators! but lips only



Video images of lip constrictions in Norwegian (speaker: S. S. Johnsen).

Techniques

- Point-tracking techniques: Optotrak
 - Diodes are attached to the face and lips
 - Three cameras are tracking 3D movements
 - Excellent spatial resolution, excellent temporal resolution
 - Requires lots. of. money.
 - And lab space

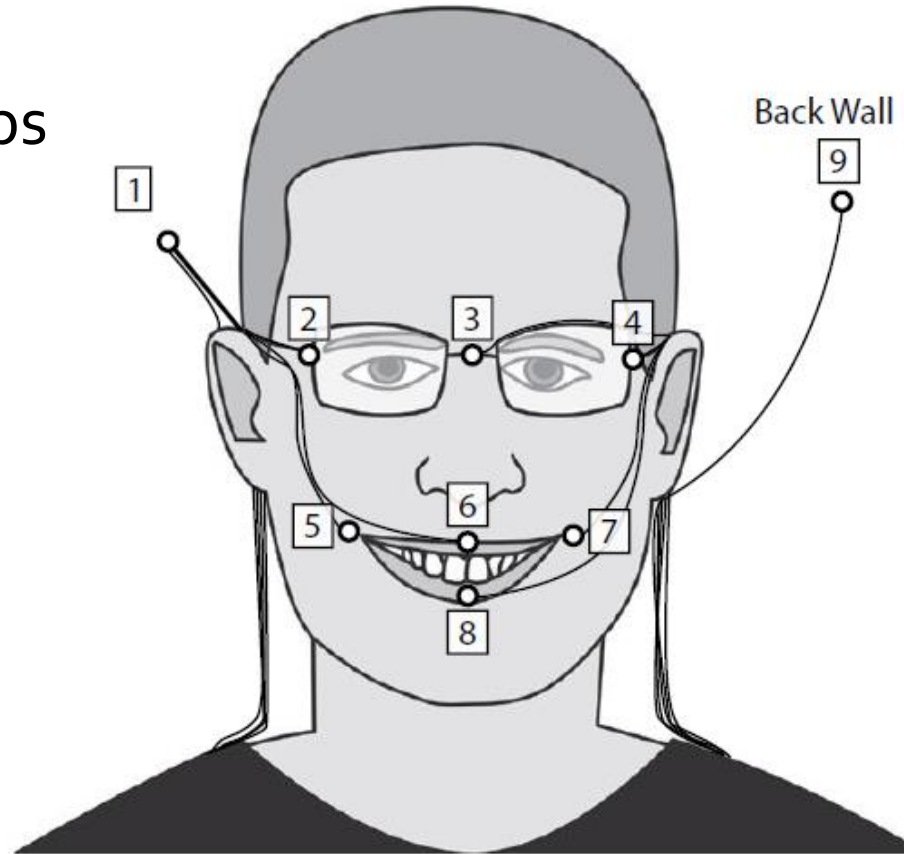


Figure 10.6 Optotrak: example placement of nine infrared markers (image by D. Derrick).

Techniques

- Static (traditional) **palatography** and **linguography**
traces on the palate traces on the tongue

Video!



Ideal for the field!
No equipment, quickly

but



Only a single instance
Unpleasant experience

- **Electropalatography** (EPG): a palatal insert with electrodes

Dynamic picture
Excellent temporal resolution
Add the ultrasound

Inserts are made for a person
Inserts are expensive
Inserts are time consuming

Techniques

- **Electropalatography (EPG):**
a palatal insert with electrodes

Video!

