Speech assessment: to what purpose?

- For rehabilitation: pathology is known, rehabilitation goal is defined
  - Assessment = to control the goal
  - Important to evaluate the results (only 1 patient /10 finish voice rehabilitation)
- The patient is its own reference
- Example: rehabilitation of parkinsonian hypophonia
  - Measurement of SPL intensity
Speech assessment: to what purpose?

- To quantify the speech disorder and compare patients


✓ 449 speakers (including 391 patients)
✓ Perceptual assessment with GRBAS scale (Nakano, 1981)
✓ Instrumental assessment:
  - Jitter, signal/noise ratio
  - Max phonation time, voice range,
  - Estimated sub-glottal pressure, oral airflow

✓ Correlation between (perceptual) severity and measures

Multiparametric voice assessment

- Jitter
- TMP
- ESGP
- SR
- VR
- OAF
Hearing machines?

- Instrumental assessment as complement of perceptual assessment

- ... but instruments are not hearing machines
  - Instrument can measure phenomena which can be not audible
  - Human can hear information that instrument can not measure

Speech assessment: to what purpose?

- Speech disorder as a marker of
  - Neurological disease
  - Therapeutic effect
    - Pharmacologic
    - Stimulation

- Instrumental speech assessment: indirect way to catch the general neurological disorder

- Brain imaging is more direct
Instrumental assessment of speech

- Electromagnetic Articulography
- Electro-PalatoGraphy
- Electromagnetic Articulography
- Electromagnetic Articulography
- Electromagnetic Articulography
- Electromagnetic Articulography
- GlottoGraphy
- GlottoGraphy
- GlottoGraphy
- MyoGraphy
- IRM

Laryngeal function acoustic assessment

- Measuring F0 instability
  - Medium term instability (coef. variation of F0, trémor)
  - Short term instability (jitter, shimmer)
  - Global structural instability (coef. Lyapounov)
- Signal/noise ratio
- Effort measure
  - Maximal phonation time
  - Voice range (phonetogram)

Techniques based on automatic speaker recognition

References:
Acoustic speech assessment

- Measuring formants
  - Formant = frequency resonance
  - Linked to vowel articulation
  - In theory, F1 opening, F2 front
- Static measuring precision
- Transitions dynamic
- Vowels formants can be centralised


Acoustic speech assessment

- Voice Onset Time
  - VOT = temporal delay between burst and voice
  - Indicator of coordination between articulators and vocal folds
- Bad coordination can introduce longer/shorter time

Aerophonometry: why?

- Speech is based on air movement: phonation, consonant noise
- Speech is the result of a precise and regulated control of expiration and constraints linked to the flow in the vocal tract
- EVA 2 system: multiparametric speech recorder developed by LPL and distributed by SQLab company

Aerophonometry advantages

- Acoustic signal = source + complex filter
- Aerophonometry
  - more direct
  - more selective
- Information on dynamic and coordination of organs
Clinical applications of aerophonometry

- Objectives measures of pneumo-phonatory disorders
- Objectives measures of articulatory disorders
  - Velum (rhinolaly)
  - Precision and coordination of lingual and labial gestures

Voice analysis with aerophonometry


- 63 female ALS patients:
  - 40 with bulbar symptoms (sALS patients)
  - 23 without bulbar symptoms (aALS patients)
- 40 normal female subjects
- Acoustic and aerodynamic measures were significantly different between sALS patients and control patients
- Measurements can predict bulbar involvement in 73% of those in the sALS group
Pneumophonatory coordination


- Parkinson disease and effect of DBS

- Estimated sub glottal pressure of PD patients (with DBS ON/OFF) and control speakers
Aerophonometry and velum motricity

- « normal » speaker

- Parkinson woman ON-dopa (884)
  « ta toupie va trop vite »

<table>
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<th></th>
<th>Expiré</th>
<th>Inspiré</th>
<th>Total</th>
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<td>-0.000</td>
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<tr>
<td>Nasal</td>
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<tr>
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<tr>
<td>% nasalité</td>
<td>36.4 %</td>
<td>36.1 %</td>
<td>36.4 %</td>
</tr>
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</table>
Aerophonometry and velum motricity

- Parkinson woman ON-dopa (884)
  « ta tante a chanté »

- Nasal Airflow is more important on stop consonants

Loc5 : maladie de Steinert

Document From Amelot et Roubeau (HEPG, Tenon, Paris, France)
Aerophonometry and velum motricity


