Multiparametric speech assessment

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Speech DBS
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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

Speech assessment : to what purpose?

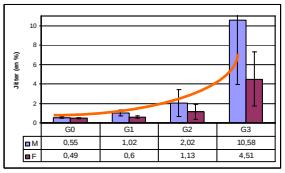
- To quantify the speech disorder and compare patients

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

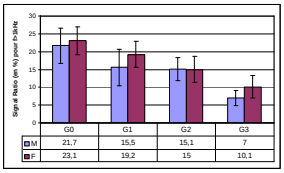
- ✓ 449 speakers (including 391 patients)
- ✓ Perceptual assessment with GRBAS scale (Hirano, 1981)
- ✓ Instrumental assessment :
  - ✧ Jitter, signal/noise ratio
  - ✧ max phonation time, voice range,
  - ✧ Estimated sub-glottal pressure, oral airflow
- ✓ Correlation between (perceptual) severity and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

Multiparametric voice assessment

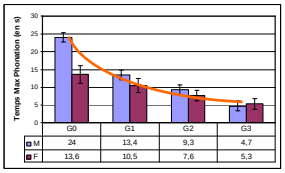
- Jitter



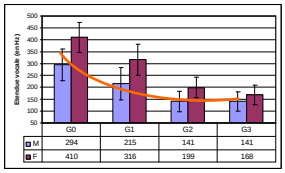
- SR



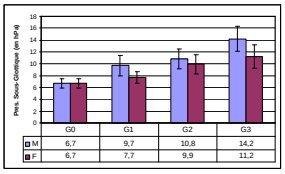
- TMP



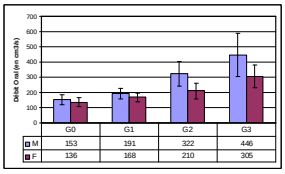
- VR



- ESGP

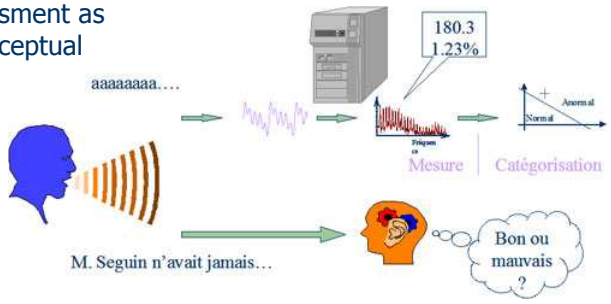


- OAF



Hearing machines?

- Instrumental assessment as complement of perceptual assessment

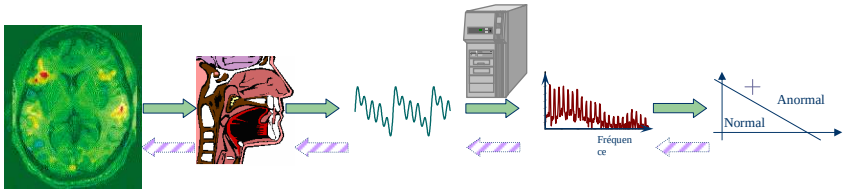


- … but instruments are not hearing machines
  - ✓ Instrument can measure phenomena which can be not audible
  - ✓ Human can hear information that instrument can not measure

Speech assessment : to what purpose?

