

Nasal 2009

5 JUIN 2009

Nasal 2009

Problems in the interpretation of the data related to nasality

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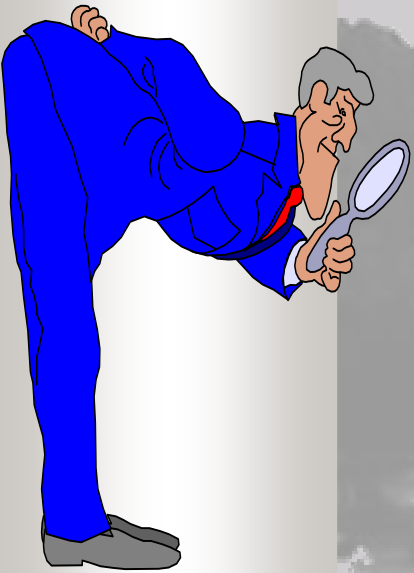
UMR 7018 (CNRS, Sorbonne Nouvelle)

5 Juin 2009



Problems in the interpretation of the data related to nasality

Introduction



difficulty of assembling the wealth of available data on nasality into a coherent whole, taking into account all of the seemingly divergent findings

EMG, articulatory, aerodynamic, acoustic (and perceptual investigation)

Problems in the interpretation of the data related to nasality

Sources?



5 Juin 2009



Problems in the interpretation of the data related to nasality

Sources?

confronting data published in the literature

(Beddor, Bell-Berti, Benguerel, Clumeck, Ohala, Vaissière, to cite a few),

Ph. D. dissertations about nasality (Amelot, Cohn, Delvaux, Krakow, and Rossato)

A set of new data (ongoing research by students at our laboratory) .

Available “old” data (X-ray micro-beam)

Atelier x :

Nasal 2009



Problems in the interpretation of the data related to nasality

- A) On some discrepancies that can be explained in part
- A1) instrumentation-dependent results ???

Atelier x :

Nasal 2009



Problems in the interpretation of the data related to nasality

A) On some discrepancies that can be explained in part

- A1) instrumentation-dependent results



**More anticipation than carry-over
More carry-over than anticipation**

suppression of the activity of the levator palatini

Velotrace

EMG

fiberscope

(Perception)

descent of the velum

X-ray data

Acoustics

Microbeam

Piezo

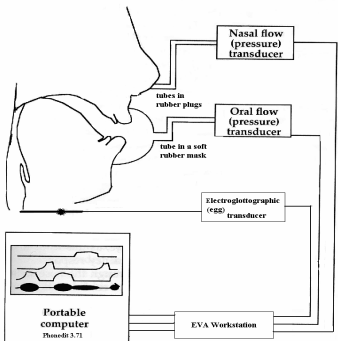
EMA

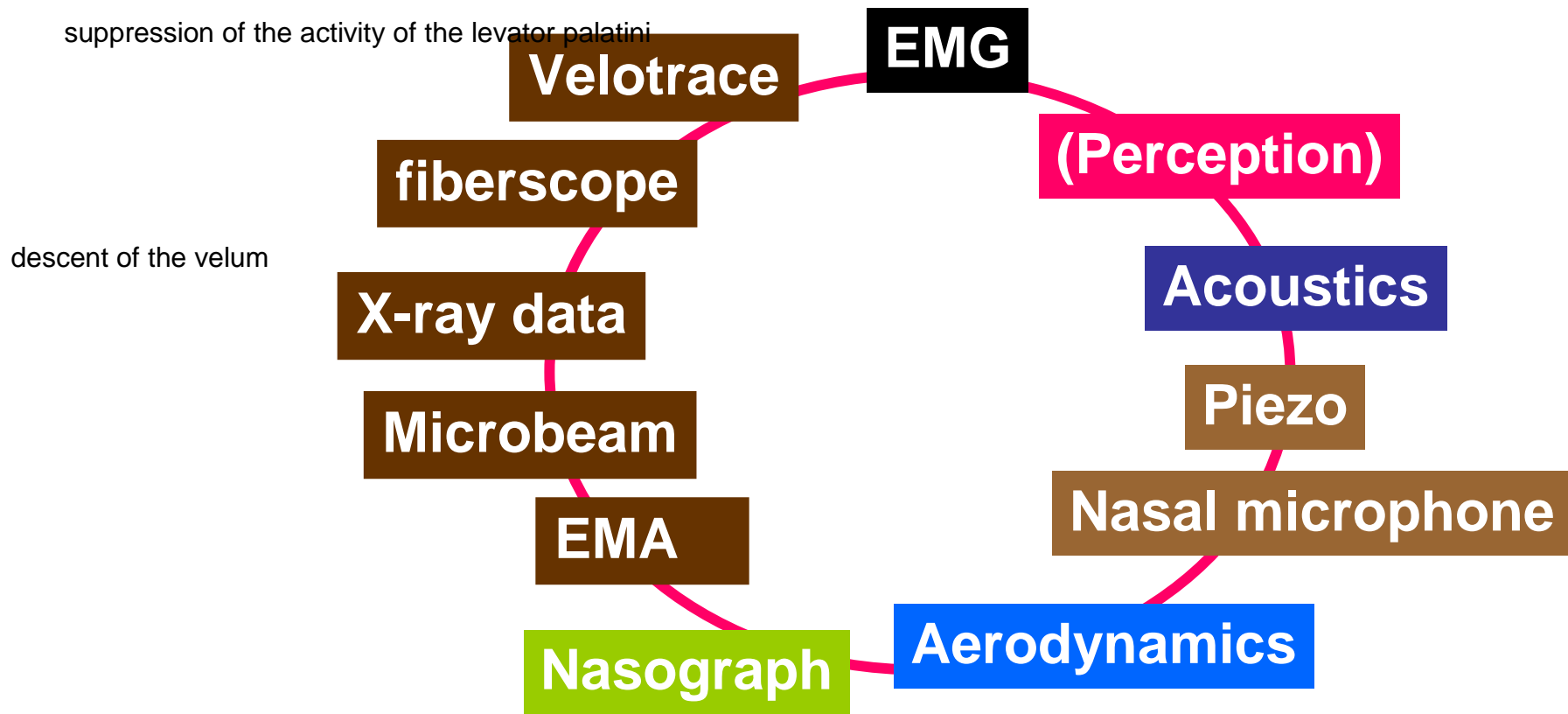
Nasal microphone

Nasograph

Aerodynamics

When two instrumentations comparison possible

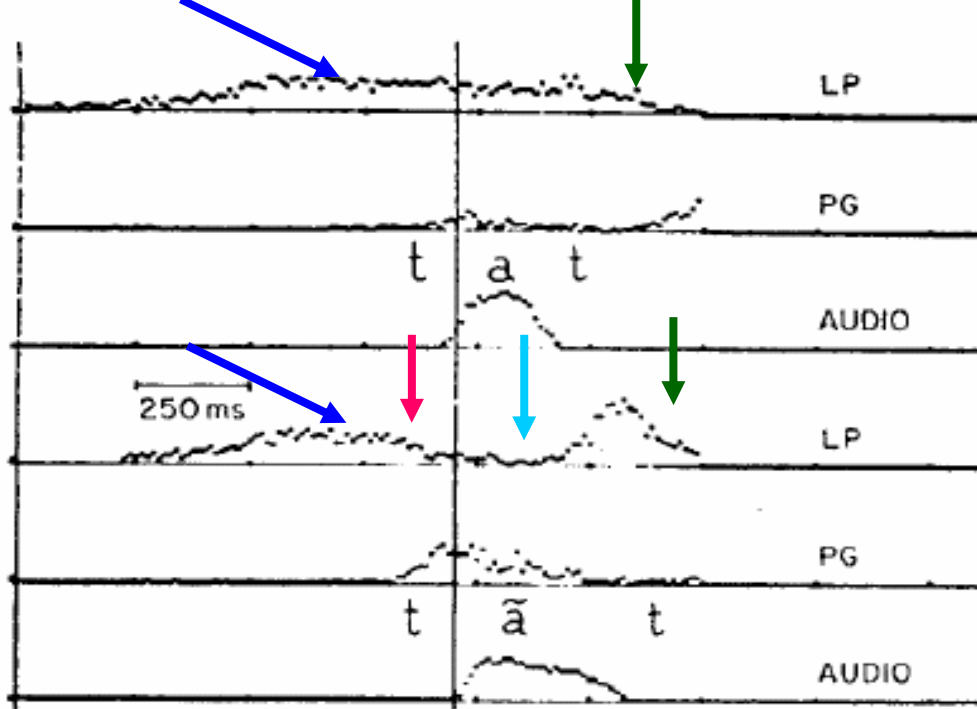




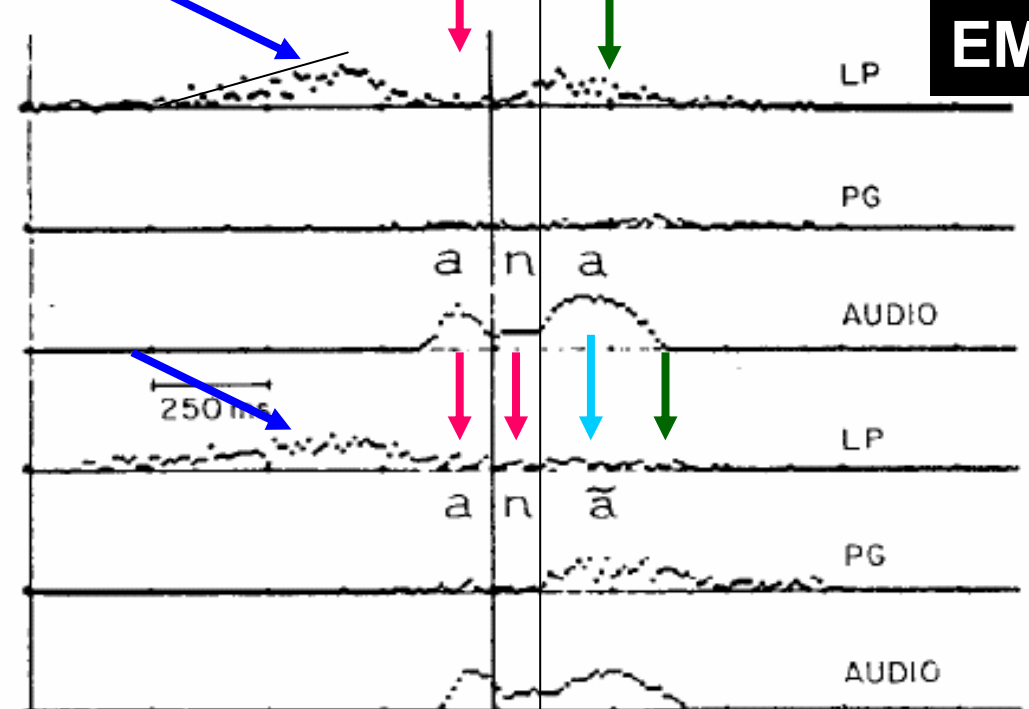
When two instrumentations comparison possible



EMG-based studies ~~[9][6]~~ therefore tend to conclude to a large **anticipation**, as do **fiberscopic** studies [1]. **Aerodynamic** data generally report more extensive carry-over than **anticipatory** [4][8]



Comparison of /tat/ and /tāt/ in isolation.



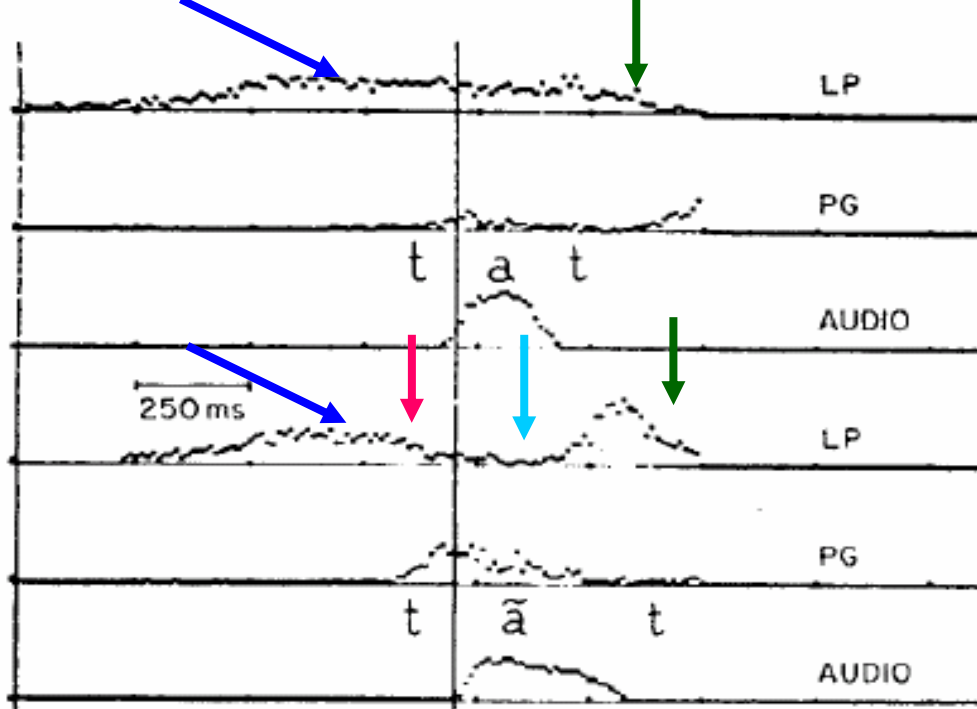
Comparison of /ana/ and /anā/ in isolation.

Suppression LP durant le phonème
qui **précède** une **consonne nasale** et un temps avant la pause

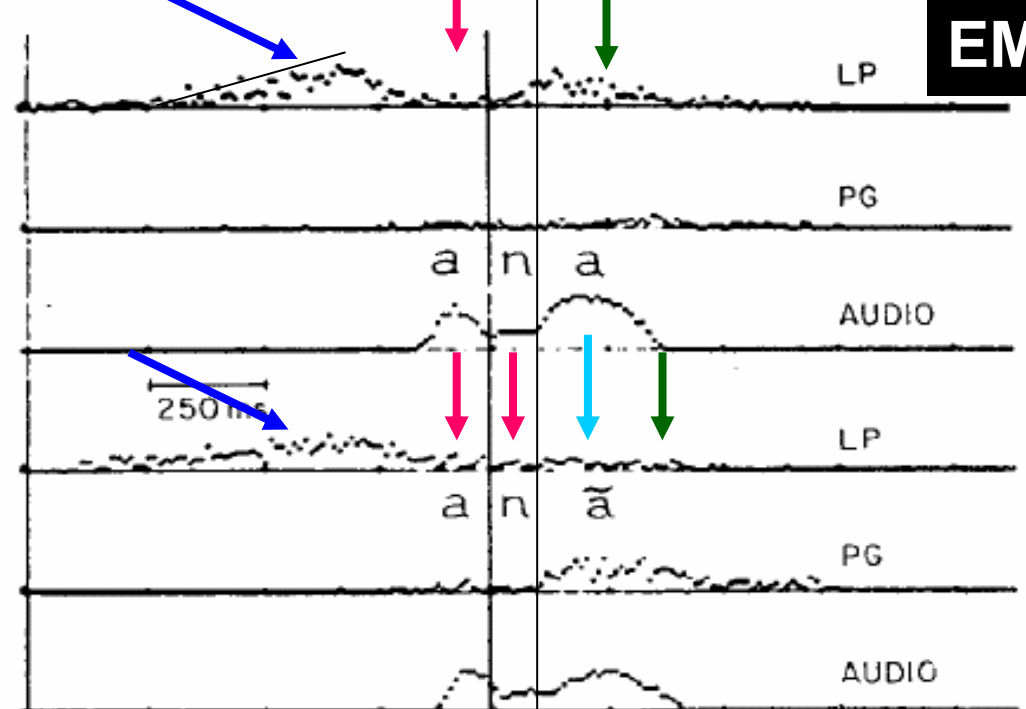
Suppression LP **avant** et jusqu'au milieu de la **voyelle nasale**



1) **EMG** = more anticipation, for sure



Comparison of /tat/ and /tāt/ in isolation.



Comparison of /ana/ and /anā/ in isolation.

Suppression of LP precedes velar movements, of course

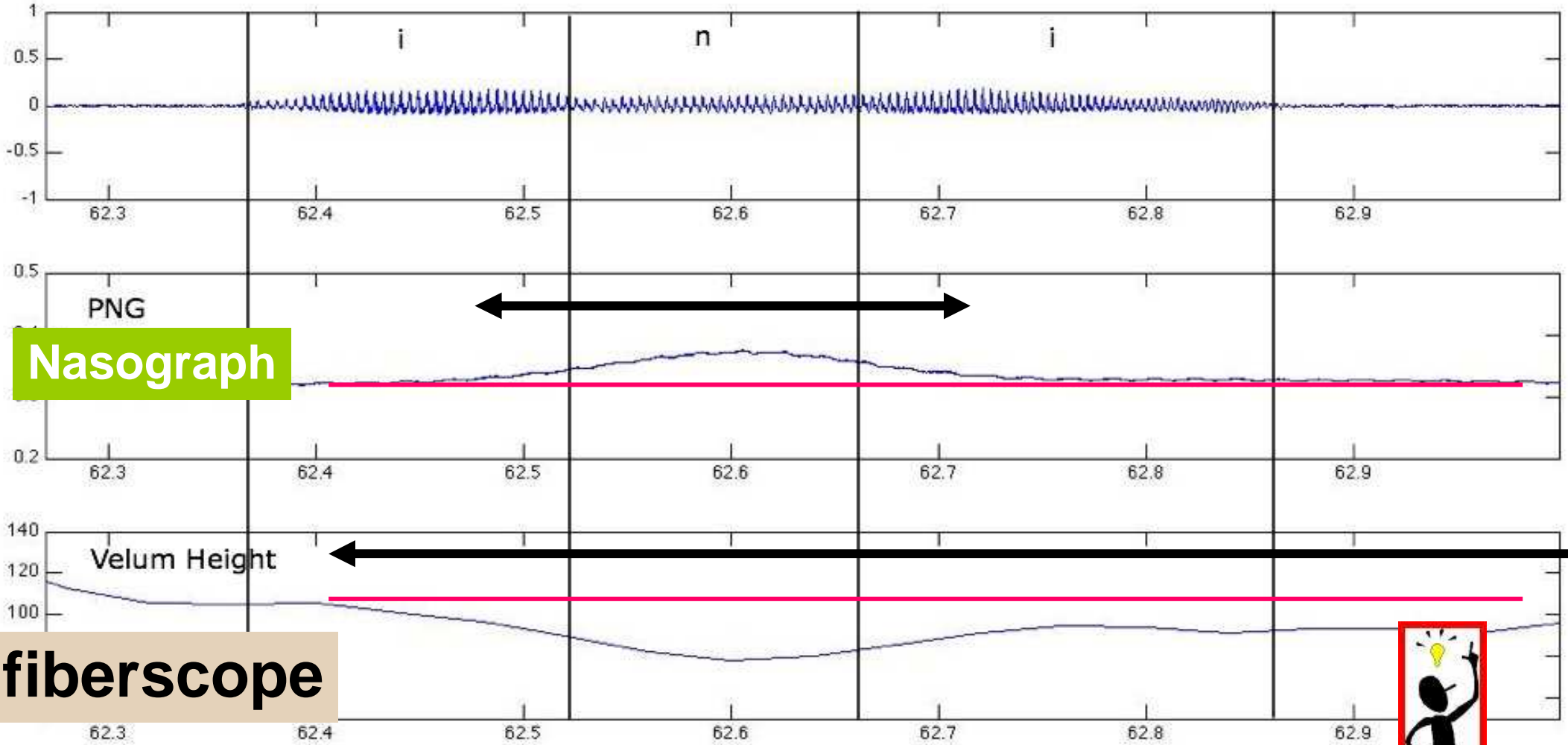
Suppression LP durant le phonème
qui **précède** une **consonne nasale** et un temps avant la pause

Suppression LP **avant** et jusqu'au milieu de la **voyelle nasale**



1) **EMG** = more anticipation, for sure

ini



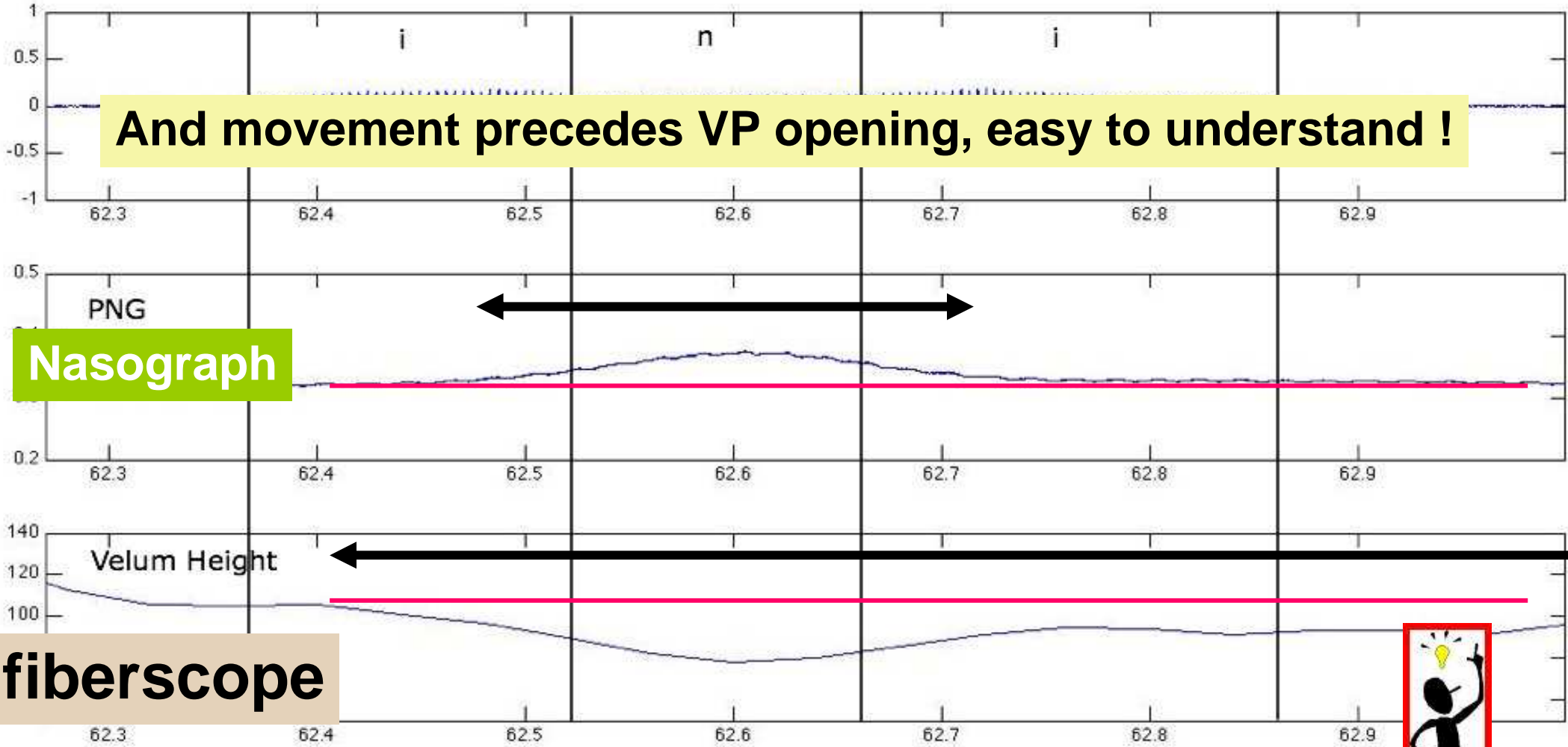
Nasograph

fiberscope

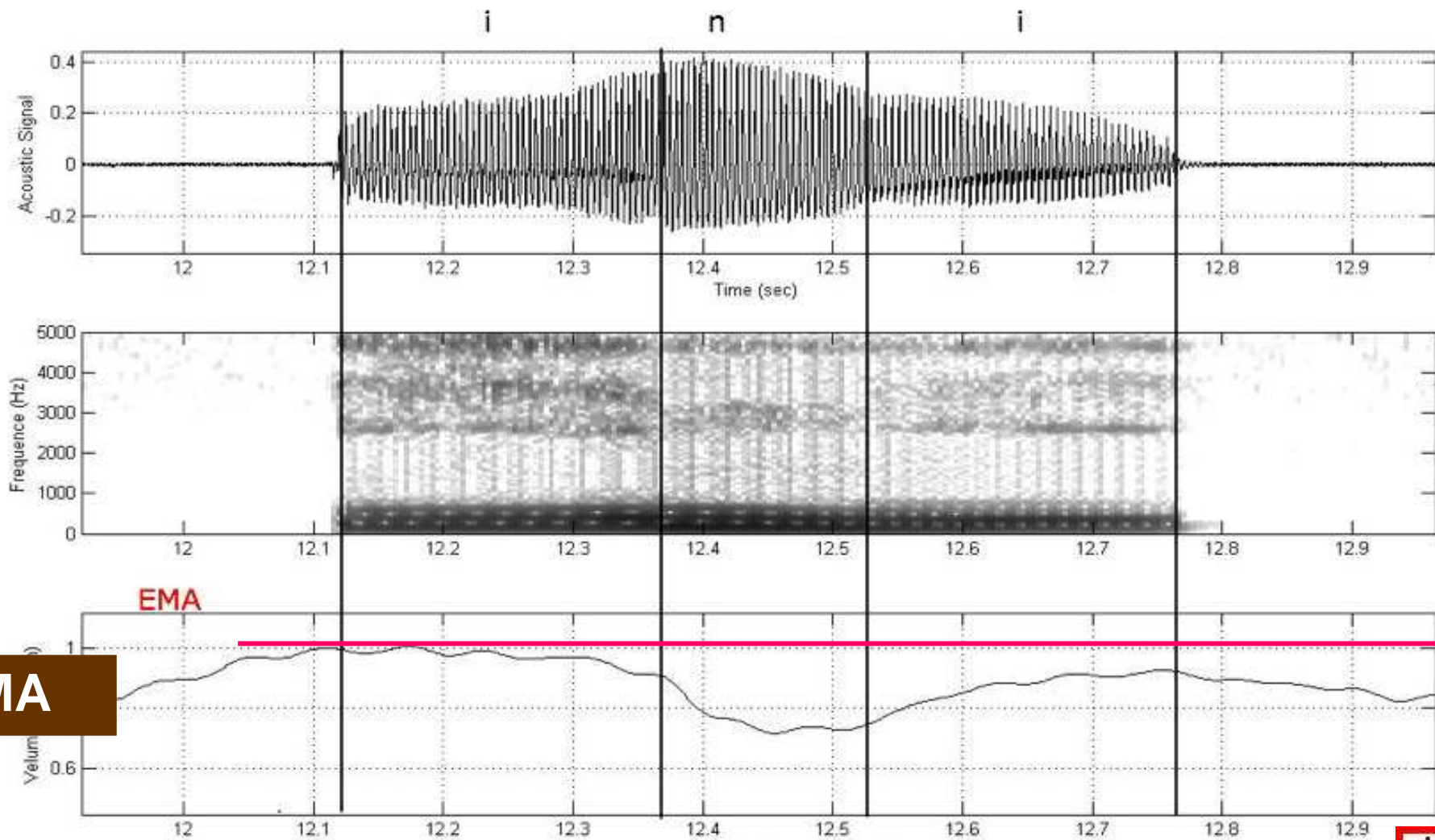


2) nasograph; opening of the VP much after lowering start

ini



2) nasograph; opening of the VP much after lowering start



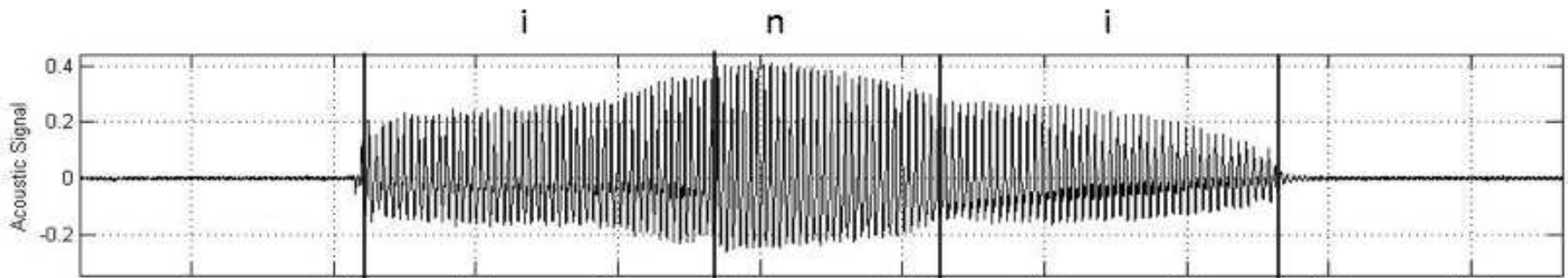
EMA

Same speaker

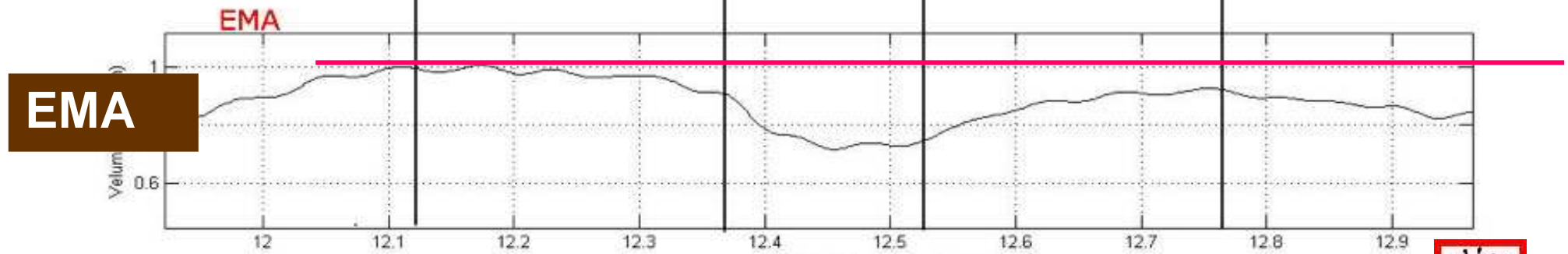
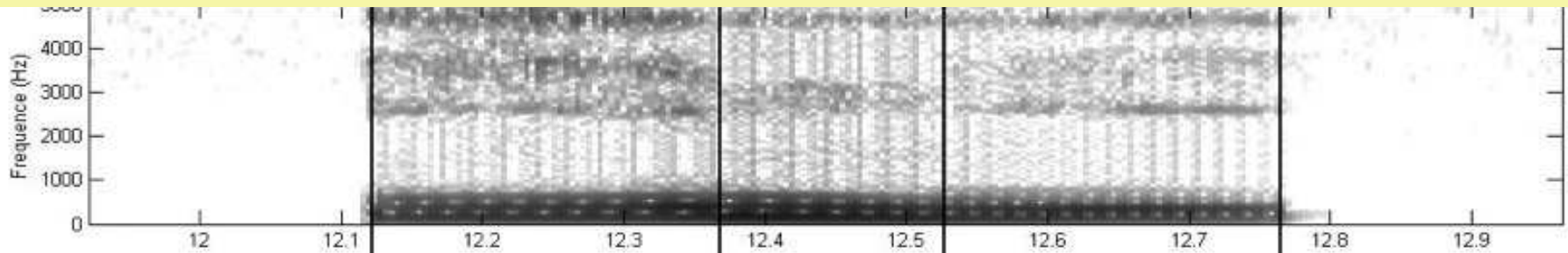


4) EMA less anticipation than fiberscope

Data ICP Grenoble



Good correlation between fiberscope and EMA, for the same speaker

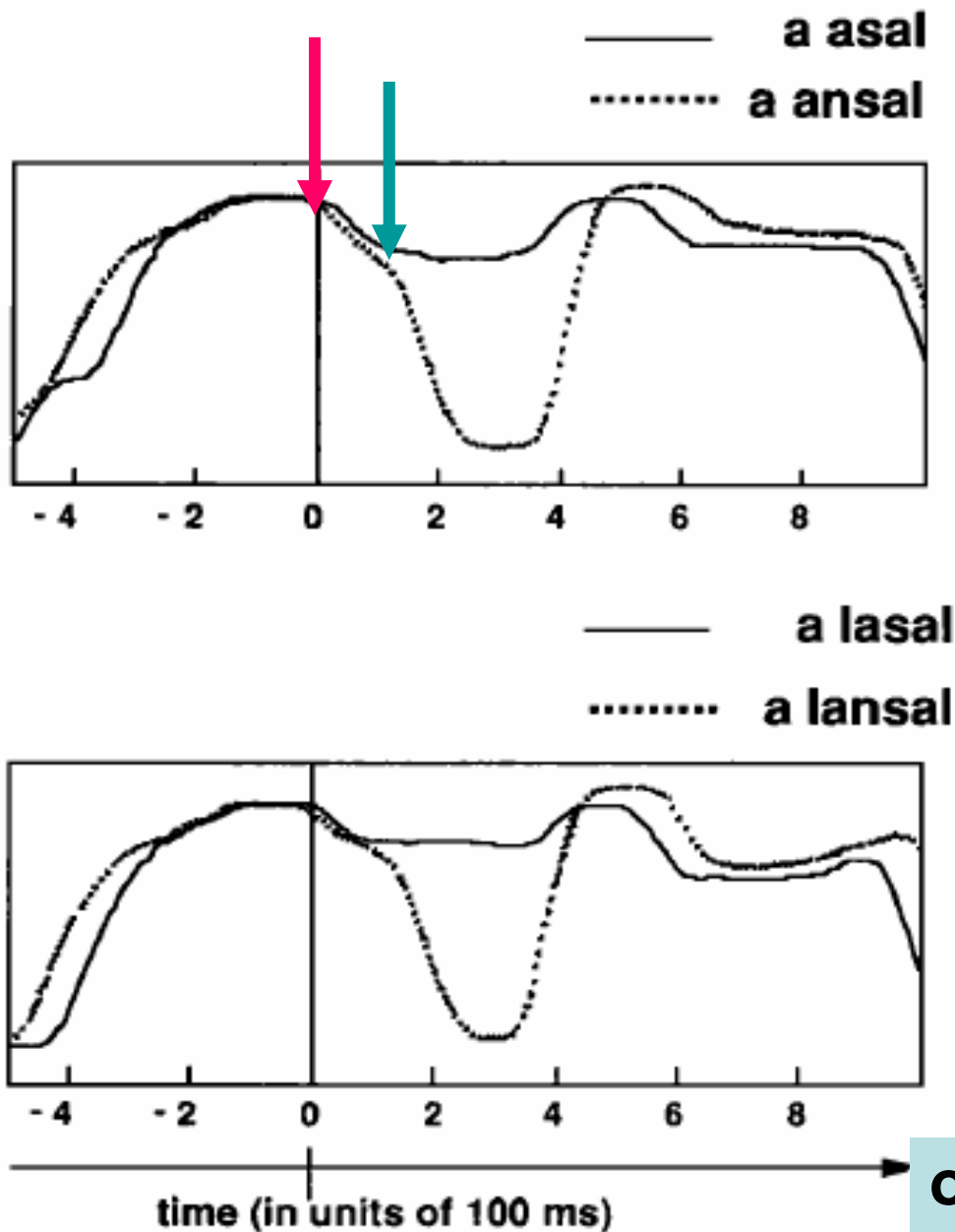


Same speaker



Data ICP Grenoble

4) EMA less anticipation than fiberscope



In CVC, the velum is lower during V than C

So the intrinsic lower value of the velum during V is (mis) taken as anticipatory (Bell-Berti)

overrestimation of anticipatory lowering

FIG. 8. Displacement functions of two representative mini oral and nasal utterance pairs, demonstrating similar behavior within each pair for subject 3. Displacement is represented on the ordinate.

