

Multiparametric speech assessment

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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

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Speech assessment : to what purpose?

- To quantify the speech disorder and compare patients

Yu P., Garrel R., Nicollas R., Ouaknine M., Giovanni A., "Objective voice analysis in dysphonic patients. New data including non linear measurements", Folia Phoniatrica et Logopaedica, 59:20-30, 2007

- ✓ 449 speakers (including 391 patients)
- ✓ Perceptual assessment with GRBAS scale (Hirano, 1981)
- ✓ Instrumental assessment :
 - ✦ Jitter, signal/noise ratio
 - ✦ max phonation time, voice range,
 - ✦ Estimated sub-glottal pressure, oral airflow
- ✓ Correlation between (perceptual) severity and measures

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Multiparametric voice assessment

- Jitter
- SR
- TMP
- VR
- ESGP
- OAF

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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

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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

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Instrumental assessment of speech

KINESIO

- Electromagnetic Articulography
- Electro-Palatography

AERO

- Audio
- Airflows
- Pressures

ELECTROPHYSIO

- Electro-Glottography
- Electro-Myography

IMAGING

- IRM

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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

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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

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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

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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

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Aerophonometry advantages

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

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Cinical applications of aerophonometry

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

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13

Voice analysis with aerophonometry

Robert D., Pouget J., Giovanni A., Azulay J.P., Triglia J.M., (1999) "Quantitative Voice Analysis in the Assessment of Bulbar Involvement in Amyotrophic Lateral Sclerosis", Acta Otolaryngol (Stockh), 119:724-731

- 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

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14

Pneumophonatory coordination



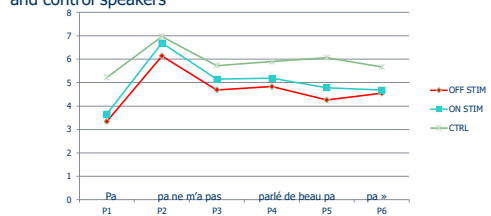
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15

Pneumophonatory coordination

SARR, M.; PINTO, S.; JANKOWSKI, L.; PURSON, A.; GHIO, A.; ESPESSER, R.; TESTON, B.; VIALLET, F. (2009). L-dopa and STN stimulation effects on pneumophonic coordination in Parkinsonian dysarthria: intra-oral pressure measurements. International Congress of Parkinson's Disease and Movement, vol. 24, no. S1. 2009, p. S342.

- Parkinson disease and effect of DBS
- Estimated sub glottal pressure of PD patients (with DBS ON/OFF) and control speakers

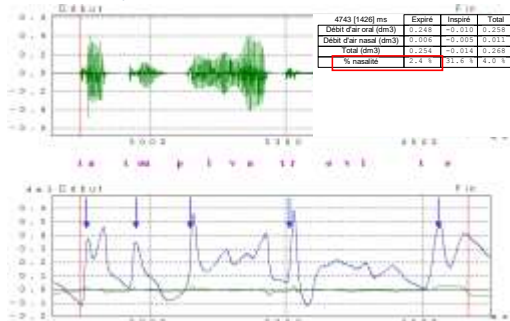


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16

Aerophonometry and velum motricity

- « normal » speaker

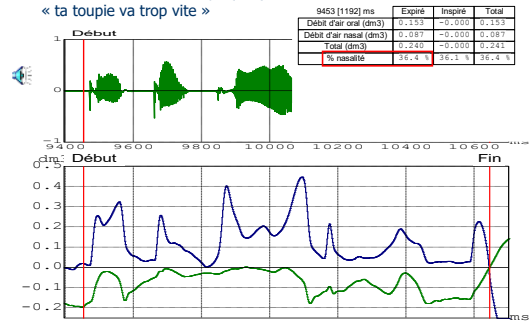


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17

Aerophonometry and velum motricity

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



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18

Aerophonometry and velum motricity

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

- Nasal Airflow is more important on stop consonants

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Aerophonometry and velum motricity

LocS : maladie de Steinert

Document From Amelot et Roubeau (HEPG, Tenon, Paris, France)

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Aerophonometry and velum motricity

Robert D., Sangla I., Azuley J.P., Giovanni A., Canjoni M., Pouget J. (1995).
"Diagnostic et suivi de l'insuffisance vélaire dans les formes bulbaire des maladies du motoneurone", Actes du Congrès sur la Voile Pathologique, Société Française de phoniatry, Lyon, p.63-74.