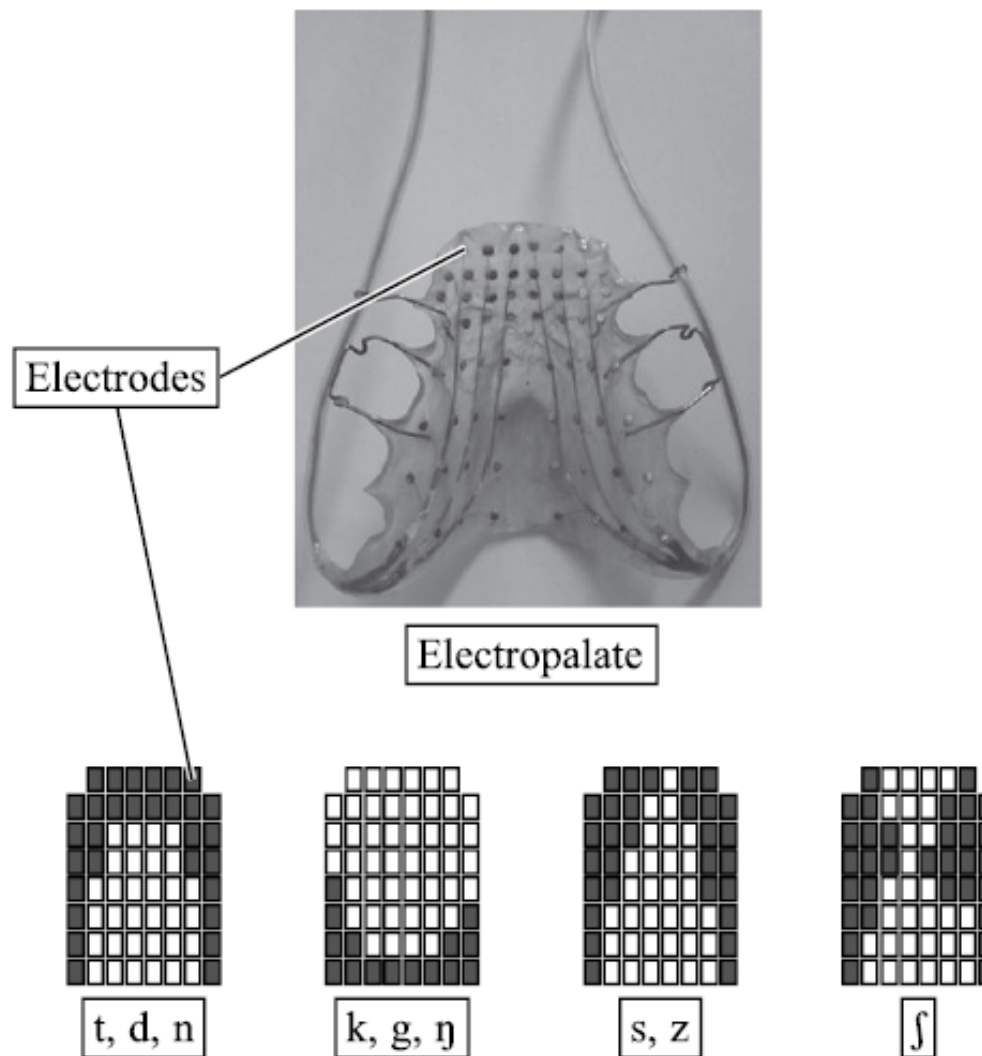


Figure 9.5 An electropalate (top) and electropalatography data (bottom); black cells indicate tongue contact on the electropalate (image by D. Derrick).

Techniques: X-ray video

(= cineradiography = cinefluorography = cineroentgenography)

- High frequency radiation is able to pass through many material
- The denser – the harder to pass through – the lighter colour
- High-density tissues (bones) absorb X-rays → white
- Less dense (muscle, fat) absorb less X-rays → shades of gray
- The least dense (air) is penetrated → black

Techniques: X-ray video

😊 Shows the entire head

😞 Shadows: not easy to interpret

😊 Everything is perfect but...

😞 Exposes subjects to ionizing radiation

😊 Many old videos are ok

Techniques: computer tomography (CT)

3D X-ray taken around a rotational axis

😊 extremely high spatial resolution

😞 poor temporal resolution

😞 irradiates a person with too much ionizing radiation
some risk of causing cancer

Techniques: Ultrasound, ultrasound tongue imaging (UTI)



- The tongue's surface shape, from epiglottis to tongue tip!
- How much time it takes for sound waves to travel back to the transducer?
- Bones, air doesn't go back – not imaged
- Air, air goes back sharply – white
- White line marks the upper surface of the tongue

Video!

Techniques: magnetic resonance imaging (MRI)

😊 All the vocal tract!