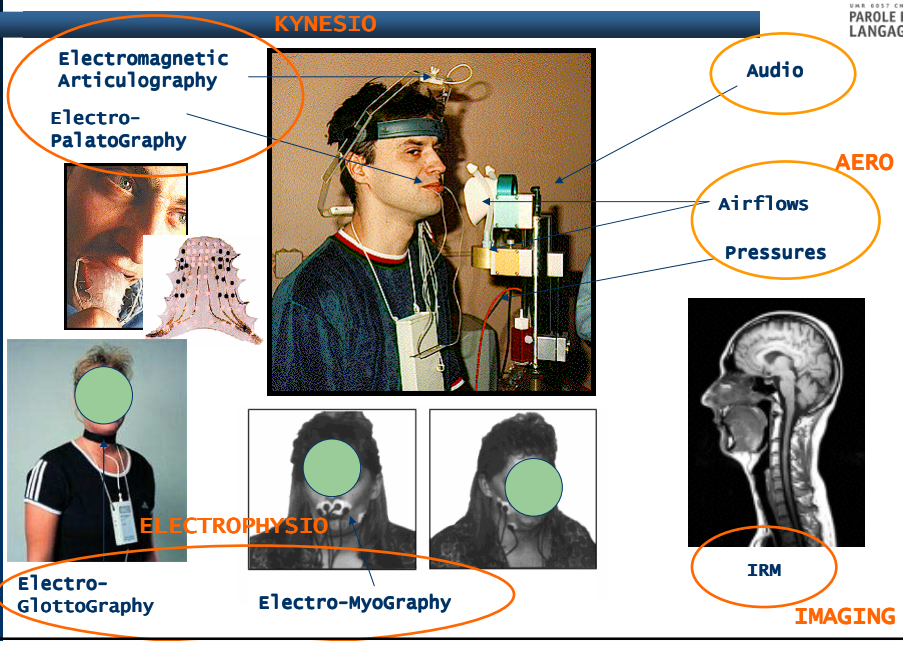
- Speech disorder as a marker of
  - ✓ Neurological disease
  - ✓ Therapeutic effect
    - ➢ Pharmacologic
    - ➢ Stimulation

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



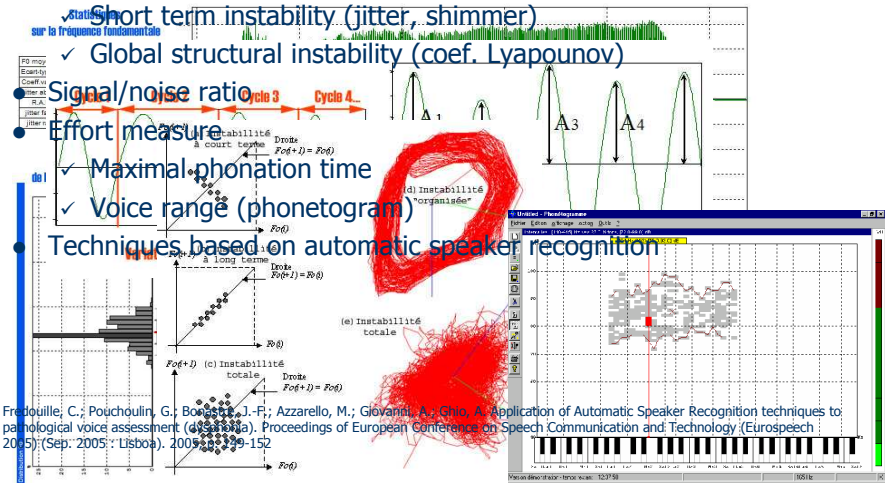
- Brain imaging is more direct

Instrumental assessment of speech



Laryngeal function acoustic assessment

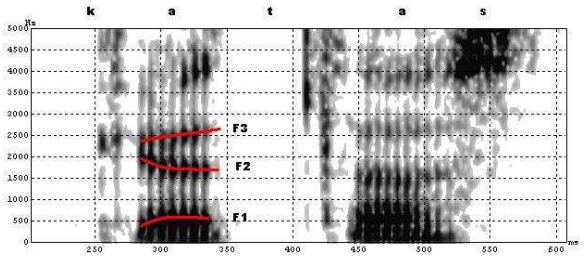
- Measuring F0 instability
  - ✓ Medium term instability (coef. variation of F0, trémor)
  - ✓ Short term instability (jitter, shimmer)
  - ✓ Global structural instability (coef. Lyapounov)
- Signal/noise ratio
- Effort measure
  - ✓ Maximal phonation time
  - ✓ Voice range (phonetogram)
- Techniques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