Anticipatory velar lowering: A coproduction account

Fredericka Bell-Berti

Still caution needed, due to lower position of velum for V (as compared to C)

Problems start with aerodynamics ???



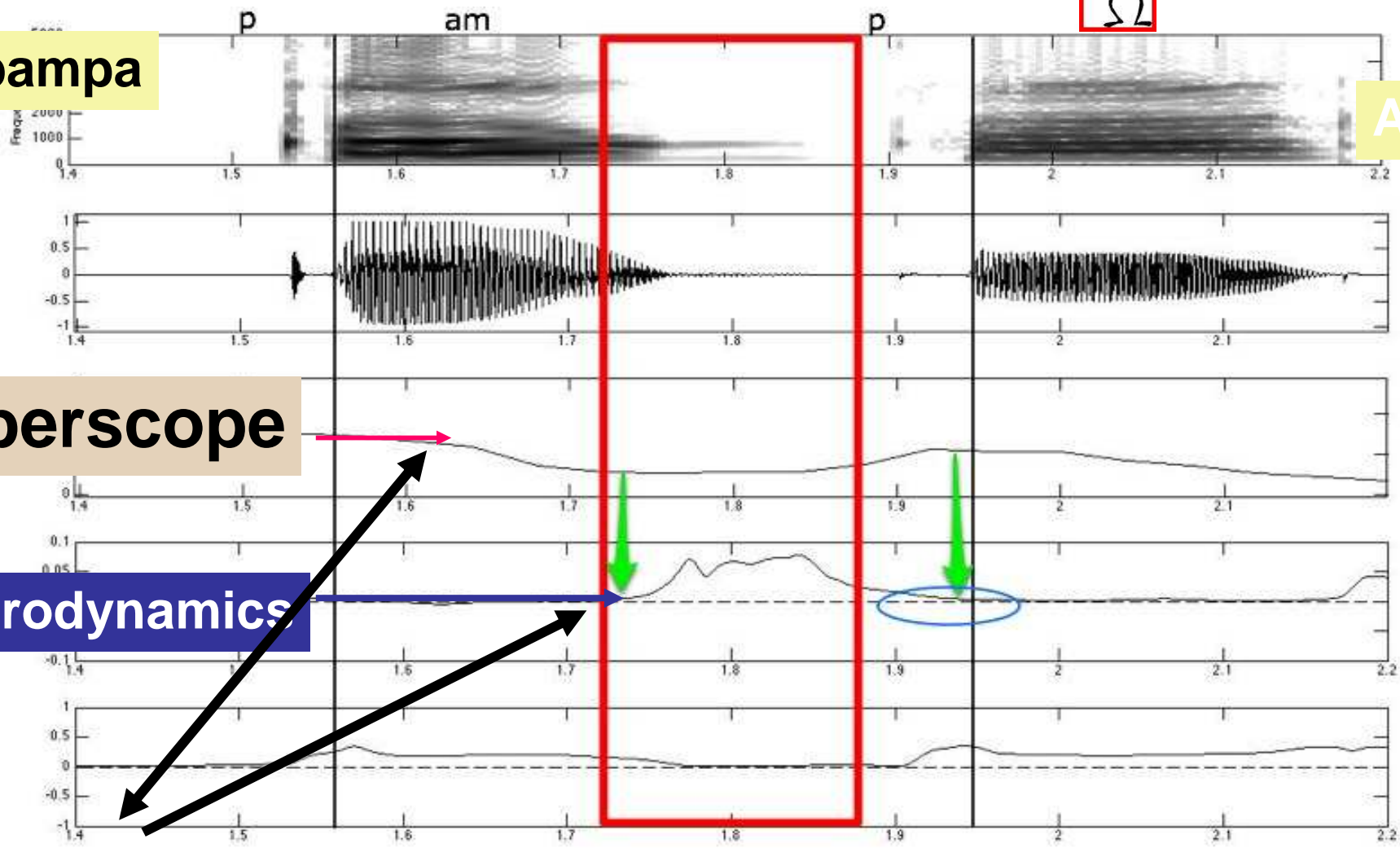
EMG

fiberscope

Aerodynamics



pampa



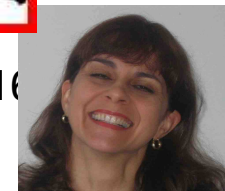
fiberscope

Aerodynamics

Étude de données synchronisées, articulatoire, aérodynamique, acoustique et perceptive : le cas de la nasalisation en portugais brésilien.

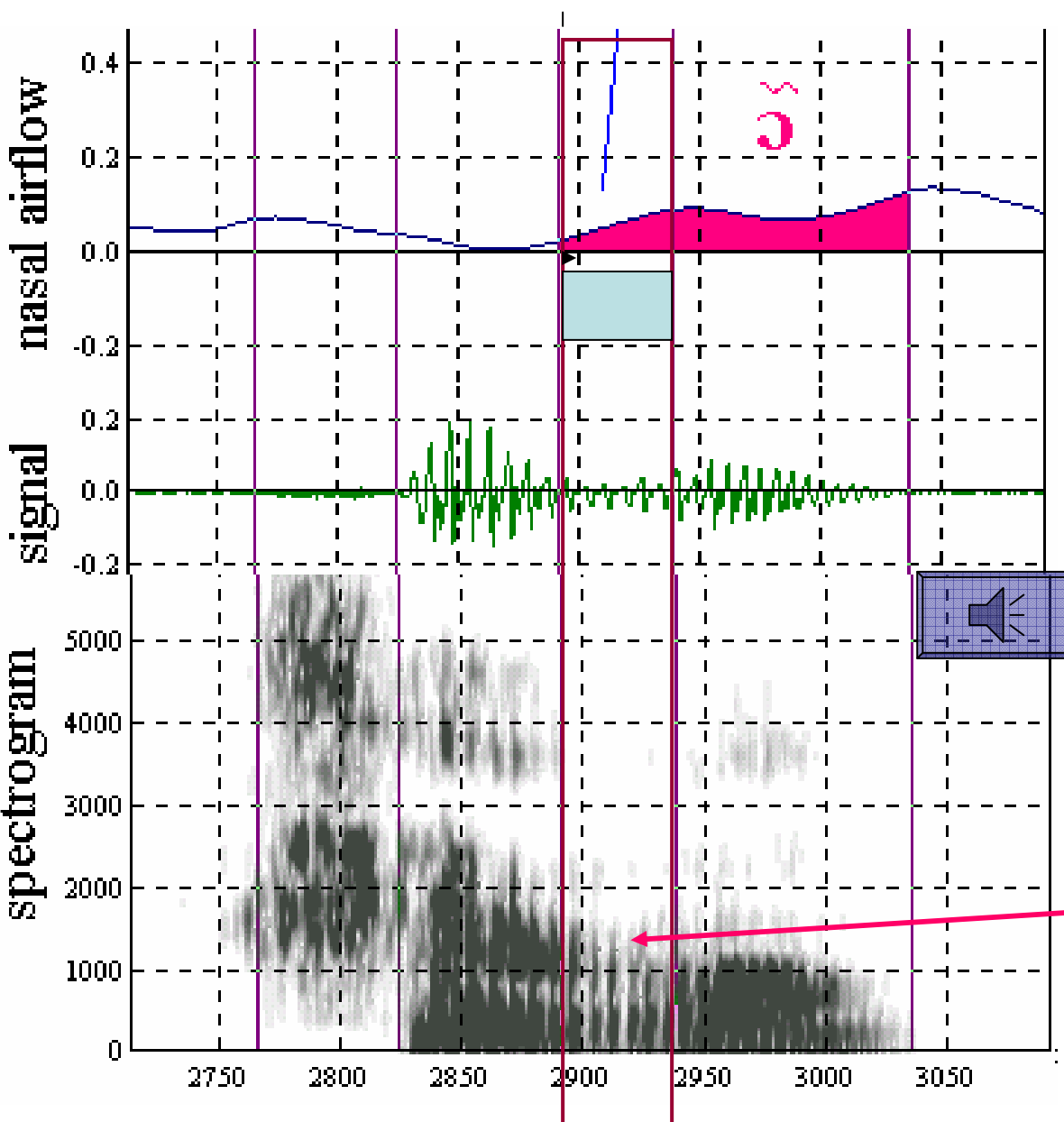


2) fiberscopic and aerodynamic: mvt much before airflow



- Going back to aerodynamics pb later ...
- Acoustics is also a problem ...
- later

Agreement: nasal airflow and acoustic nasalization



EMG

fiberscope

C'est bon

Aerodynamics

aerodynamics

Acoustics

Nasal airflow durant /b/

acoustics

Presence of formants during /b/

Contextually nasalized /b/



5) Aero and acoustics: agreement or not

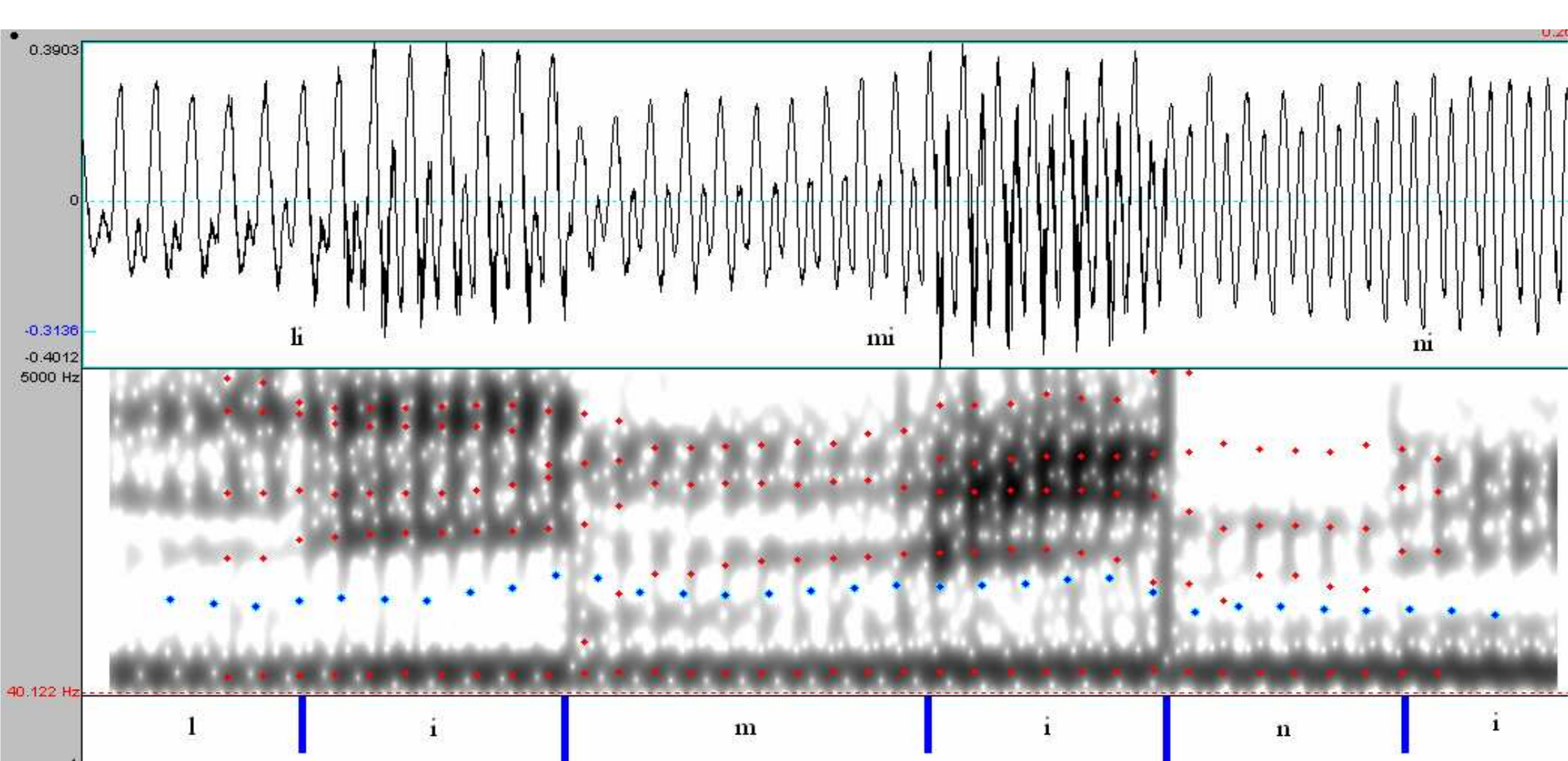
Atelier x :

Nasal 2009



Problems in the interpretation of the data related to nasality

- A) On some discrepancies that can be explained in part
- A1) instrumentation-dependent results
 - A2) acoustic cues to nasalisation , airflow, and microbeam

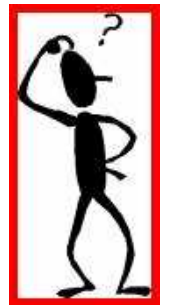
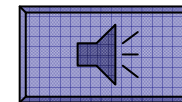
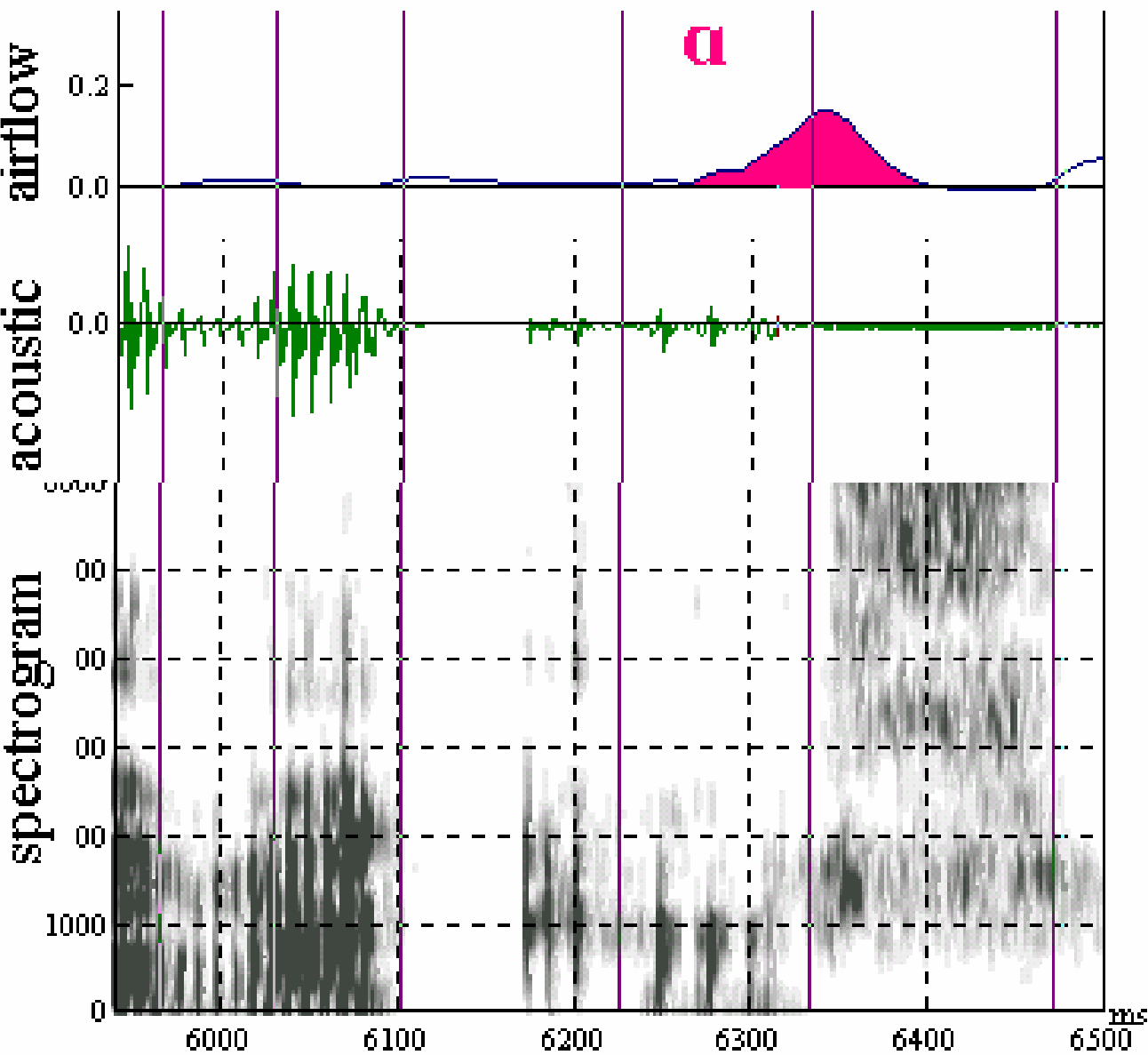


But very difficult to work from acoustics only

Acoustically contextually nasalized /i/

Remark: nasalisation cues easier on /i/ than /a/

???: nasal airflow and acoustic nasalization

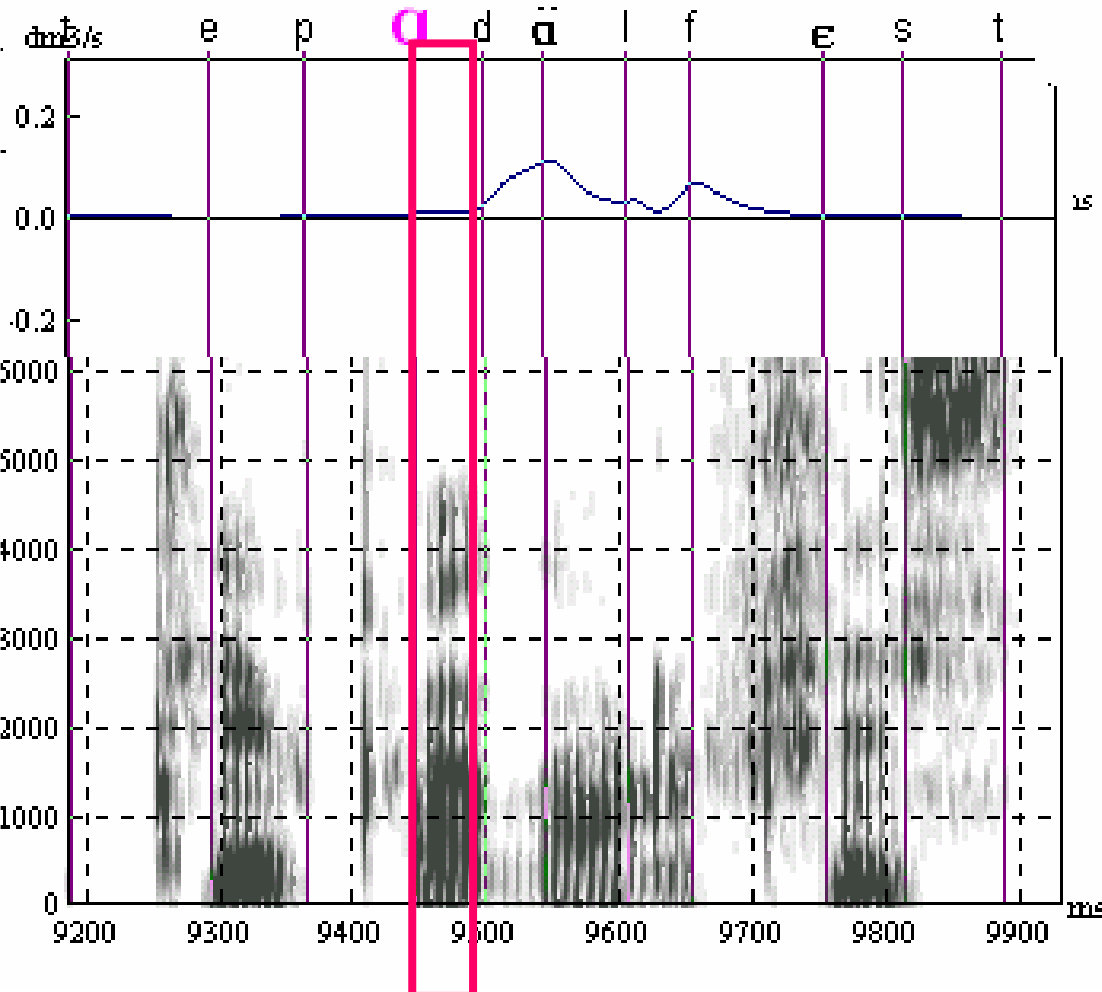


Acoustic nasalisation not seen during fricative?

Agreement: nasal airflow and acoustic nasalization

[pãdãlfɛstival] « Pendant le festival »

pã dã



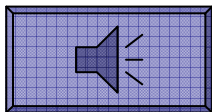
aerodynamics

No nasal airflow durant /ã/

acoustics

No much cues to nasalisation

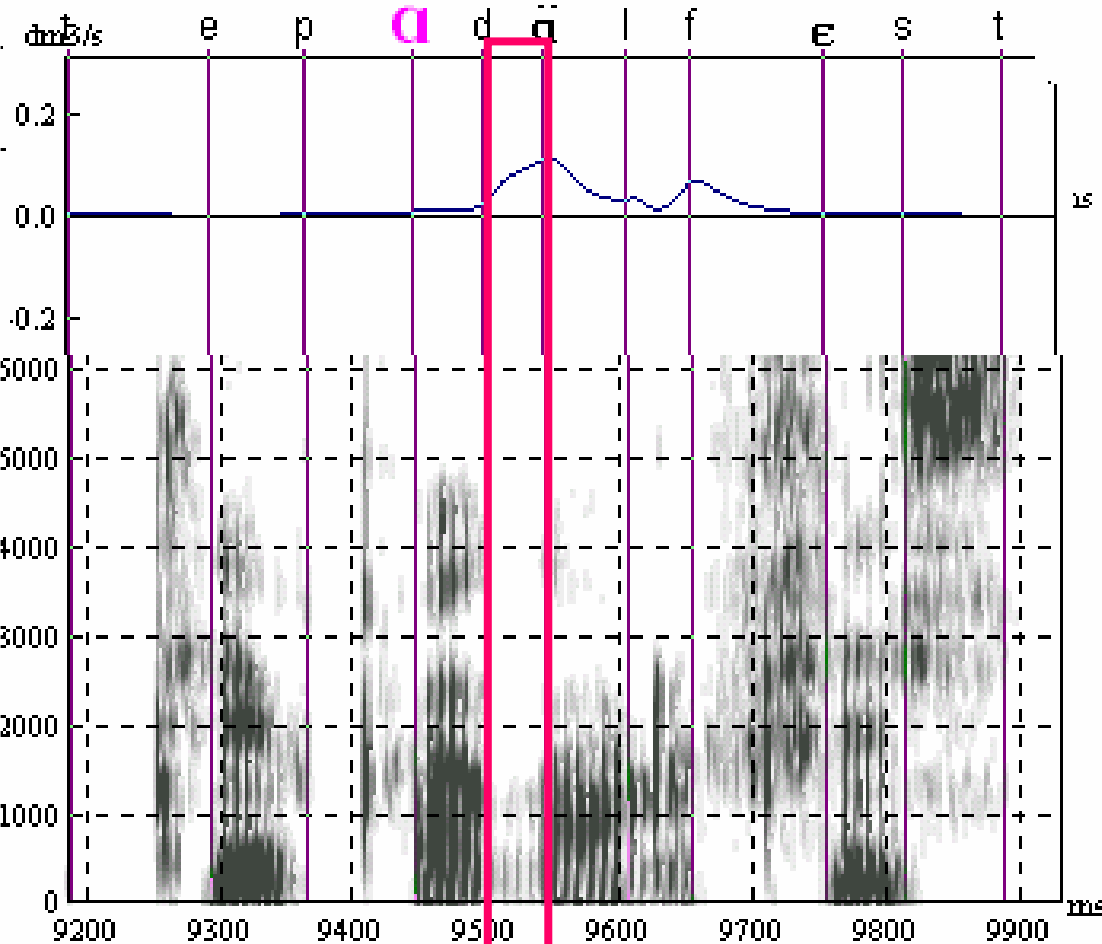
Aerodynamically and acoustically oralized nasal vowel



Agreement: nasal airflow and acoustic nasalization

[pãdãlfestival] « Pendant le festival »

pãdã



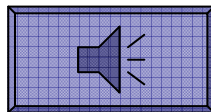
aerodynamics

No nasal airflow durant / d /

acoustics

Presence of formants during / d /

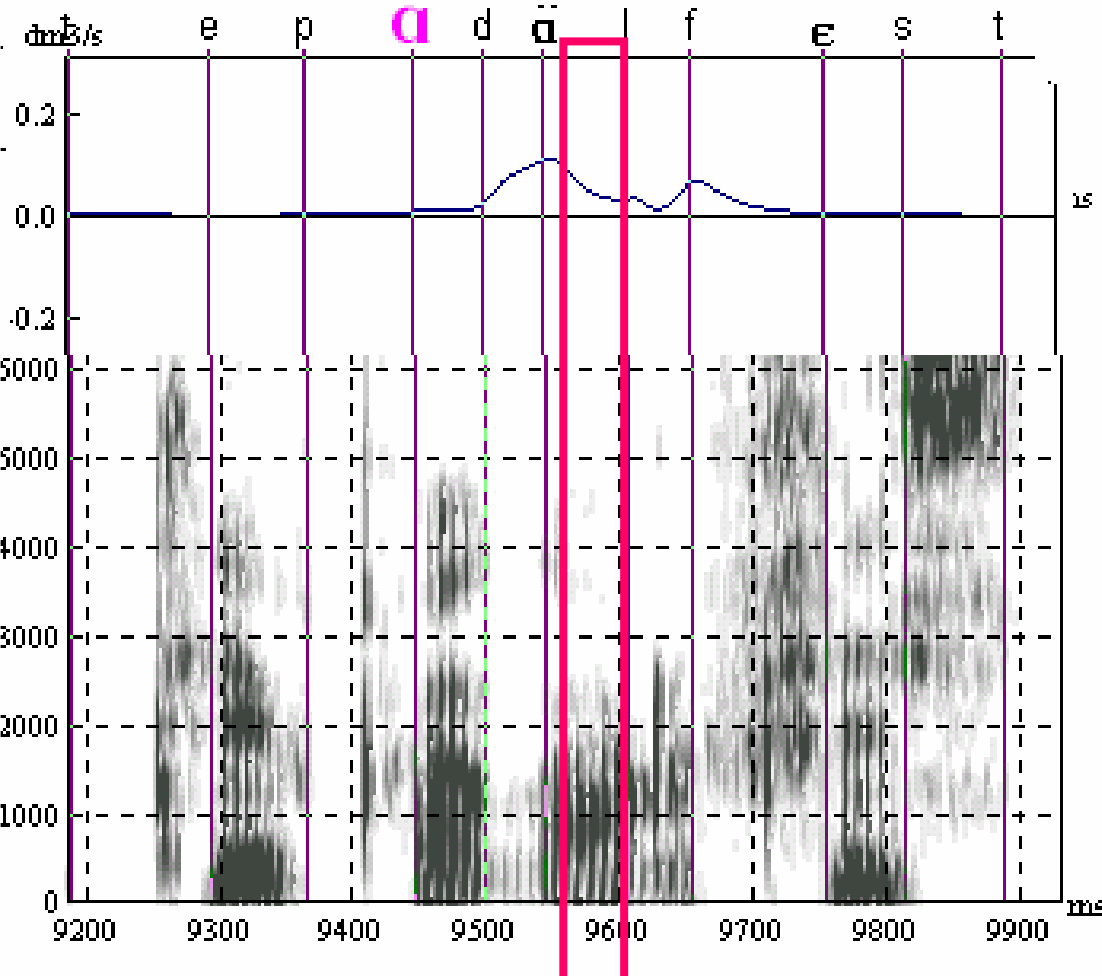
Aerodynamically and acoustically nasalized oral stop



Agreement: nasal airflow and acoustic nasalization

[pãdãlfestival] « Pendant le festival »

pã dã



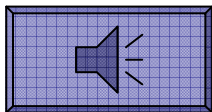
aerodynamics

Nasal airflow durant /ã/

acoustics

Reduction of energy in the region
Of the first formant for
The second vowel

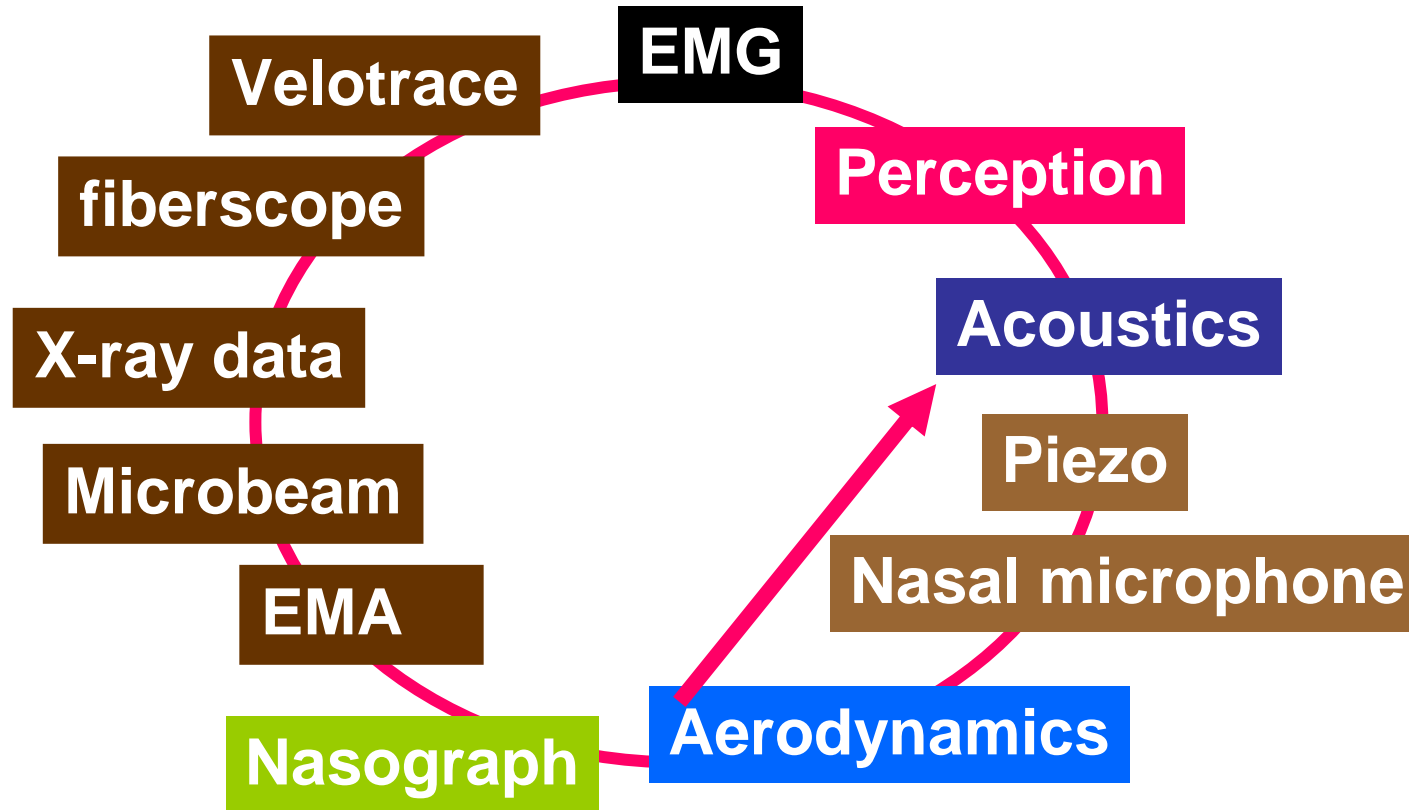
Aerodynamically and Acoustically nasalized nasal vowel



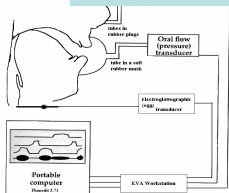
suppression of the activity of the levator palatini

Remark:

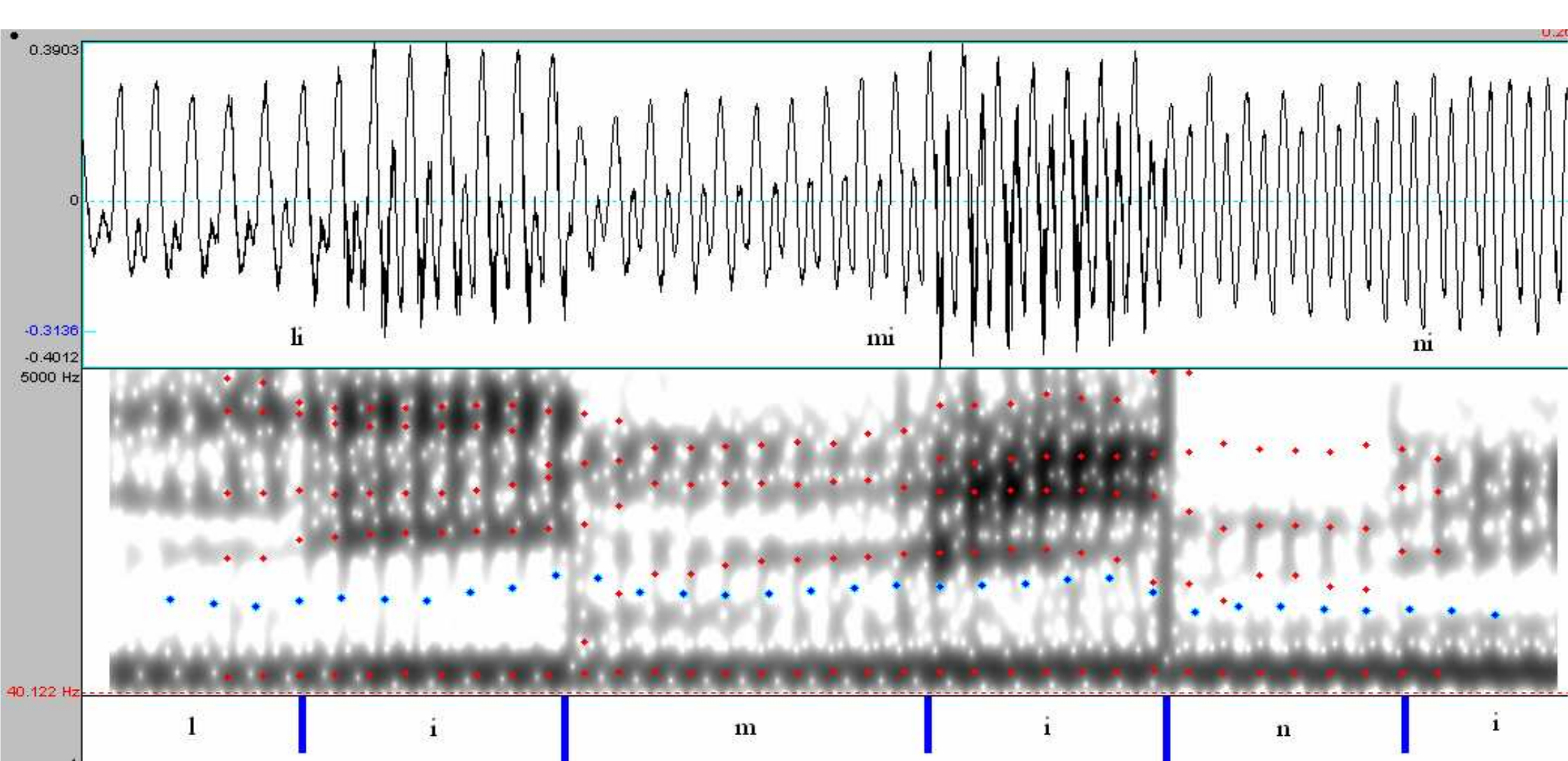
descent of the velum



Perception difficult when aerodynamic data



opening of the velopharyngeal port

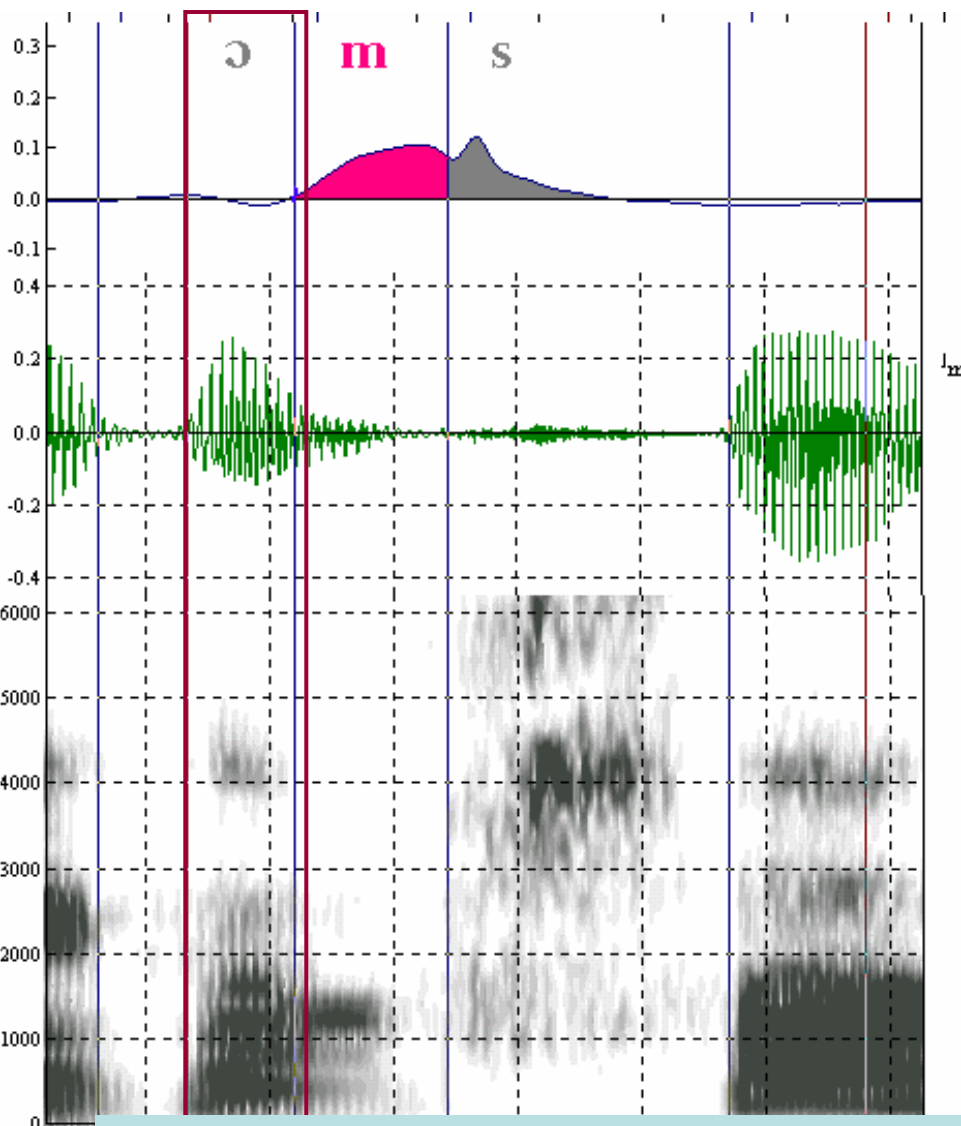


But very difficult to work from acoustic only

Acoustically contextually nasalized /i/

And also from acoustics: depend on the window

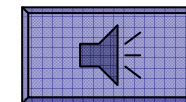
no nasal airflow but acoustic nasalization



aerodynamics

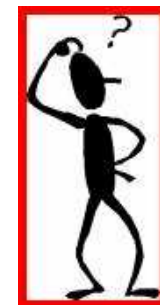


**No anticipation of nasal airflow
Before N in coda**



acoustics

Cues to nasalisation



Acoustically nasalized oral vowel without nasal airflow

Agreement difficult to check



Size of the whole gesture in
“tend” and “tent”

similar

Beddor

(longer in “tend”)

- unexplained



very different
Vaissière

Acoustics

microbeam

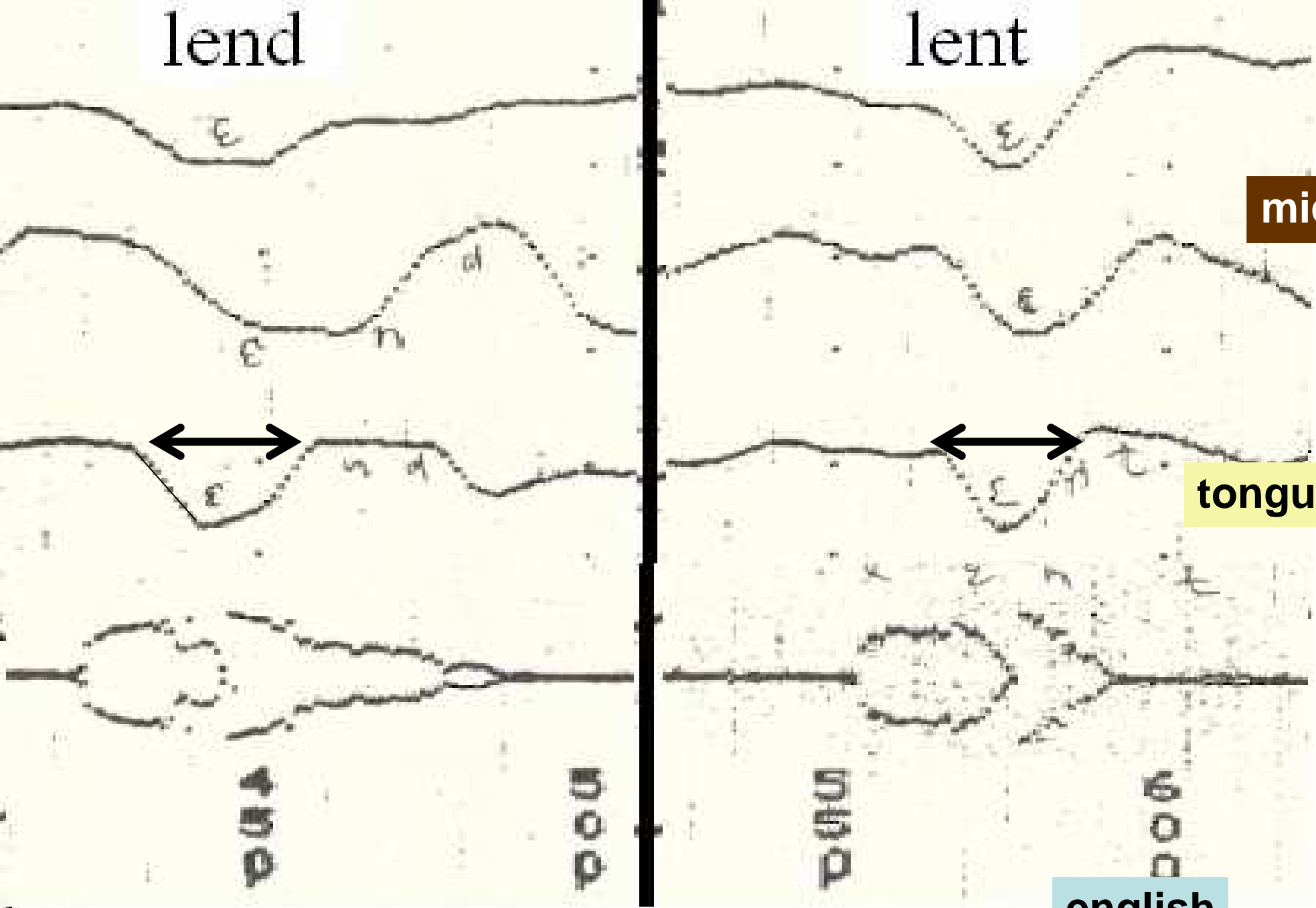
lend

lent

microbeam

tongue

english



lend

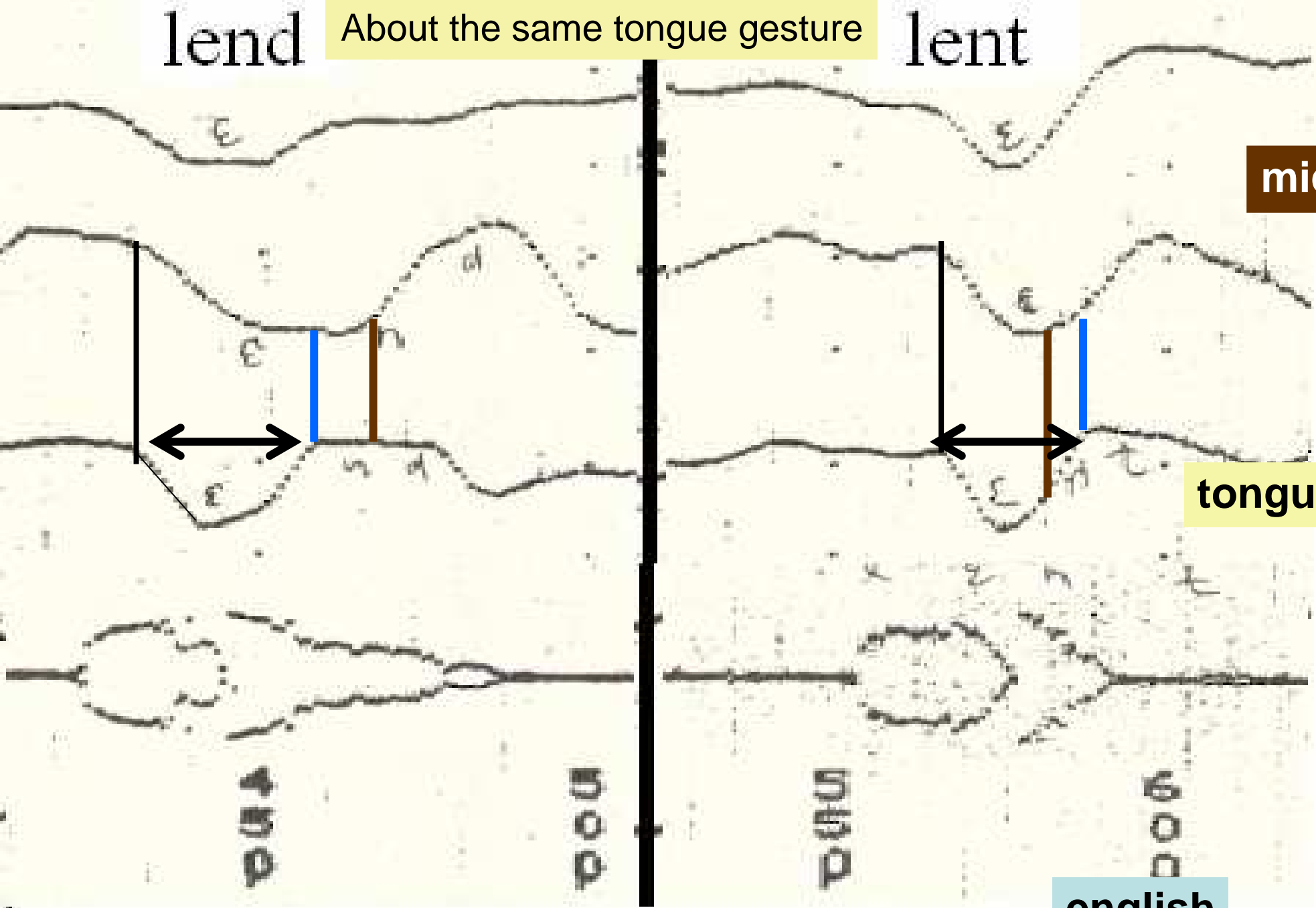
About the same tongue gesture

lent

microbeam

tongue

english



lend

About the same tongue gesture
But very different velum movement

lent

Same timing of velar lowering a // offset

microbeam



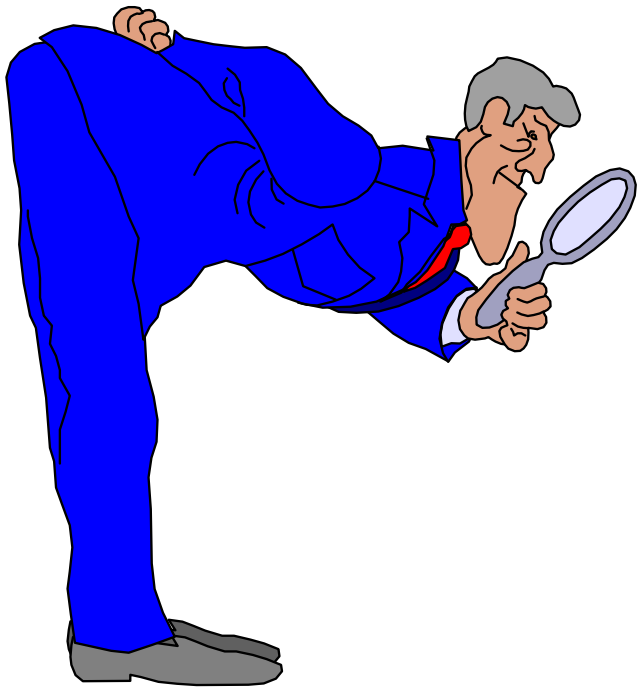
More rapid velar lowering and tongue lowering in the case of lent versus lend

Velum starts to rise again after /n/ onset in /lend/
but before in /lent/

english

What to conclude?

What do you mean by « nasalized »?

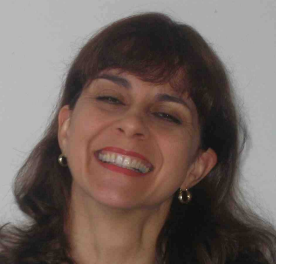


- Phonologically oral or nasal +-
 - Contextually nasalized
 - Articulatory +-
 - Movement (fiberscope)
 - Opening (nasograph)
 - location
 - Aerodynamically +-
 - Acoustically +-
 - Perceptually +-
- spontaneous**

Problems in the interpretation of the data related to nasality



- A) On some discrepancies that can be explained in part
- A1) instrumentation-dependent results
 - A2) acoustic cues to nasalization and airflow
 - A3) acoustics: distinction between nasal mora and voice decay time ???
Not so clear

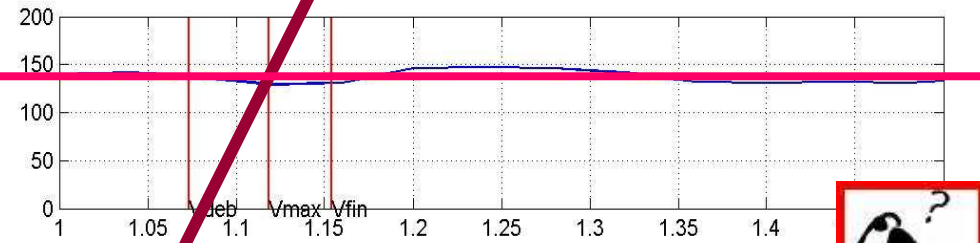
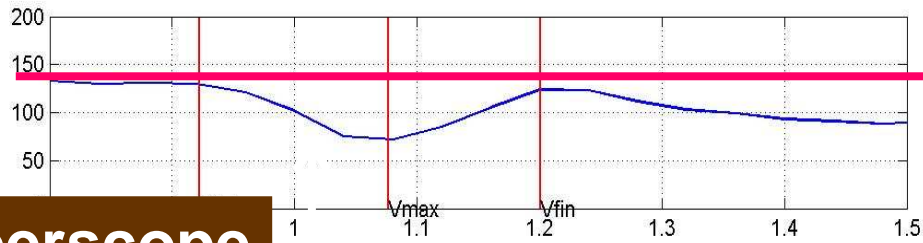
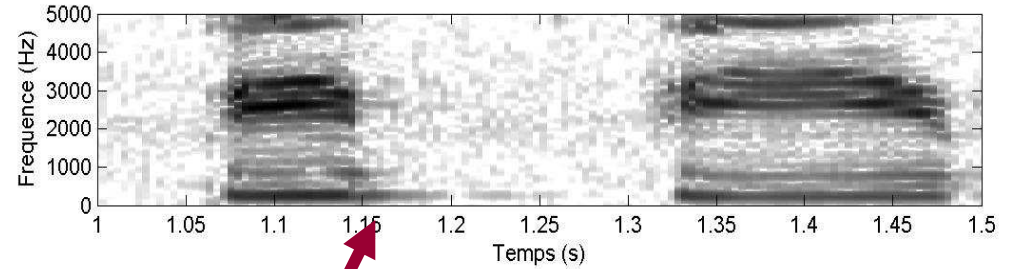
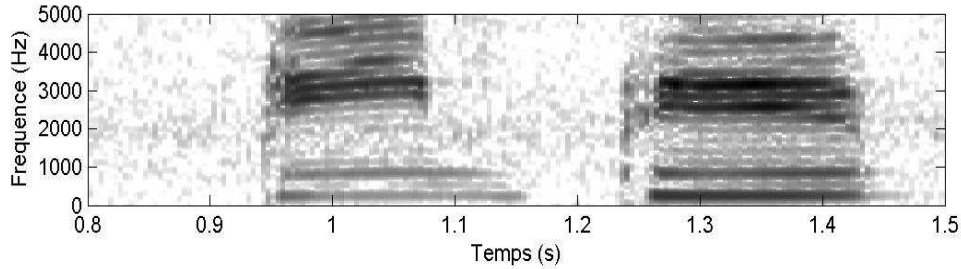
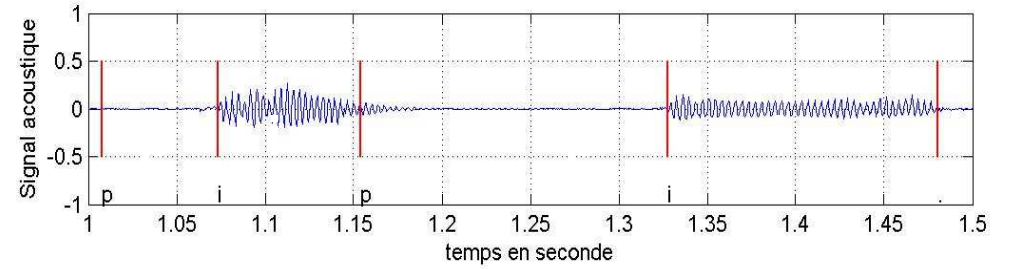
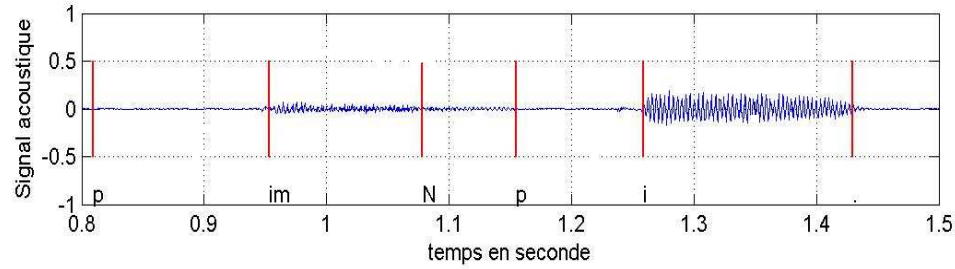


???: acoustics not sufficient

pimpi



pipi



fiberscope

Play view

Pla...

Play view



Difficult to separate acoustic nasal mora and voice decay time

Problems in the interpretation of the data related to nasality



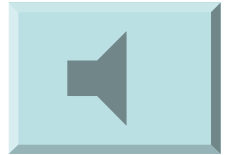
- A) On some discrepancies that can be explained in part
- A1) instrumentation-dependent results
 - A2) acoustic cues to nasalization and airflow
 - A3) acoustics: distinction nasal mora and voice decay time
 - A4) aerodynamics: positive or negative airflow with VP close

Pumping effect
Pushing effect

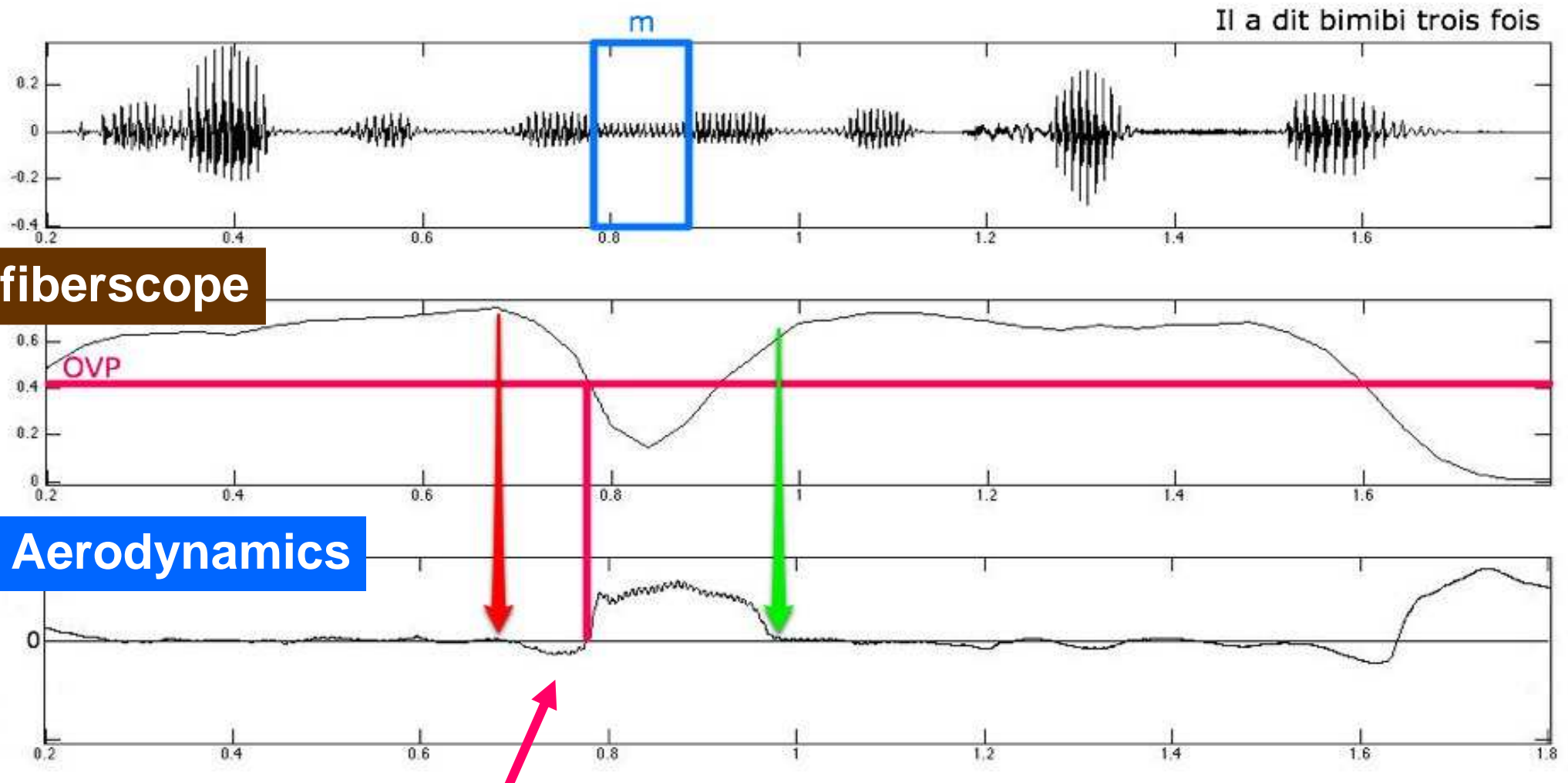


Pumping effect

Pushing effect



Known, not taken into account



fiberscope

Aerodynamics



Pumping effect

Pushing effect



the upward movement of the velum along the pharyngeal wall may create a positive nasal airflow, while the velopharyngeal port may be already closed.

What to conclude?



- Pumping effect: underestimation of anticipation
- Pushing effect: overestimation of carry-over

Problems in the interpretation of the data related to nasality



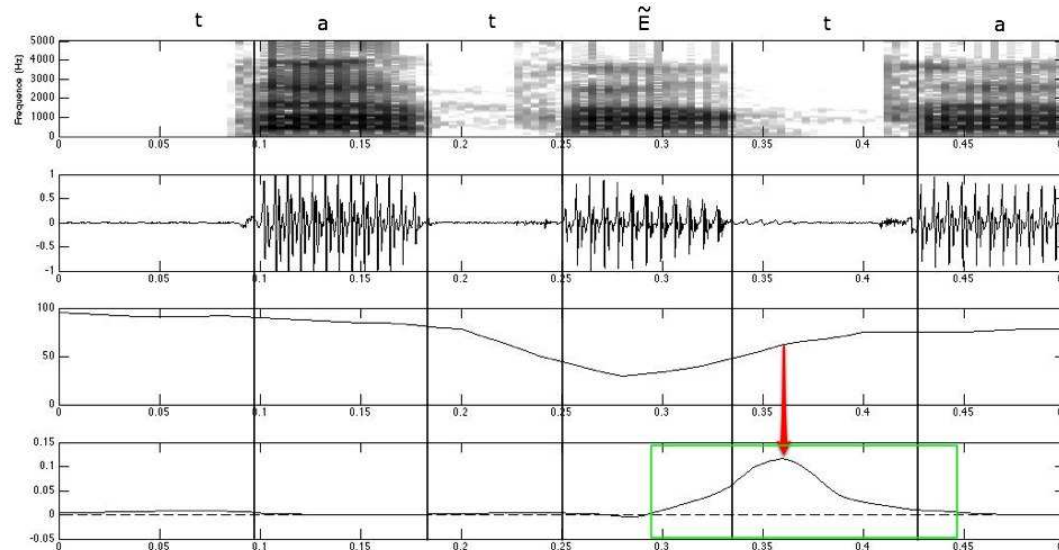
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 - A3) distinction nasal mora and voice decay time
 - A4) aerodynamics: positive or negative airflow with VP close
 - A5) nasal airflow and airflow resistance



The point of maximal airflow often appears in the next oral phoneme



French



airflow resistance in the oral cavity
(while the velum has almost achieved closing).

Point of maximum airflow defined by airflow resistance

O~

LM



Portuguese

Spectrogramme

Signal Acoustique

MVélaire

after

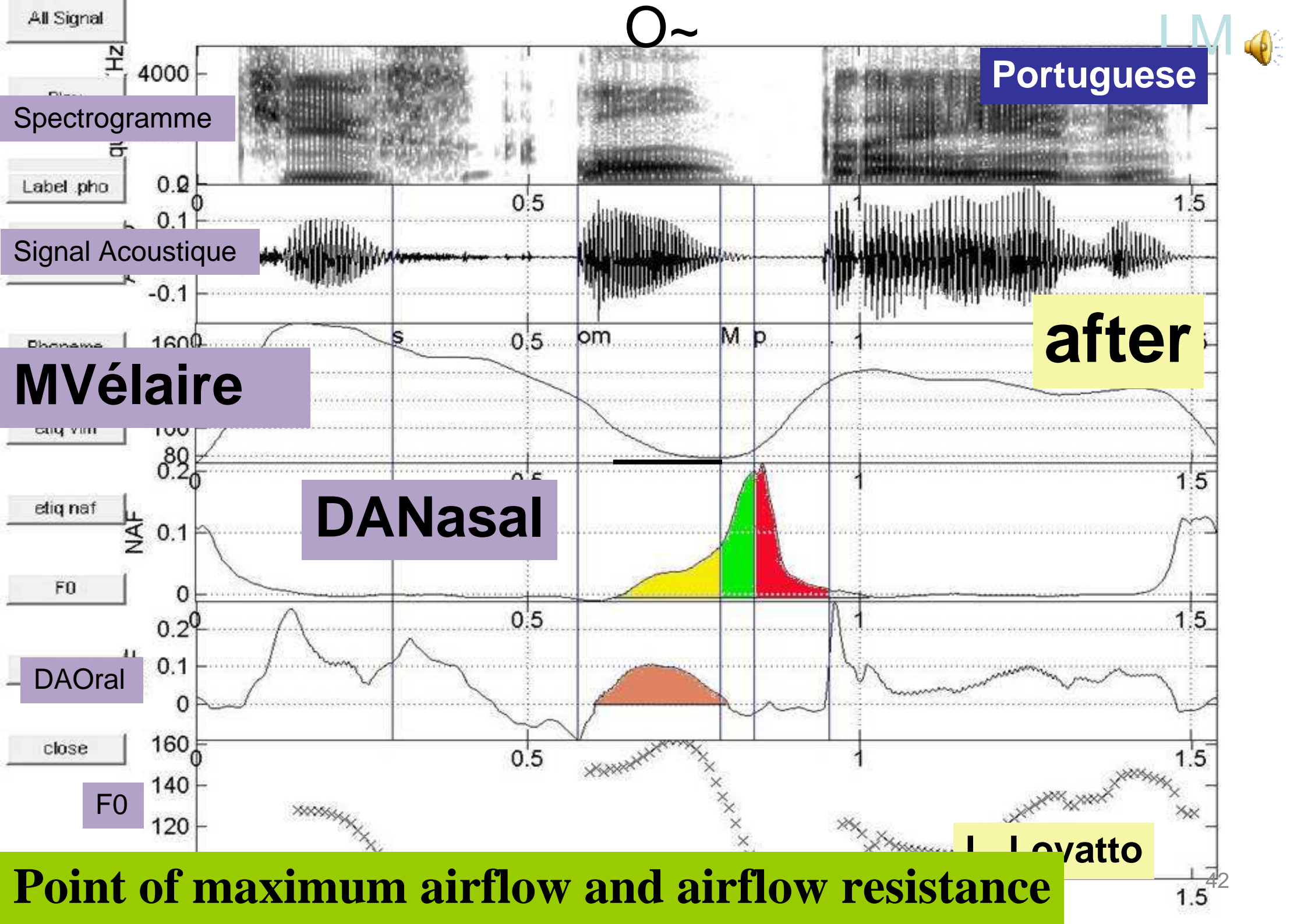
DANasal

DAOral

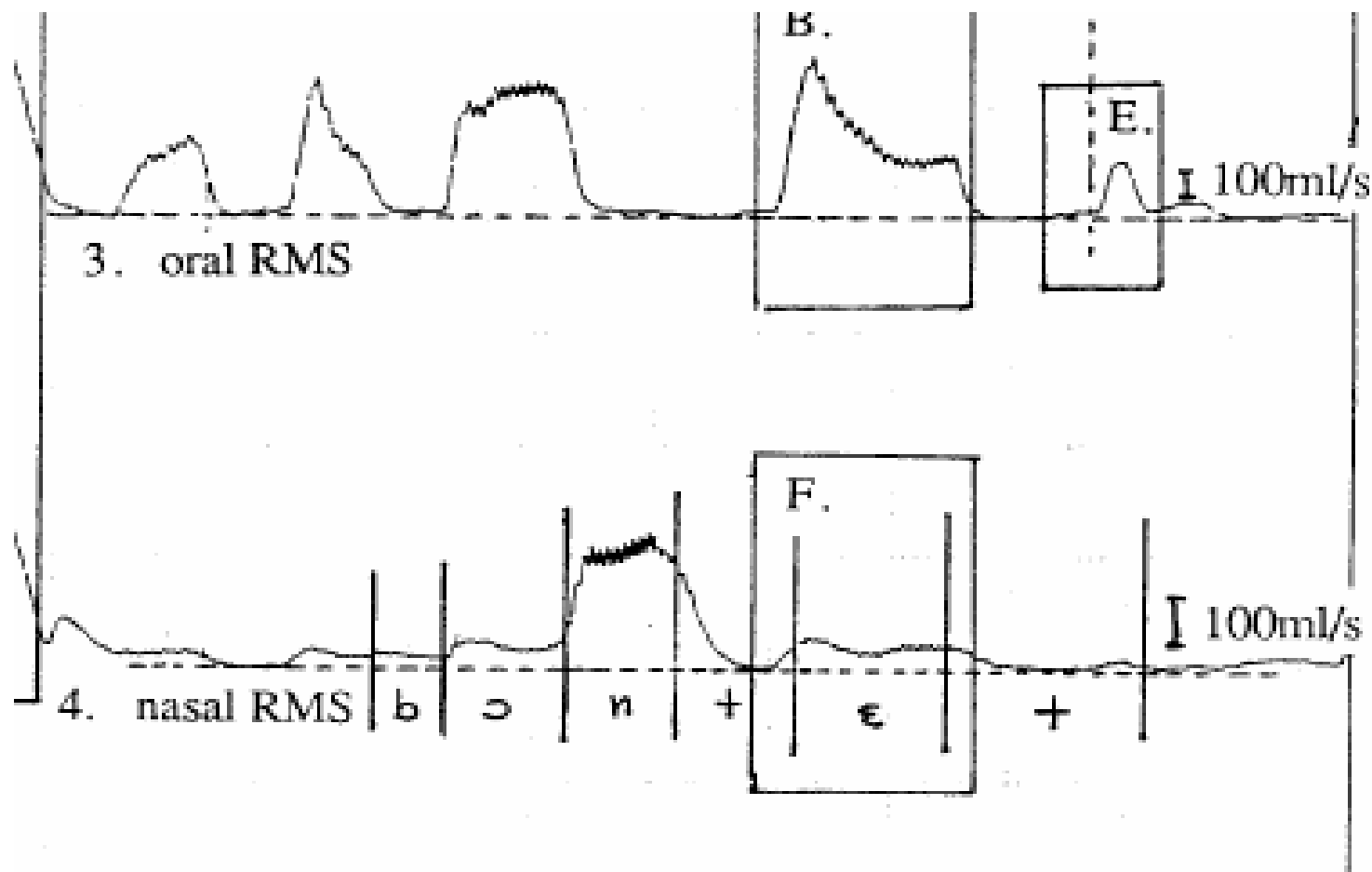
F0

J. Loyatto

Point of maximum airflow and airflow resistance



The point of maximal airflow often appears in the next oral phoneme but not always