- ENT
- Neurologists

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Electrophysiological techniques

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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

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Electroglottography (EGG)

- Comments:
 - +Very good measurements of the glottis oscillation frequency
 - does not measure the glottis aperture area
 - It is not an acoustic signal
- Remarks
 - Modulation impédance: 100mOhm
 - Courant injecté: 1mA
 - Amplitude de l'information: 100µV

Vocal folds closed

Vocal folds open

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EGG signal

« qu'en pensez vous ? »

A Fourcin, J, McClashan, R, Blowes. Measuring voice in the clinic - Laryngograph® Speech Studio analyses (Presented at the 6th Voice Symposium of Australia, Adelaide, Oct. 2002)

25

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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

Pellat J, Gentil M, Chevalier C, Vila A, Pollak P, Perret J., (1983). Electromyographic study of 4 lip muscles and acoustic findings in parkinsonian dysarthria, Rev Neurol., 1983;139(3):205-13.

26

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EMG signal analysis

« Tu es sûr ? Tu l'as vu ? »

Effect of the crico thyroïdien on the F0 control

27

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EMG signal analysis

« Tu es sûr ? Tu l'as vu ? »

Labial (lips) activity

28

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Electropalatography (EPG)

AN EPG THERAPY PROTOCOL FOR REMEDIATION AND ASSESSMENT OF ARTICULATION DISORDERS

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ABSTRACT

The paper describes technical and methodological advances in the development of a procedure for measuring changes in accuracy and stability of linguopalatal contact patterns during a course of visual feedback therapy with electropalatography (EPG). The procedure is exemplified in case in which therapy was aimed at reducing a pattern of velar fricative phoneme target /k/ to /t/ and also similar placements /t, d, n/. The EPG procedure in assessment procedures can be implemented using existing methods and software designed for the purpose.

1. INTRODUCTION

The primary research objective and direct purpose of the articulation disorder is electropalatography (EPG) records details of the location and timing of tongue contact with the hard palate during speech [1]. The instrument measures electrical impedance between the tongue and the hard palate and other placements in the oral cavity. The EPG procedure in assessment procedures can be implemented using existing methods and software designed for the purpose.

29

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Exploitations des mesures EPG

Stamping Frequency 200Hz

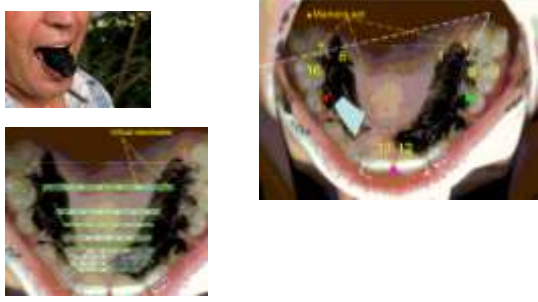
Le début (d) et la fin (f) de chaque phase linguopalatale (G pour geste, O pour occlusion et M pour maximum de contacts) sont indiqués sur l'oscillogramme et le signal EPG [10cv]

30

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Static palatography (SPG)

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



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ElectroMagnetic Articulograph (EMA)

Why?: To study relative position, speed and accelerations of main articulators (jaw, tongue, lips).
 How?: The participant is placed 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 positions and orientation.

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

Jaeger M, Hertrich I, Stattrop U, Schönlé PW, Ackermann H. (2000). Speech Disorders following Severe Traumatic Brain Injury: Kinematic Analysis of Syllable Repetitions Using Electromagnetic Articulography. Folia Phoniatrica et Logopaedica, Vol. 52, No. 4




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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

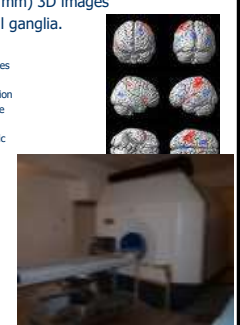
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Magnetic Resonance Imaging (MRI)

- Why?: because MRI can acquire accurate (1 mm) 3D images of cortex, white matter, cerebro-spinal and basal ganglia.
- How?:
 - by observing the biological tissue through the magnetic properties of one of their principal constituents: **the nucleus of hydrogen**.
 - 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)
 - 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 ($\pm 110dB$)



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These techniques can be combined...but not too much!?



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Thank you for your attention



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