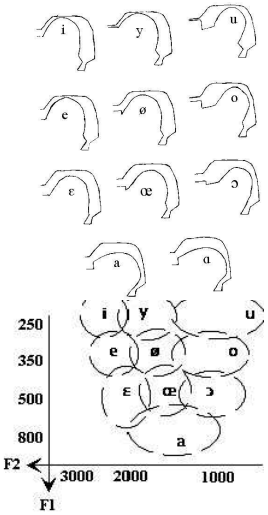


Fredouille, C.; Pouchoulin, G.; Bonastre, J.-F.; Azzarello, M.; Giovanni, A.; Ghio, A. Application of Automatic Speaker Recognition techniques to pathological voice assessment (dysphonia). Proceedings of European Conference on Speech Communication and Technology (Eurospeech 2005) (Sep. 2005 : Lisboa). 2005. p. 149-152

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

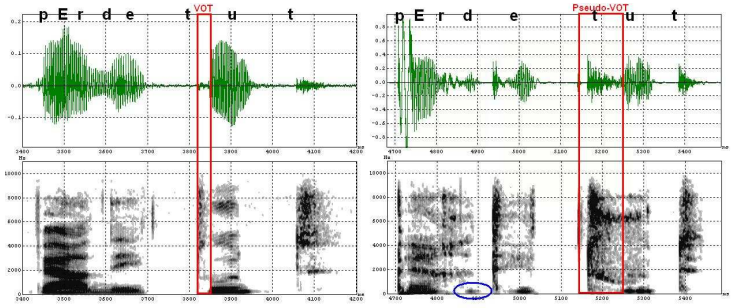




Weismer G, Jeng JY, Laures JS, Kent RD, Kent JF (2001), Acoustic and intelligibility characteristics of sentence production in neurogenic speech disorders, Folia Phoniatr Logop. 2001 Jan-Feb;53(1):1-18

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

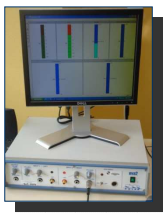


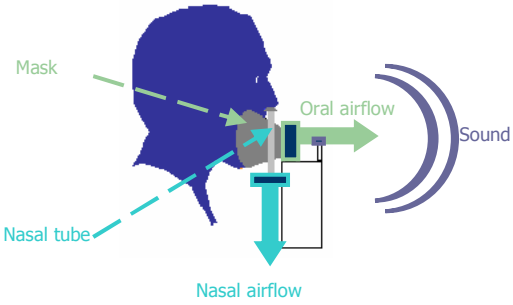
Morris R. J., "V.O.T. and dysarthria: a descriptive study", Journal of communication disorders (J. commun. disord.), 1989, vol. 22, no1, pp. 23-33

Özsancak C. ; Auzou P.; Jan M. ; Hannequin D. (2001), « Measurement of voice onset time in dysarthric patients : Methodological considerations (Mesure du VOT chez les patients dysarthriques: aspects méthodologiques) », Folia phoniatrica et logopaedica (Folia phoniatr. logopaed.) vol. 53, no1, pp. 48-57

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 developped 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

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

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

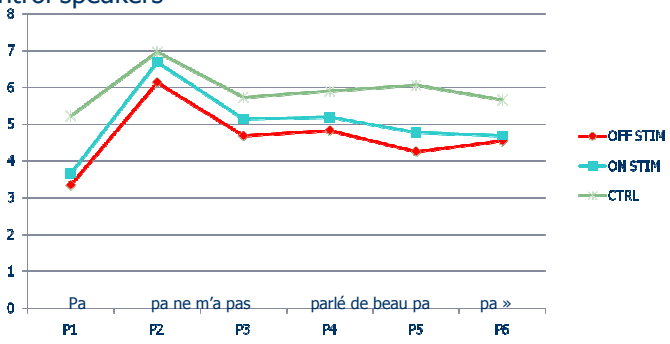
- Acoustic and aerodynamic measures were significantly different between sALS patients and control patients
- Measurements can predict bulbar involvement in 73% of those in the sALS group

