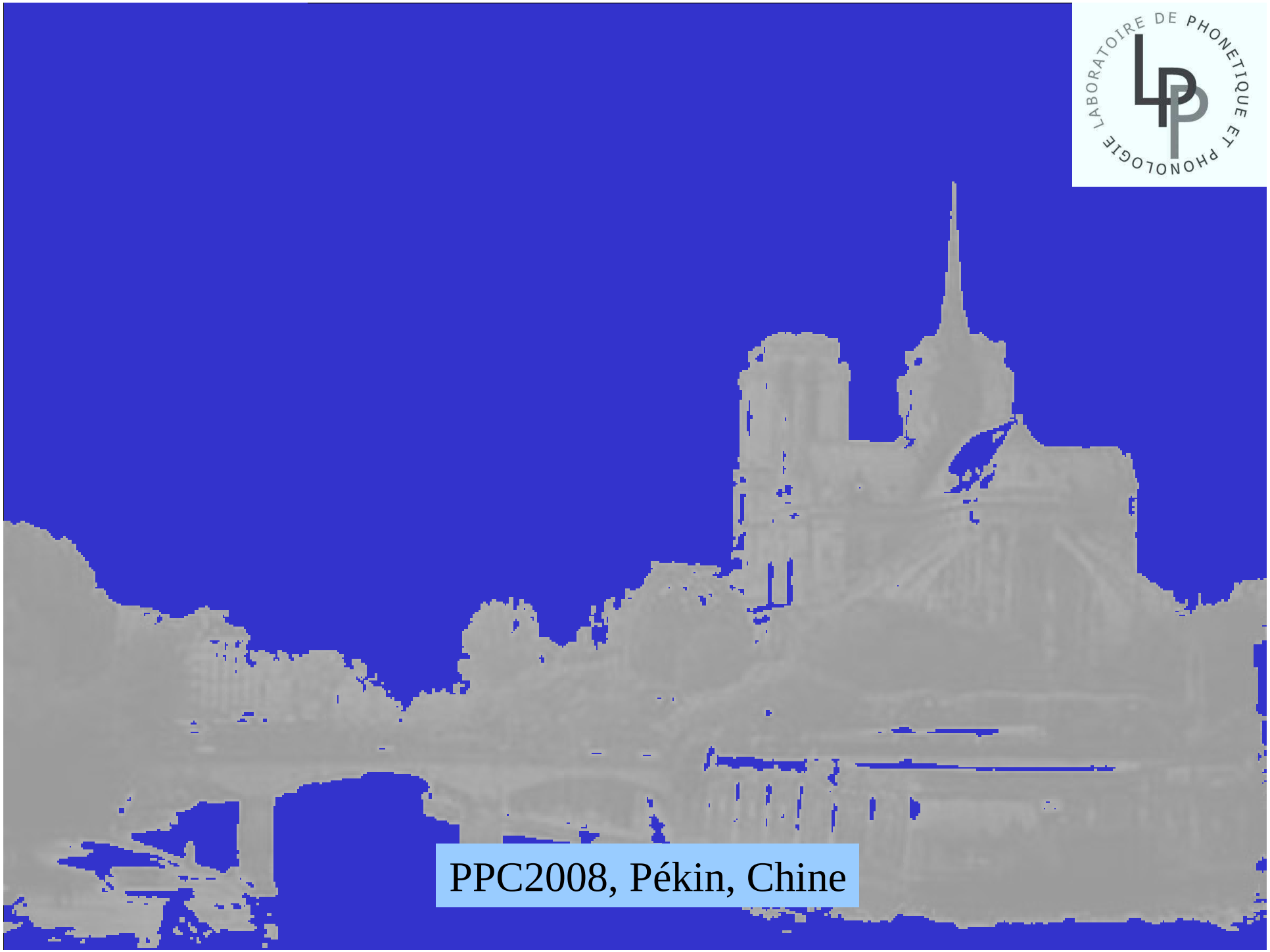
On acoustic salience of vowels and consonants predicted from articulatory models

Jacqueline Vaissière


LABORATOIRE DE PHONETIQUE ET PHONOLOGIE
PPC2008, Pékin, Chine

On acoustic salience of vowels and consonants predicted from articulatory models

Many thanks to
Shinji Maeda
And LPP students
In Paris

Jacqueline Vaissière

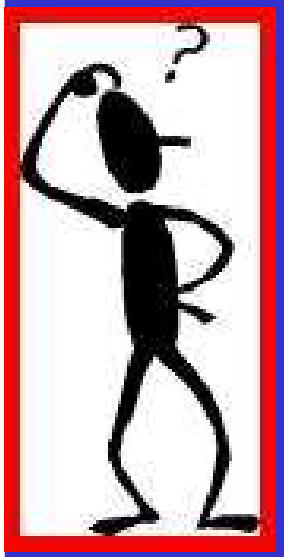
Université Sorbonne Nouvelle - Paris

Laboratoire de Phonétique et de Phonologie

PPC2008, Pékin, Chine

Menu?

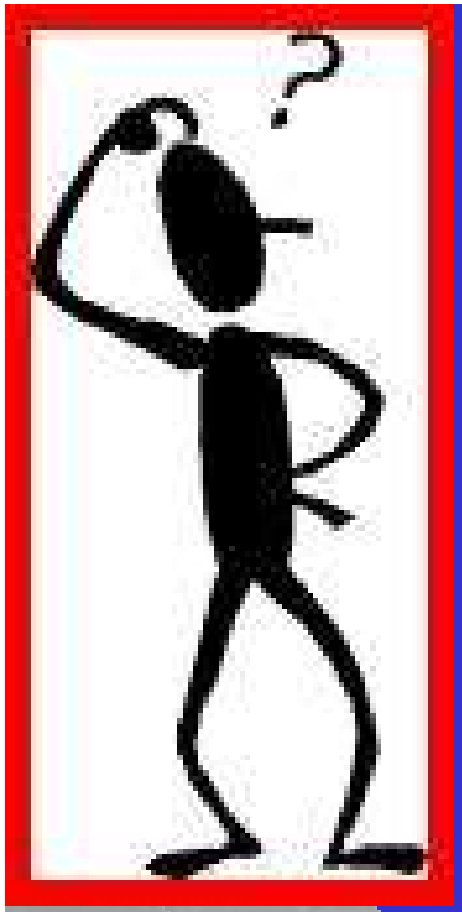
A



1. What is a model?
2. Why modelling?
3. Which models?
4. What is a useful model?
5. Demo (vowels consonants)
6. How done?
7. Other uses

- speaker anatomy
- speaker strategy
- singing formant
- inversion
- etc

B



The questions

2

What is a model?

A model is a simplified description of a complex system

A model is not a goal per se, but a tool

1. **to know what we know**
2. **and what we don't know**
3. **And where to look for …**

3

Why modelling?

Modeling is needed to apprehend *complex* phenomena

Speech is *complex* enough to need modelisation

Modeling allows to evaluate the separate contribution of individual parameters and the acoustic and perceptual consequences of large and small movements

Modelisation in turn makes speech looking less or *sometimes more complex*

Which models?

Phonetics

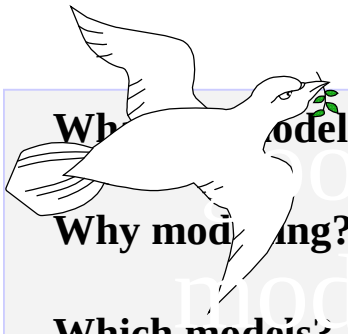
- *Prosodic modelling*
- *Source modelling*
- *Vocal tract*
  - *2D articulatory*
  - *3D articulatory*

– *Articulatory modelling*

Psycholinguistics

- *perception and recognition*
  - *Phoneme*
  - *Word access*
  - *Sentences*

– **Etc.**



Wh odel?

Why mod ng?

Which models?

What is a useful model?

How done?

Demo
- vowels
- consonants

Other uses
- speaker anatomy
- ategy
- rmant

5

Useful models?

Be compatible with the observations

Be testable

Describes well the data and to be able to reproduce them from

Few number of parameters

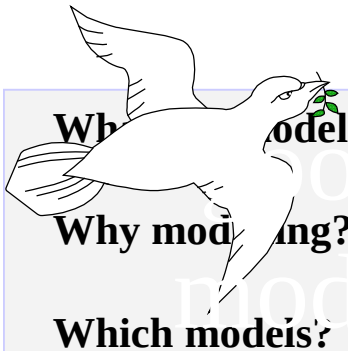
As motivated as possible

As independent as possible

And for AM, react as a human vocal tract

no stop without a burst, or no frication when humans do.

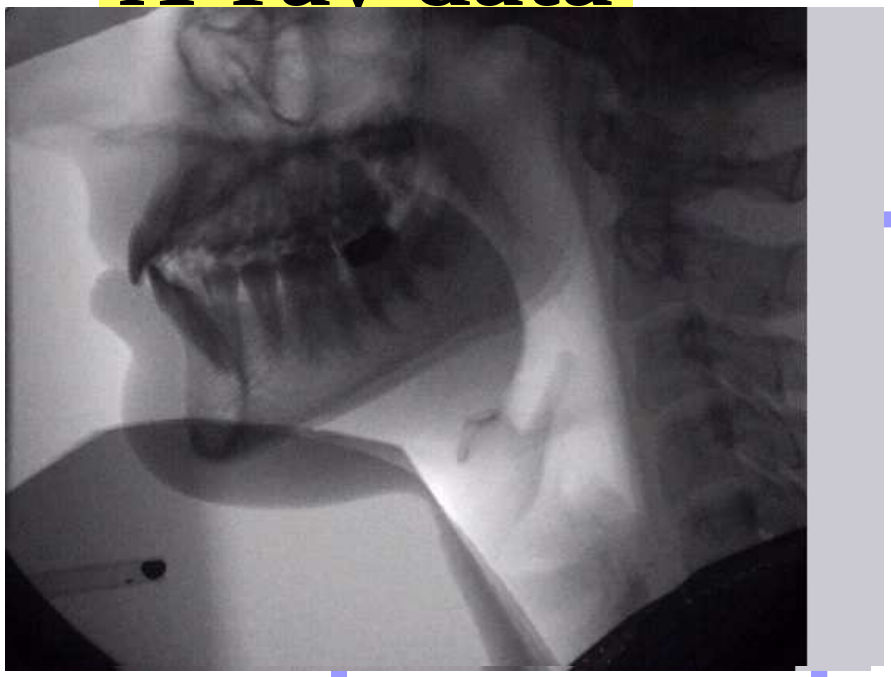
To draw a direct link between articulatory, acoustic and perceptual observations



How done?

- *By Shinji Maeda*
- *From X-ray data for French (from Strasbourg)*
- *By statistical analysis*
- *The most widely used AM*
- *Used for pedagogical purpose in our lab and research in Grenoble, Nancy, UCLA, MIT, etc.*

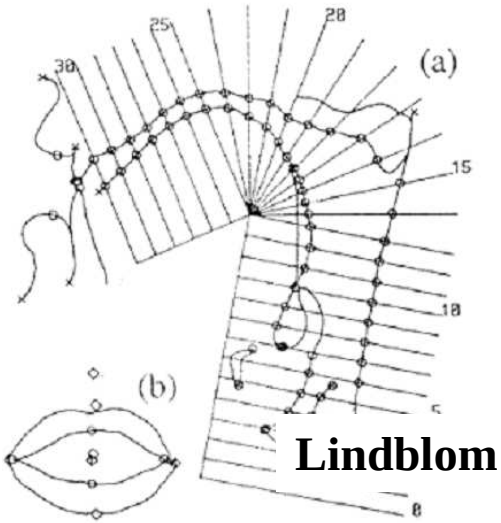
1 **X-ray data**



One speaker

10 sentences
>1000 images

2



Lindblom & al, 1971

3 **Guided PCA**

4 7 parameters

VT shapes

5

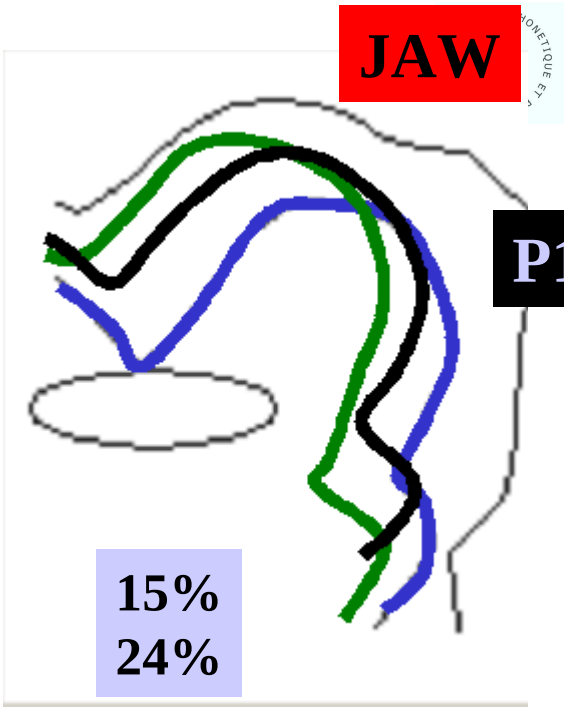
First substract the effect of the jaw

4 first parameters
Jaw + tongue

How done?

Demo

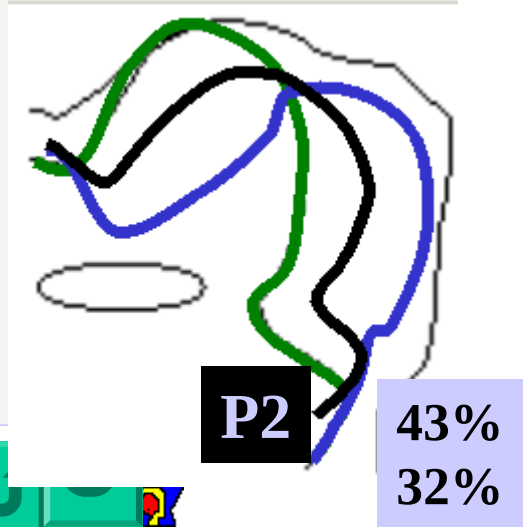
Other uses

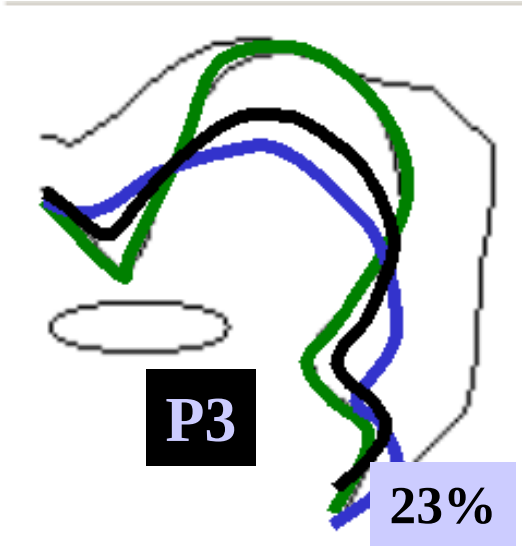


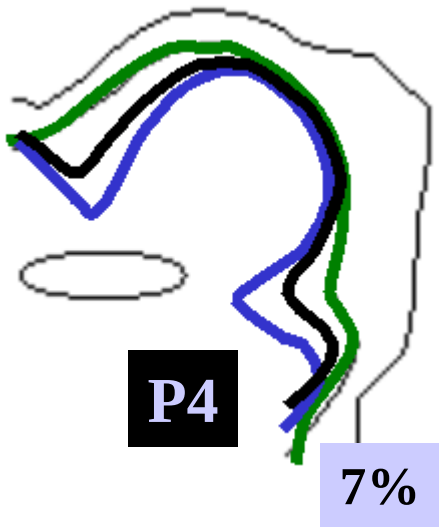
1+2= 58%, 56%

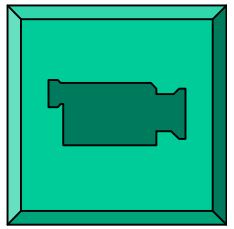
1+2+3= 81%, 79%

1+2+3+4= 88%, 86%







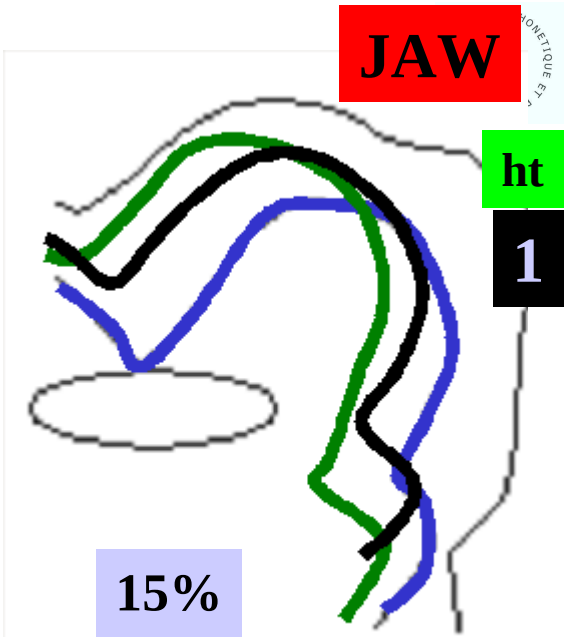


4

3 more = Lip and larynx

LIP
- ht 5
- pr 6

larynx
- ht 7

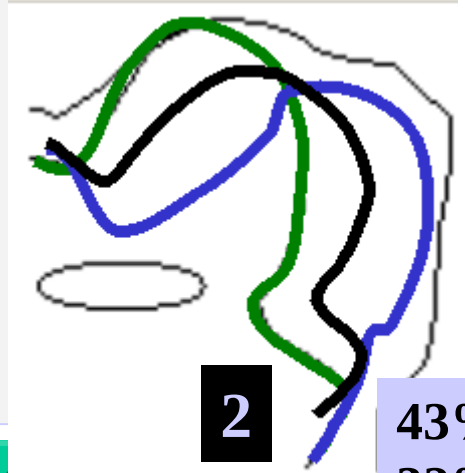


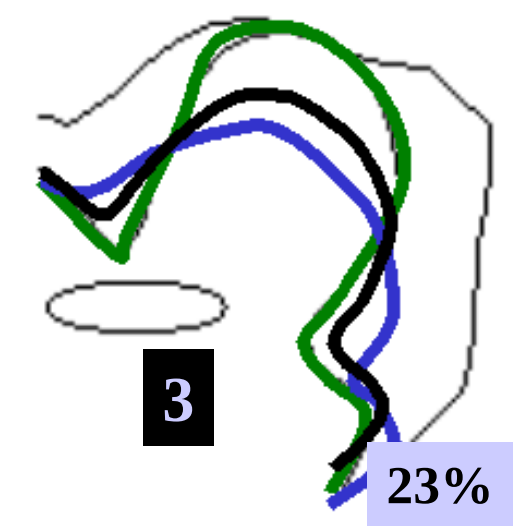
nasal 8

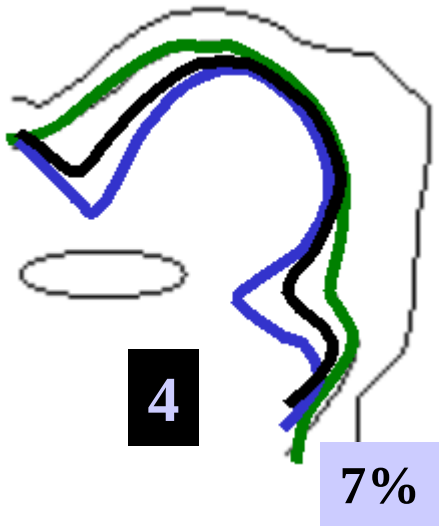
How done?