A.Cohn

Problems in the interpretation of the data related to nasality



- A) On some discrepancies that can be explained in part
- A1) instrumentation-dependent results
 - A2) acoustic cues to nasalisation and airflow
 - A3) distinction nasal mora and voice decay time
 - A4) positive or negative airflow with VP close
 - A5) nasal airflow and airflow resistance
- B) Uncontrollable post-pausal raising, prepausal lowering and declination

A) On some discrepancies that can in part be explained

- 1) post-pausal raising
- 2) Pre-pausal lowering
- 3) declination

fiberscope

X-ray data

Aerodynamics

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5 Juin 2009

Speech ready gesture

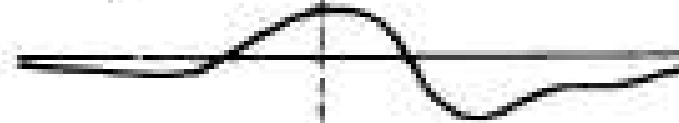
10b. COMMENT

221

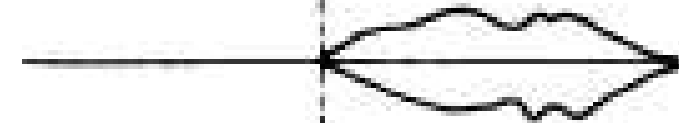
VELUM



LIP



SIGNAL

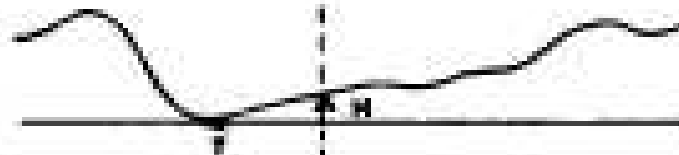


m e l t (12418)

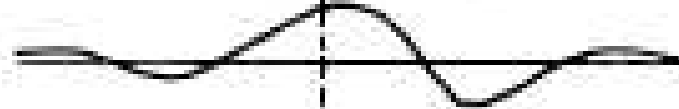
Microbeam

Vaissière, 1986

VELUM



LIP



SIGNAL



m e l t (12418)

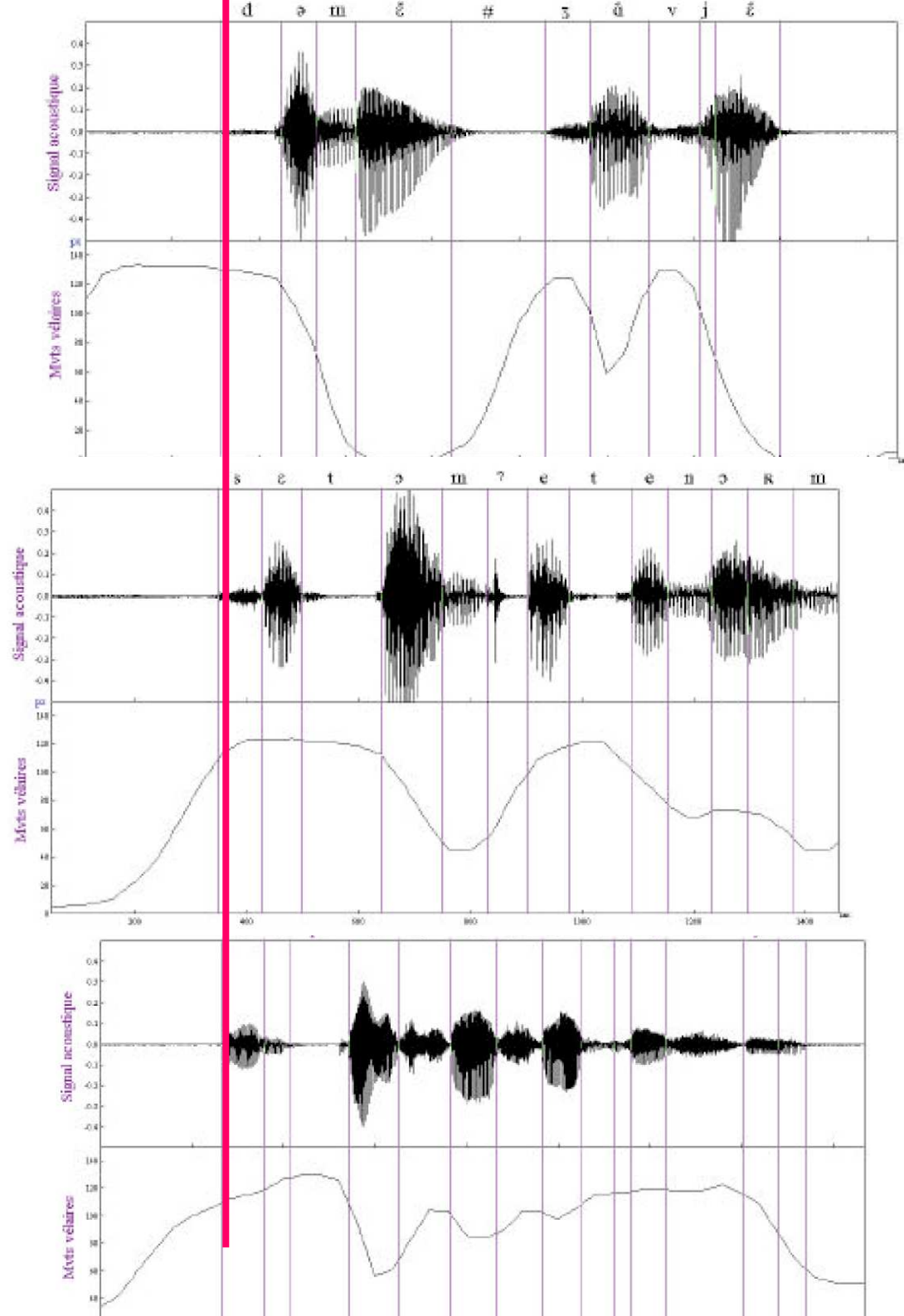
Randomness not taken into account

Speech ready gesture unpredictable



fiberscope

Amelot, thesis



A) On some discrepancies that can in part be explained

- 1) post-pausal raising
- 2) Pre-pausal lowering**
- 3) declination

fiberscope

X-ray data

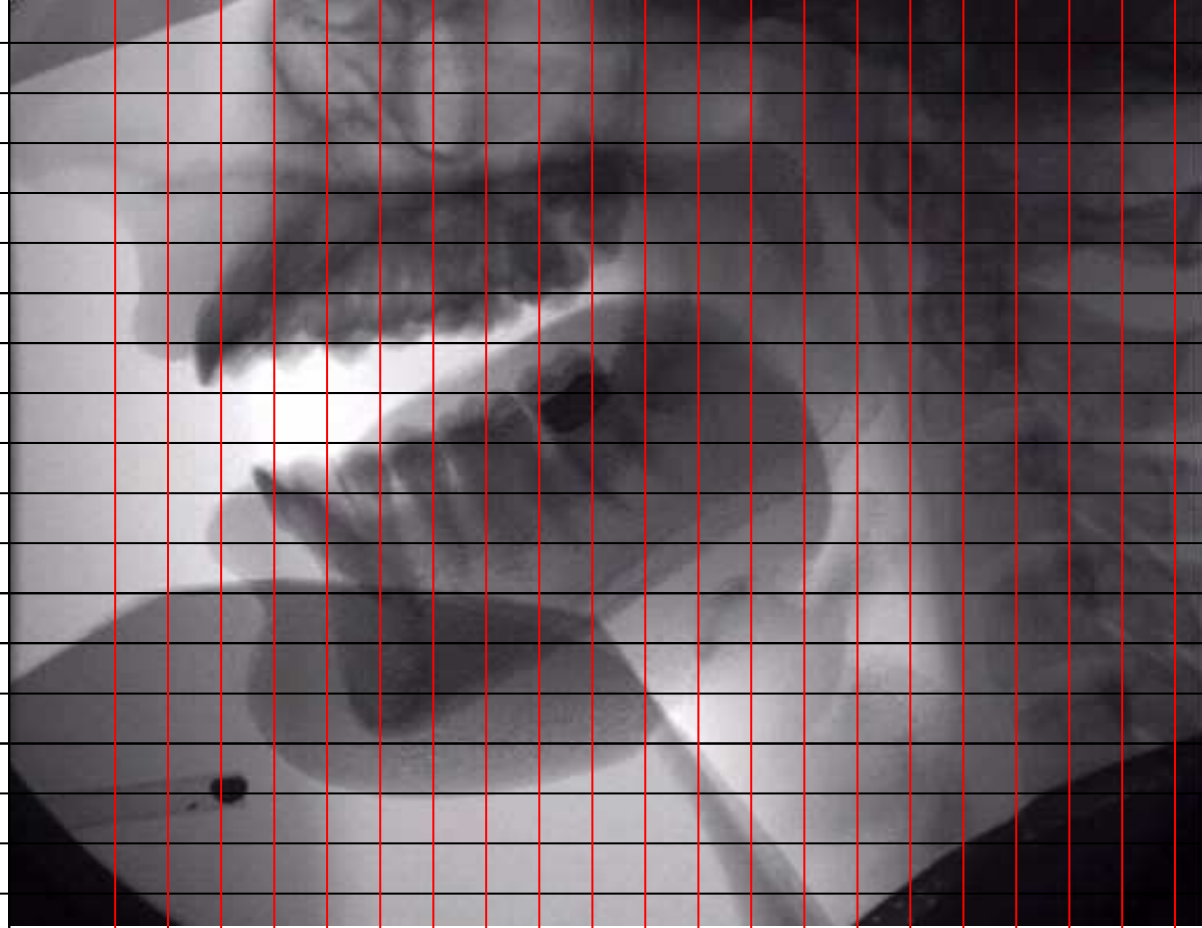
Aerodynamics

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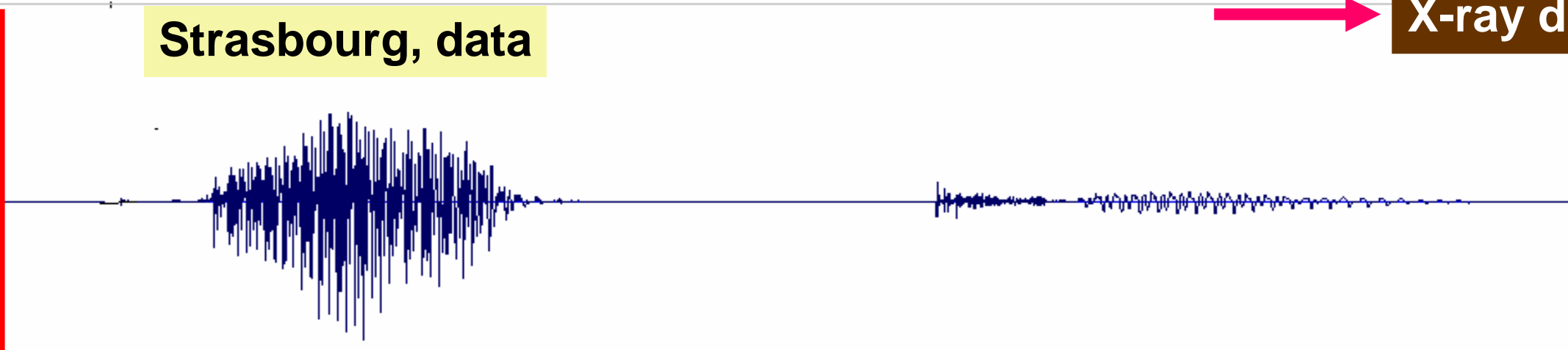
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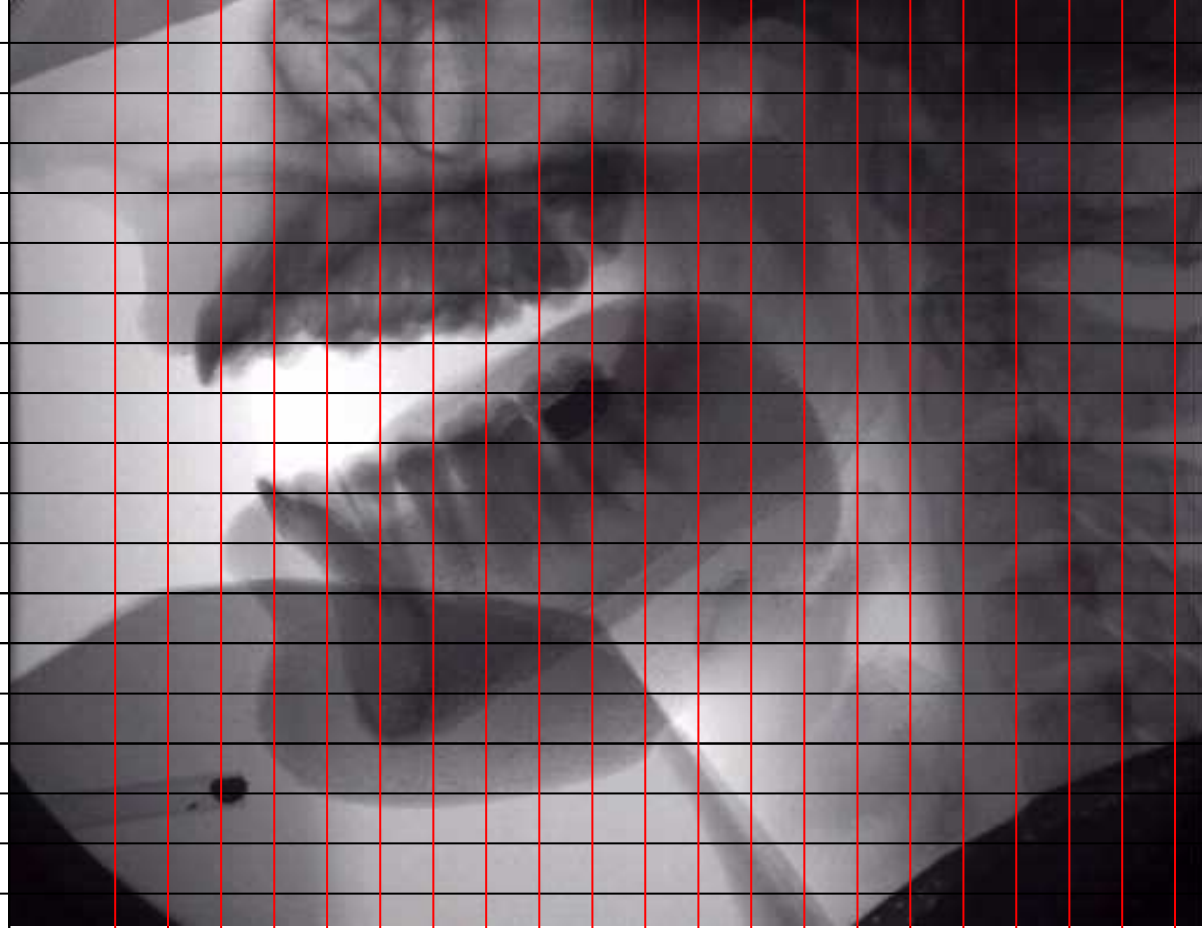
Strasbourg, data



X-ray data



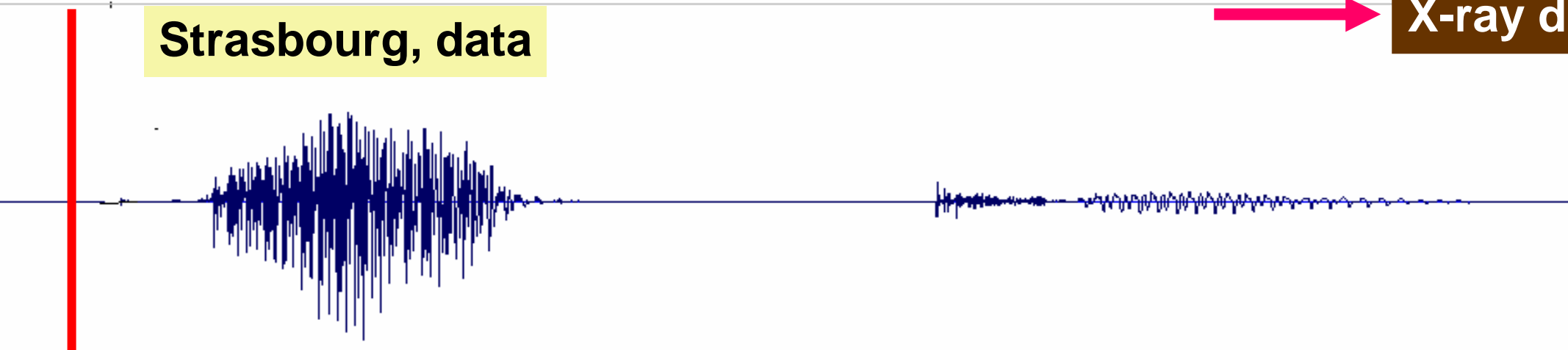
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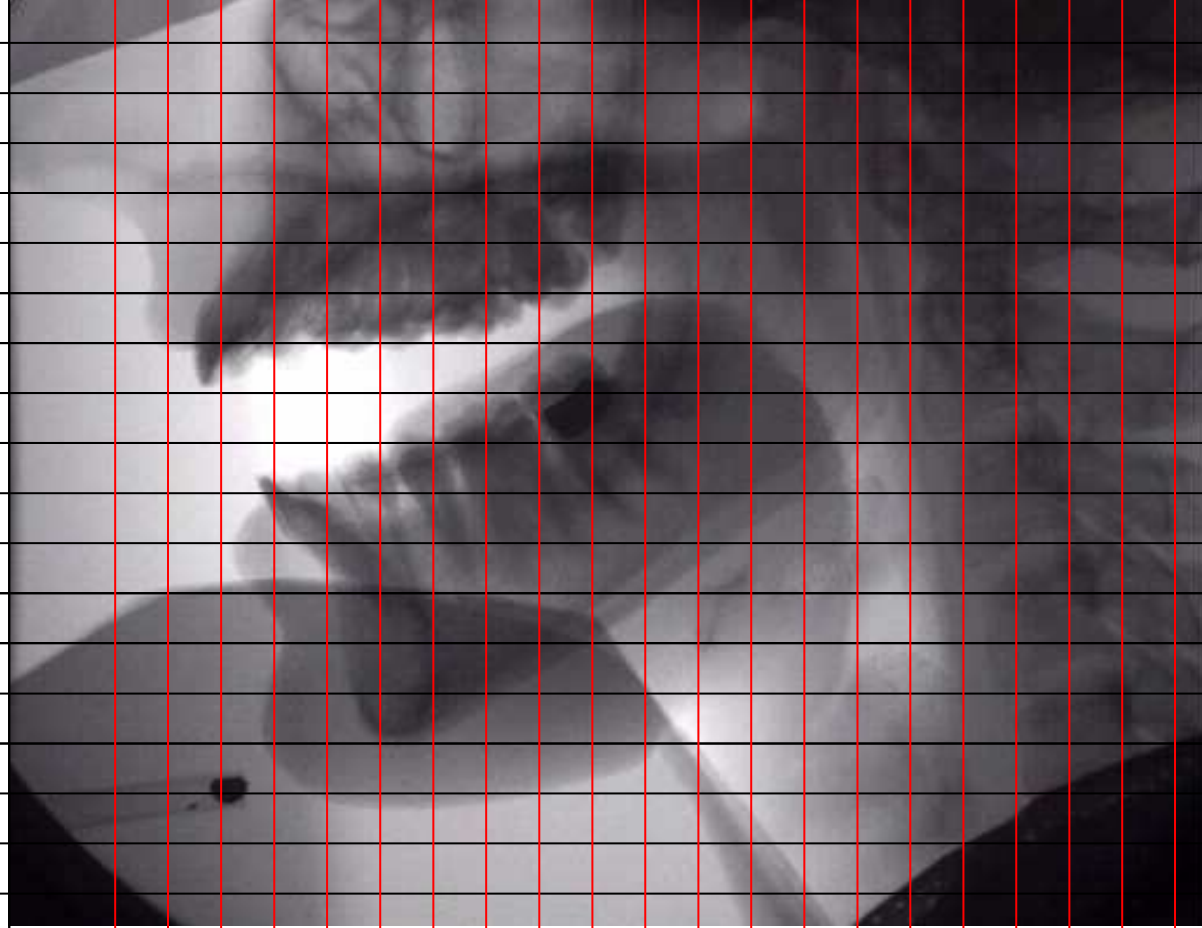
Strasbourg, data



X-ray data



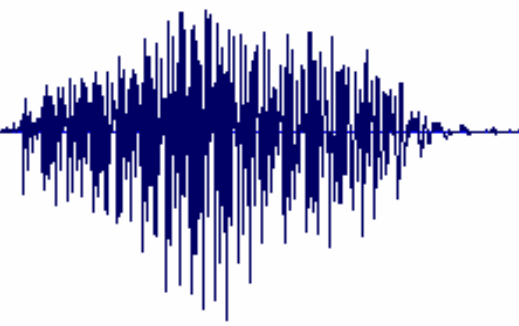
/atu/



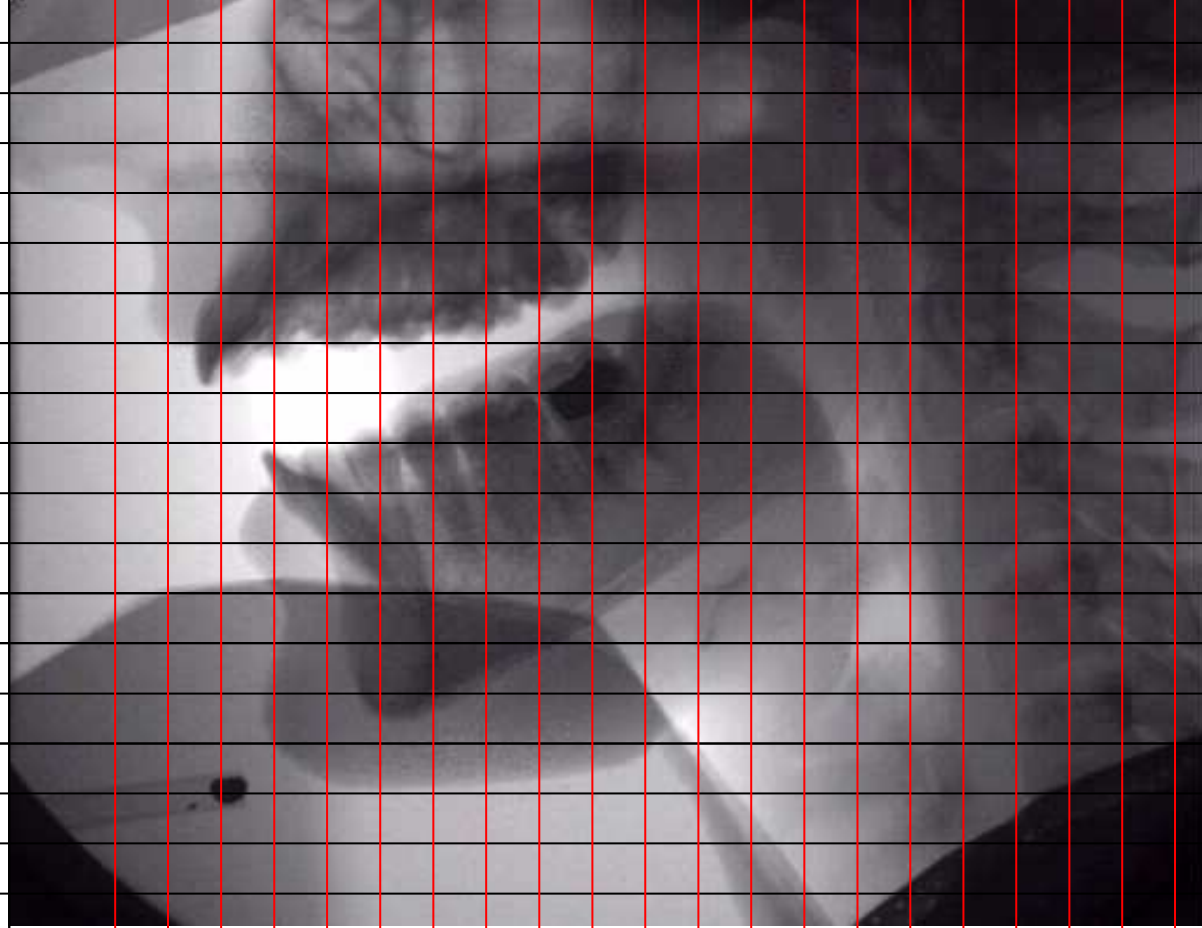
Strasbourg, data

Maximum opening
(before /a/!!!)

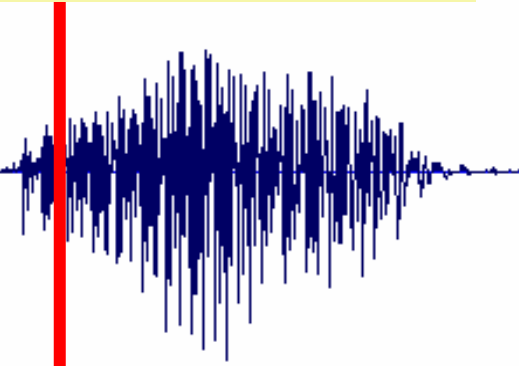
X-ray data



/atu/



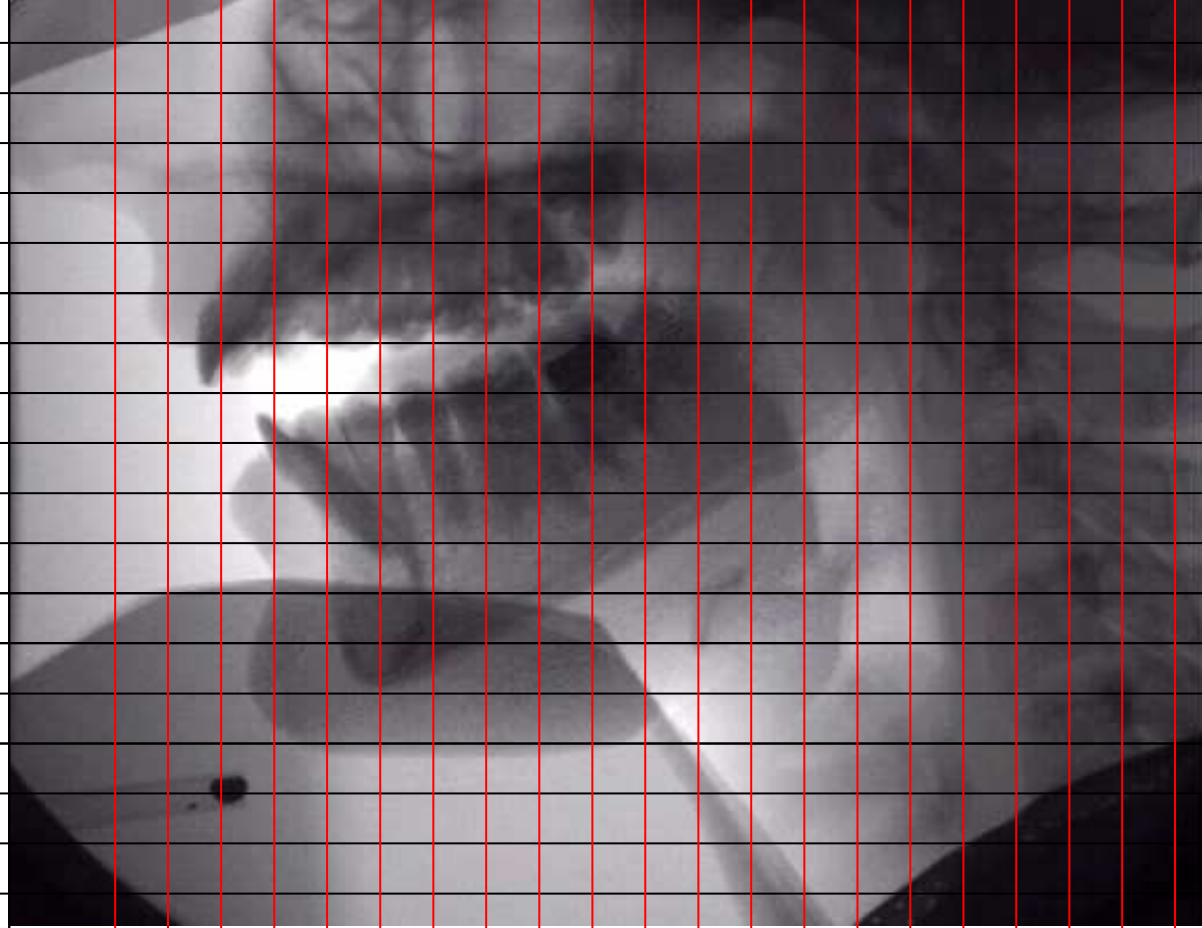
Strasbourg, data



Jaw starts to rise → **X-ray data**
Closing gesture starts
At the vowel beginning !!!



/atu/

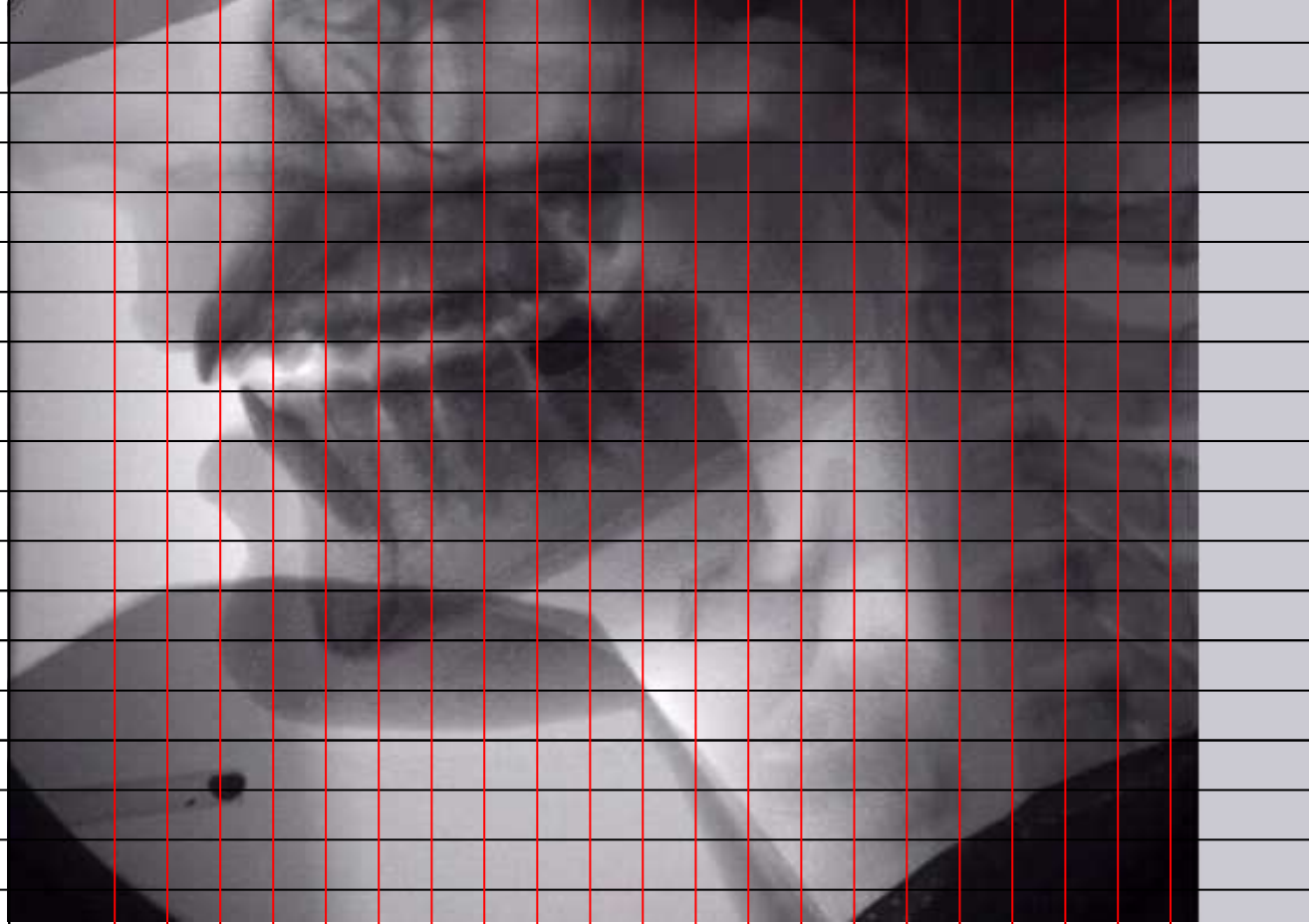


Strasbourg, data



Vocal tract already has **X-ray data**
Closed (in the middle of the
« acoustic » vowel !!!