Pneumophonatory coordination

Pneumophonatory coordination

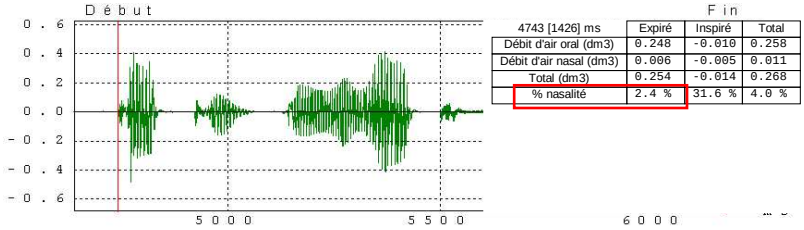
SARR, M.; PINTO, S.; JANKOWSKI, L.; PURSON, A.; GHIO, A.; ESPESSER, R.; TESTON, B.; VIALLET, F. (2009). L-dopa and STN stimulation effects on pneumophonic coordination in Parkinsonian dysarthria: intra-oral pressure measurements. International Congress of Parkinson's Disease and Movement, vol. 24, no.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

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

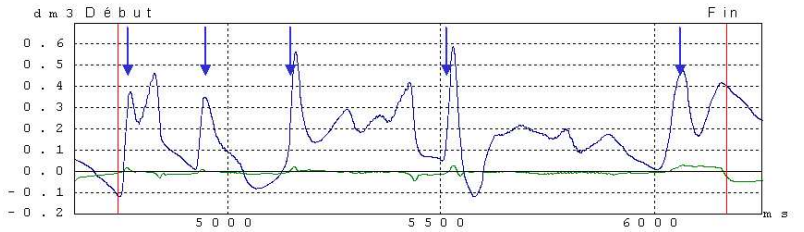


Aerophonometry and velum motricity

- « normal » speaker



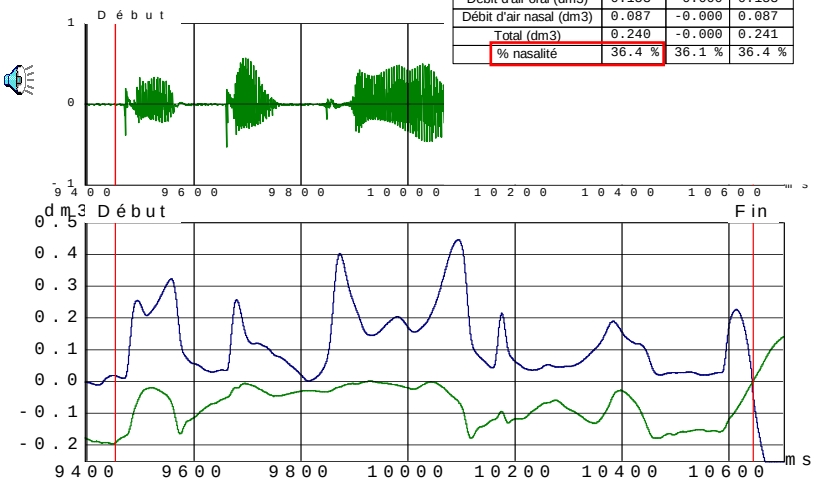
4743 [1426] ms	Expiré	Inspiré	Total
Débit d'air oral (dm3)	0.248	-0.010	0.258
Débit d'air nasal (dm3)	0.006	-0.005	0.011
Total (dm3)	0.254	-0.014	0.268
% nasalité	2.4 %	31.6 %	4.0 %



Aerophonometry and velum motricity

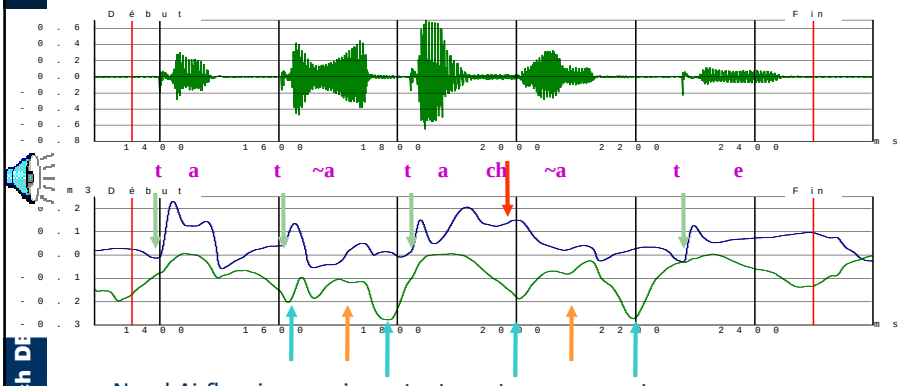
- Parkinson woman ON-dopa (884)
  « ta toupie va trop vite »