Demo
- vowels
- consonants

Other uses







4 7 parameters = Speech organs

How done?

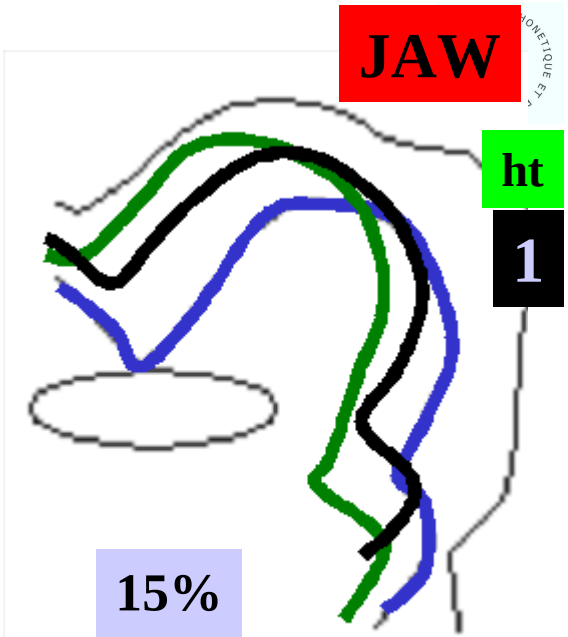
Demo
- **vowels**
- **consonants**

Other uses

LIP
ht 5
pr 6

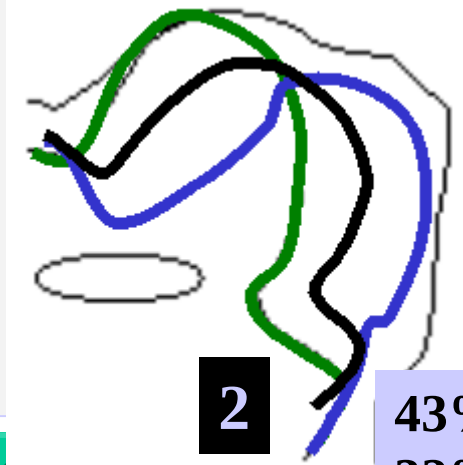
larynx
ht 7

JAW
ht 1



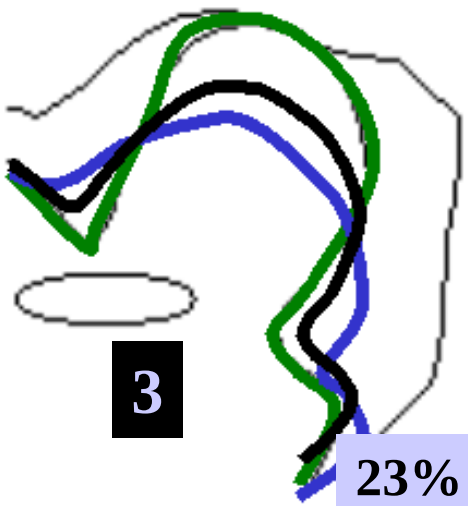
15%
24%

nasal 8



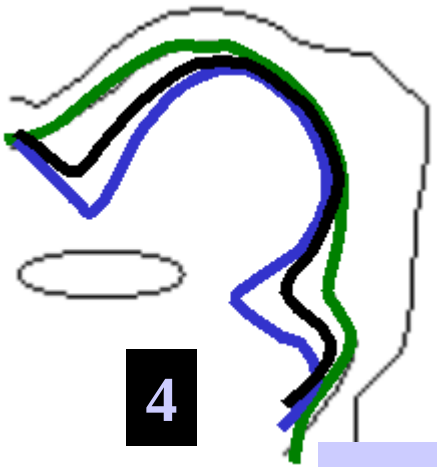
2

43%
32%



3

23%



4

7%

Surprisingly or not

The 7 statistically found parameters could be interpreted in phonetic terms

2 for lips, 3 for tongue, 1 for jaw, 1 for larynx

model?

How done?

Demo
- vowels
- consonants

Other uses

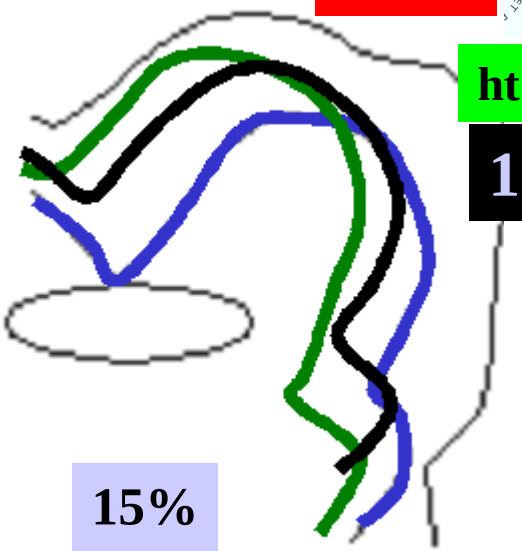
4

7 commands

LIP
- ht 5
- pr 6

larynx
- ht 7

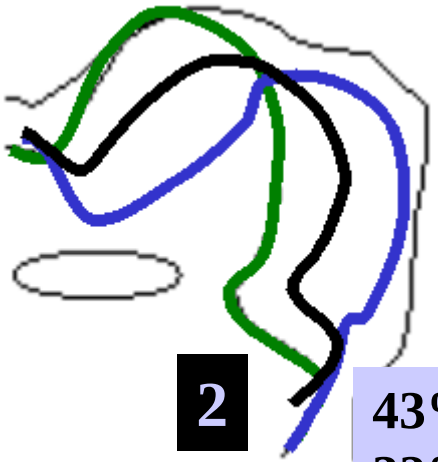
JAW
- ht 1



15%
24%

TONGUE
- body
- shape — u, k
- apex — i, e, dentals

nasal 8



2

43%
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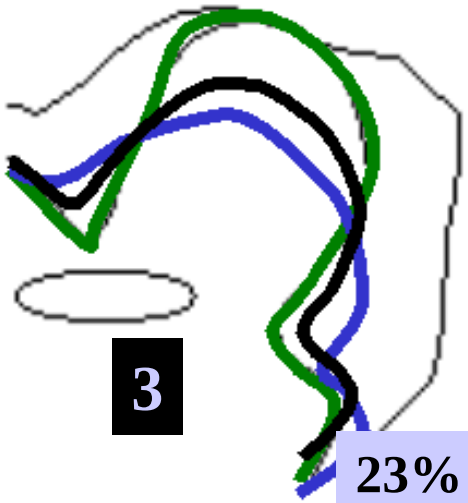

3

23%

4

7%

Nasal cavity

Sublingual cavity

Why modelling?

Which models?

What is a useful model?

How done?

Demo
- vowels
- consonants

Other uses
- speaker anatomy
- speaker strategy
- singing formant inversion
- etc;

radiation load: RL_CIRCUIT

wall: YIELDING

nasal tract: OFF

glottis: CLOSE

air density=0.00114

sound velocity=35000

wall resistance=1600

wall mass=1.5

wall compliance=300000

1

Examples?

- What is a model?
- Why modelling?
- Which models?
- What is a useful model?
- How done?
- Demo
  - vowels
  - consonants
- Other uses
  - speaker anatomy
  - speaker strategy
  - singing formant
  - inversion
  - etc;

- 1) vowels
- 2) CVC sequences

1

1) vowels

- What is a model?
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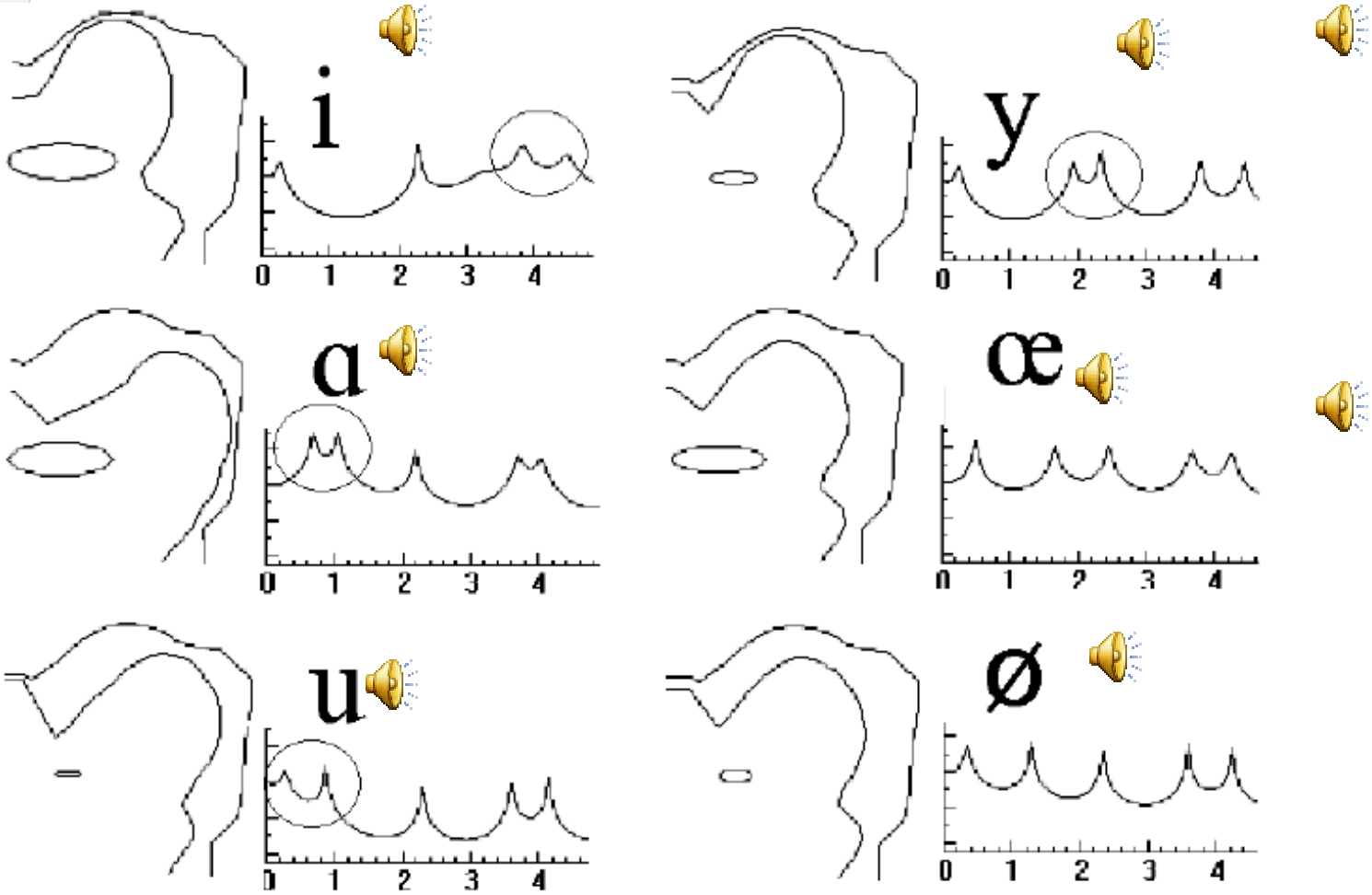
- Other uses
  - speaker anaton
  - speaker strateg
  - singing forma
  - inversion
  - etc;



Vaissière, 2007

What is a model?

Why modelling?

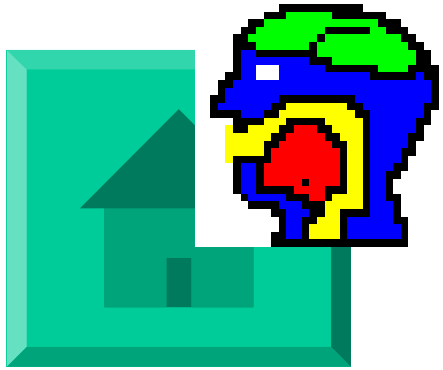
Which models?

What is a useful model?

How done?

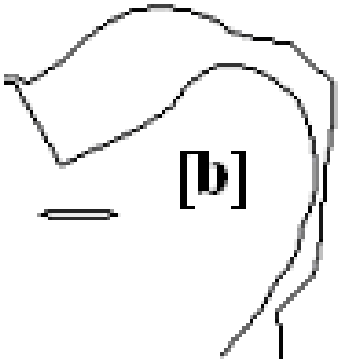
Demo
- **vowels**
- **consonants**

Other uses
- speaker anatomy
- speaker strategy
- singing formant
- inversion
- etc;



2) consonants

- What is a model?
- Why modelling?
- Which models?
- What is a useful model?
- How done?
- Demo
  - vowels
  - consonants
- Other uses
  - speaker anatomy
  - speaker strategy
  - singing formant
  - inversion
  - etc;

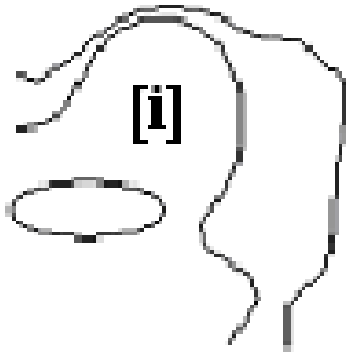


F1 371
F2 898
F3 2136
F4 3683
F5 4024

F1 712
F2 1145
F3 2229
F4 3745
F5 4024

F1 186
F2 1207
F3 2321
F4 3776
F5 4457

closure]



F1 248
F2 2290
F3 3838
F4 4457

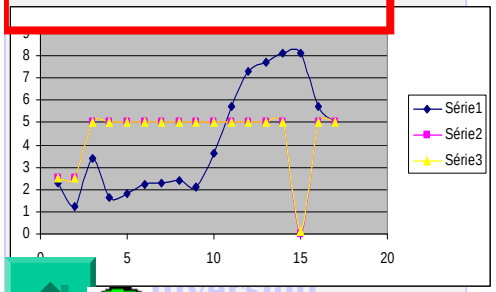
after release

Beans on a string synthesis

1

2) consonants

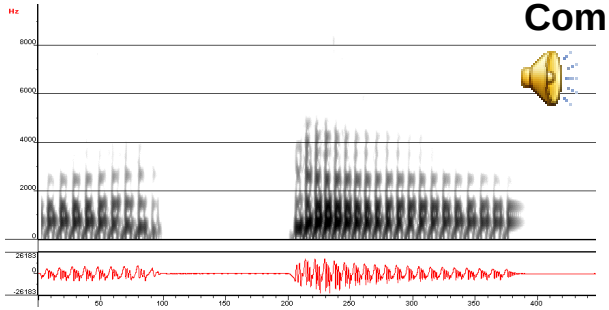
- What is a model?
- Why modelling?
- Which models?
- What is a useful model?
- How done?
- Demo
  - vowels
  - consonants