- ENT
- Neurologists

Electrophysiological techniques

- Electroglottography (EGG)
- Electromyography (EMG)
- Electropalatography (EFG)
- Electromagnetic articulography (BEA)
- EEG
- MRI
Electroglottography (EGG)

Why: To have an image of vocal folds activity

How: Measurement of the impedance between two electrodes applied on the neck

- Glottis contact variation
- Impedance modulation
- Voltage modulation

Comments:
+ Very good measurements of the glottis oscillation frequency
- Does not measure the glottis aperture area
- It is not an acoustic signal

Remarks
- Modulation impedance: 100mOhm
- Current injected: 1mA
- Amplitude of the information: 100µV

Vocal folds closed

Vocal folds open
**EGG signal**

Close quotient EGG signal only when vocal fold oscillations, signal no disturbated by any modulation of the vocal tract.

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**Electromyography (EMG)**

- **Why:** To measure the muscle activity

- **How:** by recording on the skin the electrical activity, just above the muscle. (sometimes in the muscle itself)

- **Comments:** EMG signals are difficult signals to handle,
  - a lot of kind bursts with a large variety of statistic properties,
  - a poor signal to noise (SNR) ratio

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EMG signal analysis

«Tu es sûr ? Tu l'as vu ? »

Effect of the crico-thyroidien on the F0 control

Labial (lips) activity
Electropalatography (EPG)

AN EPG THERAPY PROTOCOL FOR REMEDIATION AND ASSESSMENT OF ARTICULATION DISORDERS

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ABSTRACT
This paper describes technical and methodological advances and the development of a procedure for measuring changes in accuracy and stability of lingual and palatal tongue-palate contact patterns during a course of visual feedback therapy use of electropalatography (EPG). The procedure is exemplified by a case in which therapy was aimed at resolving a pattern of voicing where the phonetic targets /r, g, y/ had almost alveolar placement [t, d, n]. The EPG remediation assessment procedure can be implemented using recorded feedback and analysis software designed for the purpose.

1. INTRODUCTION
One potentially valuable diagnostic and therapy procedure for articulation disorders is electropalatography (EPG). It records details of the location and timing of tongue contact with the hard palate during speech. One instrument records alveolar, post-alveolar, palatal, and velar placement, a register characteristic pattern for many consonants and vowels that occur in English, making it a useful technique.

Exploitations des mesures EPG

Le début (d) et la fin (f) de chaque phase linguopalatale (G pour geste, O pour occlusion et M pour maximum de contacts) sont indiqués sur l’oscillogramme et le signal EPG [locY]

Slamping Frequency 200Hz
Static palatography (SPG)

To overcome the EPG limitations....
+ Simple instrumentation, permits to study teeth contacts, no blind zone,
- only one articulation (one shot)

ElectroMagnetic Articulograph (EMA)

Why?: To study relatives podition, speed and accelerations of main articulators (jaw, tongue, lips).
How?: The participant is place inside 3 magnetic fields. Sensors (inductors) are stuck on the articulator to study, and they record a part of each of the 3 fields depending on their potitions and orientation.

Comments:
- 12 sensors
- Not less than 10 mm between two sensors
- 200Hz sampling frequency

Electroencephalography (EEG)

- **Why?** To provide information on the neurophysiological activity of the brain over time.
- **How?** Through electrodes placed on the scalp. The electrical signal on the scalp is the result of the summation of action potentials synchronous a large number of neurons.

**Comments**
- Very weak signal recorded on the scalp,
- Average calculation is needed (large number of runs to improve the SNR),
- Time accurate, source localization is tricky.

Magnetic Resonance Imaging (MRI)

- **Why?** Because MRI can acquire accurate (1 mm) 3D images of cortex, white matter, cerebro-spinal and basal ganglia.
- **How?**
  1. By observing the biological tissue through the magnetic properties of one of their principal constituents: the nucleus of hydrogen.
  2. Placed into an intense magnetic field (T), it results a magnetization at each point of the tissue (the magnetization is proportional to the density of hydrogen nuclei).
  3. The temporal characteristics of this relaxation (after the Magnetic resonance) depends strongly on the tissue.

**Comments**
- Good localization,
- In case of fMRI quite slow (a few Hz)
- Very noisy environment (± 110dB)
These techniques can be combined...but not too much!

Thank you for your attention