9453 [1192] ms	Expiré	Inspiré	Total
Débit d'air oral (dm3)	0.153	-0.000	0.153
Débit d'air nasal (dm3)	0.087	-0.000	0.087
Total (dm3)	0.240	-0.000	0.241
% nasalité	36.4 %	36.1 %	36.4 %



Aerophonometry and velum motricity

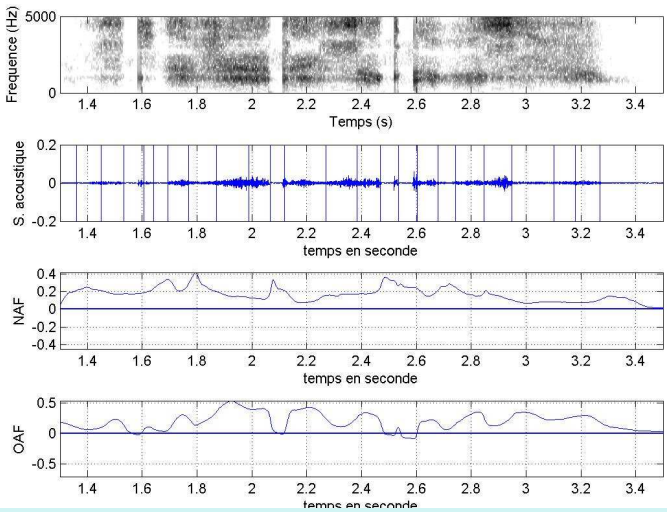
- Parkinson woman ON-dopa (884)
  « ta tante a chanté »



- Nasal Airflow is more important on stop consonants

Aerophonometry and velum motricity

Loc5 :maladie de Steinert



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

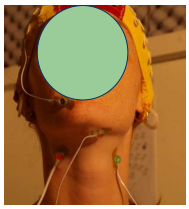
Aerophonometry and velum motricity

Robert D., Sangla I., Azulay J.P., Giovanni A., Cannoni M., Pouget J. (1995), "Diagnostic et suivi de l'insuffisance vélaire dans les formes bulbaires des maladies du motoneurone", Actes du congrès sur le Voile Pathologique, Société Française de phoniatrie, Lyon, p.63-74.

- ENT
- Neurologists

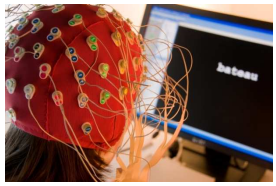
Electrophysiological techniques

ElectroGlottography
EGG



Electromyography
EMG

Electropalatographie
EPG



Electroencephalography
EEG

MRI

Electromagnetic articulograph
EMA

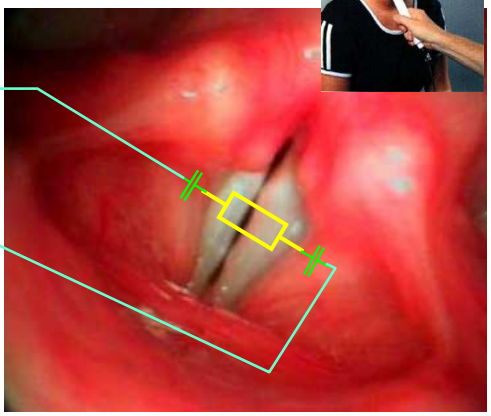
Electroglottography (EGG)

- Why: To have an image of vocal folds activity
- How: Measurement of the impedance between two electrodes applied on the neck

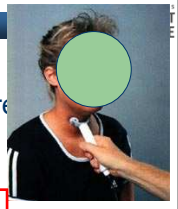
Glottis contact variation
↓
Impedance modulation
↓
Voltage modulation

I

V



Electroglottography (EGG)

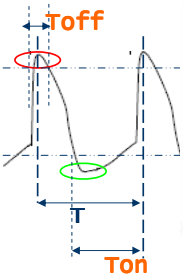


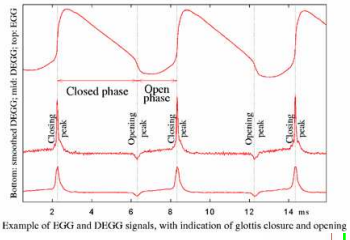
- Comments:
  - +Very good measurements of the glottis oscillation fre
  - - does not measure the glottis aperture area
  - It is not an acoustic signal