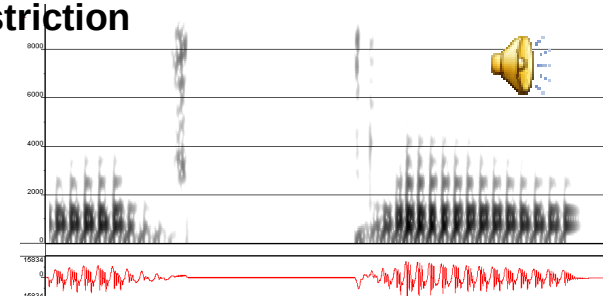


Glottis close

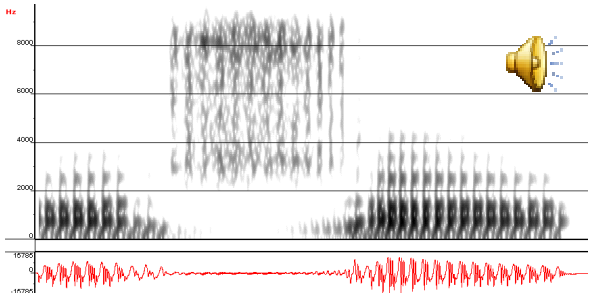
Glottis open

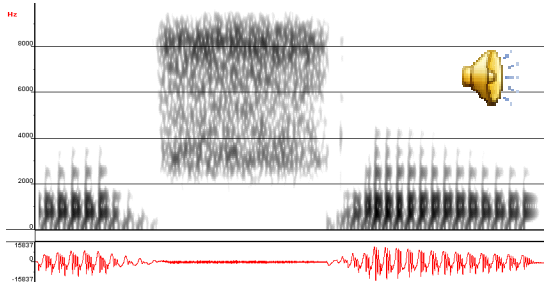
Complete constriction





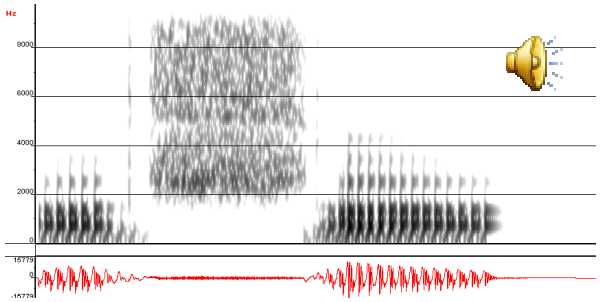
Complete constriction

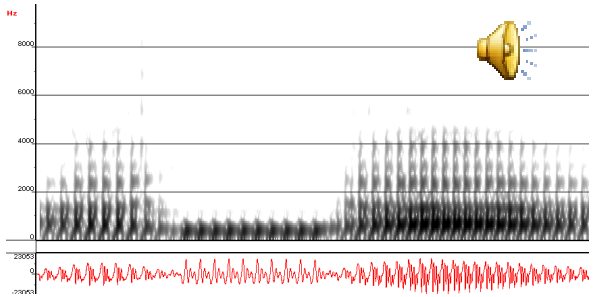




Sublingual cavity

Nasal port open





Lip constriction

What is a model?

Why modelling?

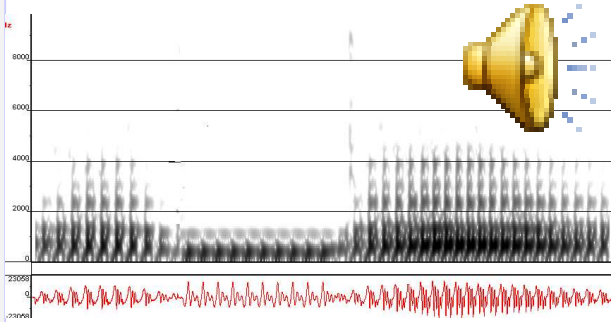
Which models?

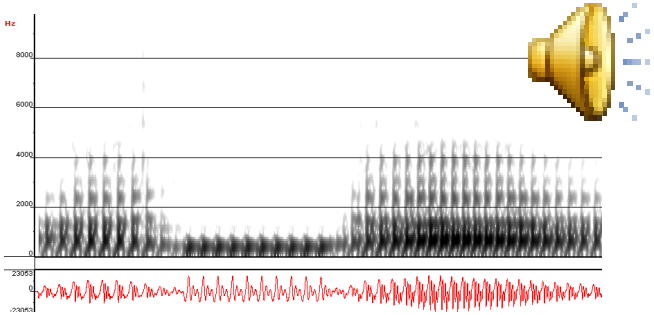
What is a useful model?

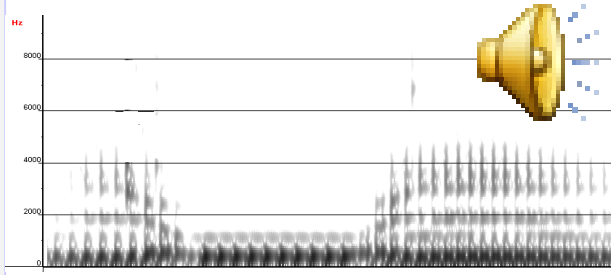
How done?

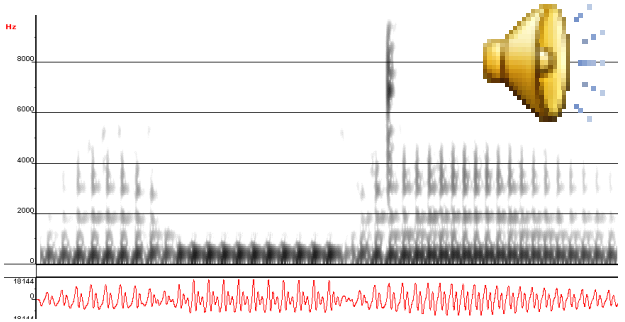
Demo
- **vowels**
- **consonants**

Other uses
- speaker anatomy
- speaker strategy
- singing formant
- inversion
- etc;









What is a mo

Why modelli

Which mode

What is a use
model?

How done?

D

- **/a/ during 30 msec**

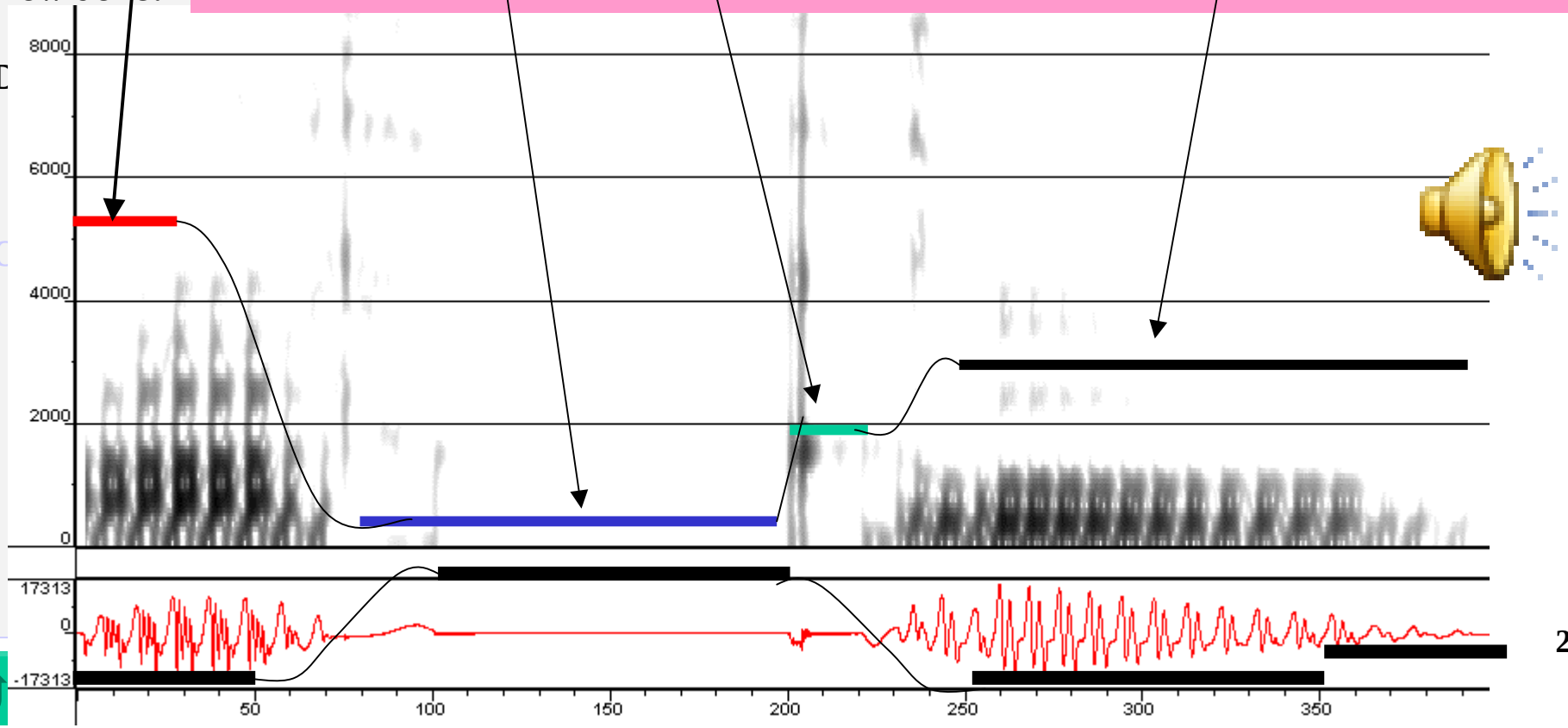
  cosine transition for 50 ms

  /k/ closure for 100 ms

  /k/ release for 17 msec

  cosine transition for 17 ms

  /u/ for 150 msec



- **Start by close VF for 50 msec**

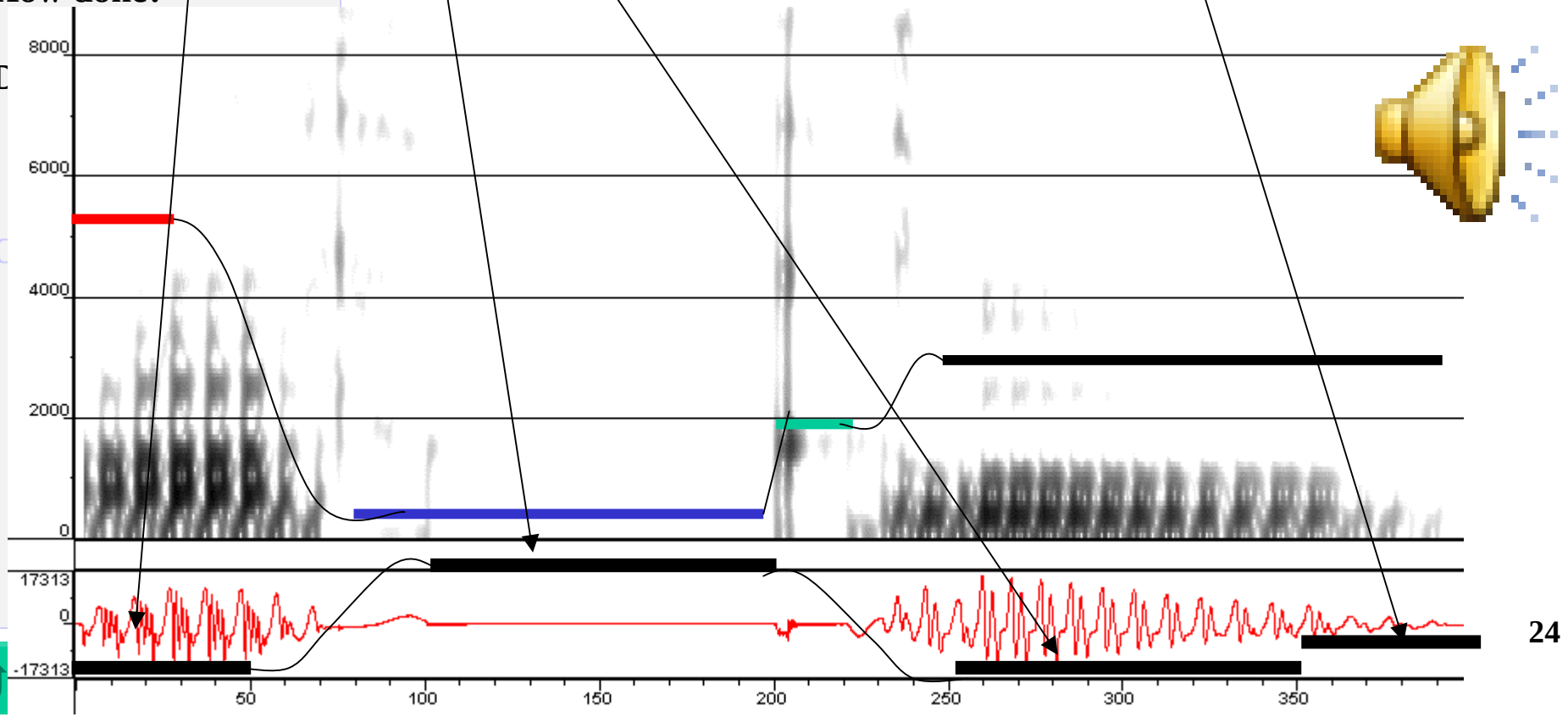
  Then cosine transition to open glottis (0.4) at 100 msec

  Stay open for 100 msec

  Then cosine transition to close glottis at 250.

  Stay close for 100 msec

  Open slightly for the last 50 msec. (prepausal opening)



Glottis and the three sources in the model

- **A) closed**
- **voicing**

- **B) open**
- If less open than VT: **aspiration**
- If VT less open than glottis: **frication**

- What is a model?
- Why modelling?
- Which models?
- What is a useful model?
- How done?
- Demo
  - vowels
  - consonants
- Other uses
  - speaker anatom
  - speaker strategy
  - singing forma
  - inversion
  - etc;

V

C

V

1)