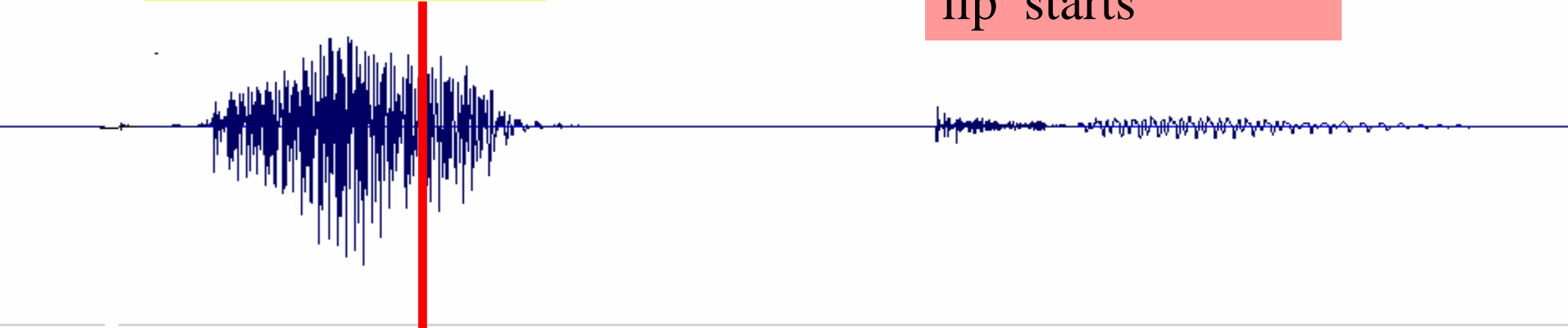
/atu/



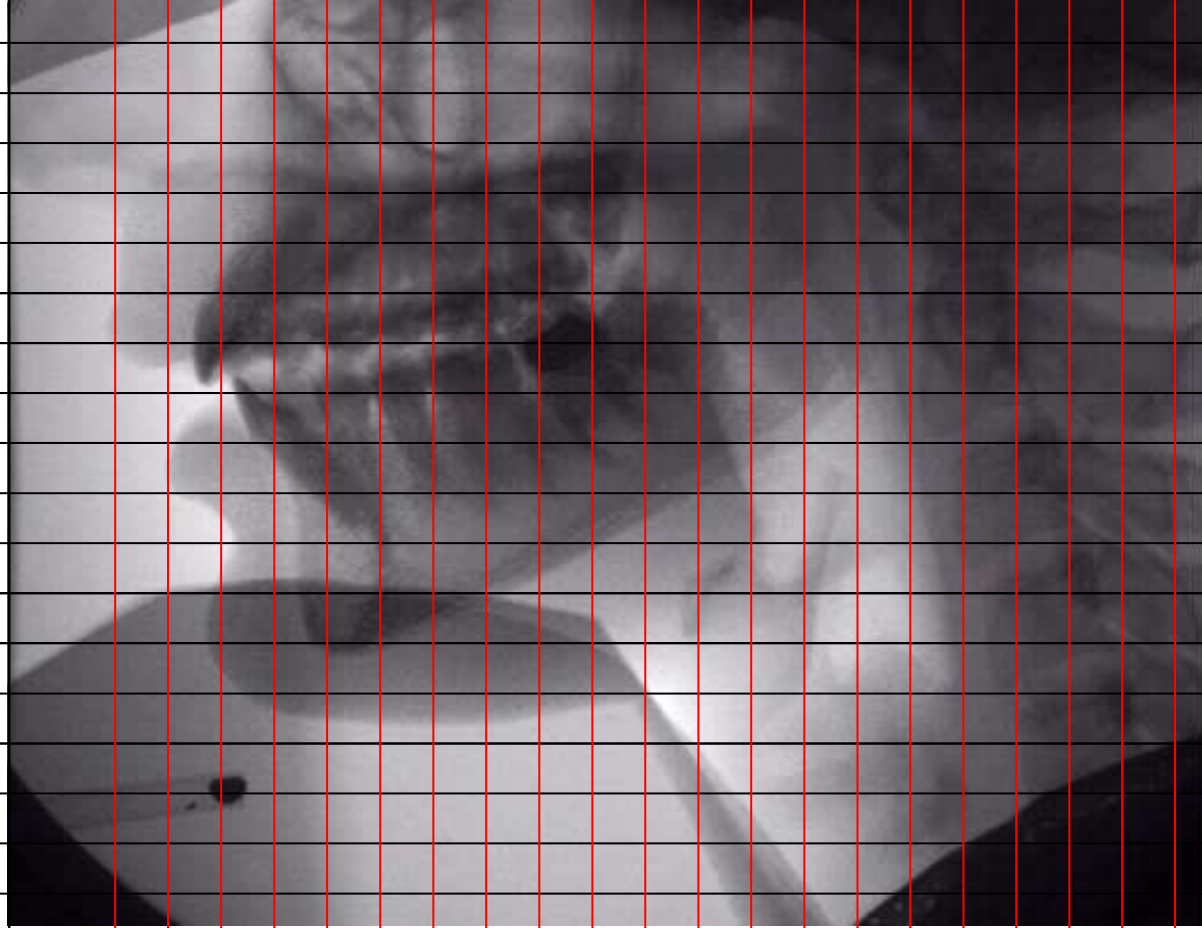
Strasbourg, data

Protrusion of the lip starts

X-ray data

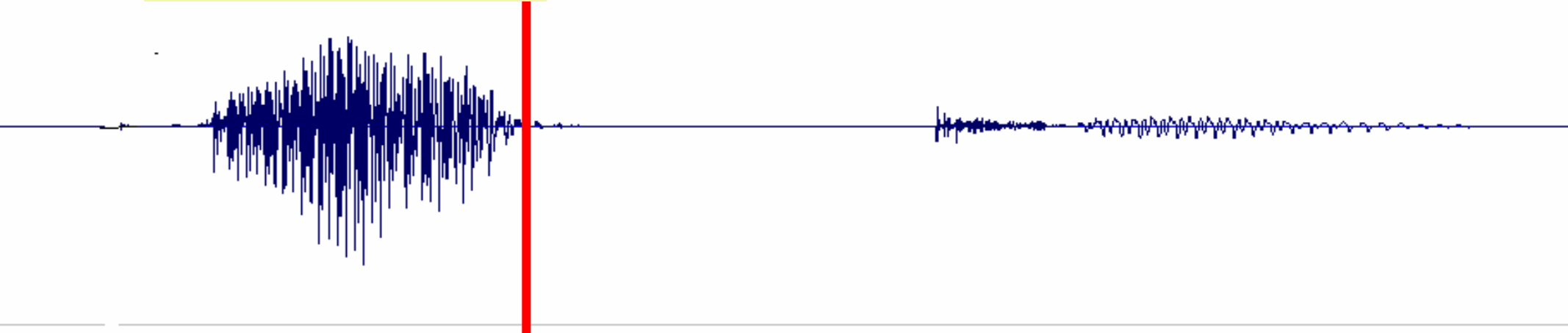


/atu/

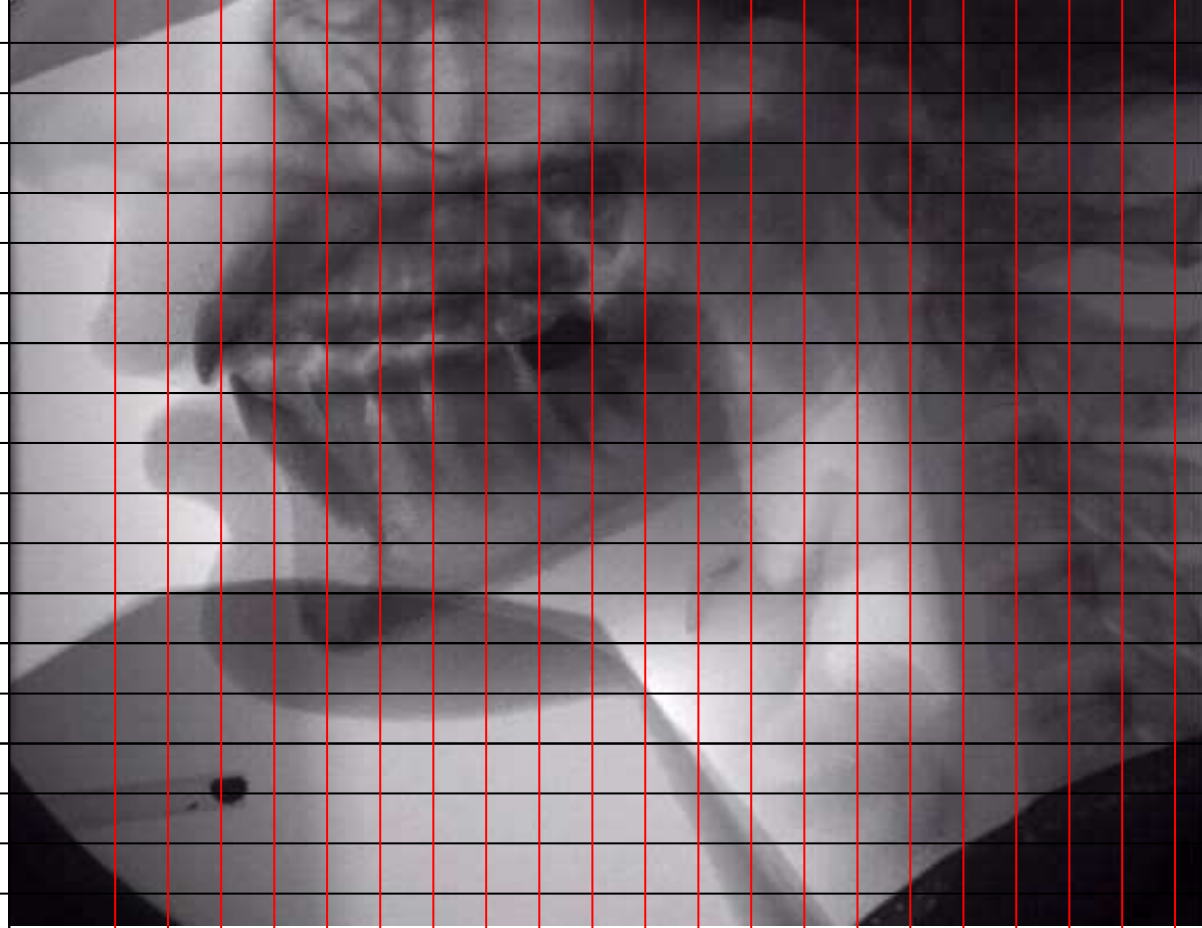


X-ray data

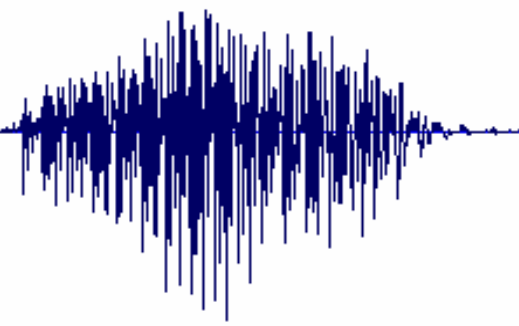
Strasbourg, data



/atu/



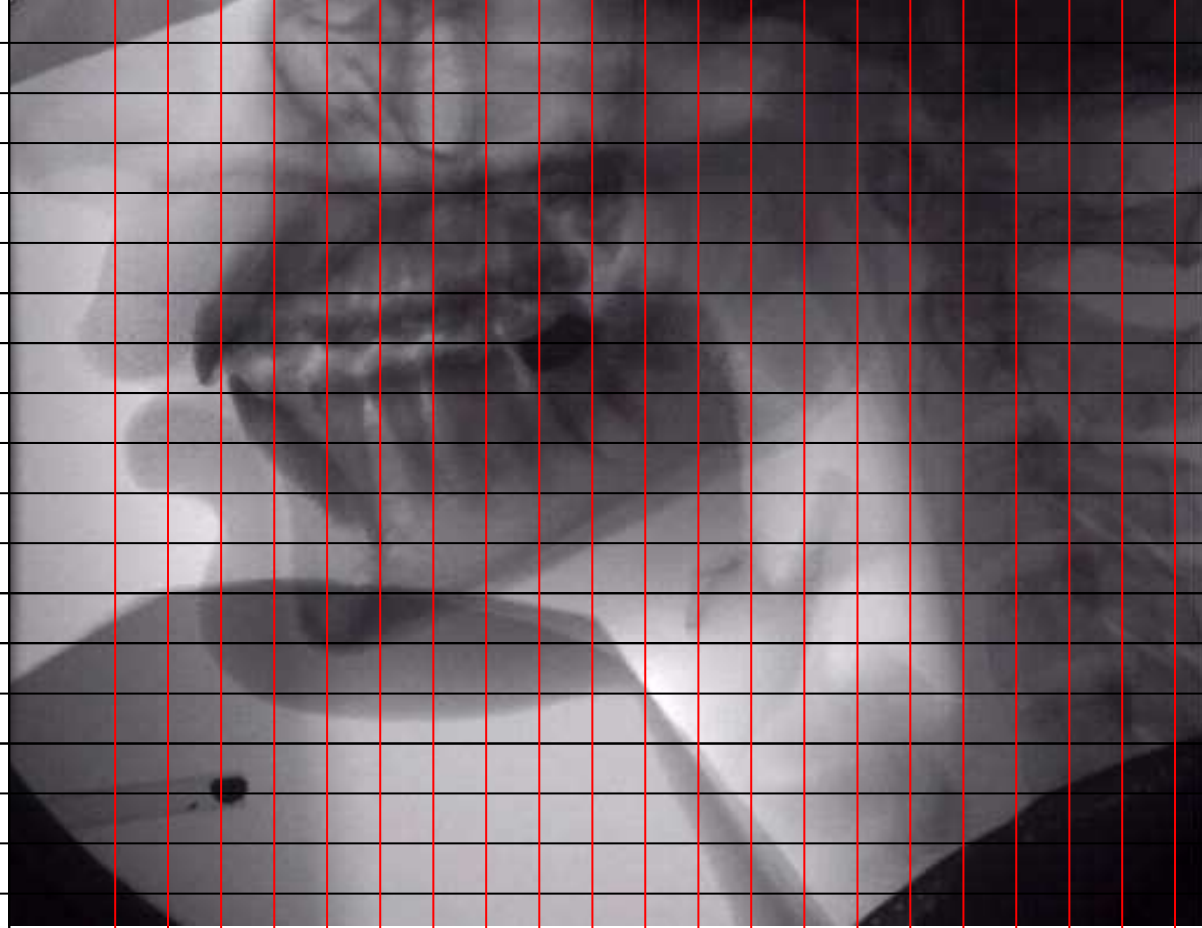
Strasbourg, data



Lip continue to round → X-ray data
(in anticipation of /u/)