Remarks

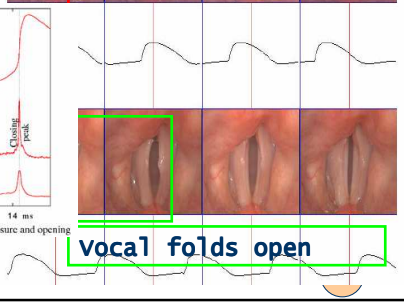
Modulation impédance: 100mOhm
Courant injecté: 1mA
Amplitude de l'information: 100µV

vocal folds closed





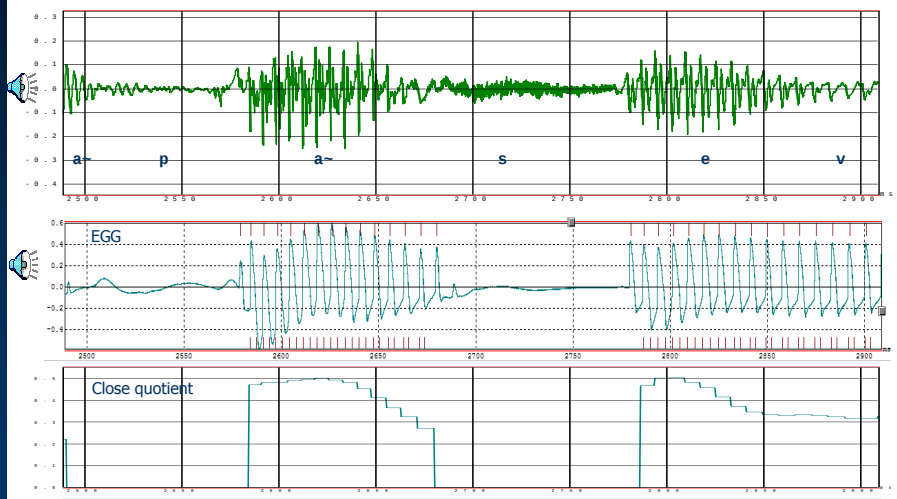
Example of EGG and DEGG signals, with indication of glottis closure and opening



vocal folds open

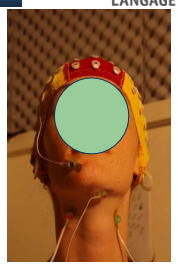
EGG signal

« qu'en pensez vous ? »



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

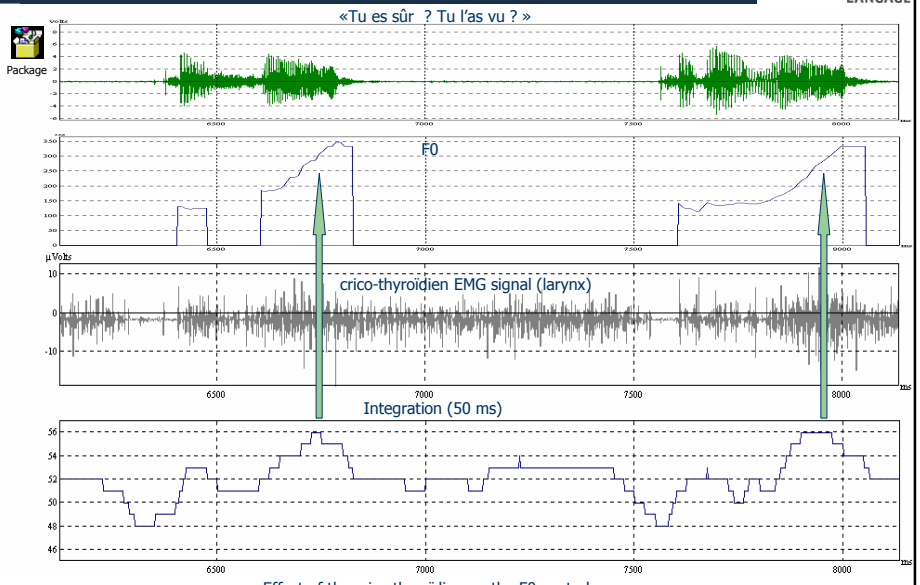
Electromyography (EMG)