Invariant place and shape

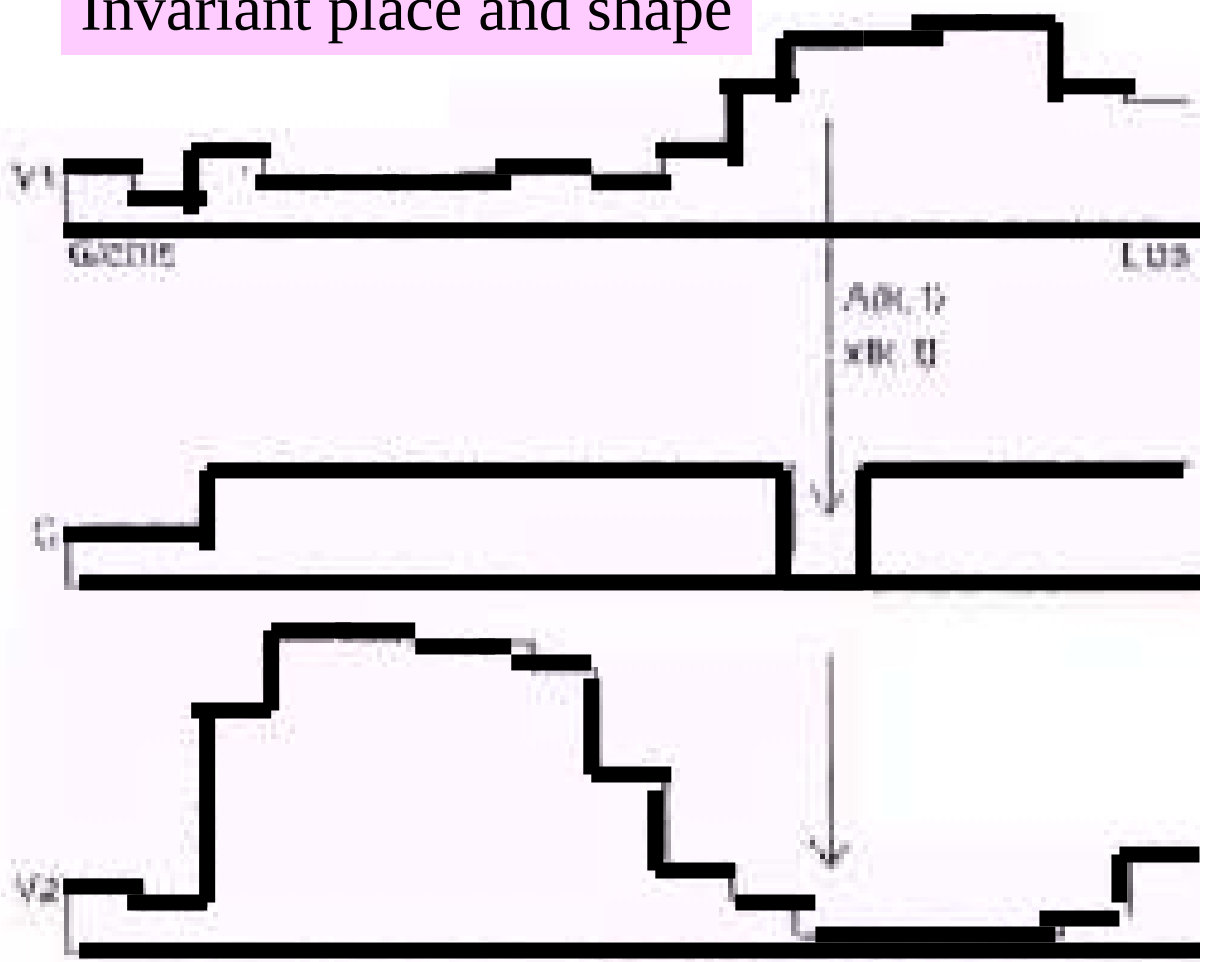


Figure 2: Interpolation of target area function

Different degrees of sophistication

1) Simple concatenation

/asa/ = 3 targets

= /a/ + /s/ + /a/

/ata/ = 4 targets

= /a/ + /tclosure/ + /t realease/ + /a/

+ Cosine transitions

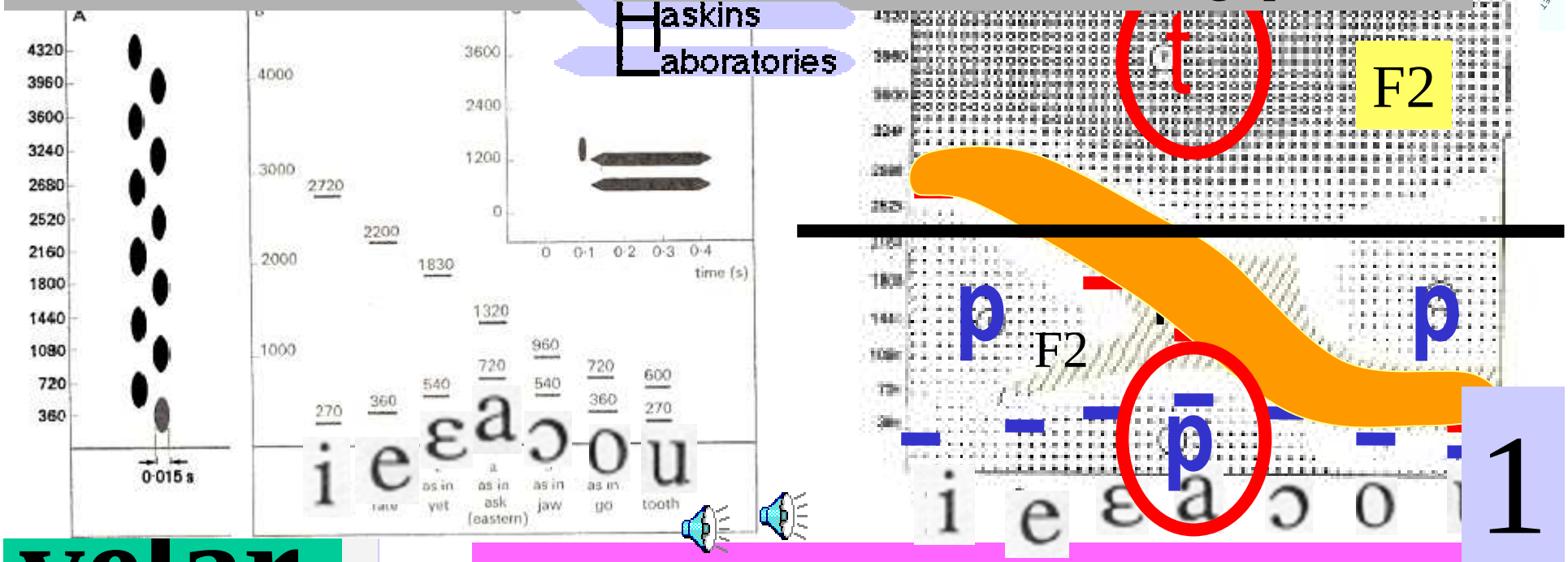
2) Contextual allophones

Ease of articulation

Necessary for velar

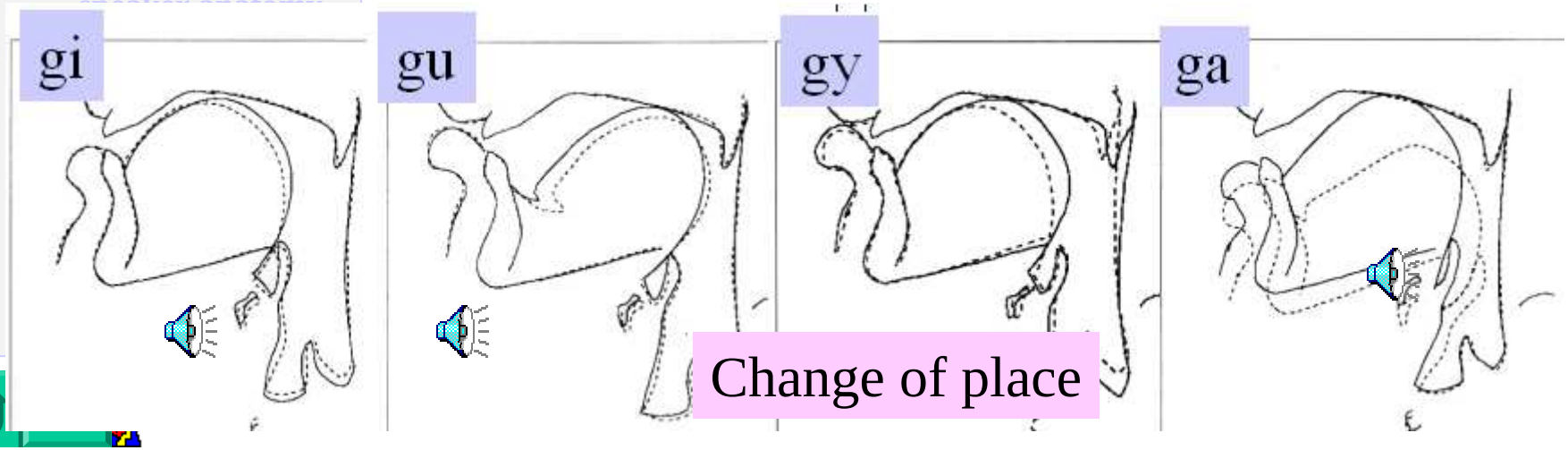
- /k/ and /g/ require the burst to be in special position to the ‘main pitch’ of the vowel
- Different /k/ allophones
- Main pitch /i/= 3000 Hz, /y/= 2000 Hz, etc.
- Not articulatory ease, but perceptual requirement
- It seems to be not a linguistic but a purely psychoacoustic phenomena (temporal masking)

the reference to the vowel is not needed for discriminating [p] and [t]



velar

Perceptual requirement?



Change of place

Different degrees of sophistication

1) Simple concatenation

2) Contextual allophones

Velar

3) Anticipation and carry over phenomena

What is a model?

Why modelling?

Which models?

What

How

Demo

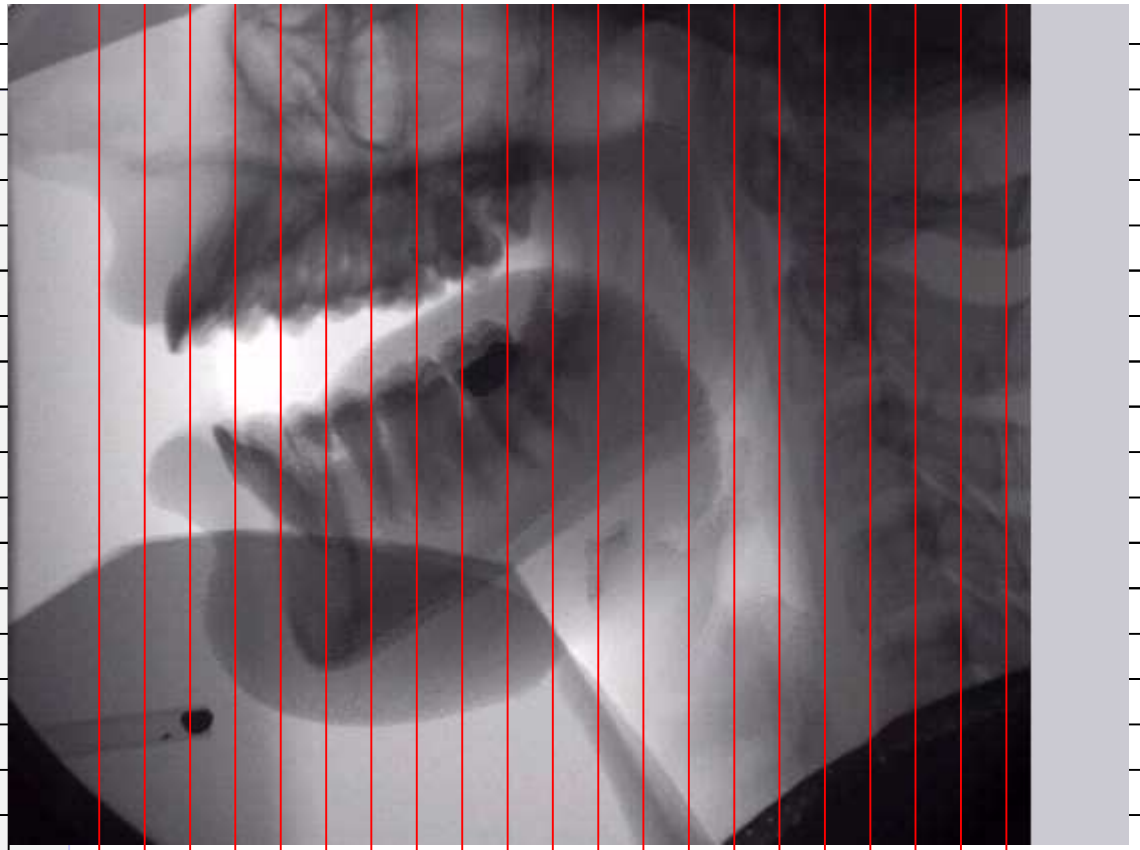
Other

- The X-ray data are due to the University in Strasbourg
- Laboratoire de phonétique
- R. Sock
- Frame by frame
- Illustration of anticipation

See the work at IPS Strasbourg (web)

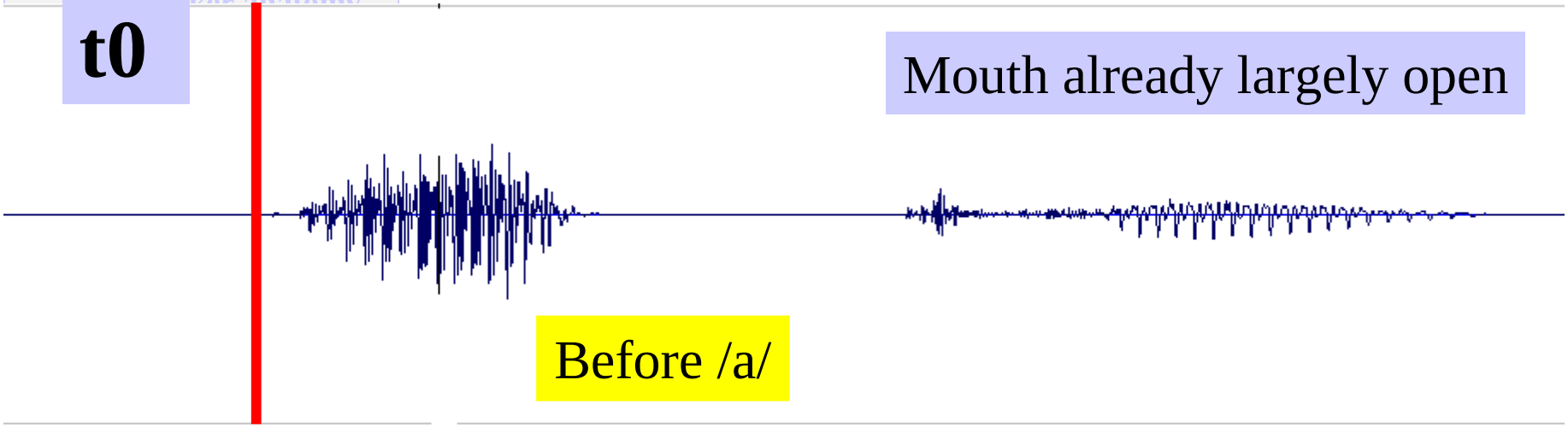
/aku/

- odel?
- Why modelling?
- Which models?
- What is a useful model?
- How done?
- Demo
  - vowels
  - consonants
- Other uses



t0

Mouth already largely open



Before /a/

/aku/

odel?

Why modelling?

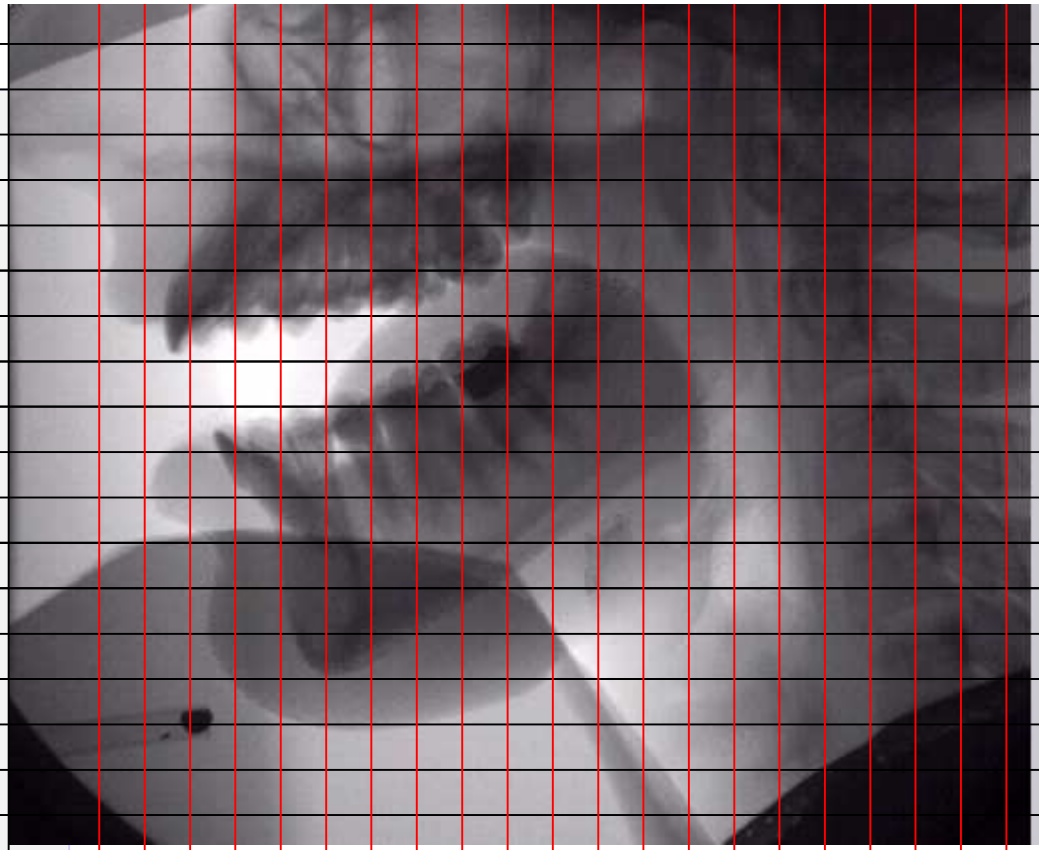
Which models?

What is a useful model?

How done?

Demo
- vowels
- consonants

Other uses



t1

Maximum opening for /a/
Jaw starts to rise again

/a/ onset

/aku/

odel?

Why modelling?

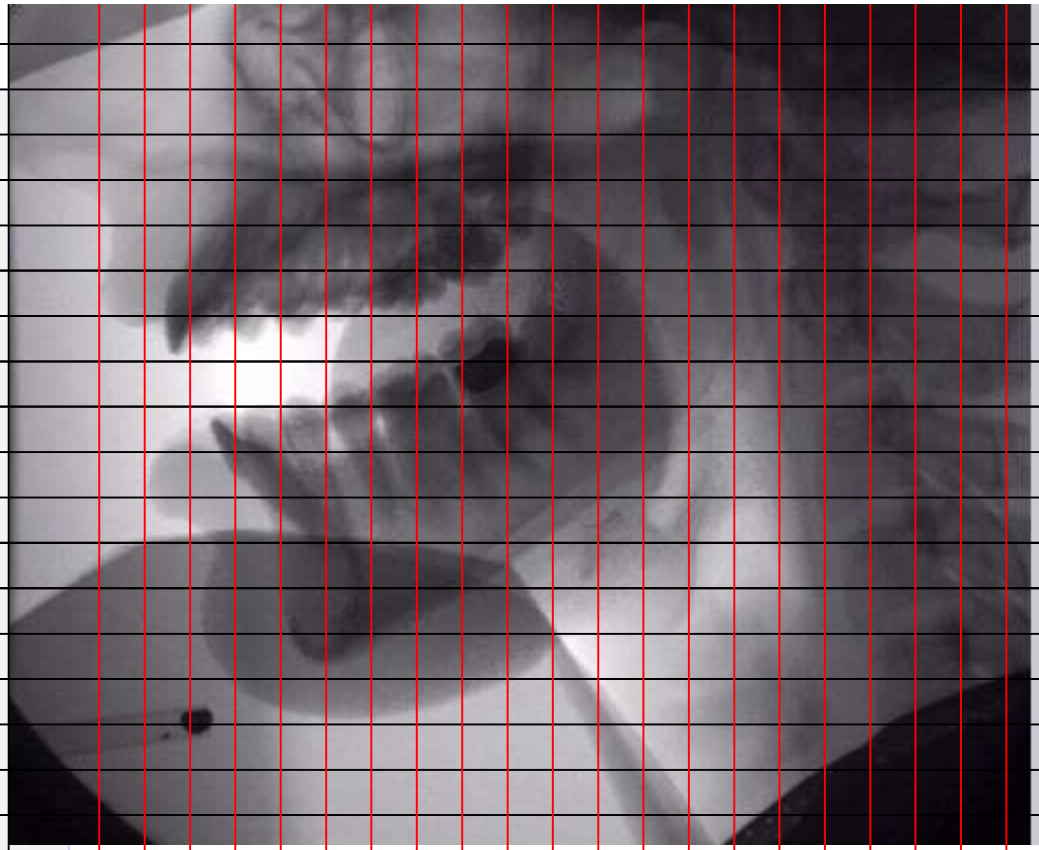
Which models?