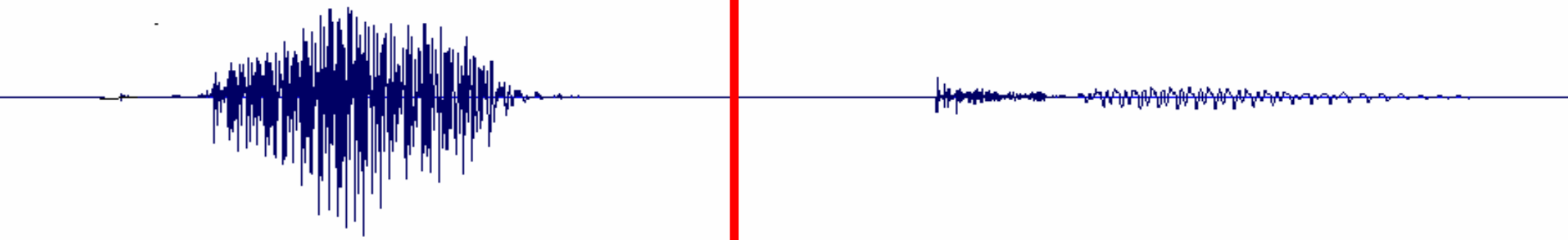


/atu/

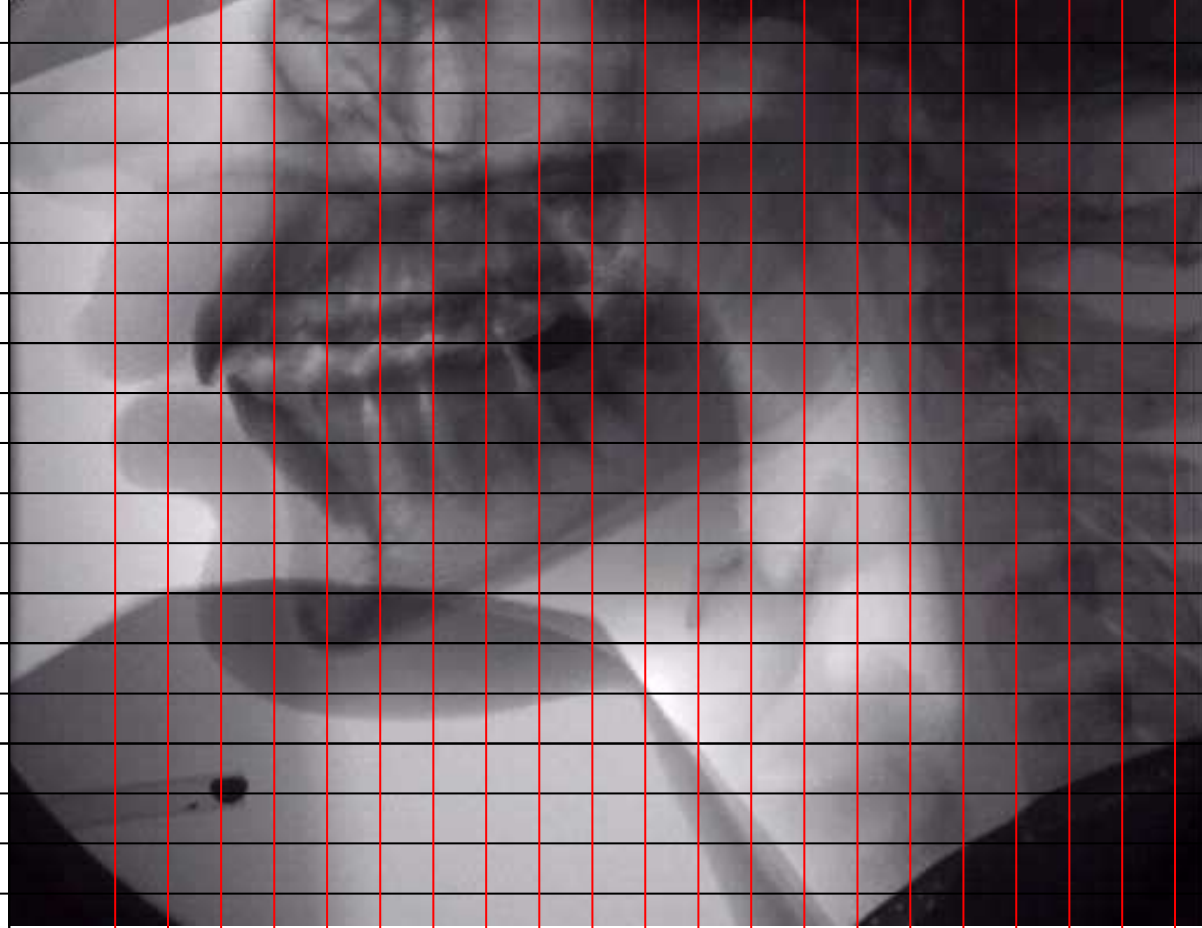


Strasbourg, data

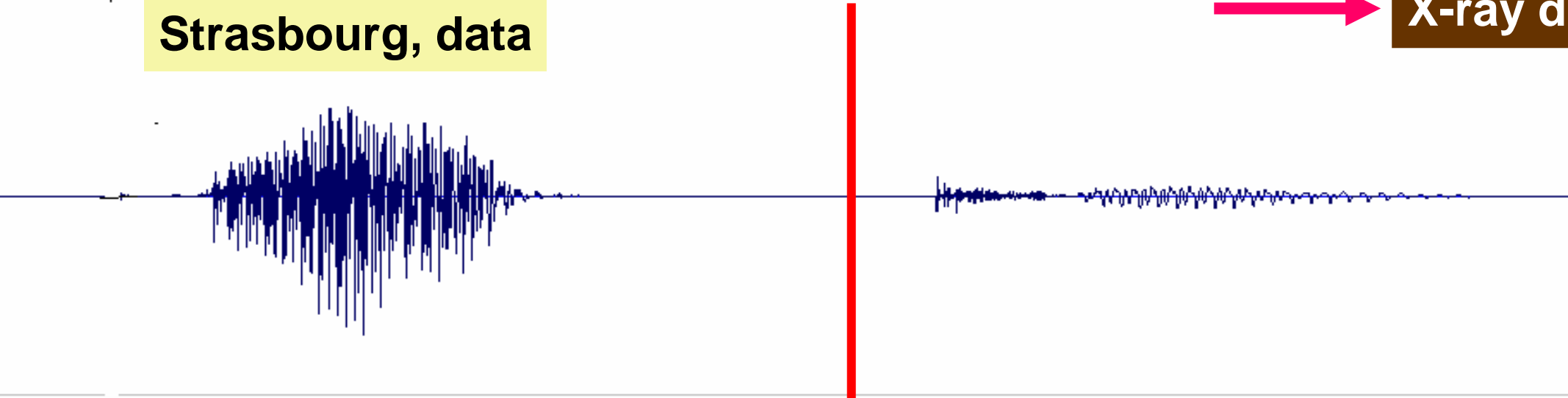
Lip continue to protrude → X-ray data



/atu/

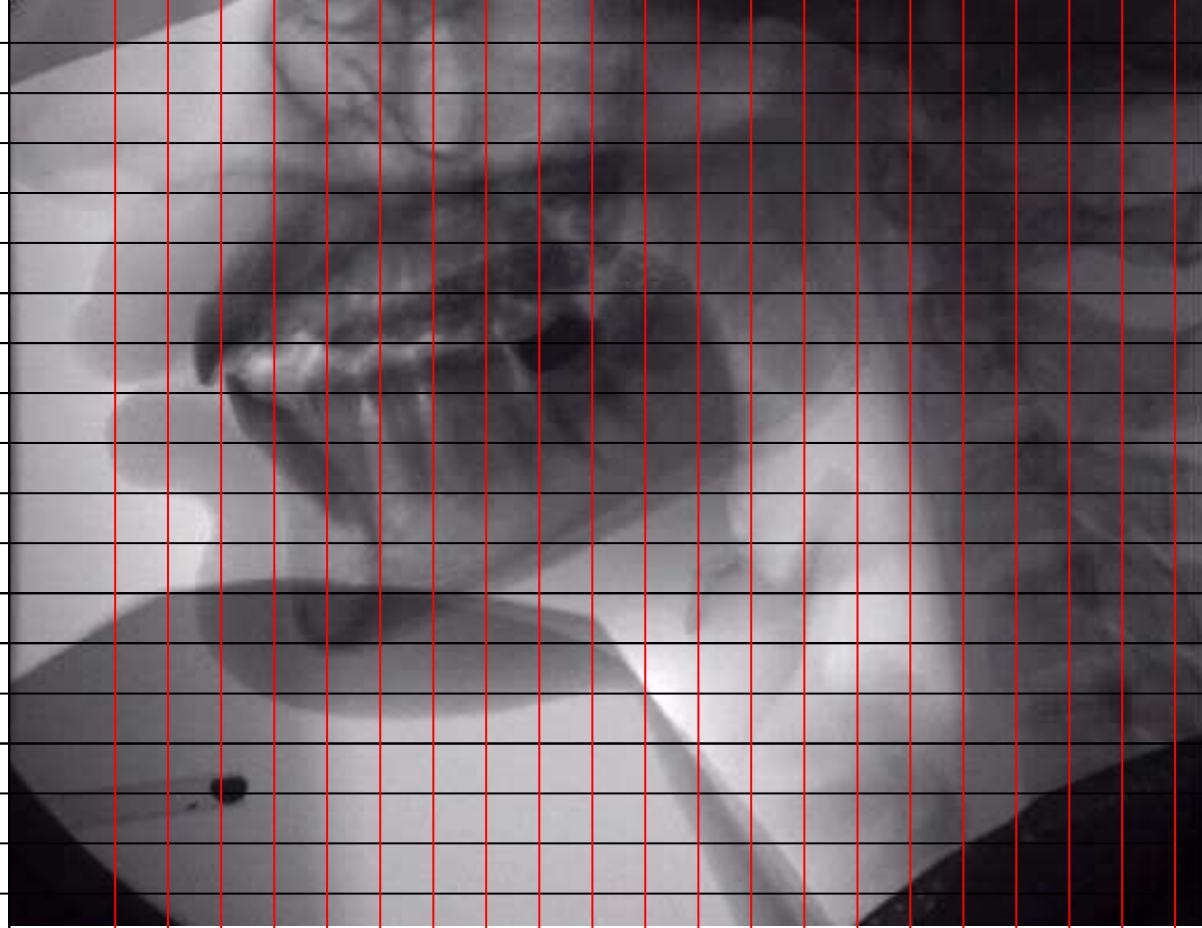


Strasbourg, data

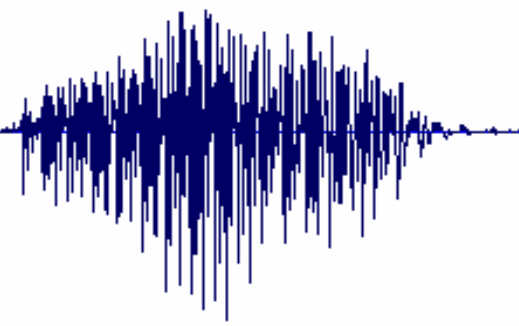



X-ray data

/atu/



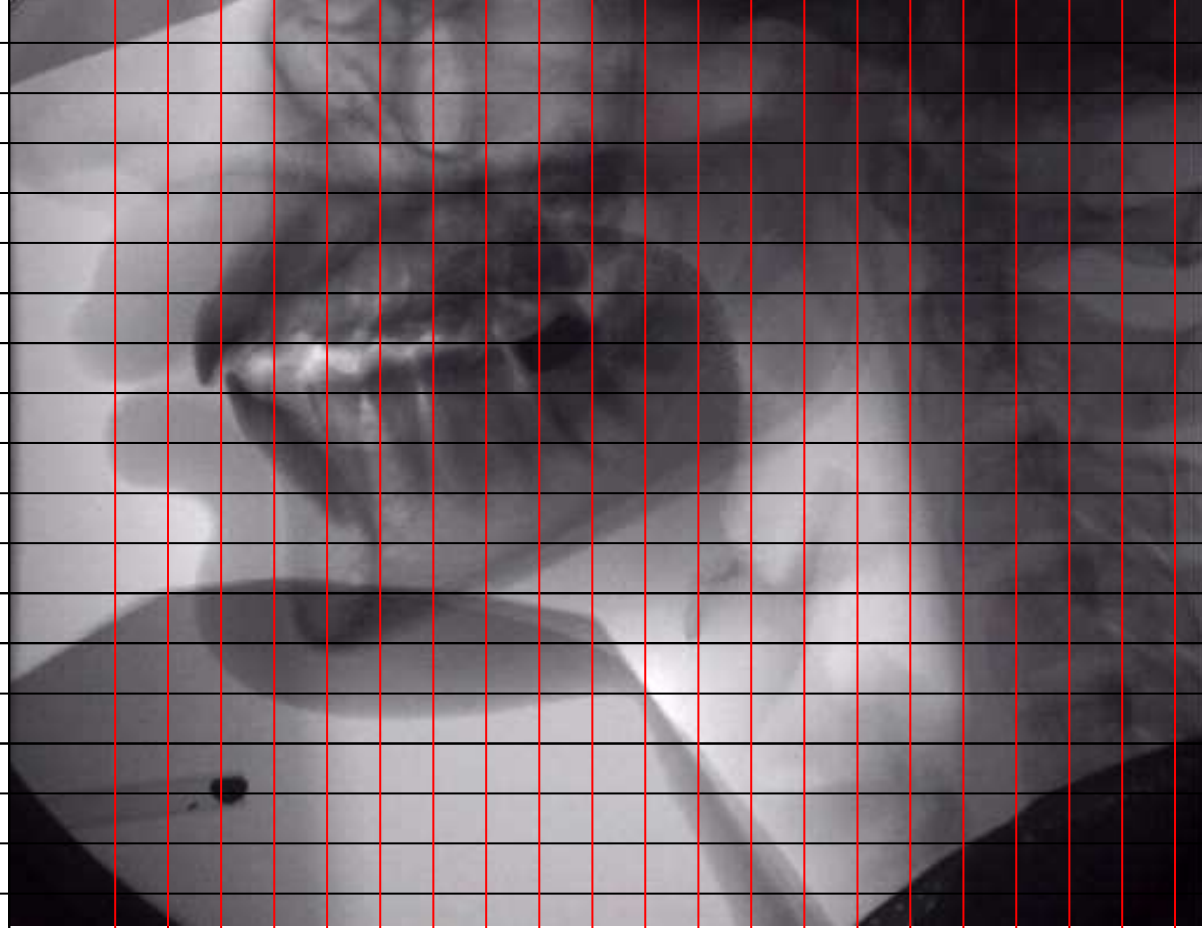
Strasbourg, data



Lip continue to protrude  X-ray data they are As protruded as for /u/

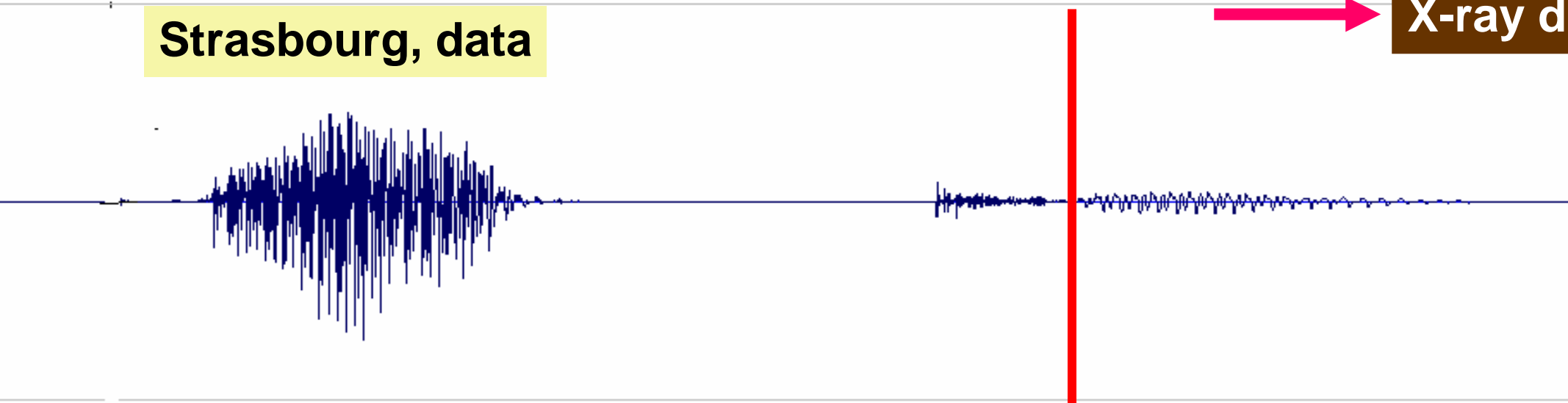


/atu/

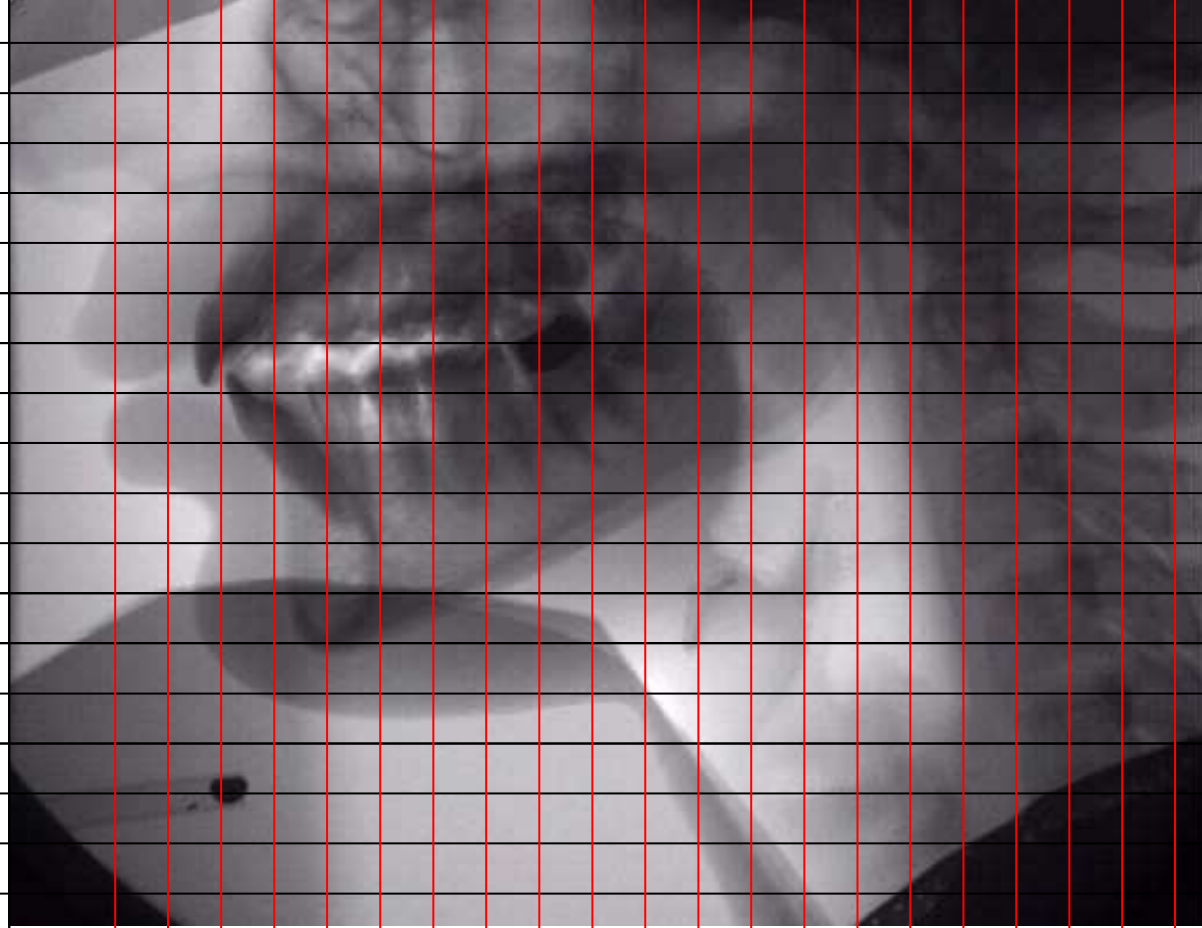


Strasbourg, data

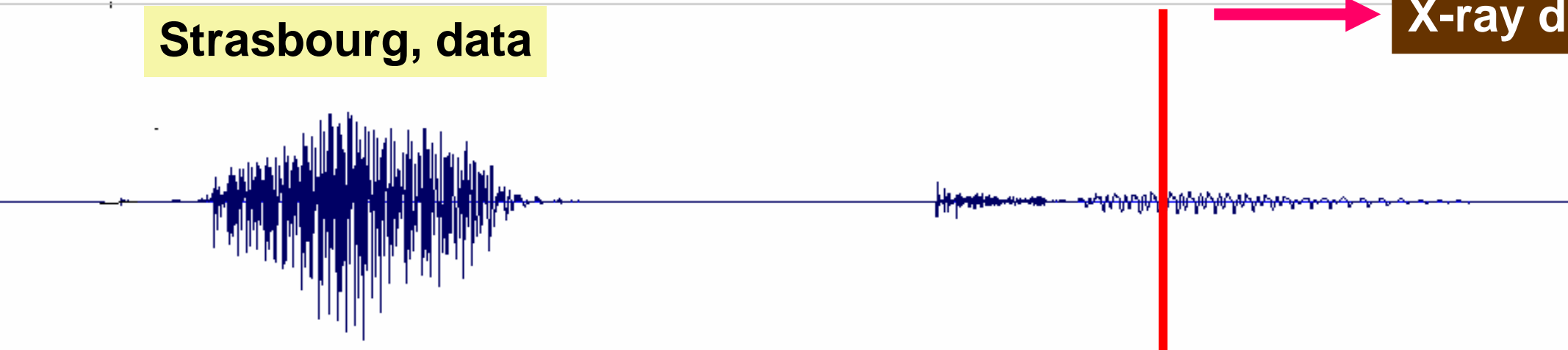
X-ray data



/atu/

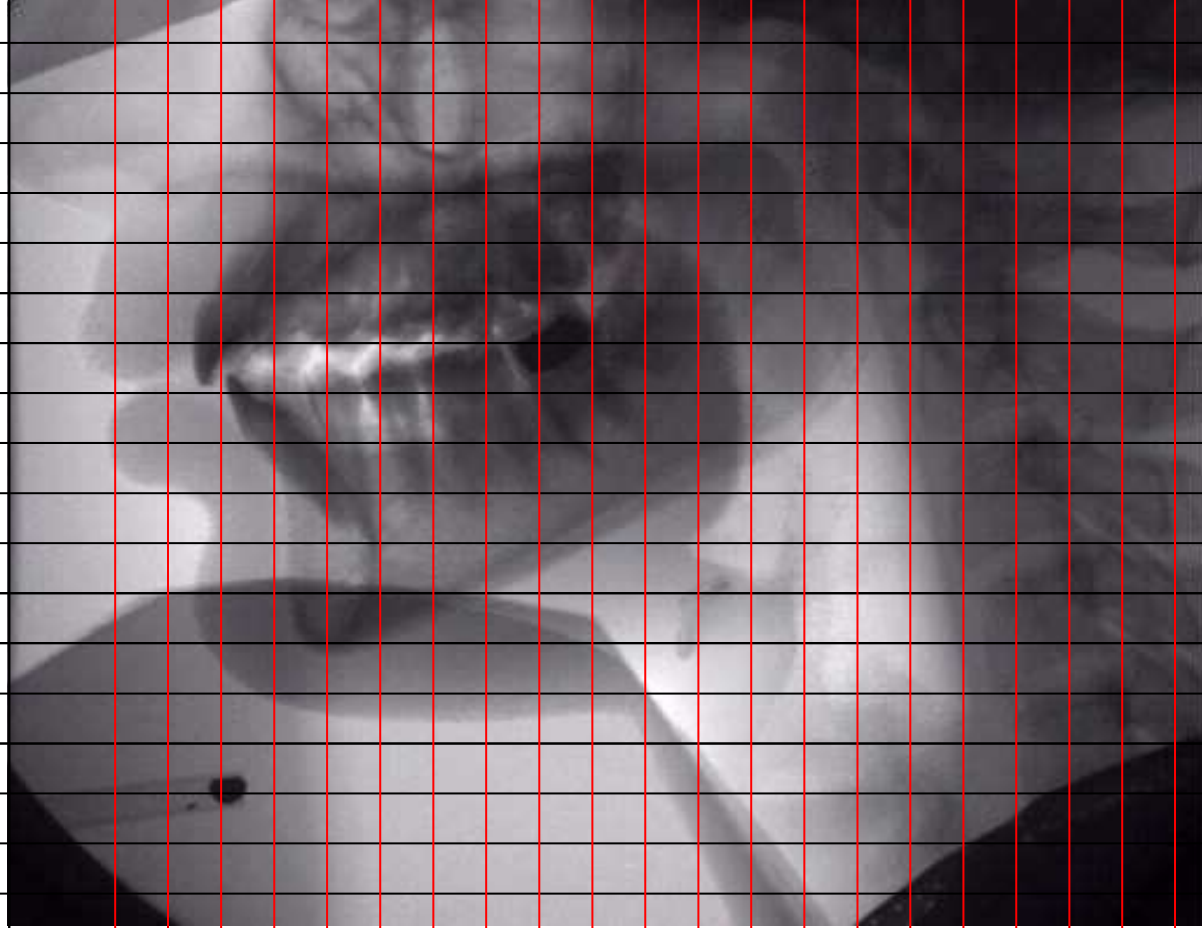


Strasbourg, data



X-ray data

/atu/



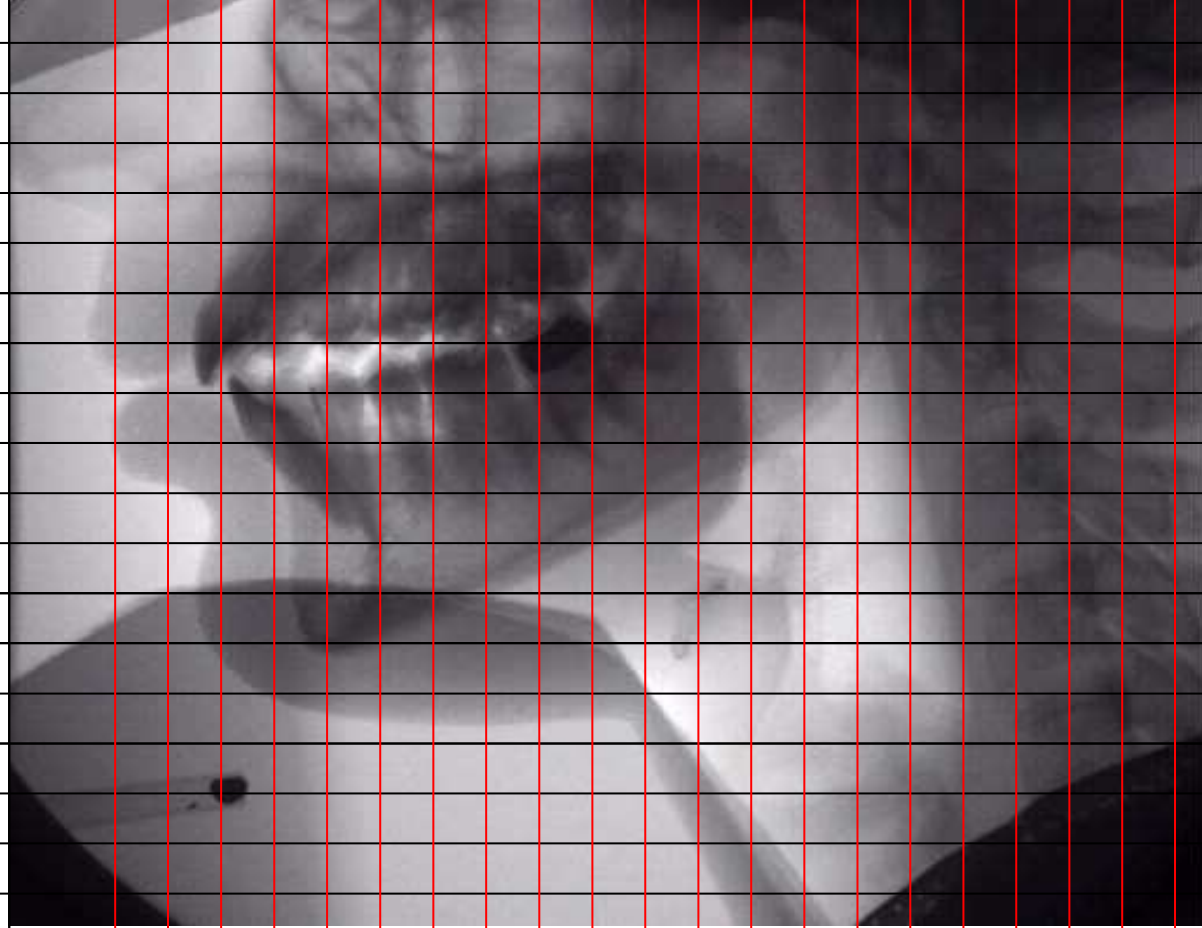
Strasbourg, data

Deprotrusion starts
Velum lowers

X-ray data



/atu/



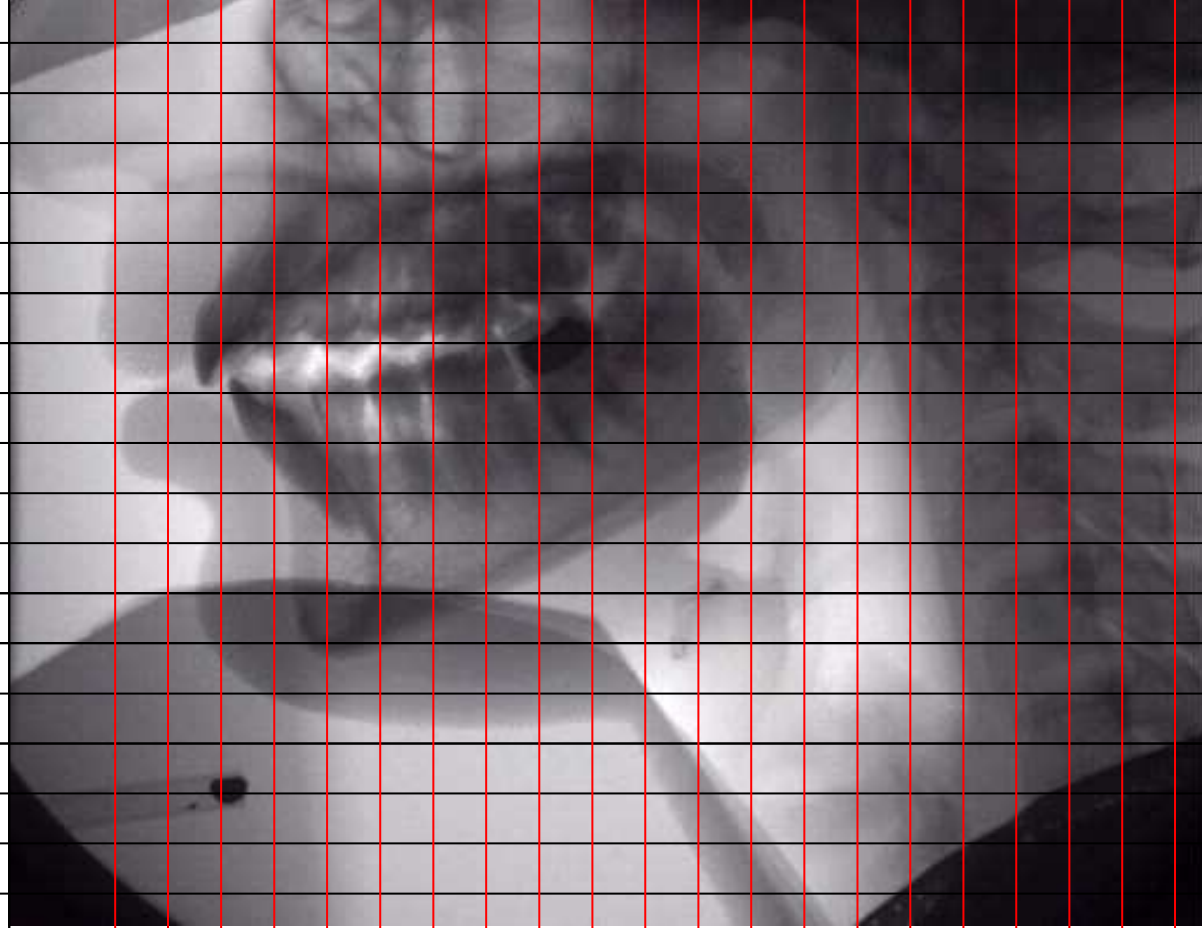
Strasbourg, data



X-ray data



/atu/

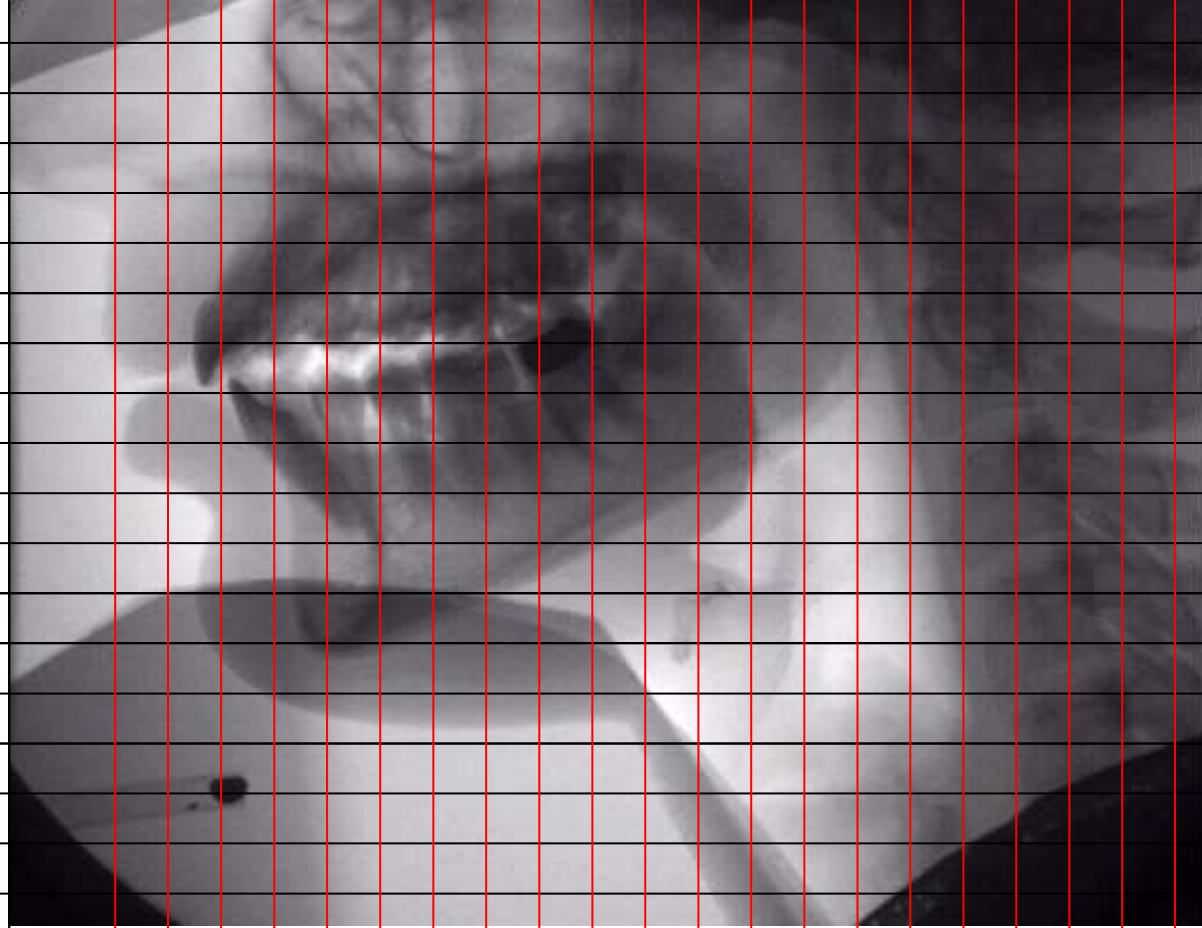


Strasbourg, data



X-ray data

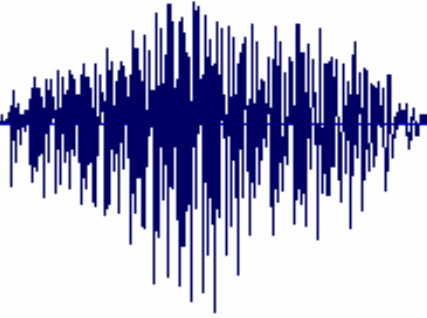




X-ray data

Strasbourg, data

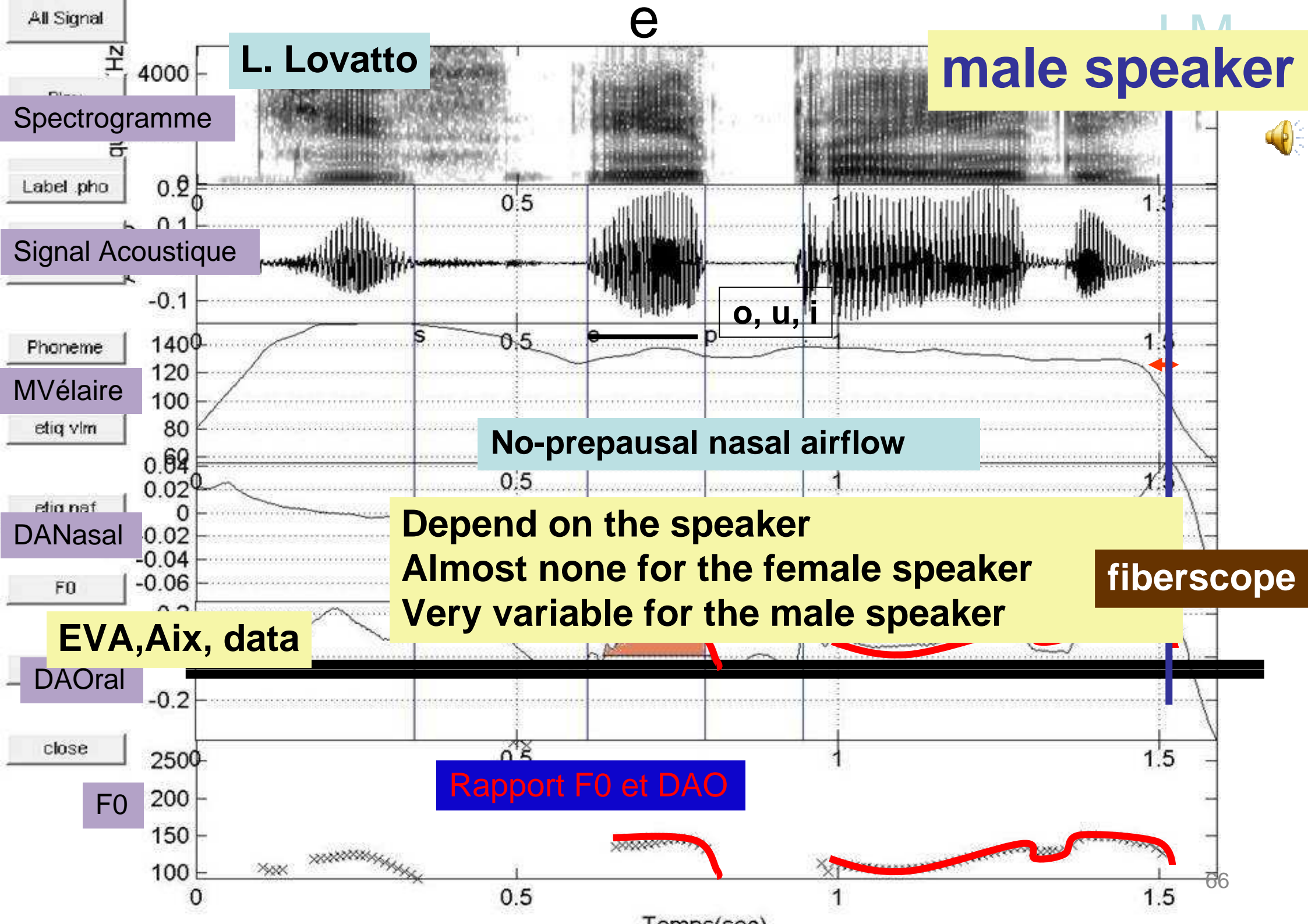
Lips still very protruded
(Carry-over; velum low)



e

L. Lovatto

male speaker



Spectrogramme

Signal Acoustique

Phoneme

MVélaire

DANasal

DAO Oral

F0

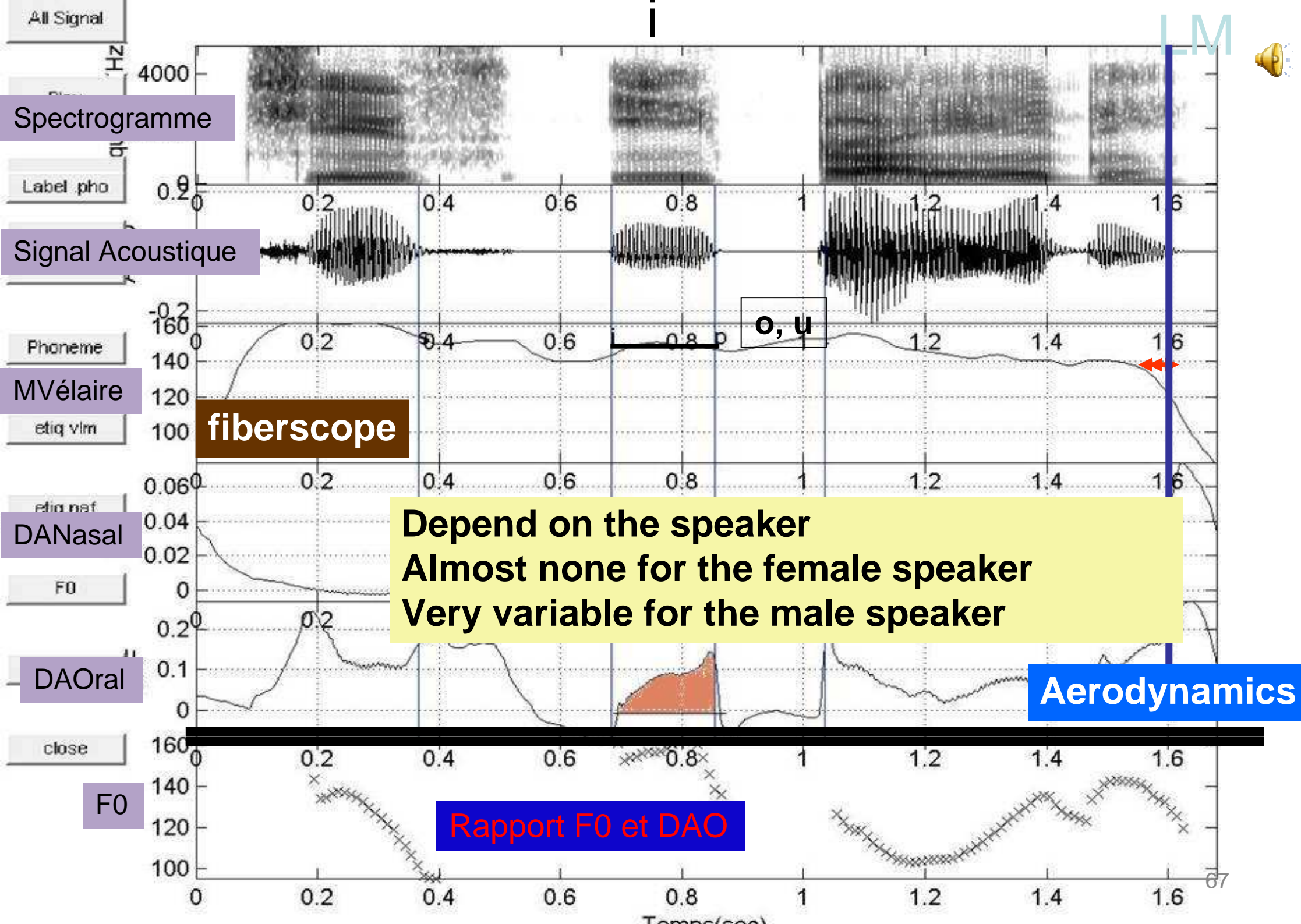
No-prepausal nasal airflow

Depend on the speaker
Almost none for the female speaker
Very variable for the male speaker

Rapport F0 et DAO

fiberscope





Spectrogramme

Signal Acoustique

Phoneme

MVélaire

DANasal

DAO Oral

F0

fiberscope

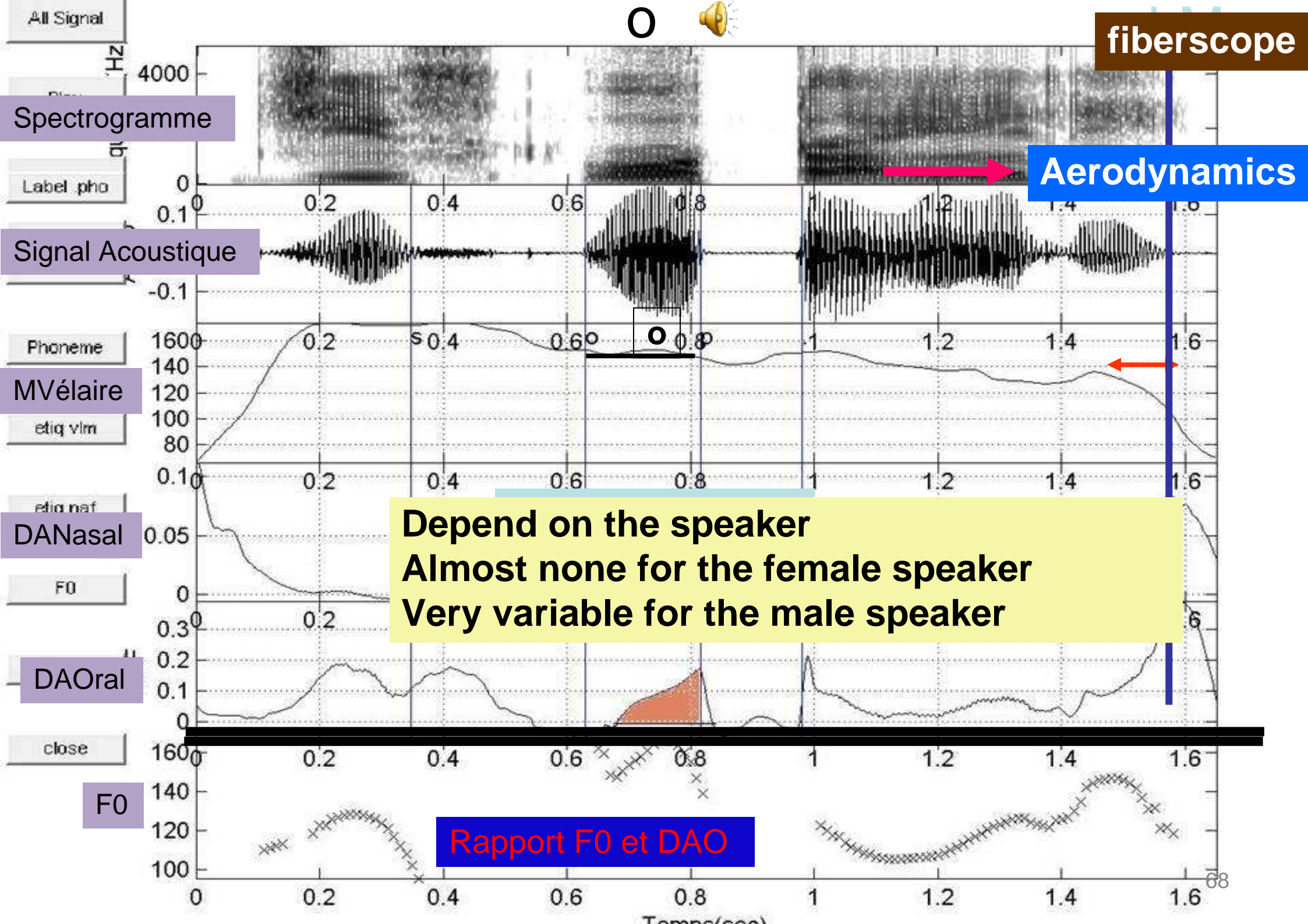
**Depend on the speaker
Almost none for the female speaker
Very variable for the male speaker**

Aerodynamics

Rapport F0 et DAO



fiberscope



Spectrogramme

Signal Acoustique

MVélaire

DANasal

DAO Oral

F0

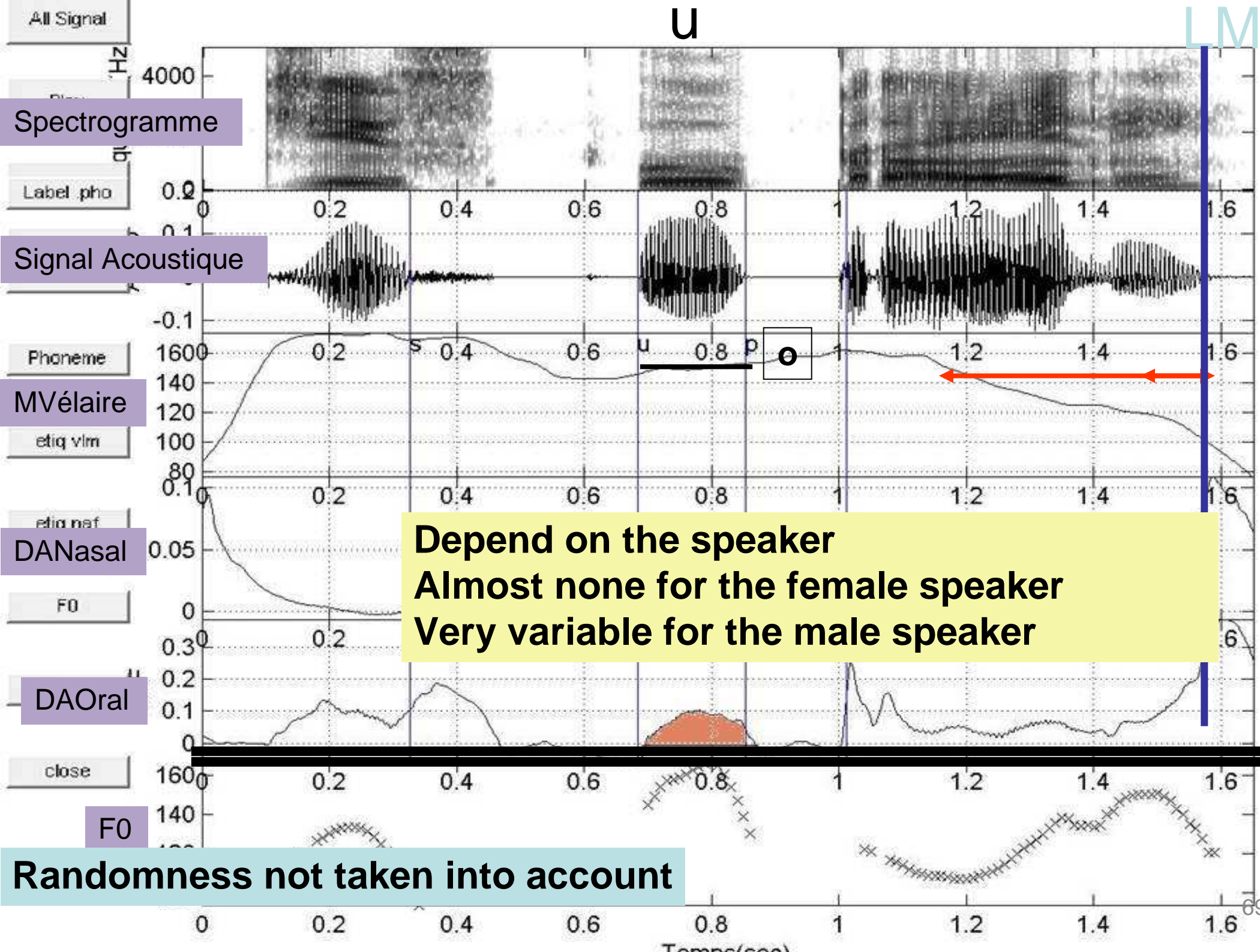
Aerodynamics

Depend on the speaker
Almost none for the female speaker
Very variable for the male speaker

Rapport F0 et DAO

u

LM



Spectrogramme

Signal Acoustique

Phoneme

MVélaire

DANasal

DAOral

F0

Randomness not taken into account

Depend on the speaker
Almost none for the female speaker
Very variable for the male speaker

A) On some discrepancies that can in part be explained

- 1) post-pausal raising
- 2) Pre-pausal lowering
- 3) declination**

fiberscope

X-ray data

Laboratoire de Phonétique et Phonologie
UMR 7018 (CNRS, Sorbonne Nouvelle)

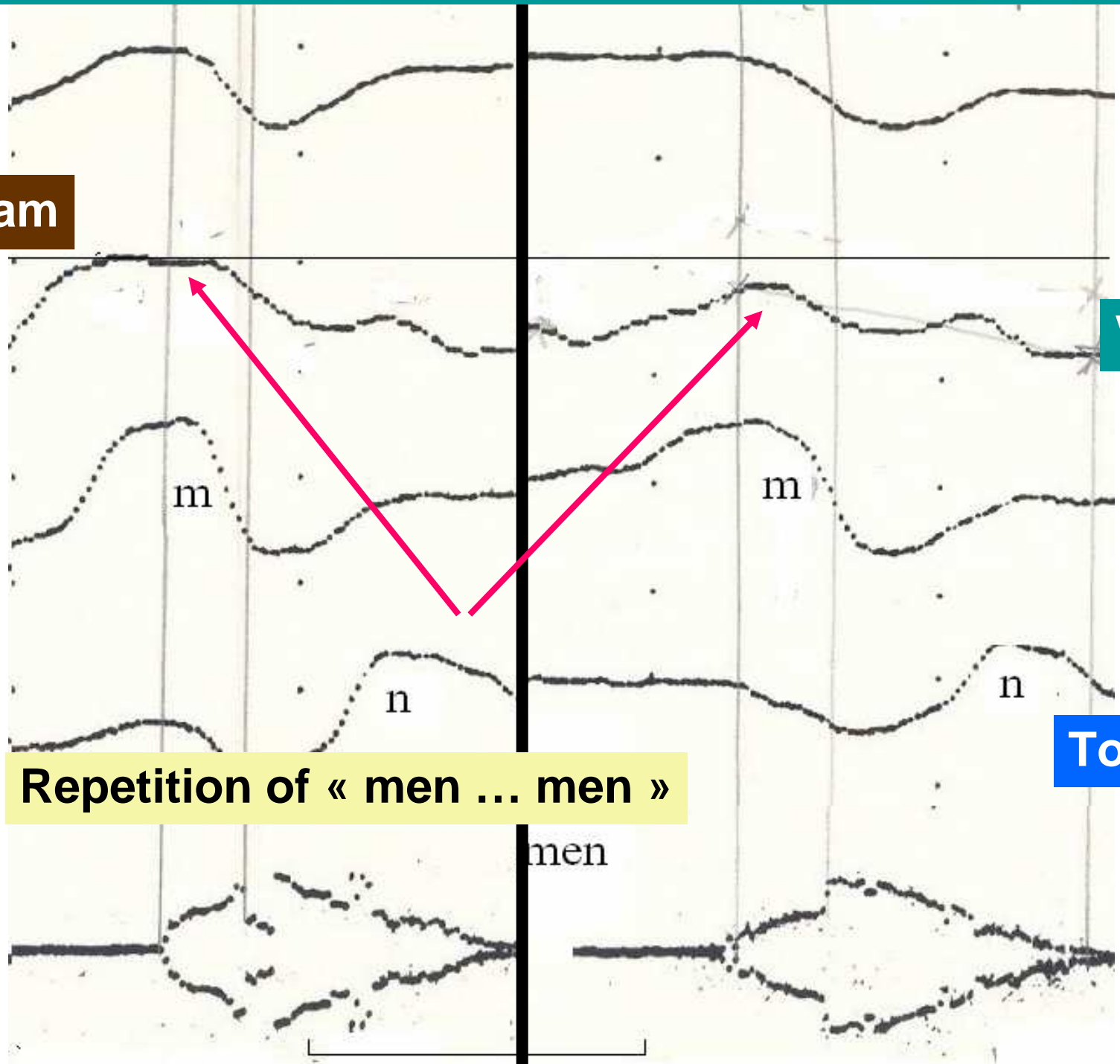


5 Juin 2009

Velar declination along the breath group

Bell-Labs
Fujimura
Tokyo

Microbeam



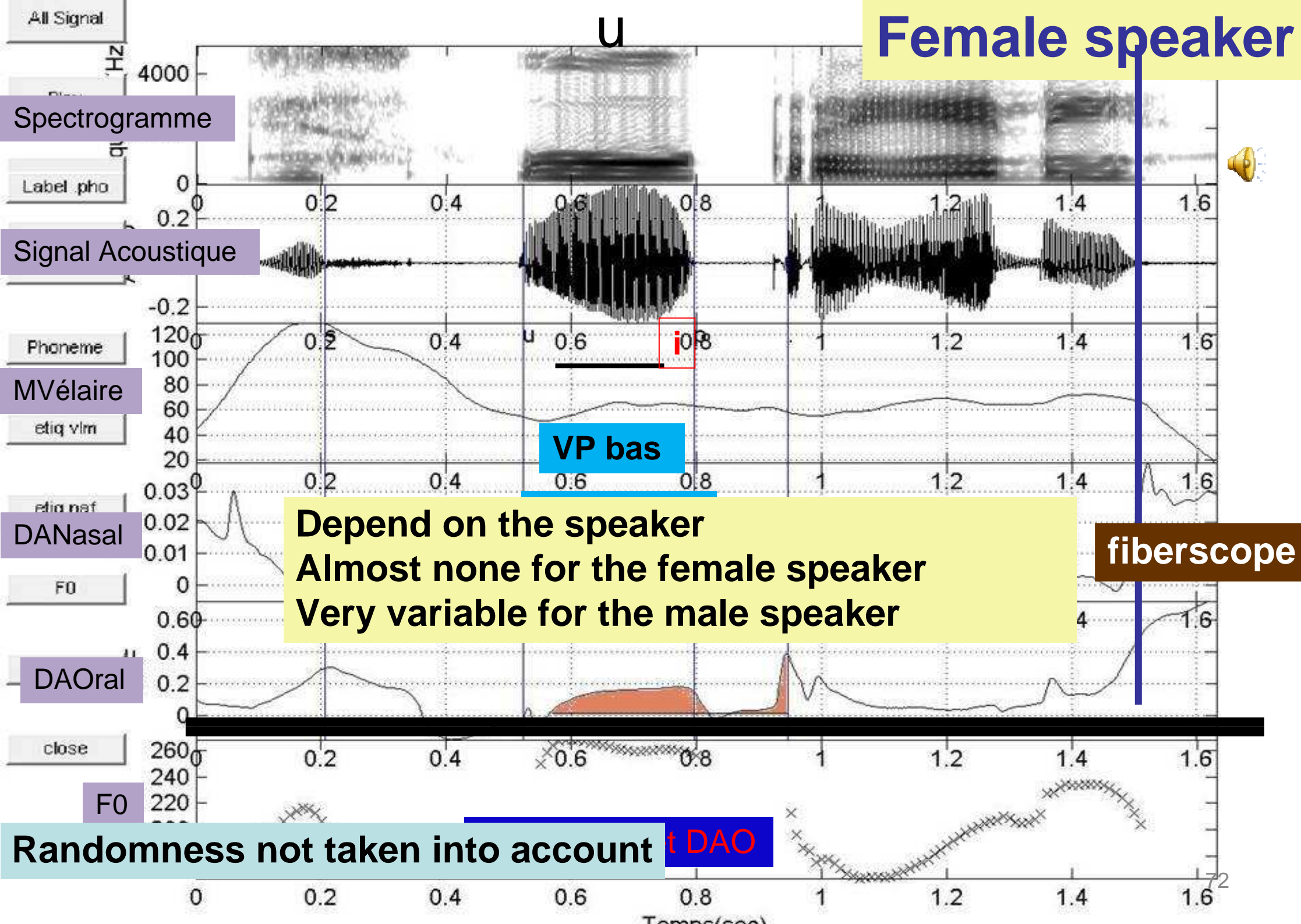
Velum pellet

Lip pellet

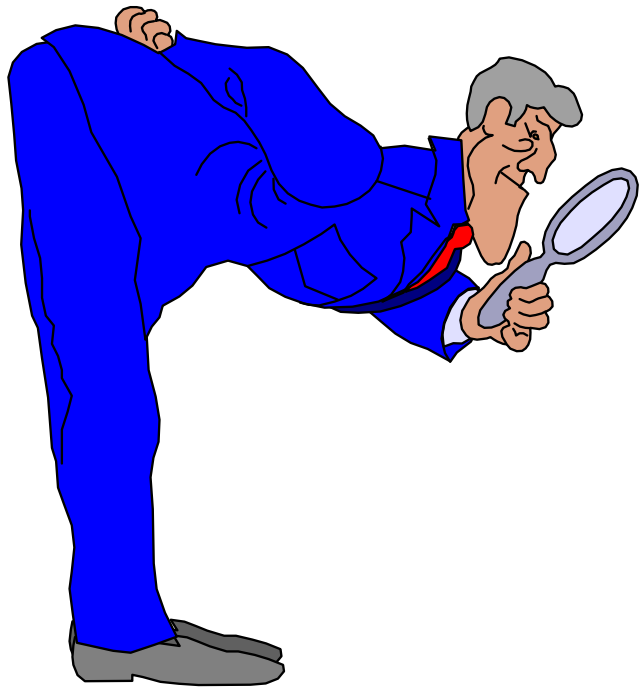
Tongue tip pellet

Repetition of « men ... men »

Female speaker



What to conclude?