😊 Amazing picture

😞 Low temporal resolution

😞 Terrible noise

😞 The speaker must lie down

UTI: only the tongue and chin

UTI: low spatial resolution

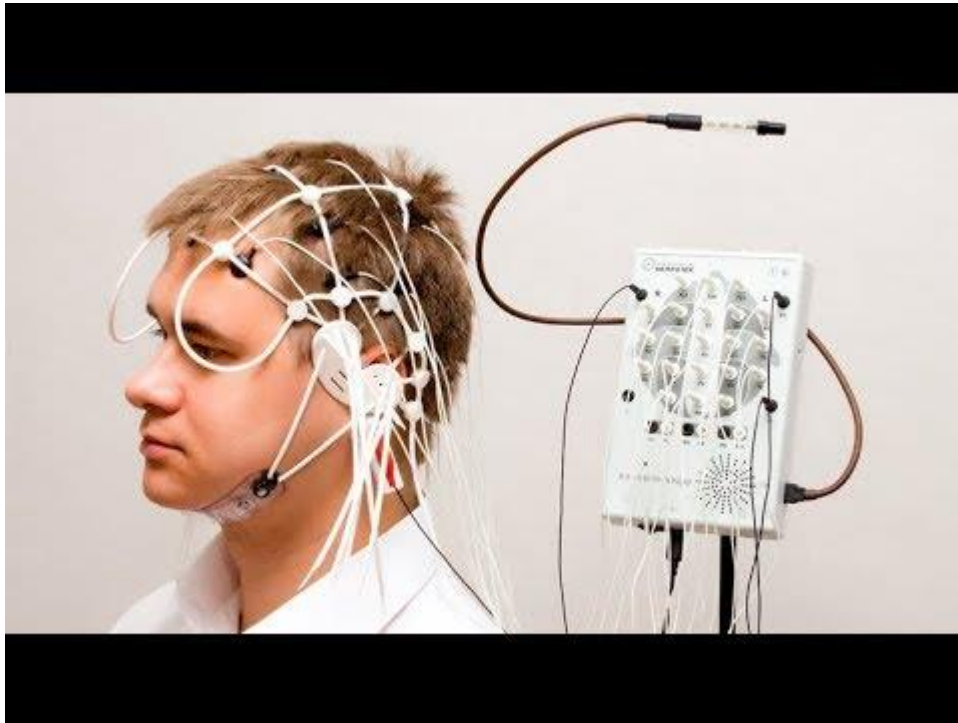
UTI: high temporal resolution

UTI: nice! and sound recording

UTI: do what you want!

Video!

Brain studies: EEG



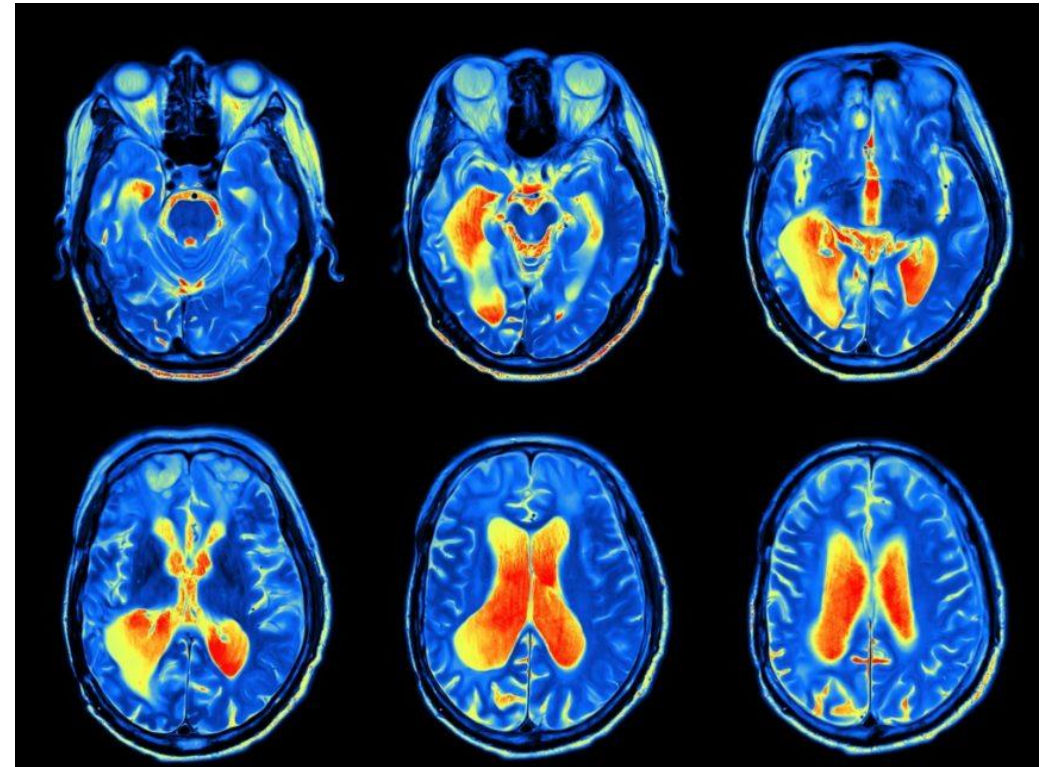
Brain studies: fMRI, PET...