What is a useful model?

How done?

Demo
- vowels
- consonants

Other uses



t2

/k/ closing gesture starts
Rounding starts

/a/ midle

/aku/

odel?

Why modelling?

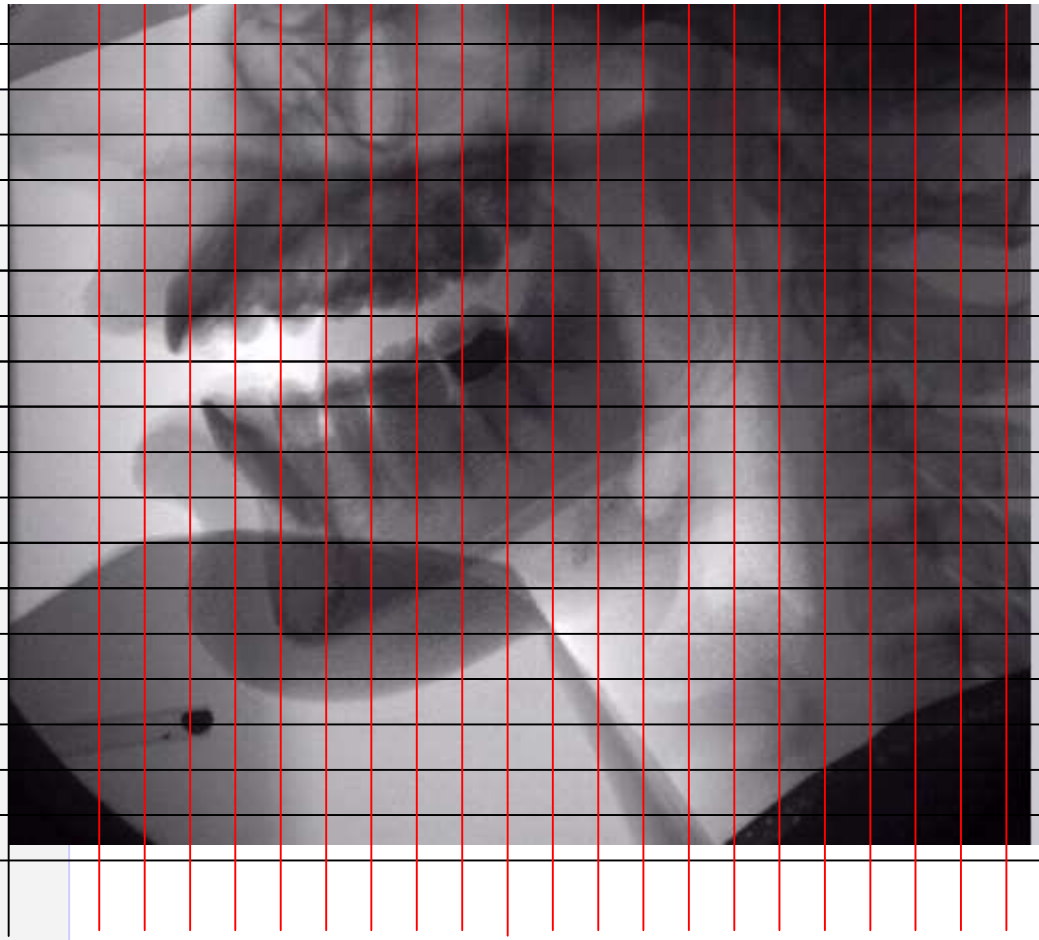
Which models?

What is a useful model?

How done?

Demo
- vowels
- consonants

Other uses



t3

/a/ offset

/aku/

odel?

Why modelling?

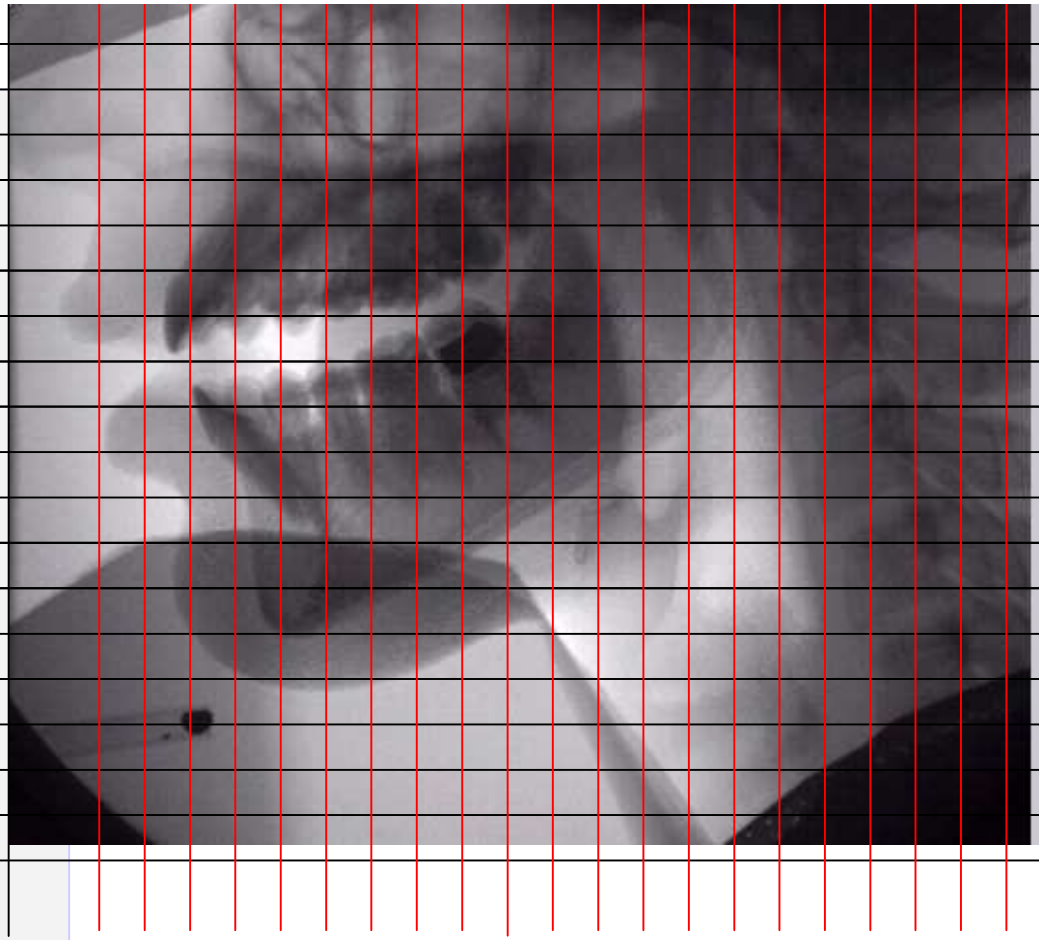
Which models?

What is a useful model?

How done?

Demo
- vowels
- consonants

Other uses



t4

Closure
Lip continue to round

/k/ first part

/aku/

odel?

Why modelling?

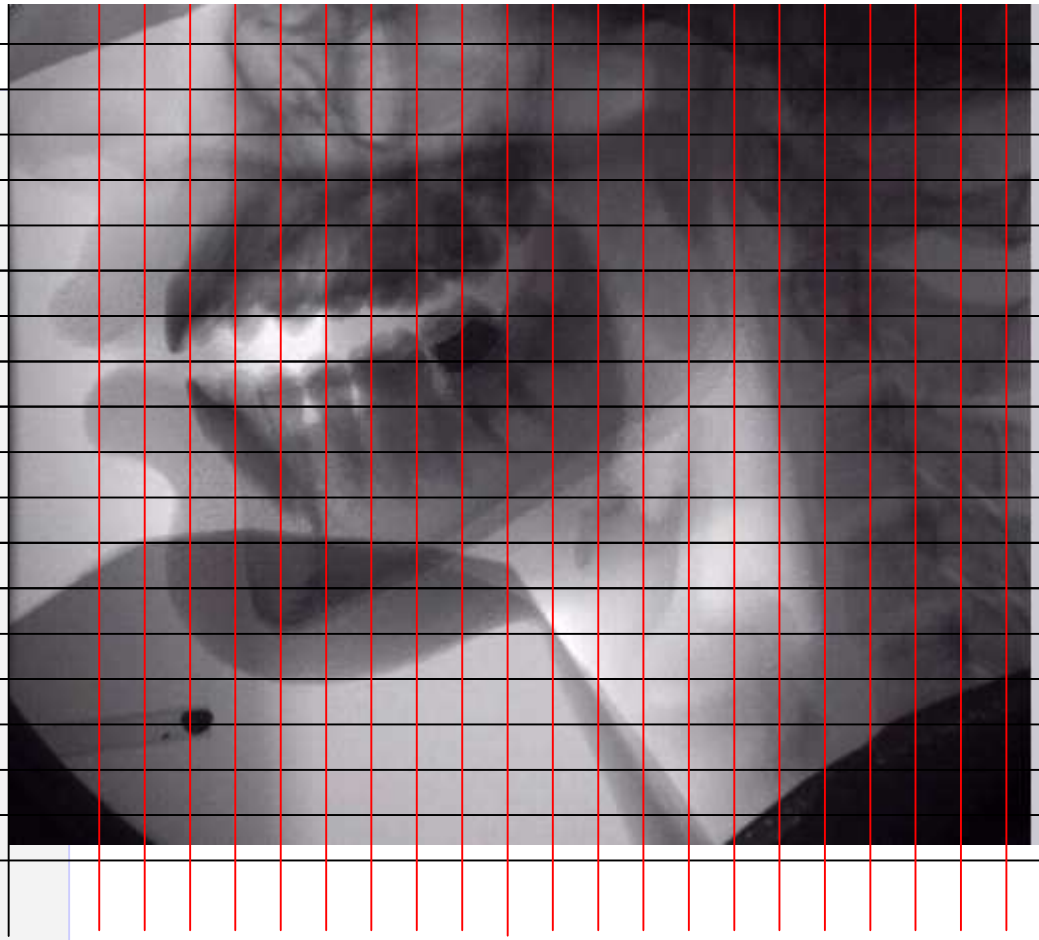
Which models?

What is a useful model?

How done?

Demo
- vowels
- consonants

Other uses



t5

/k/ midle

/aku/

odel?

Why modelling?

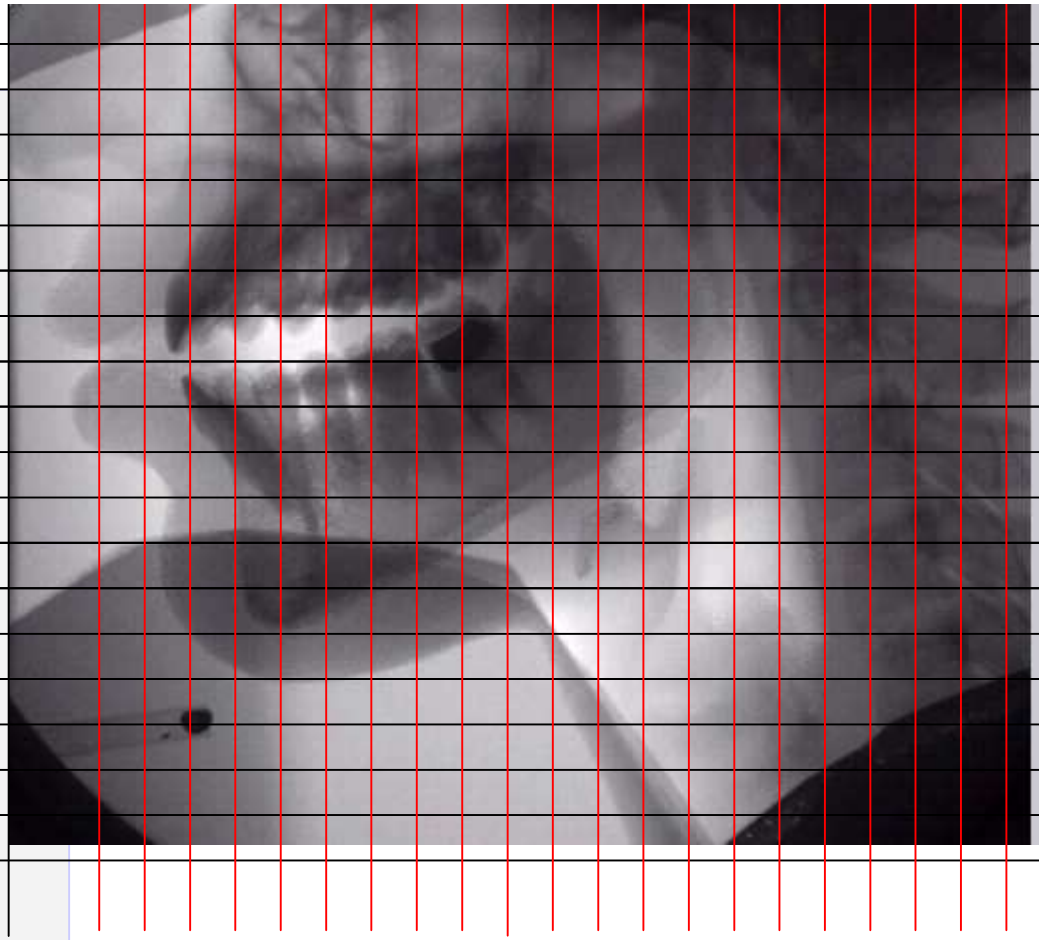
Which models?

What is a useful model?

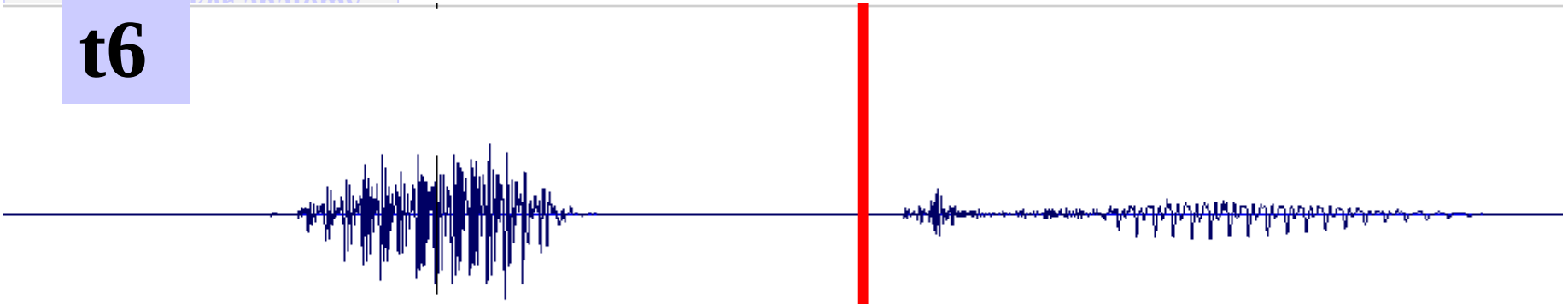
How done?

Demo
- vowels
- consonants

Other uses



t6



/k/ before release

/aku/

odel?

Why modelling?