#imi#

#ten##ned#

- **Underestimation of anticipatory lowering**
 - **Overestimation of carry-over**
 - **account the position**
 - **Of the phoneme relatively**
 - **to speech ready gesture**
 - **to the pause**
-
- **AVOID ANY PAUSE !**

Problems in the



- A) On some discrepancies that can be explained
- A1) instrumentation-dependent results
 - A2) acoustic cues to nasalisation and air
 - A3) distinction nasal mora and voice decay time
 - A4) positive or negative airflow with VP close
 - A5) nasal airflow and airflow resistance
- B) Uncontrollable post-pausal raising, prepausal lowering and declination
- C) Problem of corpus**
- choice of vowels**

Low vowels tend to have a lower velum, but have less nasal airflow, more coupling is necessary to perceive them as nasal

Kuenzel

Velotrace

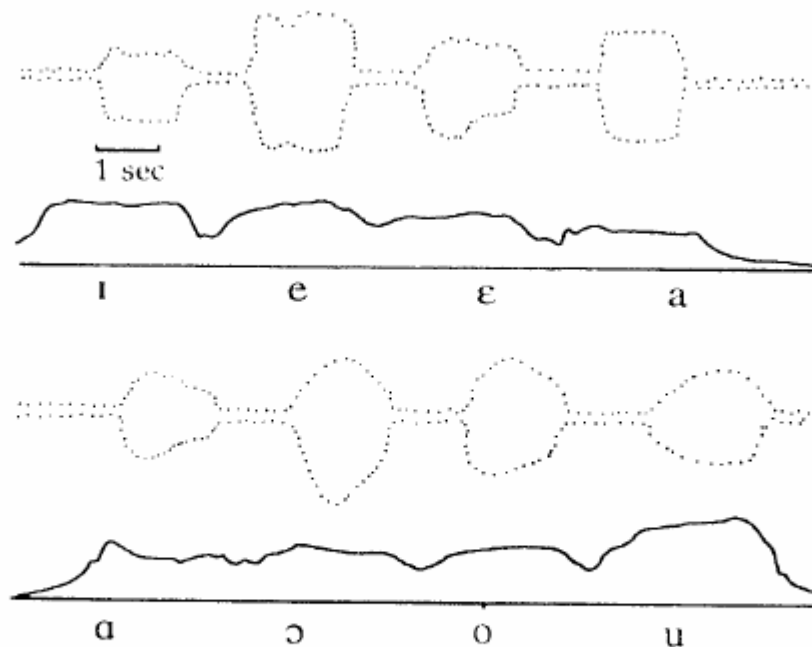


Figure 16. Data on velum height for different vowels obtained with the Velograph. Adapted from Kuenzel (1977) with permission.

X-ray data



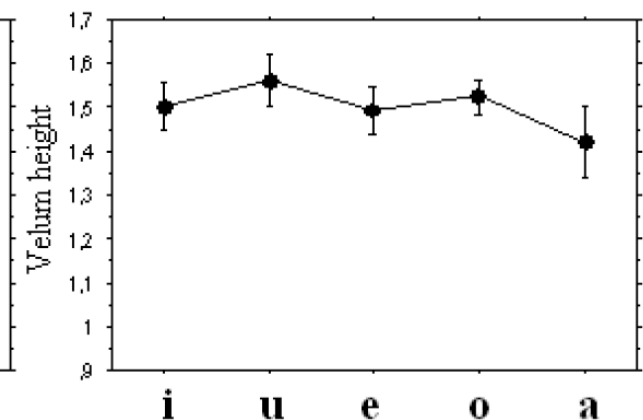
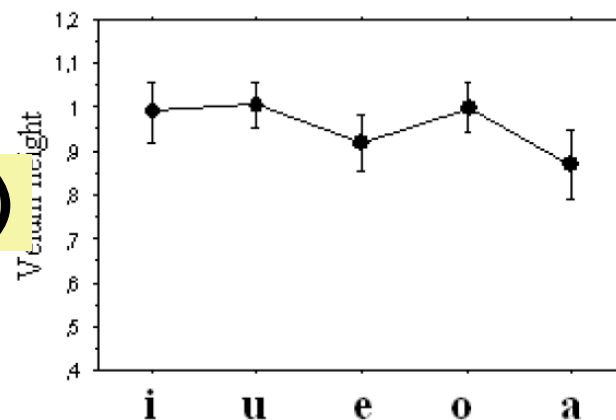
From: Krakow & Huffman. 1993. Instruments and techniques for investigating nasalization ... In Phonetics & Phonology, Vol. 5.

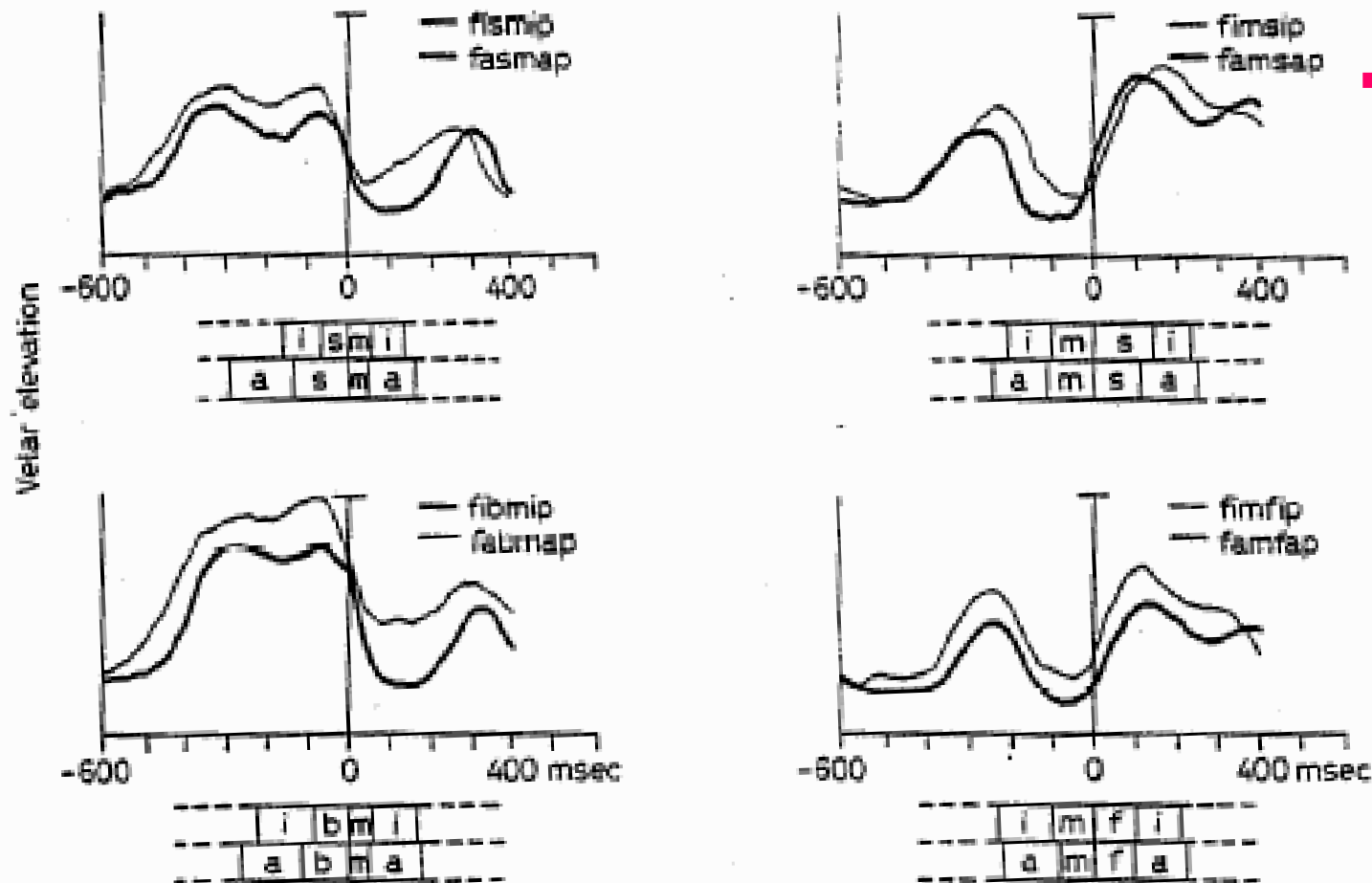
but

- Inter-speaker differences

- Different ranking

Rossato, ICP (French)





Velotrace

X-ray data

Fig. 3. Plots of average velar elevation, in arbitrary units as a function of time, for utterance pairs of contrasting vowel quality. Utterances having a medial oral/nasal consonant contrast are at the left; those having a medial nasal/oral consonant contrast are at the right.

Bell-Berti

Hypothesis?

/a/ as first nasal vowel? (tendency?)

- Stressed: PG+
- Back a: PG+
- Stressed back /a/ = PG++

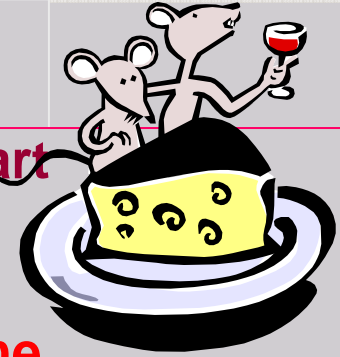
- = Nasal vowel: PG+ (Benguerel, French)

Combinaison of stress and back /a/?

Not enough EMG data (Honda?)

Problems in the

- A) On some discrepancies that can be explained in part
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- B) Uncontrollable post-pausal raising, prepausal lowering and declination



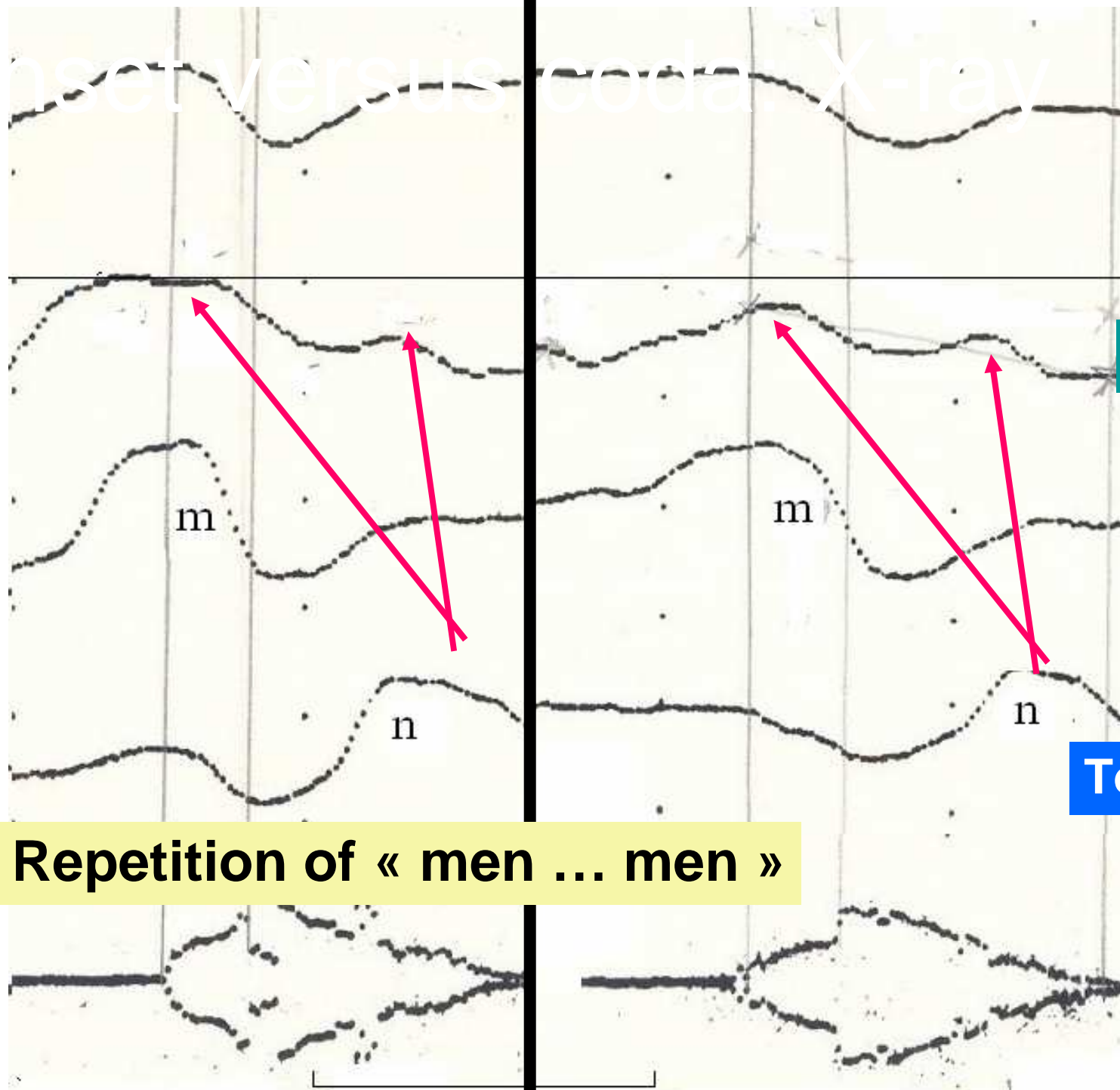
C) Problem of corpus

- choice of vowels
- onset versus coda consonant

Well-known (Krakow) but often ignored

Onset versus coda nasal

osition



Bell-Labs
Fujimura
Tokyo

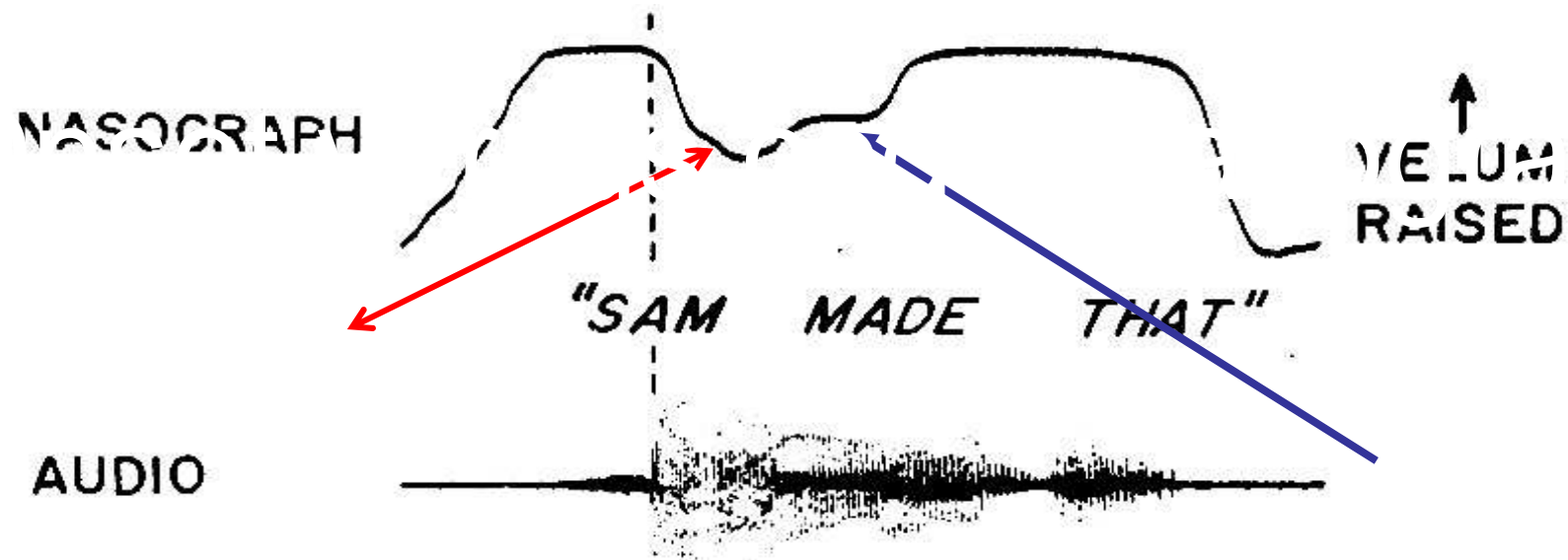
Microbeam

Velum pellet

Lip pellet

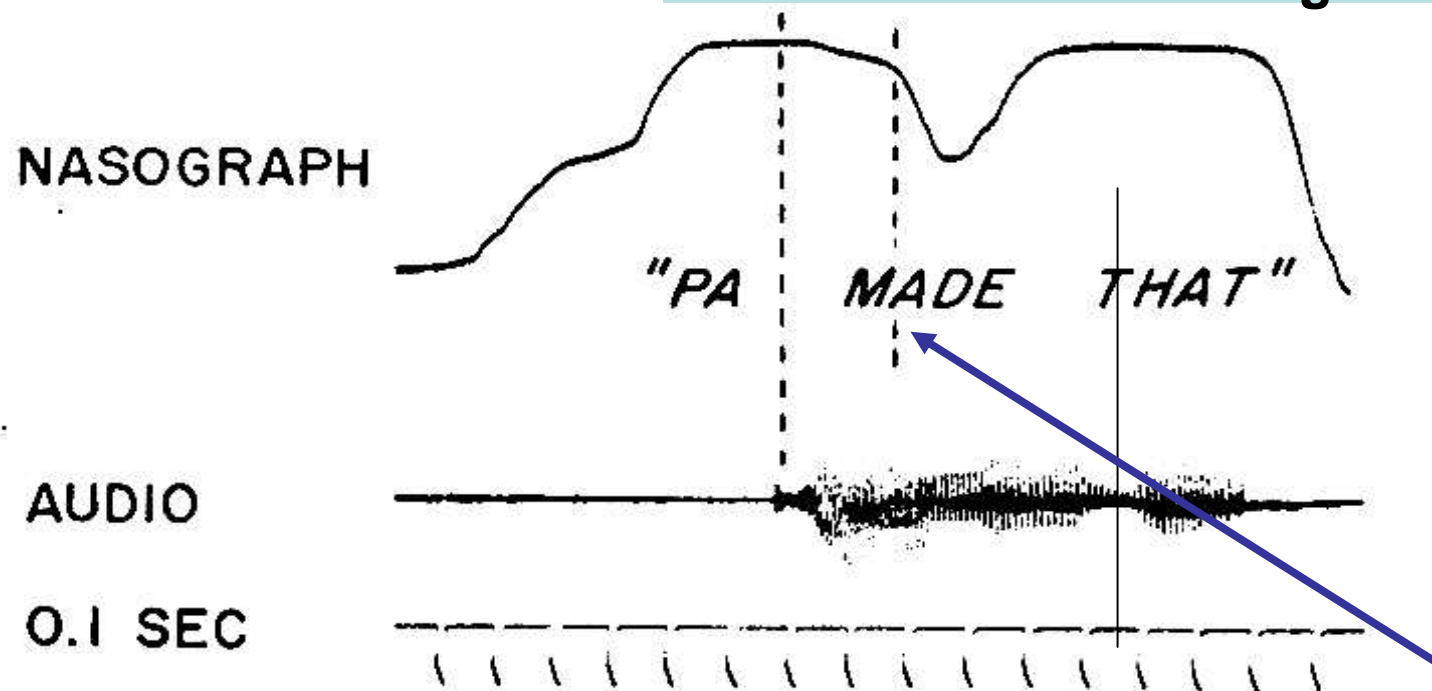
Tongue tip pellet

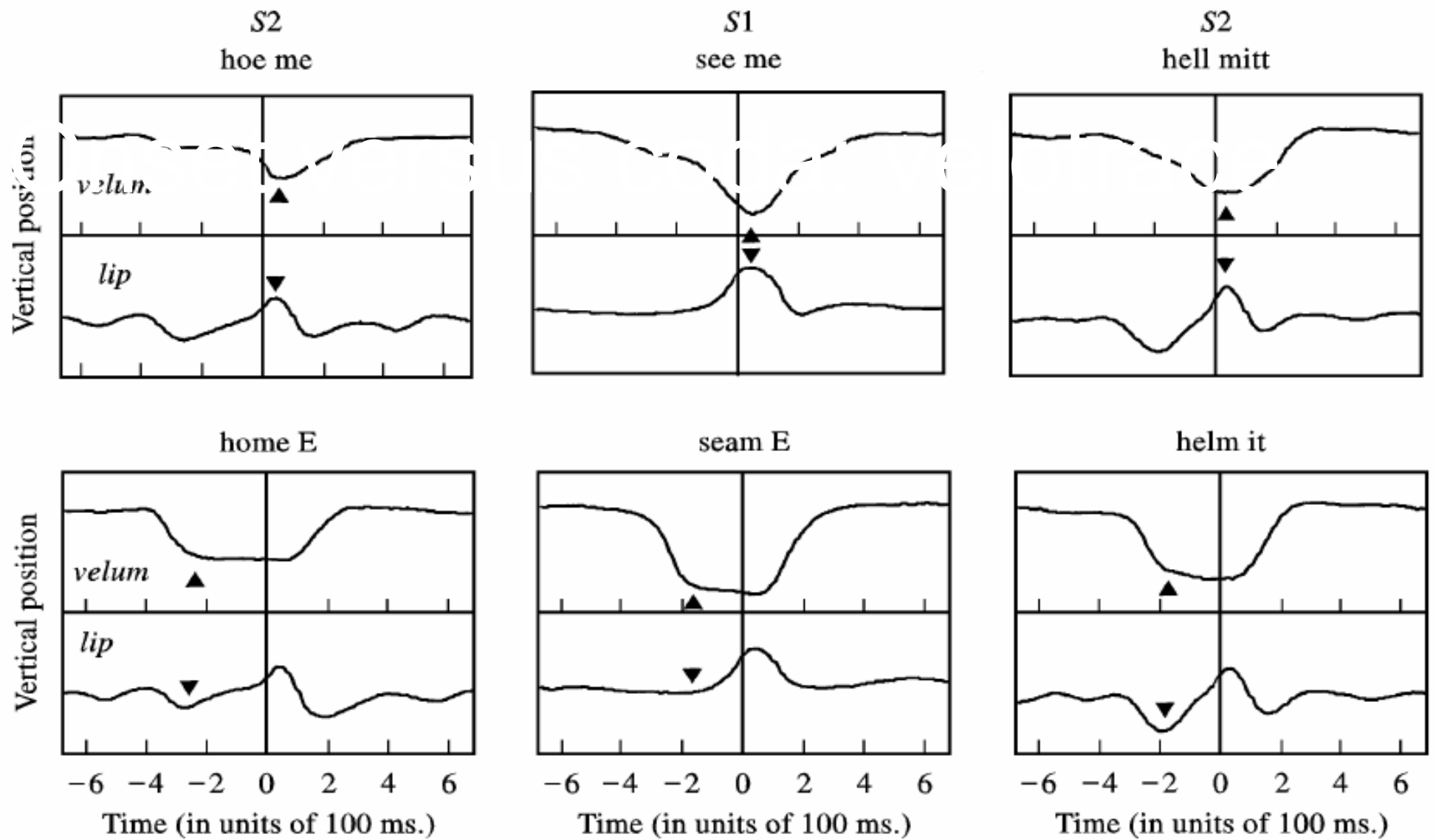
Repetition of « men ... men »



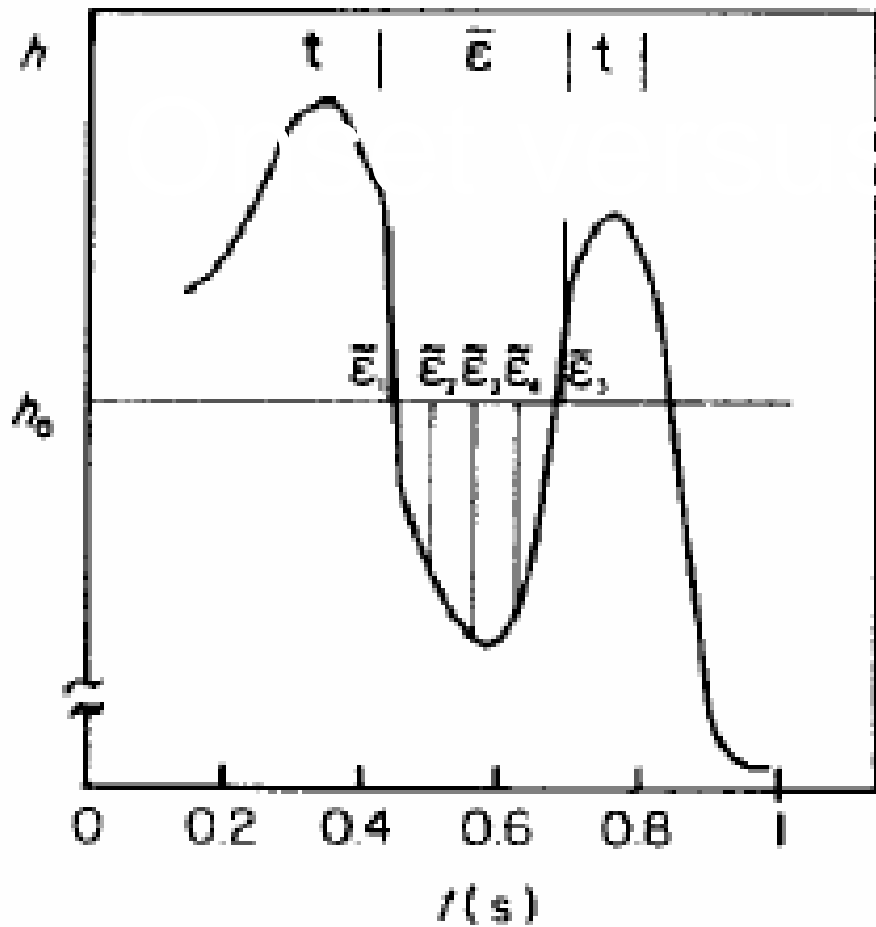
Nasograph

Differences in velar height and VP opening





Velotraces



Valid for oral consonants also

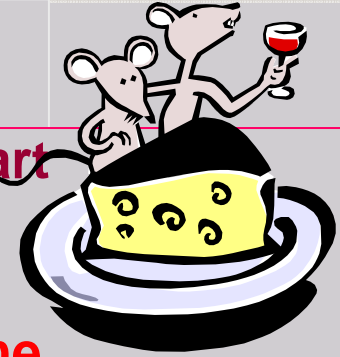
fiberscope

Time correspondence between the five \bar{e} stimuli and the velar height curve of Benguerel *et al.* (1976a).