- 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

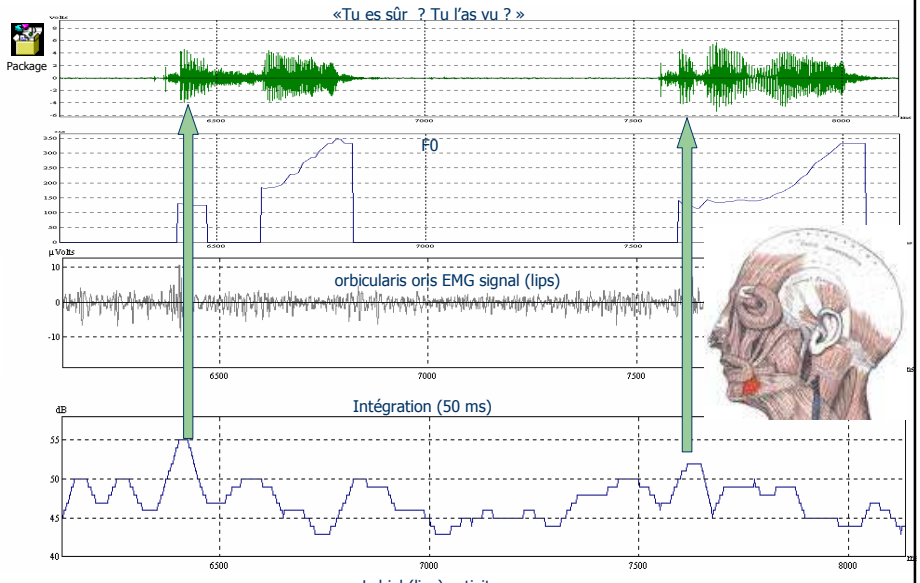
Pellat J, Gentil M, Chevalier C, Vila A, Pollak P, Perret J., (1983), Electromyographic study of 4 lip muscles and acoustic findings in parkinsonian dysarthria, Rev Neurol, . 1983;139(3):205-13.

EMG signal analysis



Effect of the crico thyroïdien on the F0 control

EMG signal analysis



Labial (lips) activity

Electropalatography (EPG)

PAROLE ET LANGAGE

AN EPG THERAPY PROTOCOL FOR REMEDIATION AND ASSESSMENT OF ARTICULATION DISORDERS

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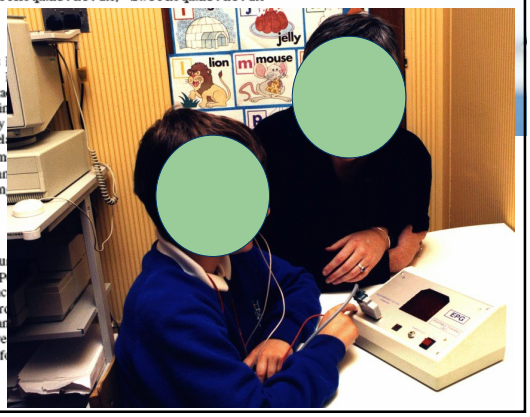
ABSTRACT

This paper describes technical and methodological advances
the development of a procedure for measuring changes
accuracy and stability of linguapalatal (tongue-palate) conta
patterns during a course of visual feedback therapy usin
electropalatography (EPG). The procedure is exemplified by
case in which therapy was aimed at resolving a pattern of vel
fronting whereby phonetic targets /k, g, ŋ/ had abnorm
alveolar placement [t, d, n]. The EPG remediation a
assessment procedure can be implemented using recordin
feedback and analysis software designed for the purpose.