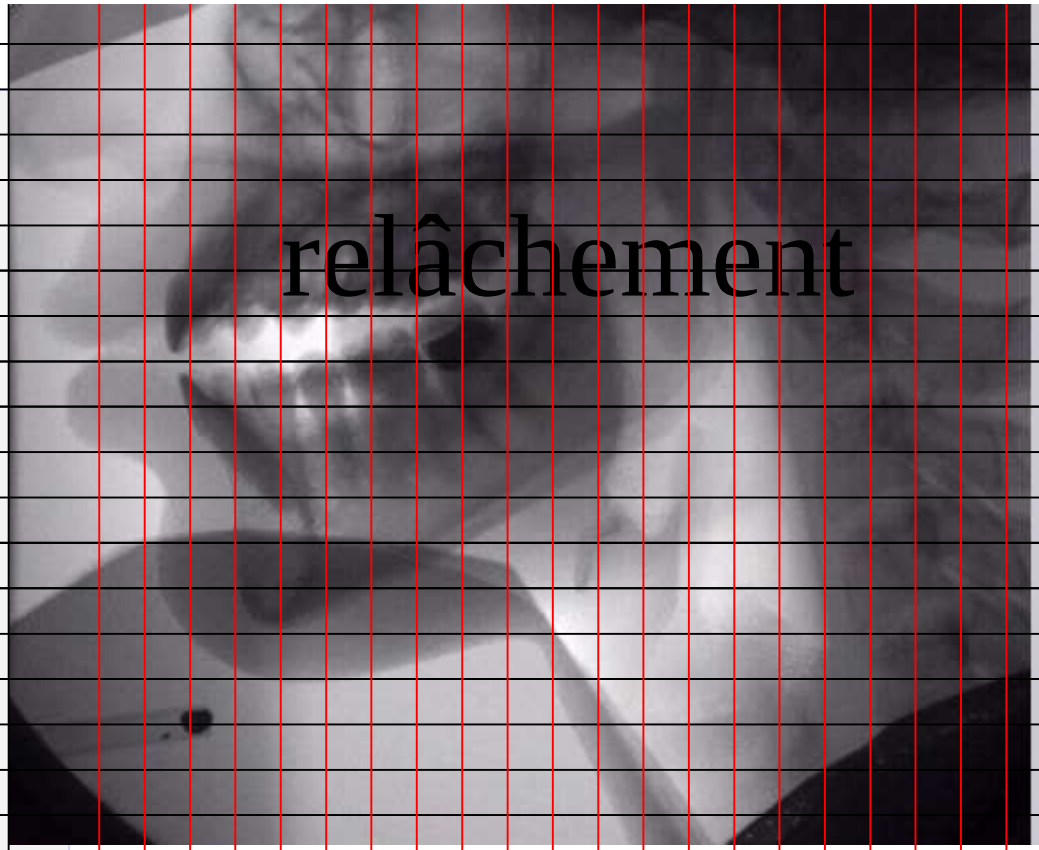
Which models?

What is a useful model?

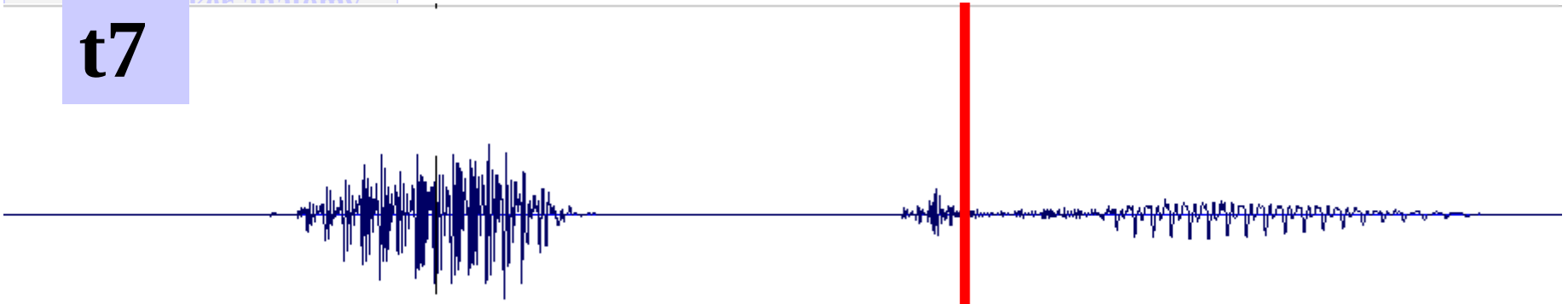
How done?

Demo
- vowels
- consonants

Other uses



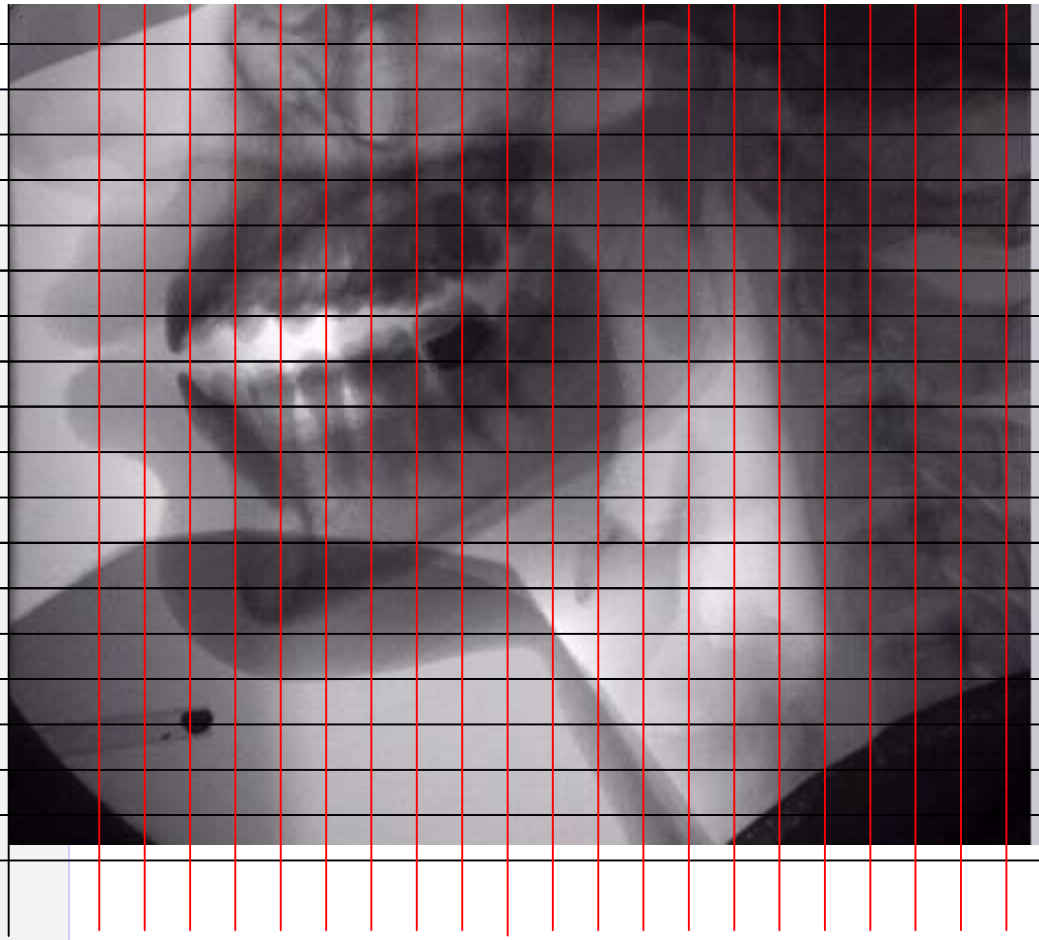
t7



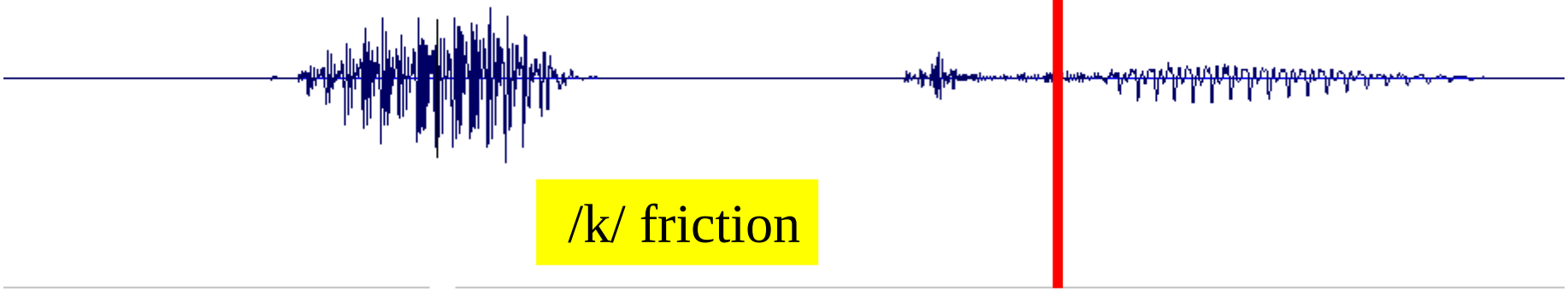
/k/ after release

/aku/

- odel?
- Why modelling?
- Which models?
- What is a useful model?
- How done?
- Demo
  - vowels
  - consonants
- Other uses



t8



/k/ friction

/aku/

odel?

Why modelling?

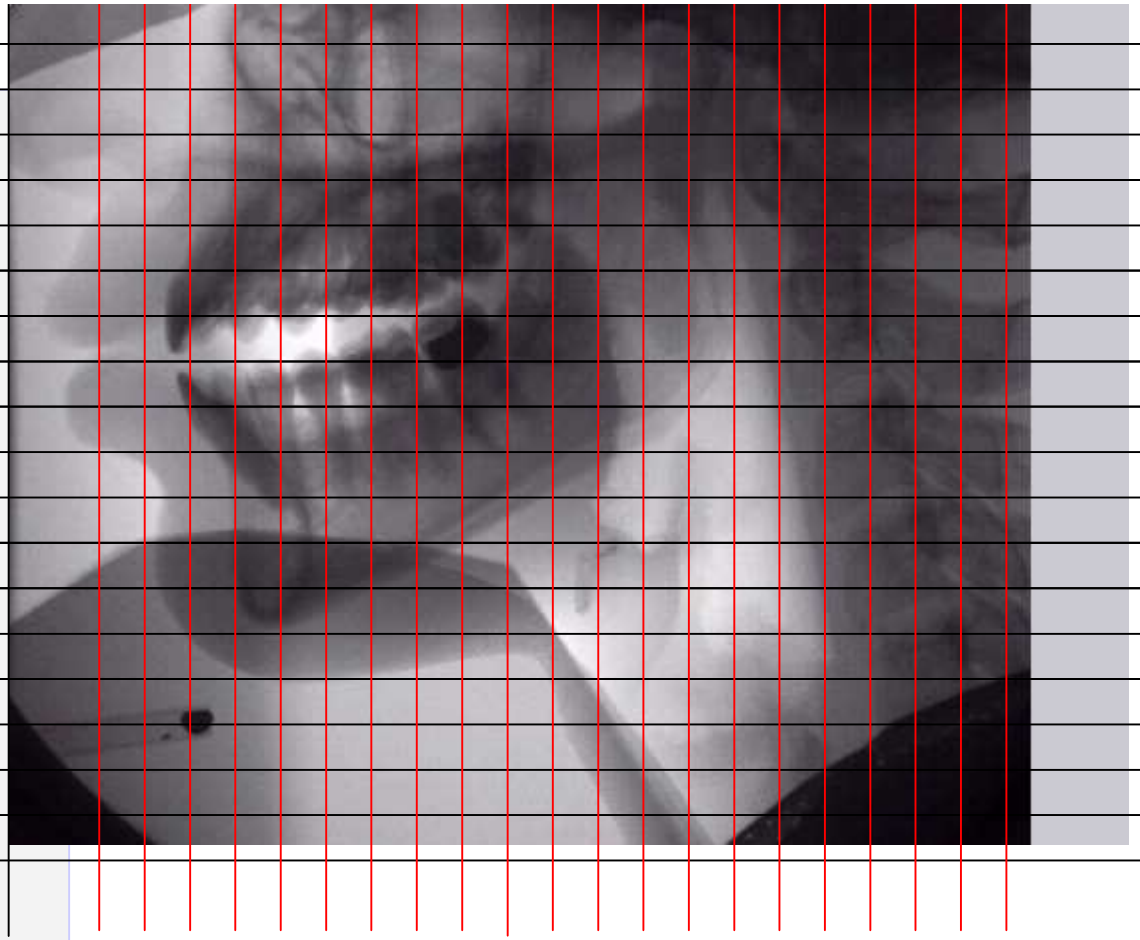
Which models?

What is a useful model?

How done?

Demo
- vowels
- consonants

Other uses



t9

Maximum rounding

/u/ onset

/aku/

odel?

Why modelling?

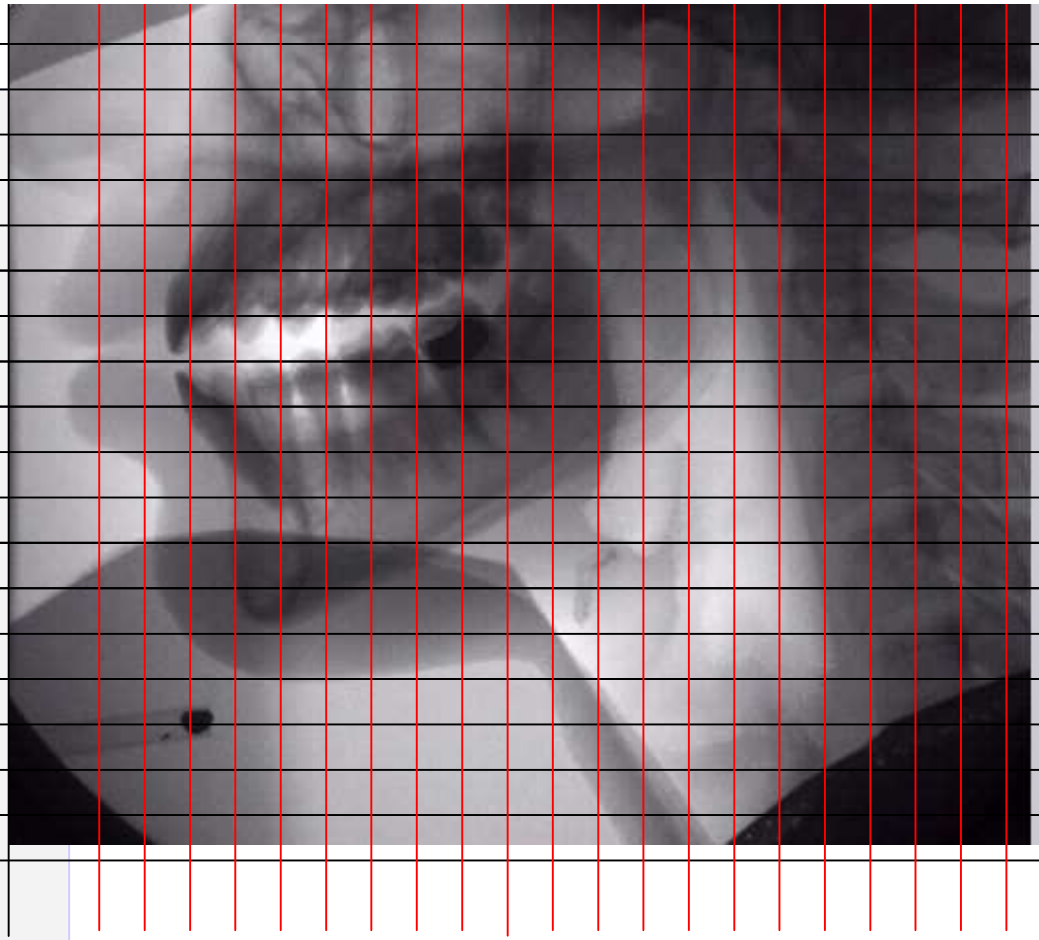
Which models?

What is a useful model?

How done?

Demo
- vowels
- consonants

Other uses



t10

Velum starts to lower
Derounding starts

/u/ middle

/aku/

odel?

Why modelling?

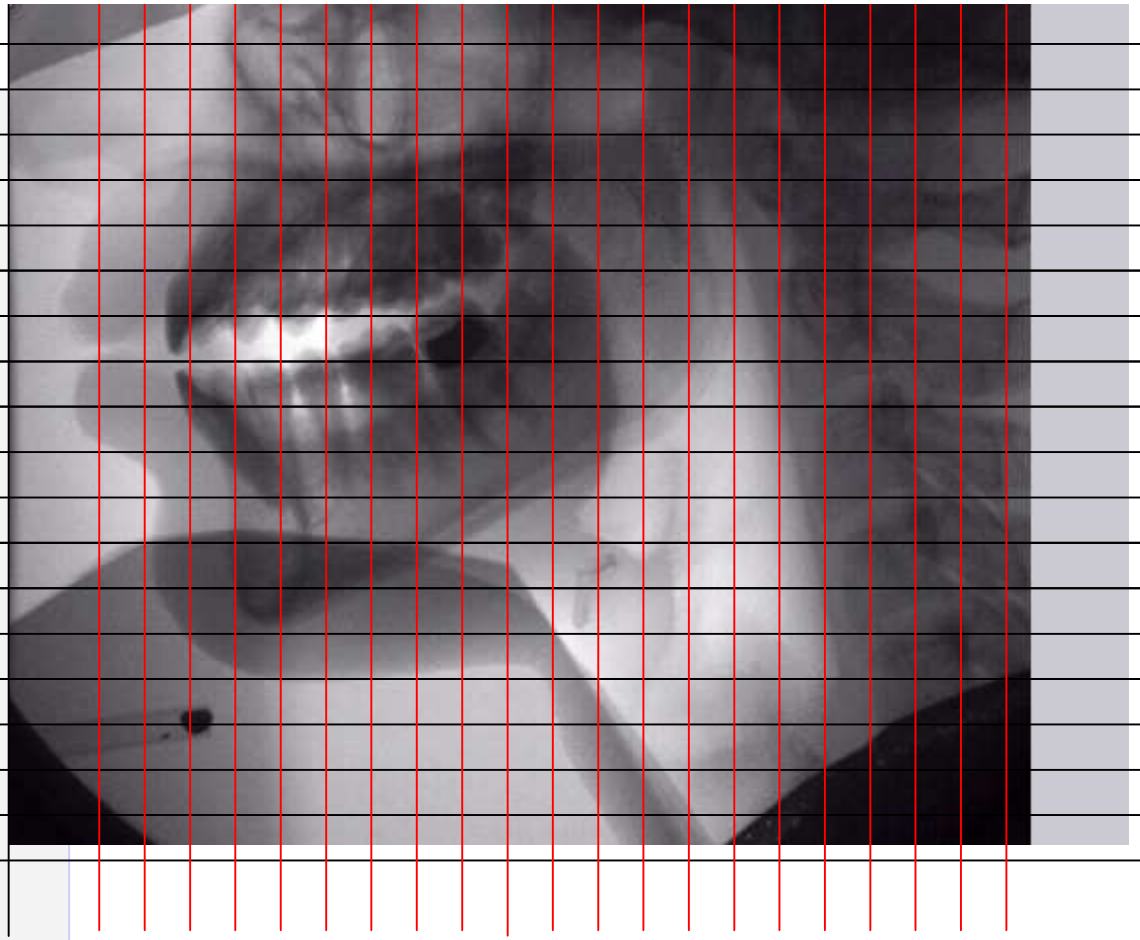
Which models?