Well-known, not often taken into account

Problems in the

- A) On some discrepancies that can be explained in part
- A1) instrumentation-dependent results
 - A2) acoustic cues to nasalisation and airflow
 - A3) distinction nasal mora and voice decay time
 - A4) positive or negative airflow with VP close
 - A5) nasal airflow and airflow resistance
- B) Uncontrollable post-pausal raising, prepausal lowering and declination
- C) Problem of corpus
- choice of vowels
 - onset versus coda consonant
- D) The language



Differences between dialects

Problems in the

A) On some discrepancies that can be explained in part

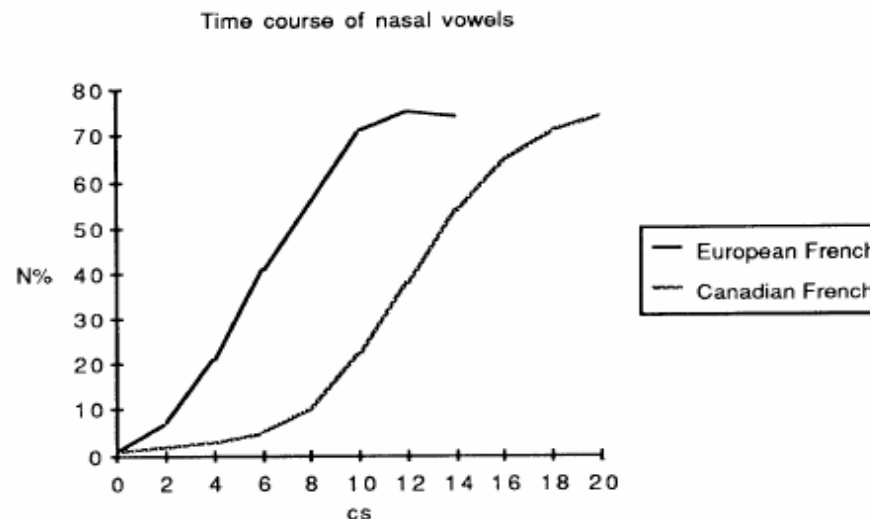
- A1) instrumentation-dependent results
- A2) acoustic cues to nasalisation and airflow
- A3) distinction nasal mora and voice decay time
- A4) positive or negative
- A5) nasal airflow and a

B) Uncontrollable post-pausal raising and declination

C) Problem of corpus

- choice of vowels
- onset versus coda

D) The language



Time course of nasal vowels of European French & Canadian French

Differences between dialects

Delvaux

5 Juin 2009



Problems in the

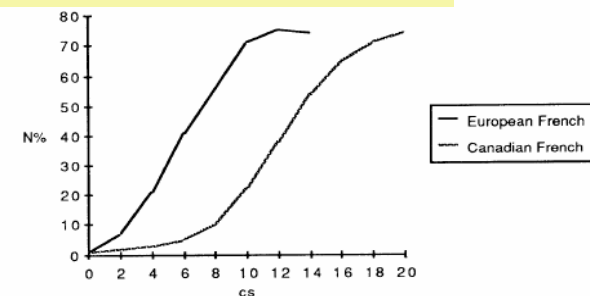
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Differences between dialects
Differences between languages

Laboratoire
UMR 7018

5 Juin 2009



Time course of nasal vowels of European French & Canadian French

- **No nasal vowels**

- **Spanish:**

- **English:**

- **nasal vowels**

- **French:**

- **Portuguese:**



**Remark: phonological status of nasalisation in PB not so clear
(Demolin, Wetzels)
Level of abstraction**

- **No nasal vowels**

- **Spanish:**
mechanistic
antipation
Ohala, Malécot

- **English:**
phonologized
antipation (Solé)

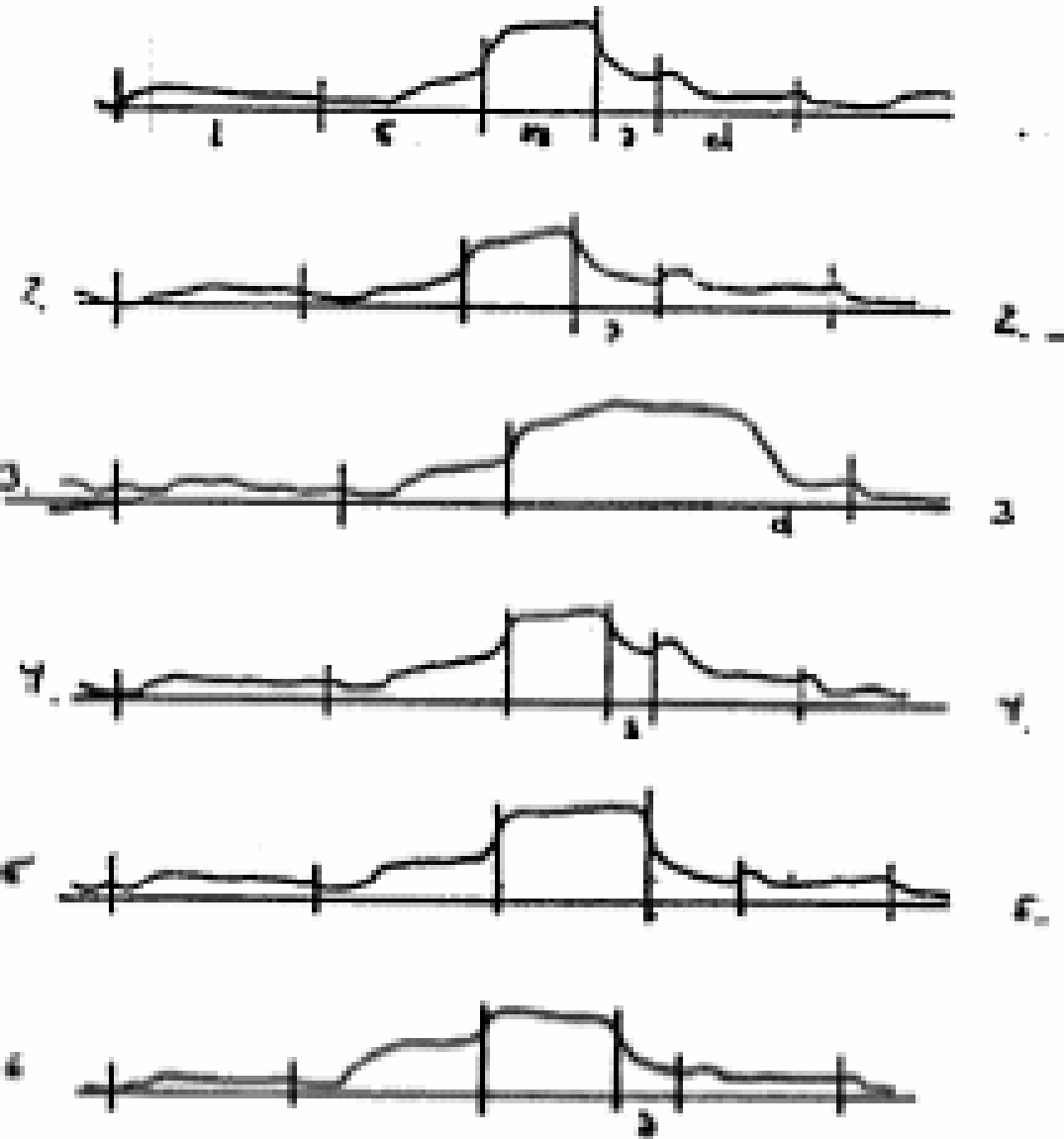
- **nasal vowels**

- **French:** reduced
antipation

- **Portuguese:**
antipation
(Cohn)

French: reduced anticipation as a model ???

ten lines

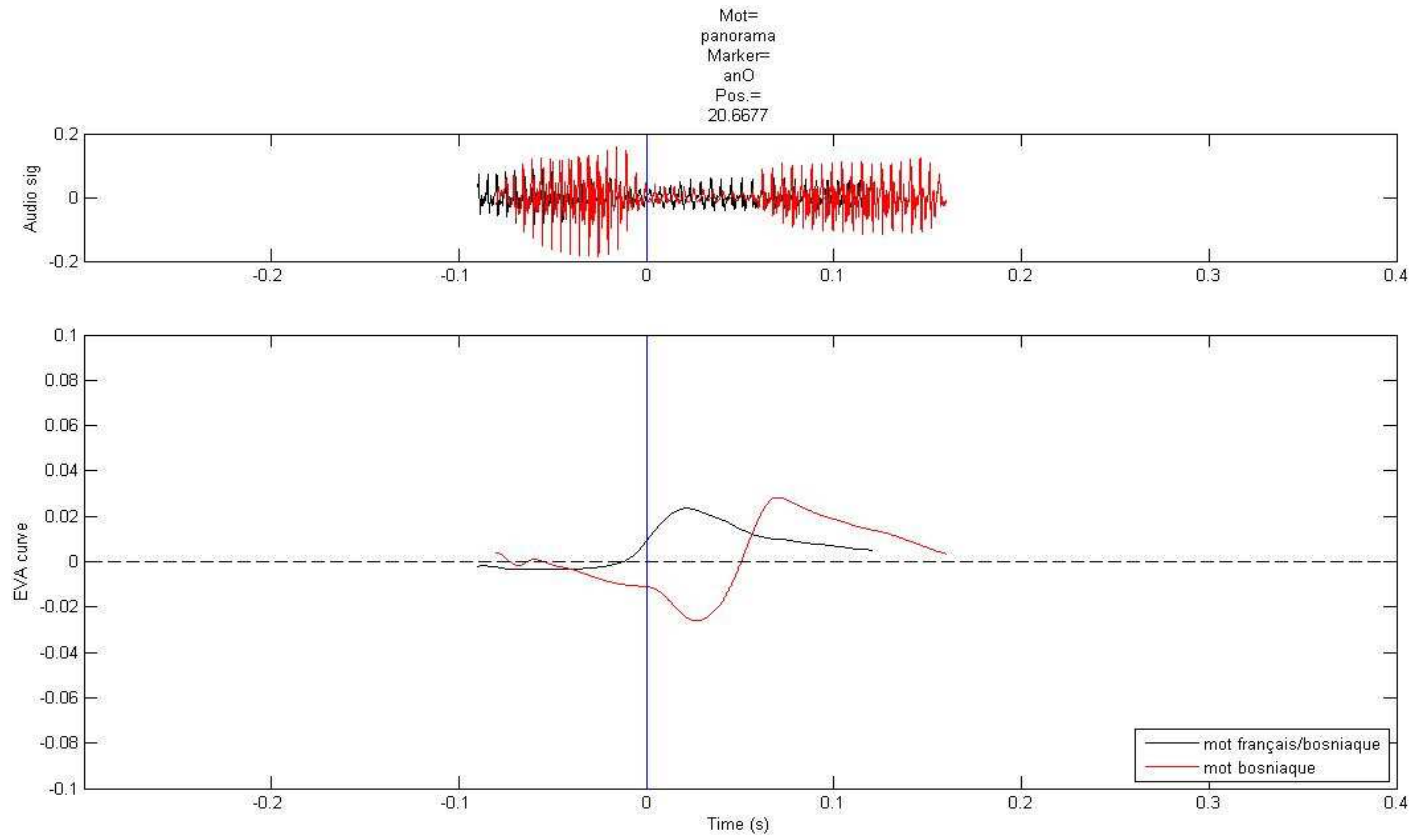


Limits according to Cohn

No limits according to Delvaux

Aerodynamics

NAF- during nasal consonant



Aerodynamics

panorama

French

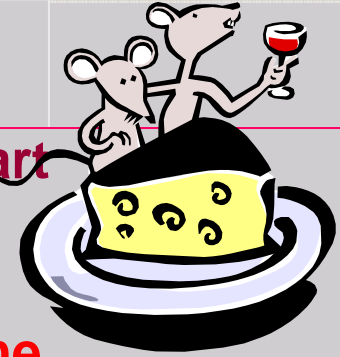


Bosniac

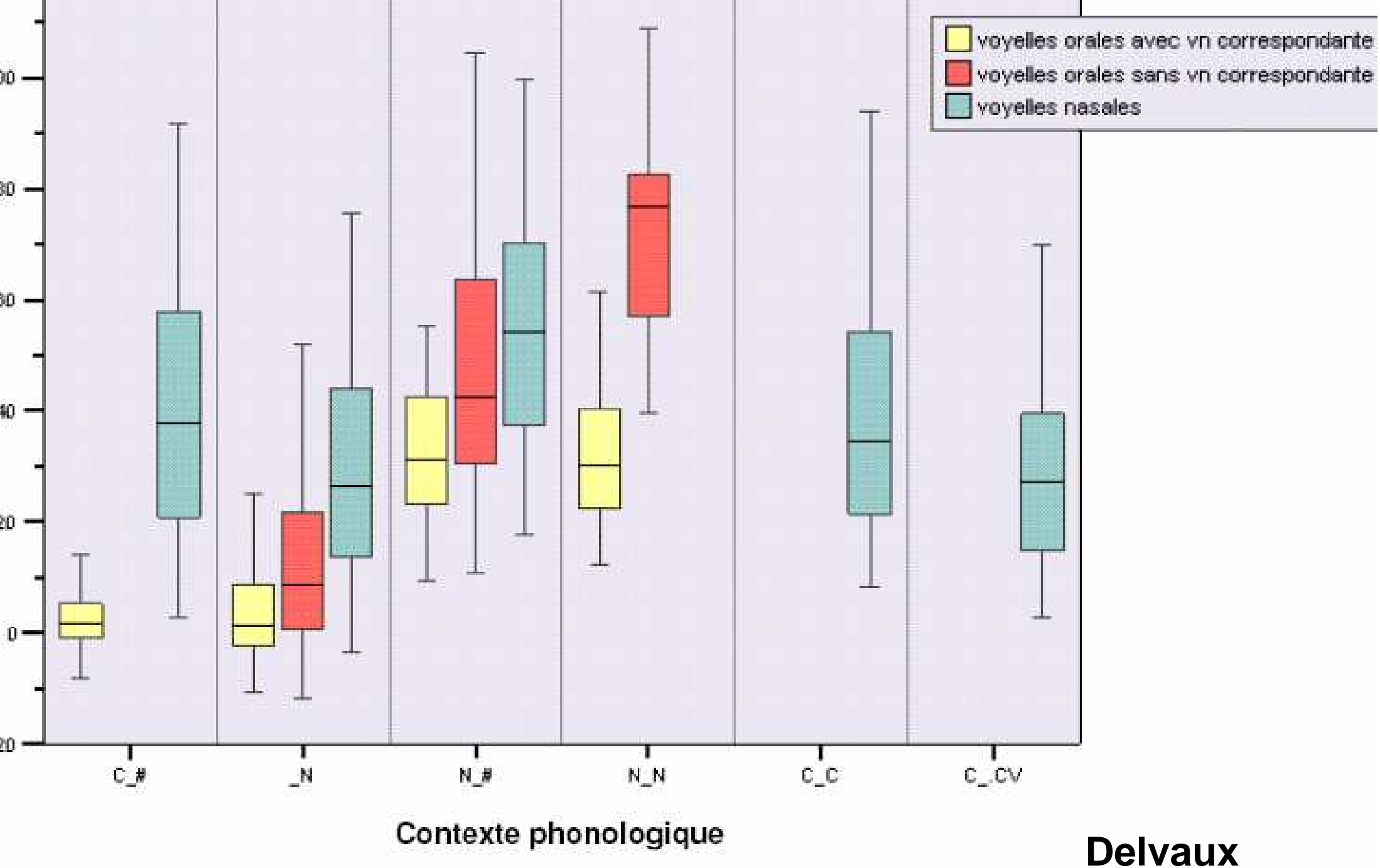


Problems in the

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- choice of vowels
 - onset versus coda consonant
- D) The language



Differences between dialects
Differences between languages
Alternative explanations



Less coarticulatory nasalisation if nasal counterparts or higher vowels

1. Boxplots représentant la répartition des valeurs de F1 (en %) pour les trois types de voyelle en fonction du contexte phonologique.

Problems in the

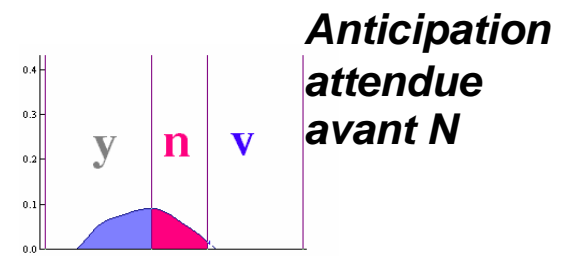
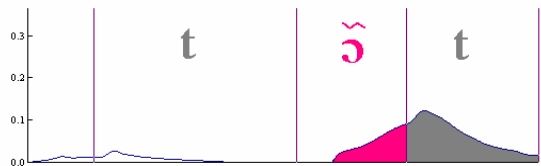


- A) On some discrepancies that can be explained in part
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 - A5) nasal airflow and airflow resistance
- B) Uncontrollable post-pausal raising, prepausal lowering and declination
- C) Problem of corpus
 - choice of vowels
 - onset versus coda consonant
- D) The language
- E) The style

Basset et al: no clear tendency in one way or another

More spontaneous speech needed

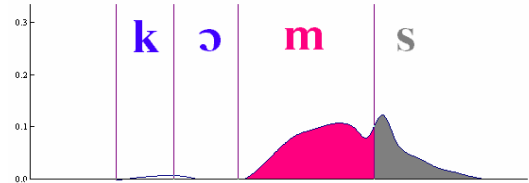
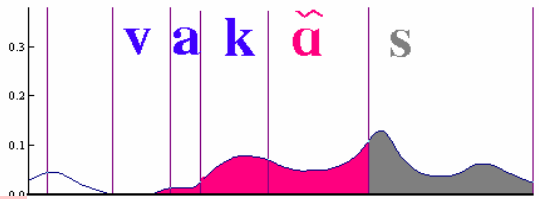
style



Basset & al, 2001

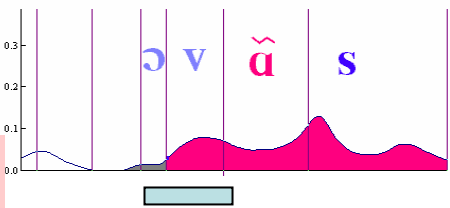
More than expected

Less than expected

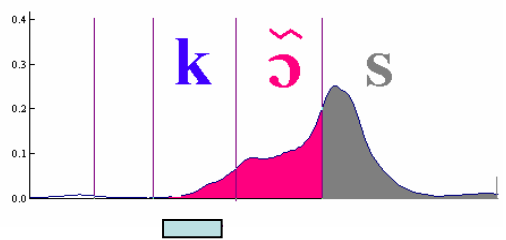


Nasalized /k/

No anticipation



Nasalized /v/



Basset & al, 2001

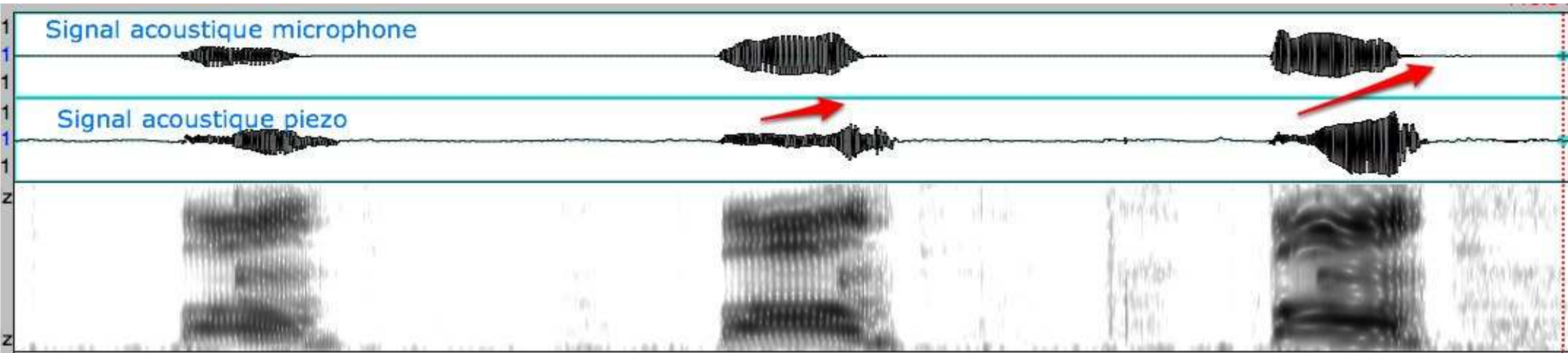
Problems in the

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- C) Problem of corpus
 - choice of vowels
 - onset versus coda consonant
- D) The language
- E) The style
- F) Speaker effort



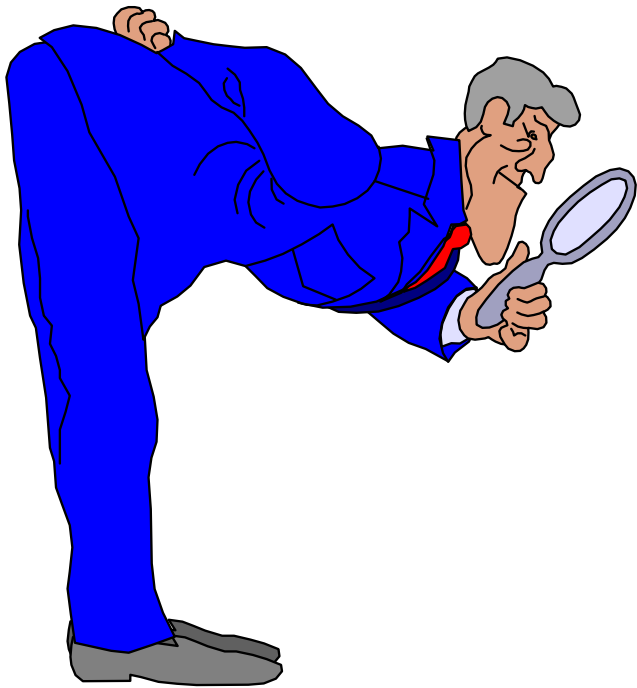


Pampe pampe pampe



French

What to do?



- **Head mounted microphone always used at LPP**

Problems in the

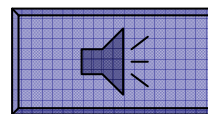
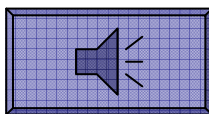
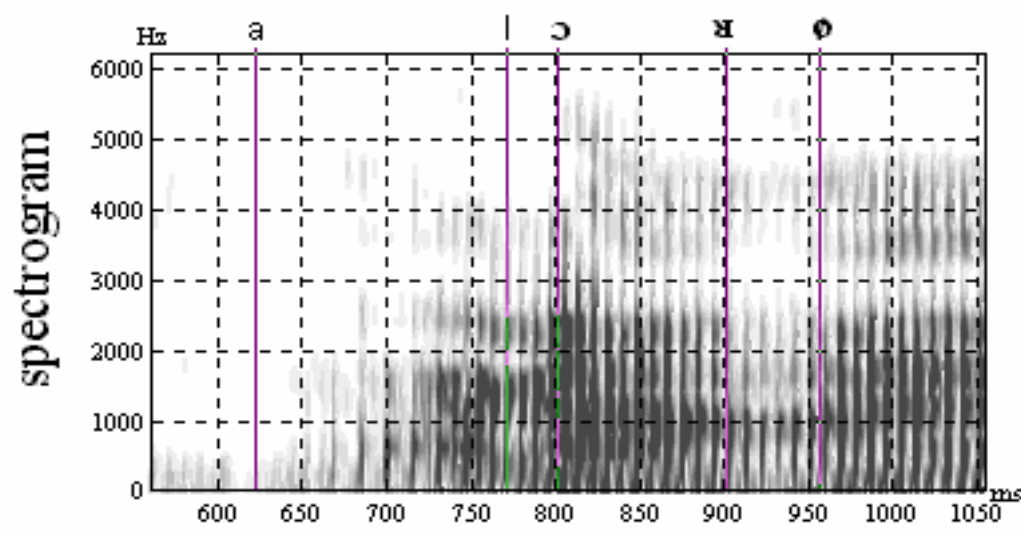
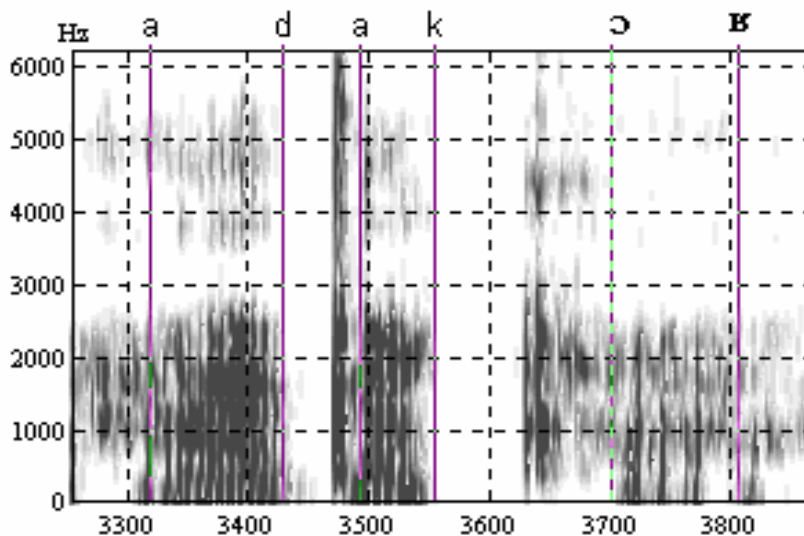
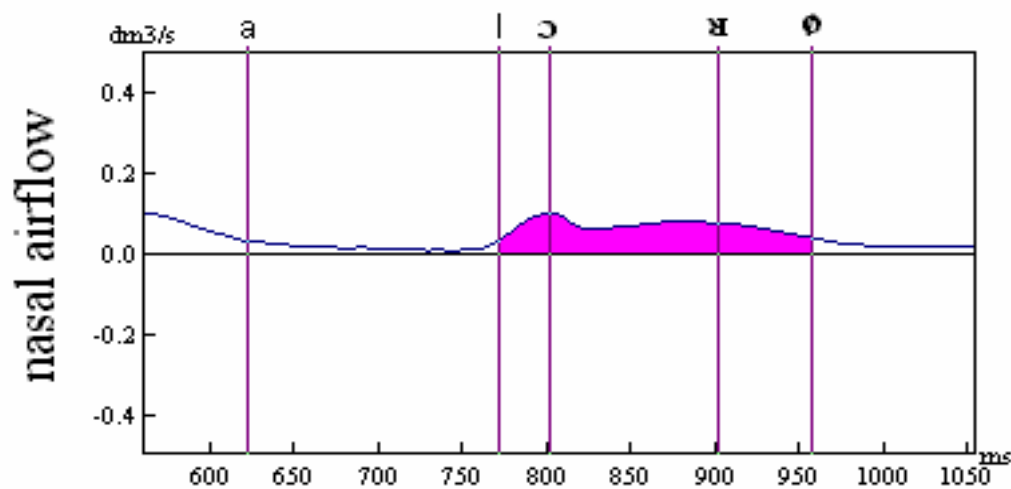
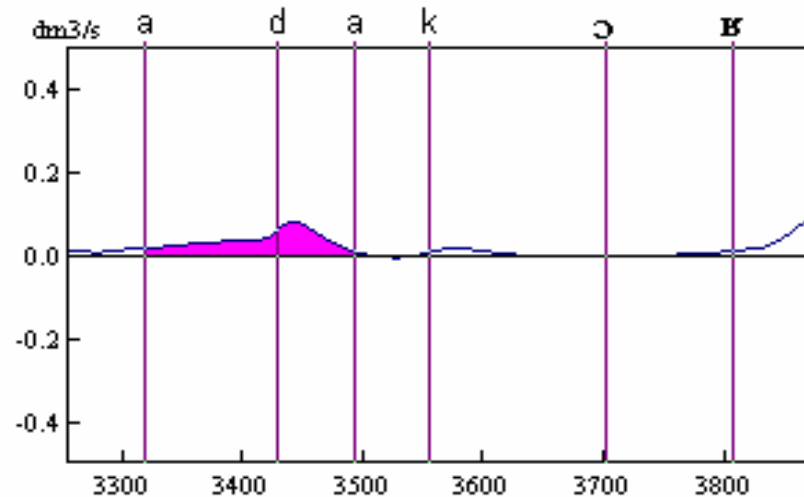
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- C) Problem of corpus
- choice of vowels
 - onset versus coda consonant
- D) The language
- E) The style
- F) Speaker effort
- G) Random variations?



[dakəʁ] « D'accord »

[alɔʁ] « alors »

Spontaneous

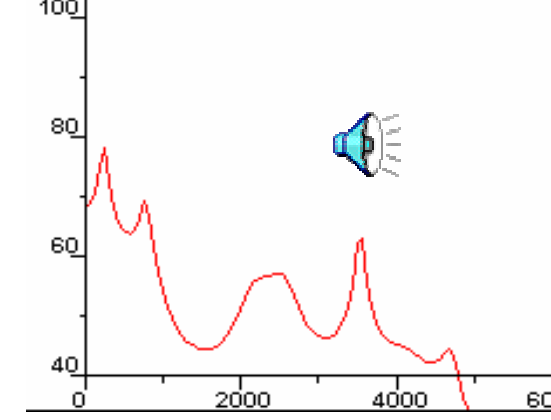
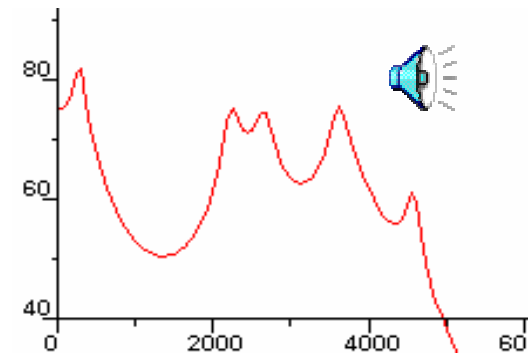
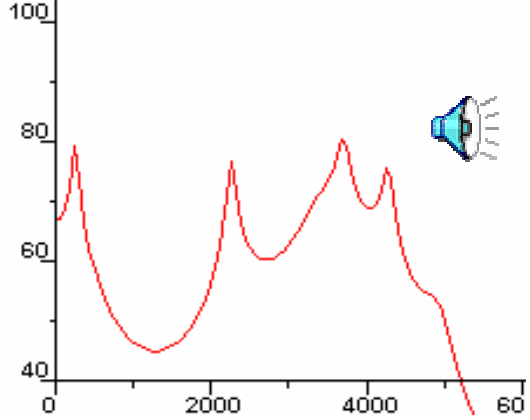


Problems in the

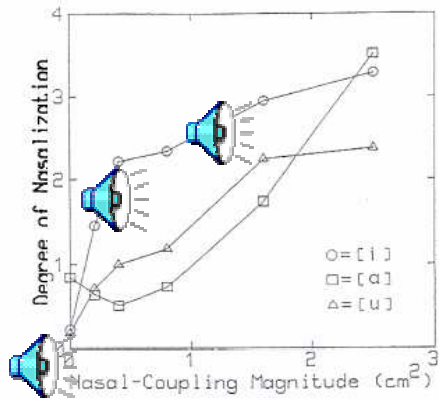


- A) On some discrepancies that can be explained in part
- A1) instrumentation-dependent results
 - A2) acoustic cues to nasalisation and airflow
 - A3) distinction nasal mora and voice decay time
 - A4) positive or negative airflow with VP close
 - A5) nasal airflow and airflow resistance
- B) Uncontrollable post-pausal raising, prepausal lowering and declination
- C) Problem of corpus
- choice of vowels
 - onset versus coda consonant
- D) The language
- E) The style
- F) Speaker effort
- G) Random variations?
- H) Errors

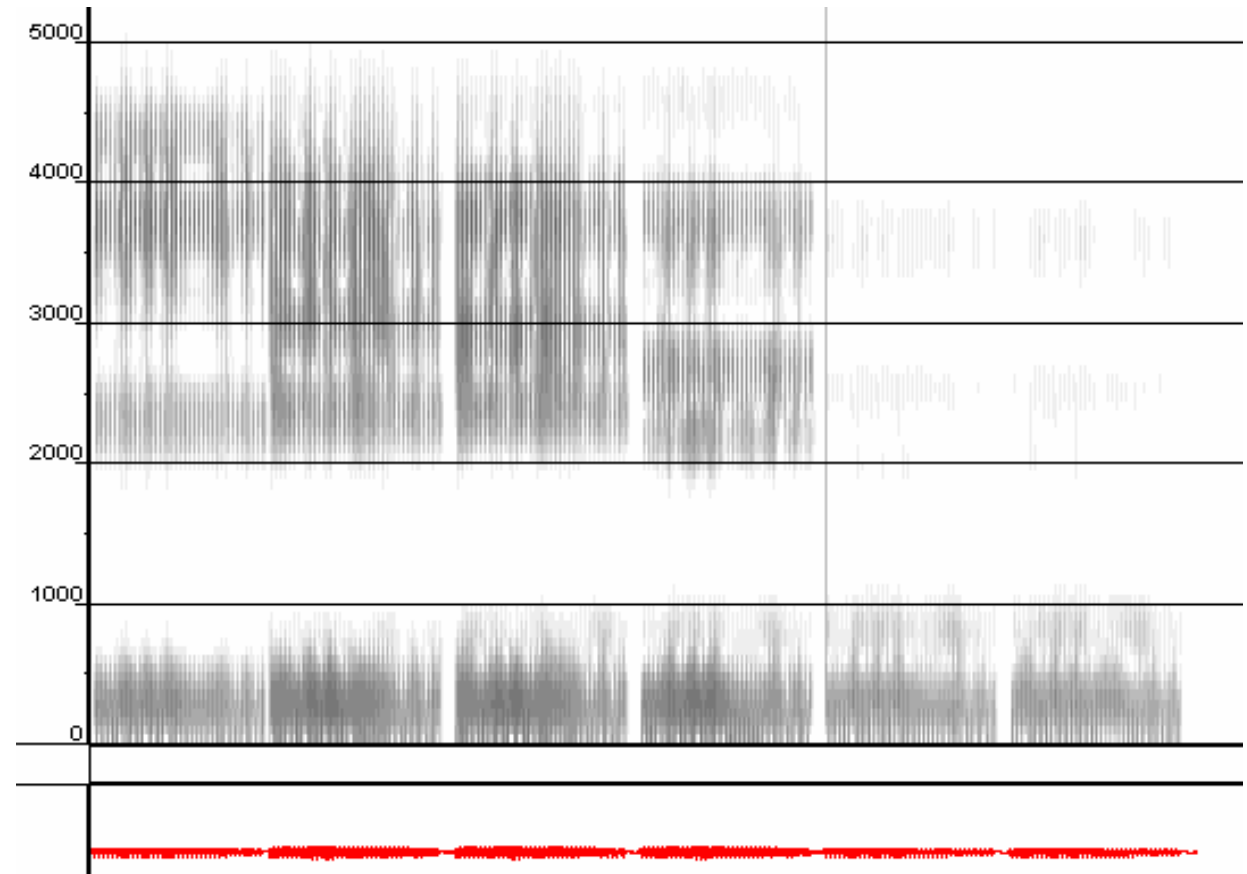
**No, the « formants » of the oral cavity cannot be measured
In nasalized portions of speech !!!
(no, F2 is not a direct indication of tongue back-front position)**



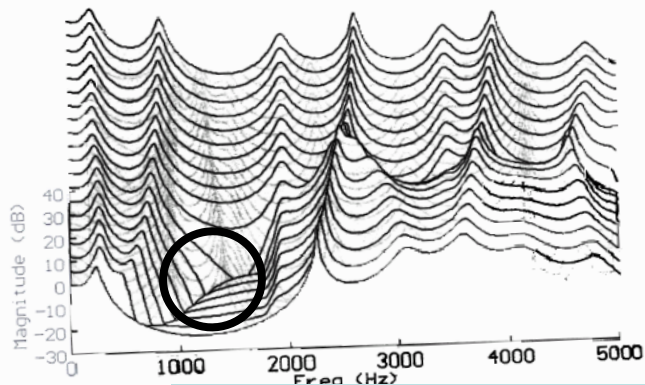
Degré subjectif de nasalisation



/i/



Variation de la fonction de transfert en fonction de Nc (cm²):
[i]



nalisation

Tongue did not move!

2

3

4

5



Atelier x :

Nasal 2009

Problems in the interpretation of the data related to nasality

Conclusion

UMR 7018 (CNRS, Sorbonne Nouvelle)

5 Juin 2009





- Specify at which level nasalisation has been observed
 - Suppression of LP activity, EMG
 - Not the whole story, Honda, Henderson, PG+
 - Mvt (fiberscope)
 - asymetry
 - Nasograph:
 - when open, how much, when most
 - Microbeam, X-ray
 - Lip, tongue, etc.
 - Aerodynamics
 - But airflow resistance, vocal effort
 - Acoustics
 - Not so easy, not always visibe
 - Perception
 - Size of the windows



- Specify at which level nasalisation has been observed
- Avoid any pause (difficult)
 - Even when frame
 - #imi#
 - Very variable
 - Less nasalisation visible in first phoneme
 - More nasalisation in the last
 - The final pause acts as a nasal segment in #imi# but not in #ibi#



- Specify at which level nasalisation has been observed
- Avoid any pause (difficult)
- Stress, position in the breath group, relatively to pause, syllable structure
 - As well known
 - But not always taken into account



- Specify at which level nasalisation has been observed
- Avoid any pause (difficult)
- Stress, position in the breath group, relatively to pause, syllable structure play a role
- Intensity
 - Head mounted microphone



- Specify at which level nasalisation has been observed
- Avoid any pause (difficult)
- Stress, position in the breath group, relatively to pause, syllable structure play a role
- Intensity
- Perception very important (not always possible)
 - Aerodynamic data
 - A lot of tubes in the nose
 - need standards



- Specify at which level nasalisation has been observed
- Avoid any pause (difficult)
- Stress, position in the breath group, relatively to pause, syllable structure play a role
- Intensity
- Perception very important (not always possible)
- Multisensor approach useful
 - LPP: invasive and not invasive combined
 - Helps description a lot
 - Platform June 24th



- Specify at which level nasalisation has been observed
- Avoid any pause (difficult)
- Stress, position in the breath group, relatively to pause, syllable structure play a role
- Intensity
- Perception very important (not always possible)
- Multisensor approach useful
- **Need to establish standards at all level**
 - how to measure? normalisation
 - what to measure?
 - Share data (after publication) to construct data base (normal and pathological)

Merci de votre attention !