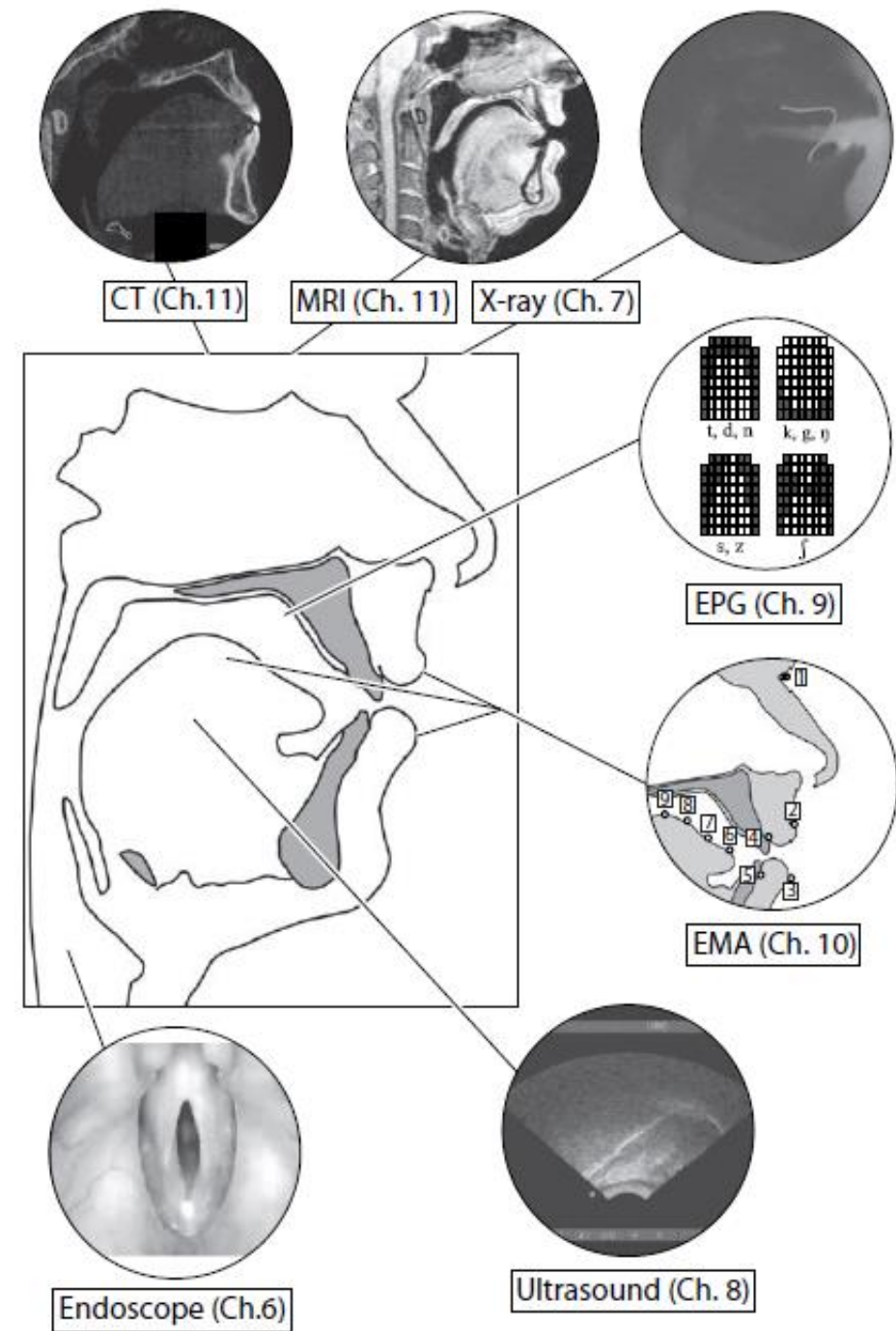
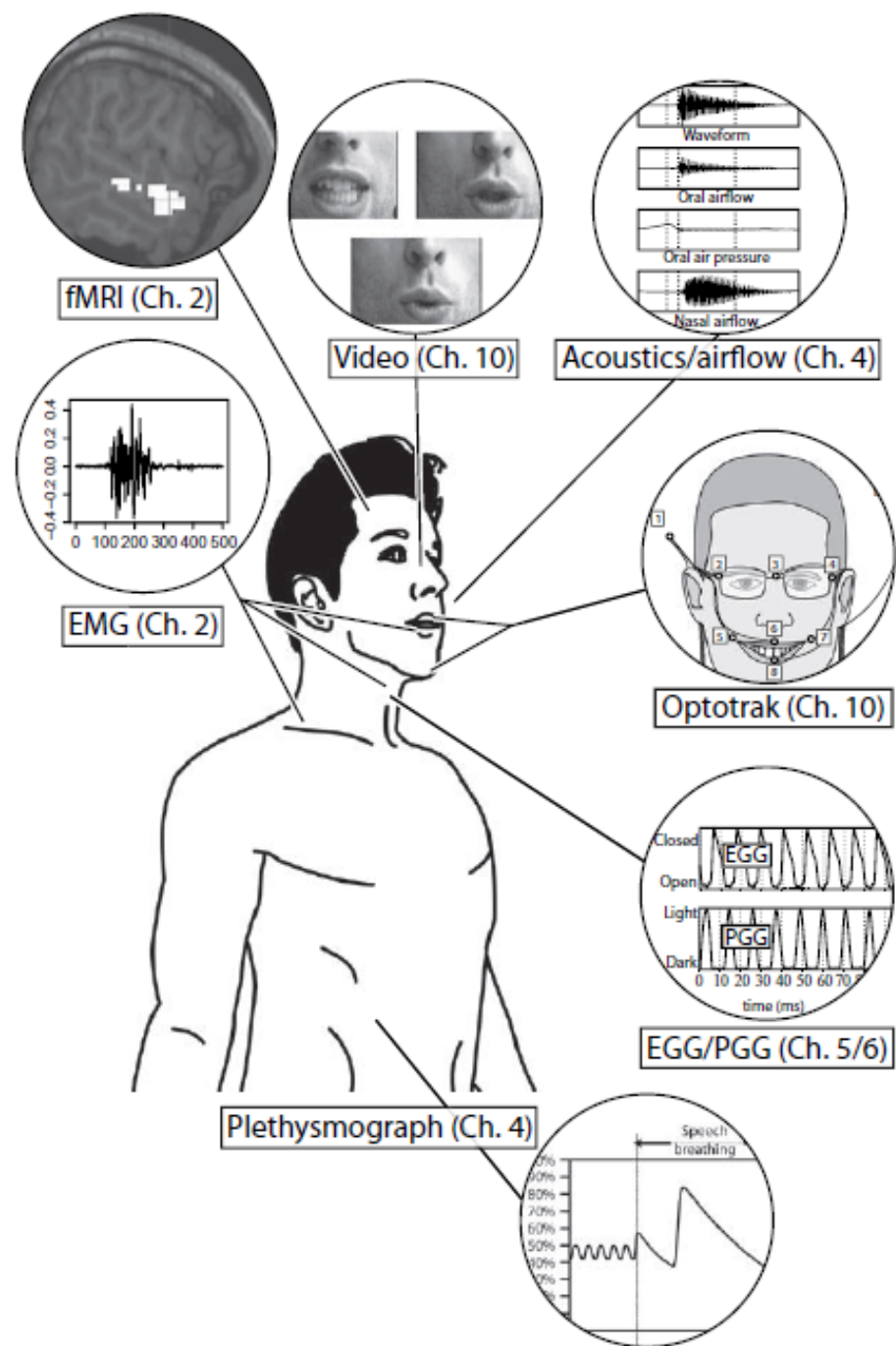
- Functional magnetic resonance imaging (fMRI)
- Positron emission tomography (PET)

😊 PET scans are quieter

😊 not susceptible to data loss from motion

☹ the need to introduce radioactive isotopes into blood





Reading

- Bernhardt, B. M., Gick, B., Bacsfalvi, P., and Adler-Bock, M. (2005). Ultrasound in speech therapy with adolescents and adults. *Clinical Linguistics and Phonetics*, 19, 605–617.
- Epstein, M. A. and Stone, M. (2005). The tongue stops here: ultrasound imaging of the palate. *Journal of the Acoustical Society of America*, 118, 2128–2131.
- Gick, B. (2002). The use of ultrasound for linguistic phonetic fieldwork. *Journal of the International Phonetic Association*, 32, 113–121.
- Gick, B., I. Wilson D. Derrick (2012). *Articulatory phonetics*. John Wiley & Sons.