What is a useful model?

How done?

Demo
- vowels
- consonants

Other uses



t11

Larynx maximally low

/u/ end

/aku/

odel?

Why modelling?

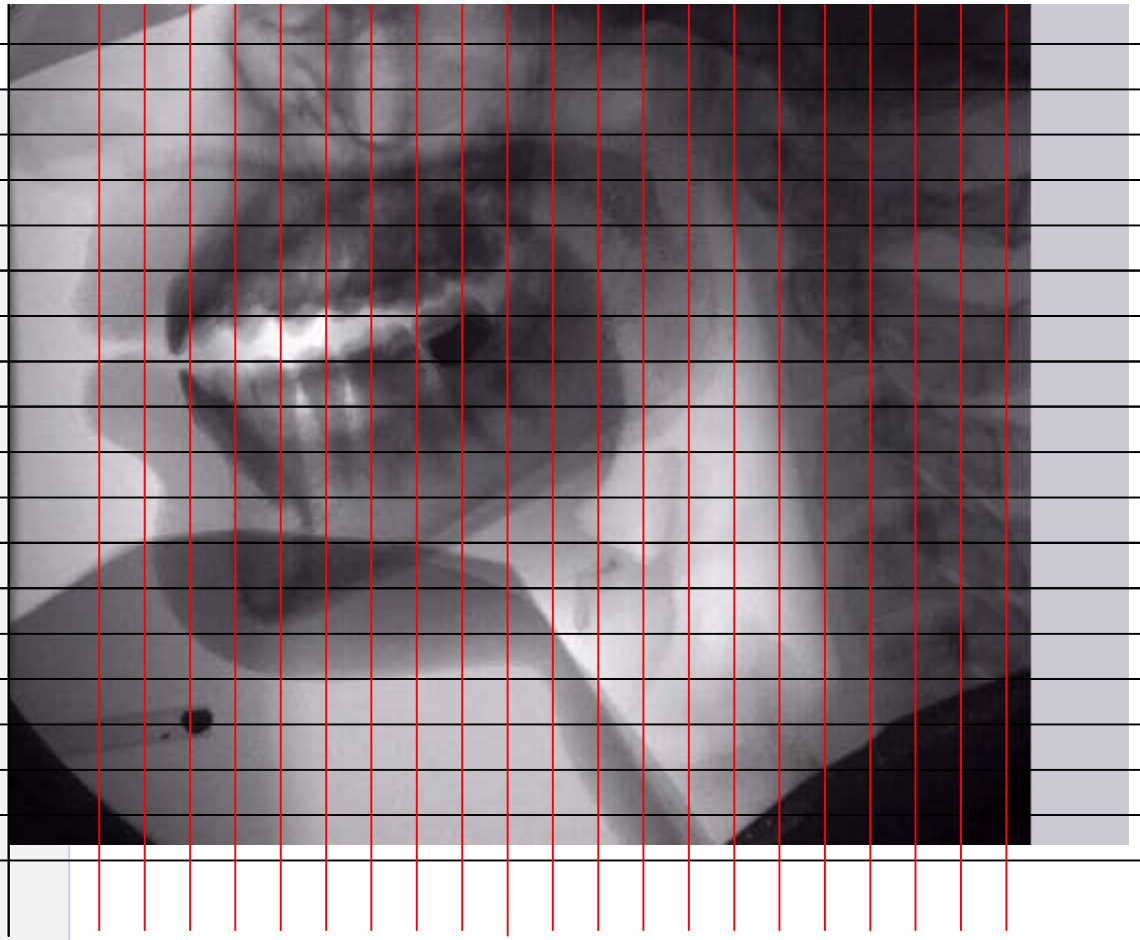
Which models?

What is a useful model?

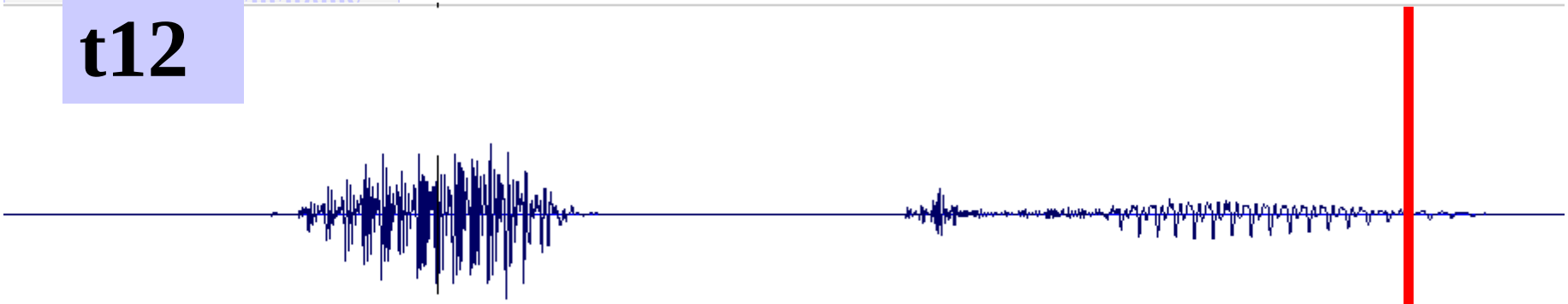
How done?

Demo
- vowels
- consonants

Other uses



t12



end

Different degrees of sophistication

1) Simple concatenation

2) Contextual allophones

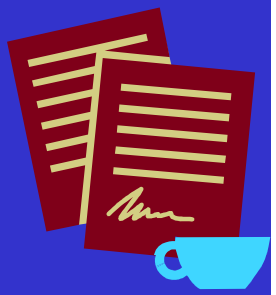
Velar

3) Anticipation and carry over phenomena

4) Suprasegmental influences

- Position in the syllable (nasal in preparation, masking)
- Position in the word or relative to stress (lenition and fortition) seen

The points



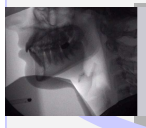
1) Pedagogical point of view

Draw the link between
-articulatory data,
-acoustic data
-and perception

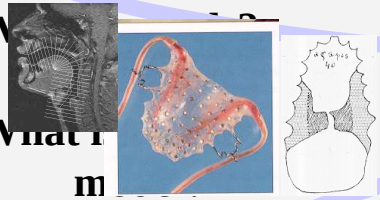
>> Understanding for linguists
the basics of
Acoustic Theory of Speech production

Ps, Pio

What is a model?



W



What

m

How done?

Demo

v

c

Other uses

spea

spea

singing formant

inversion

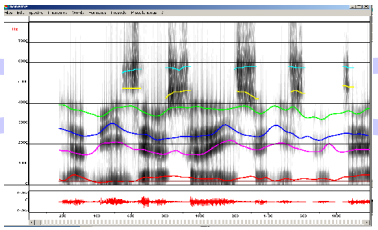
etc.

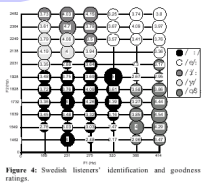
1) DATA

production

acoustics

perception





linguist

Language teacher

phonetician

2) **Coherent teaching**
Research tool

engineer

phonologist

Speech therapist

Medical students

What is a model?

Why modelling?

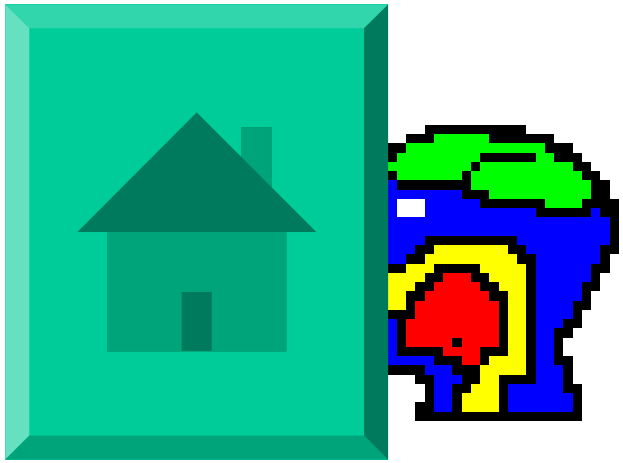
Which models?

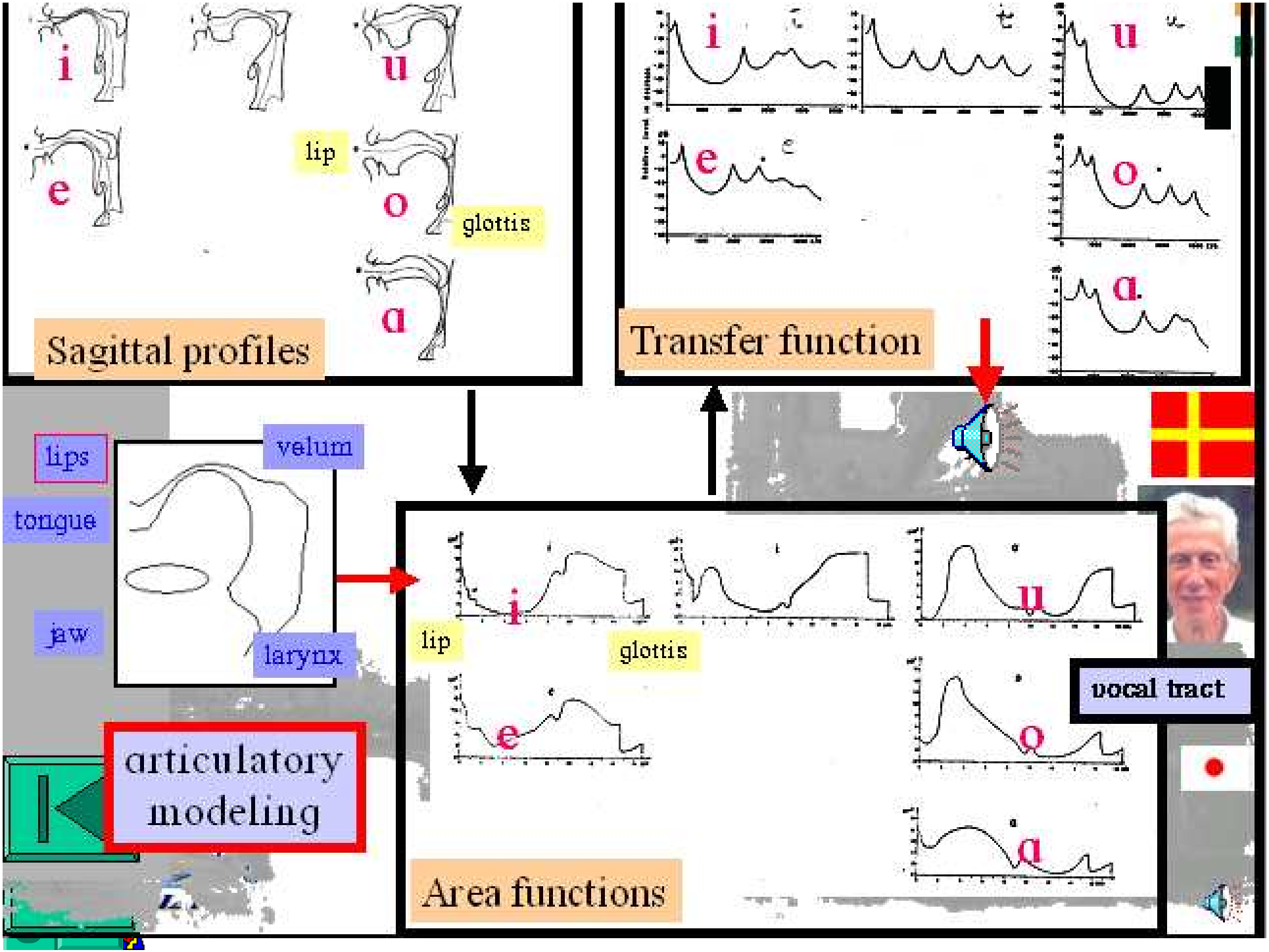
What is a useful model?

How done?

Demo
- **vowels**
- **consonants**

Other uses
- speaker anatomy
- speaker strategy
- singing formant
- inversion
- etc;

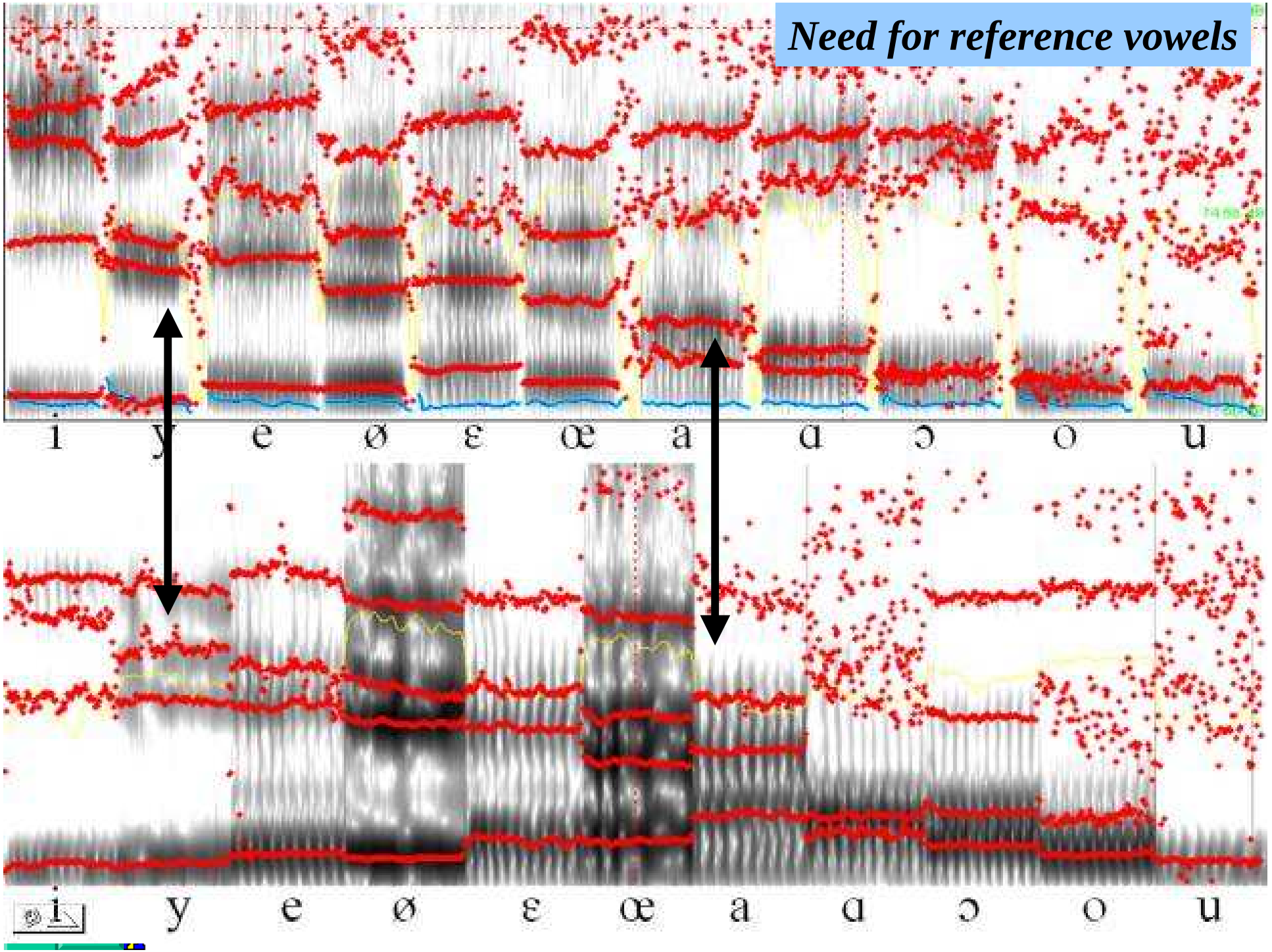



i
u
e
lip
o
glottis
a
Sagittal profiles
Transfer function
velum
lips
tongue
jaw
larynx
articulatory modeling
lip
glottis
vocal tract
Area functions