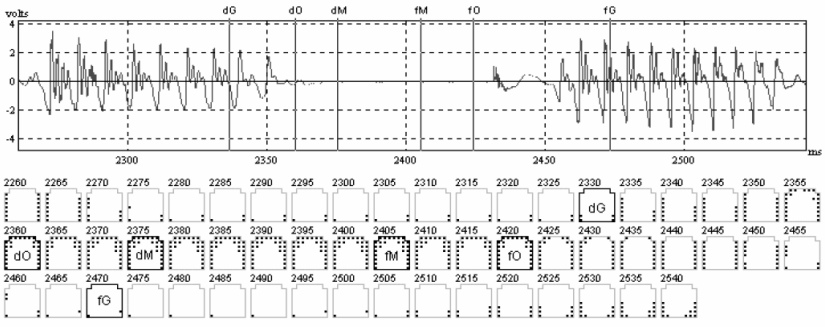
1. INTRODUCTION

One potentially valuable diagnostic and therapy procedu
for articulation disorders is electropalatography (EPG). EP
records details of the location and timing of tongue contac
with the hard palate during speech [1]. The instrument recor
alveolar, post-alveolar, palatal, and velar placement, a
registers characteristic patterns for many consonants and vowe
that occur in English, making it a useful technique f



Exploitations des mesures EPG

PAROLE ET LANGAGE

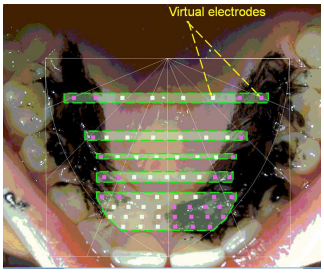


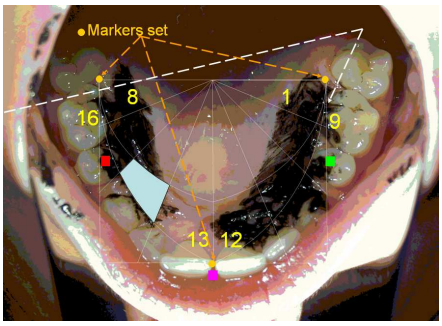
Slamping Frequency 200Hz

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 [locY]

Static palatography (SPG)

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

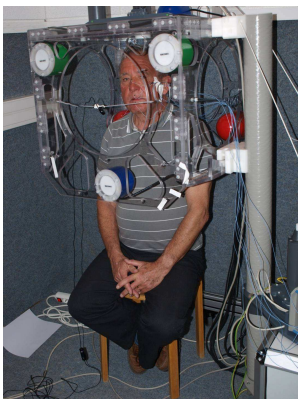




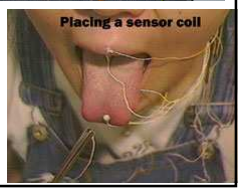
ElectroMagnetic Articulograph (EMA)

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.



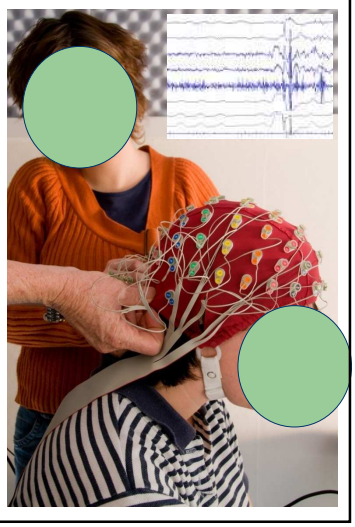
Comments:
- 12 sensors
- Not less than 10 mm between two sensors
- 200Hz sampling frequency



Jaeger M, Hertrich I, Stattrop U, Schönle 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

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 Resonnance 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 resonnance) depends strongly on the tissue

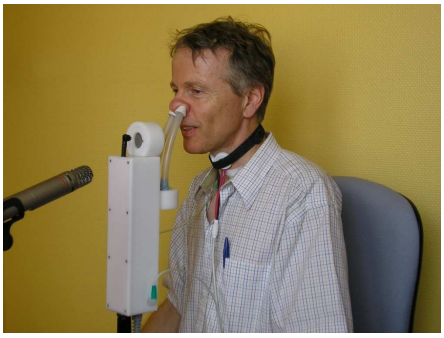
- Comments

Good localization,

In case of fMRI quite slow (a few Hz)

Very noisy environement (± 110dB)

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



Thank you for your attention