2) For what concerns the vowels

a) Need for reference vowels
Cardinal vowels
Sensibility to formant amplitude and bandwith

AM could help


Need for reference vowels
i y e ø ɛ œ a ɑ ɔ o u
i y e ø ɛ œ a ɑ ɔ o u

observations

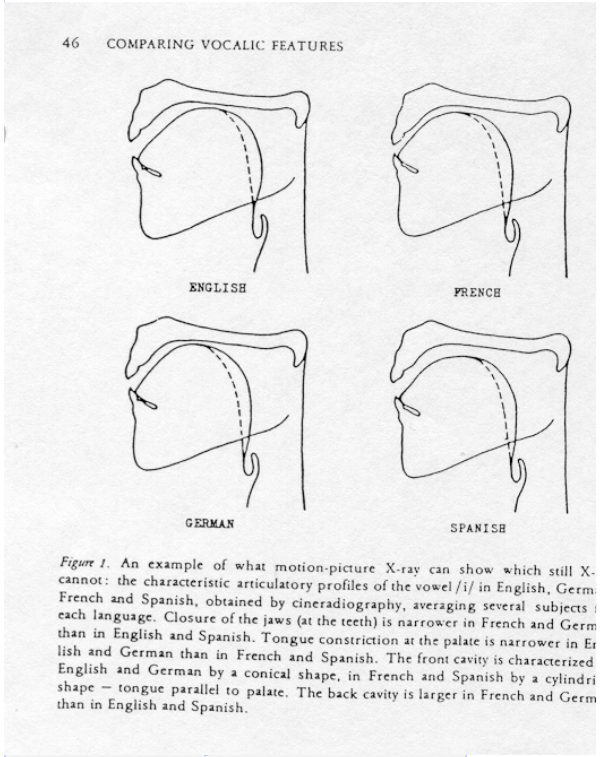
Need for reference vowels

/i/

articulatory

acoustic

perceptual


46 COMPARING VOCALIC FEATURES

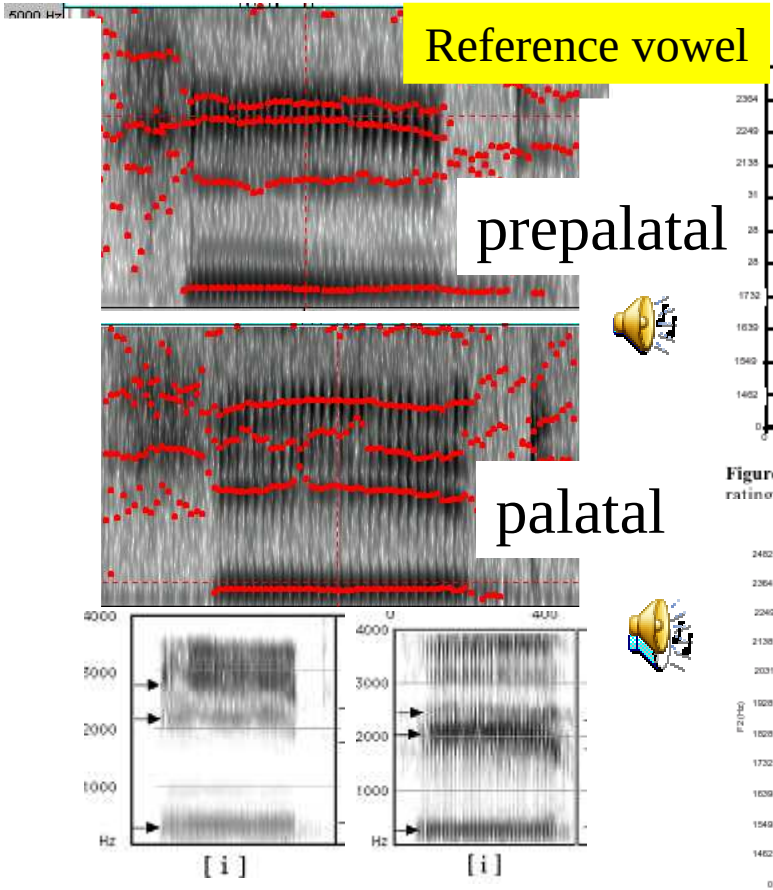
ENGLISH

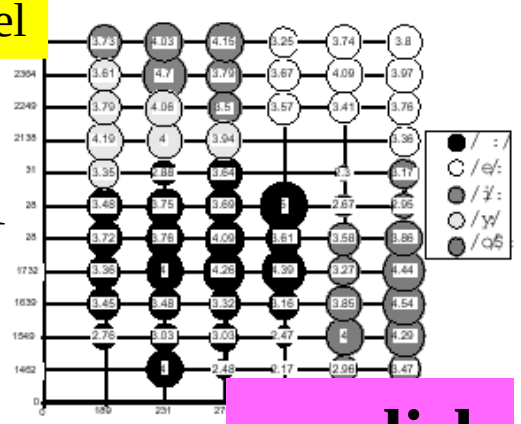
FRENCH

GERMAN

SPANISH

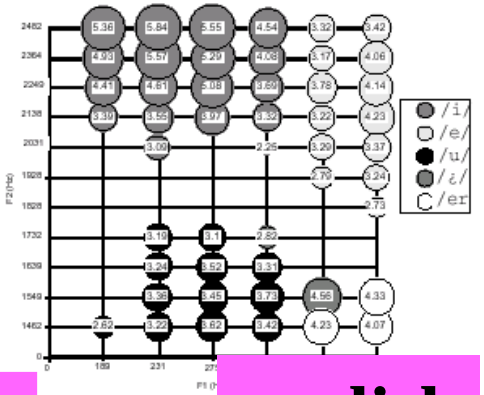
Figure 1. An example of what motion-picture X-ray can show which still X-
cannot: the characteristic articulatory profiles of the vowel /i/ in English, Germ
French and Spanish, obtained by cineradiography, averaging several subjects
each language. Closure of the jaws (at the teeth) is narrower in French and Germ
than in English and Spanish. Tongue constriction at the palate is narrower in E
lish and German than in French and Spanish. The front cavity is characterized
English and German by a conical shape, in French and Spanish by a cylindri
shape – tongue parallel to palate. The back cavity is larger in French and Germ
than in English and Spanish.





swedish

Figure 4: Swedish listen
ratings



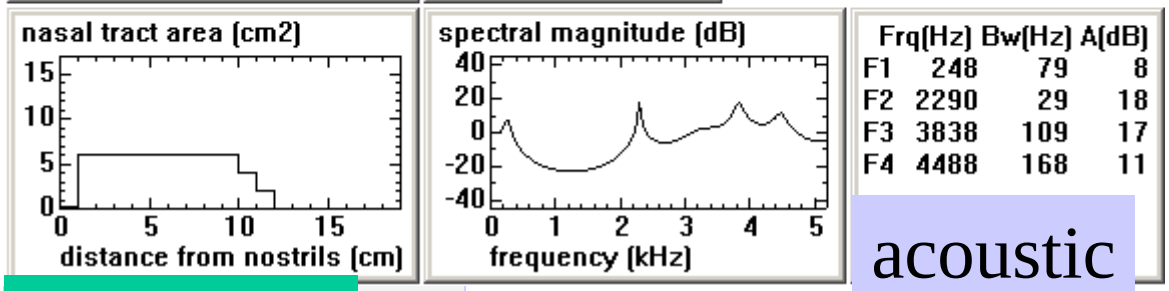
english

re 5: American Englis
ness ratings.

1) Helps to represent in a comprehensive way the language-specific prototypes

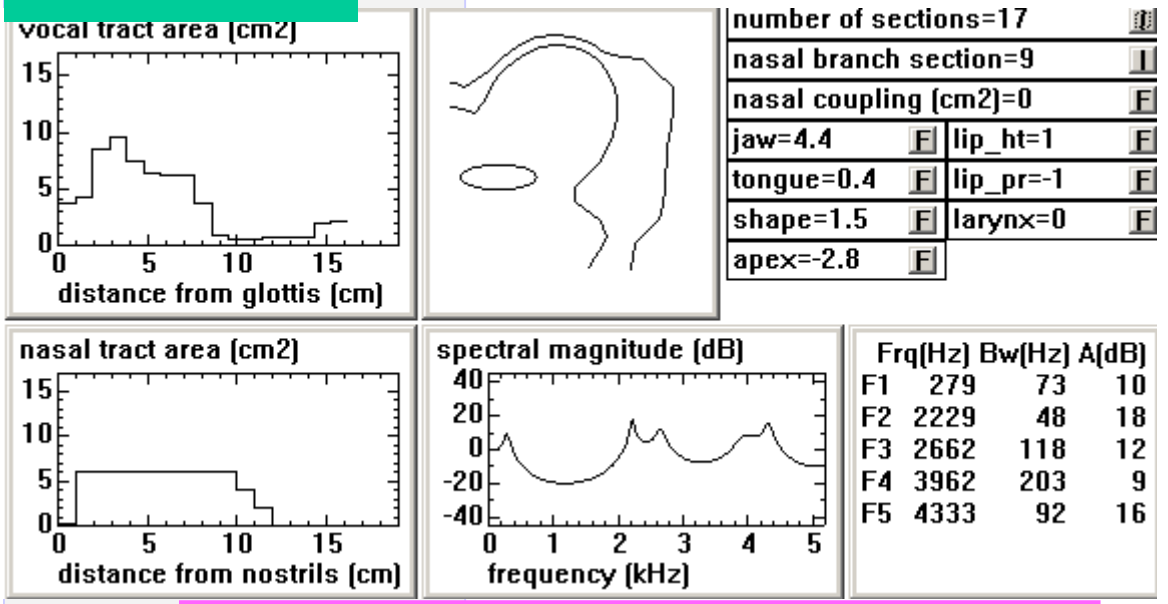
Willerman and Kuhl

articulatory

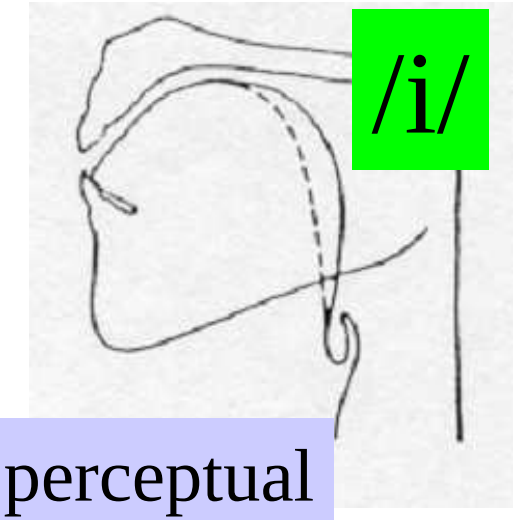


acoustic

simulation

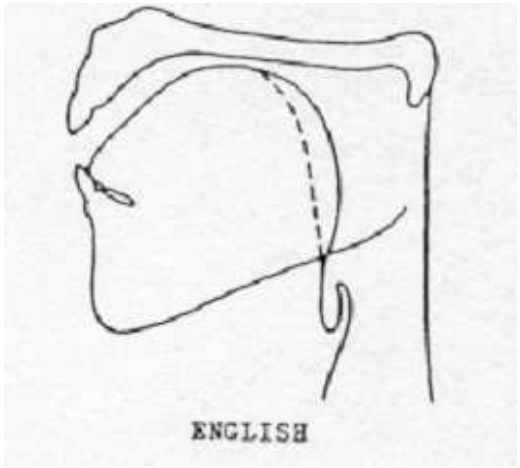


1) Helps to represent in a comprehensive way the language-specific prototypes

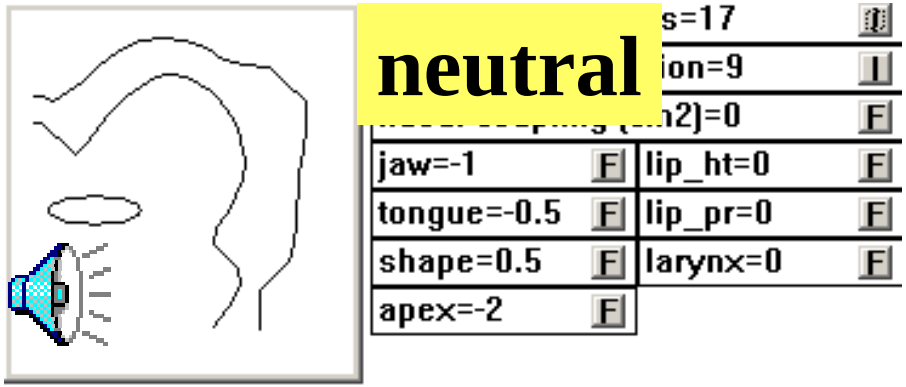


perceptual

F1 (↑F3. F4)



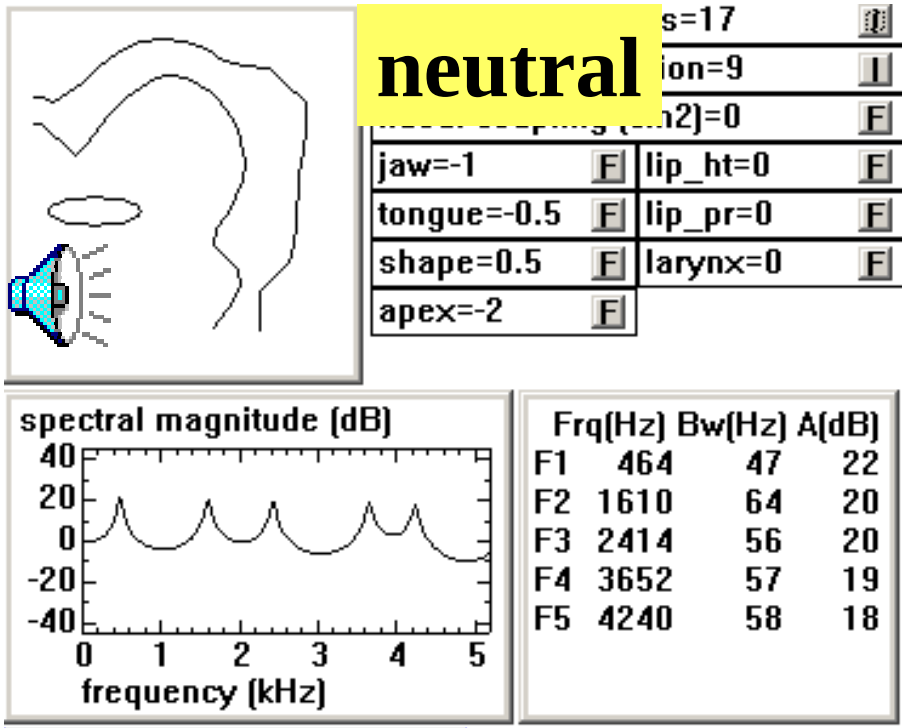
F1 ↑ F2

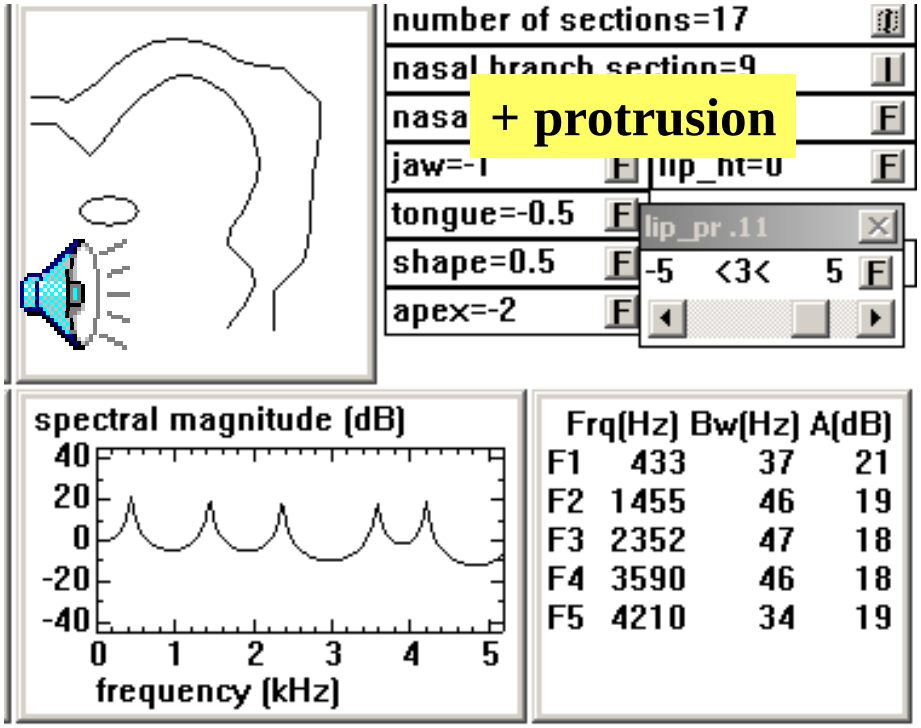


vowels
consonants

Other uses
- speaker anatomy
- speaker strategy
- singing formant
- inversion
- etc;

Need for reference vowels



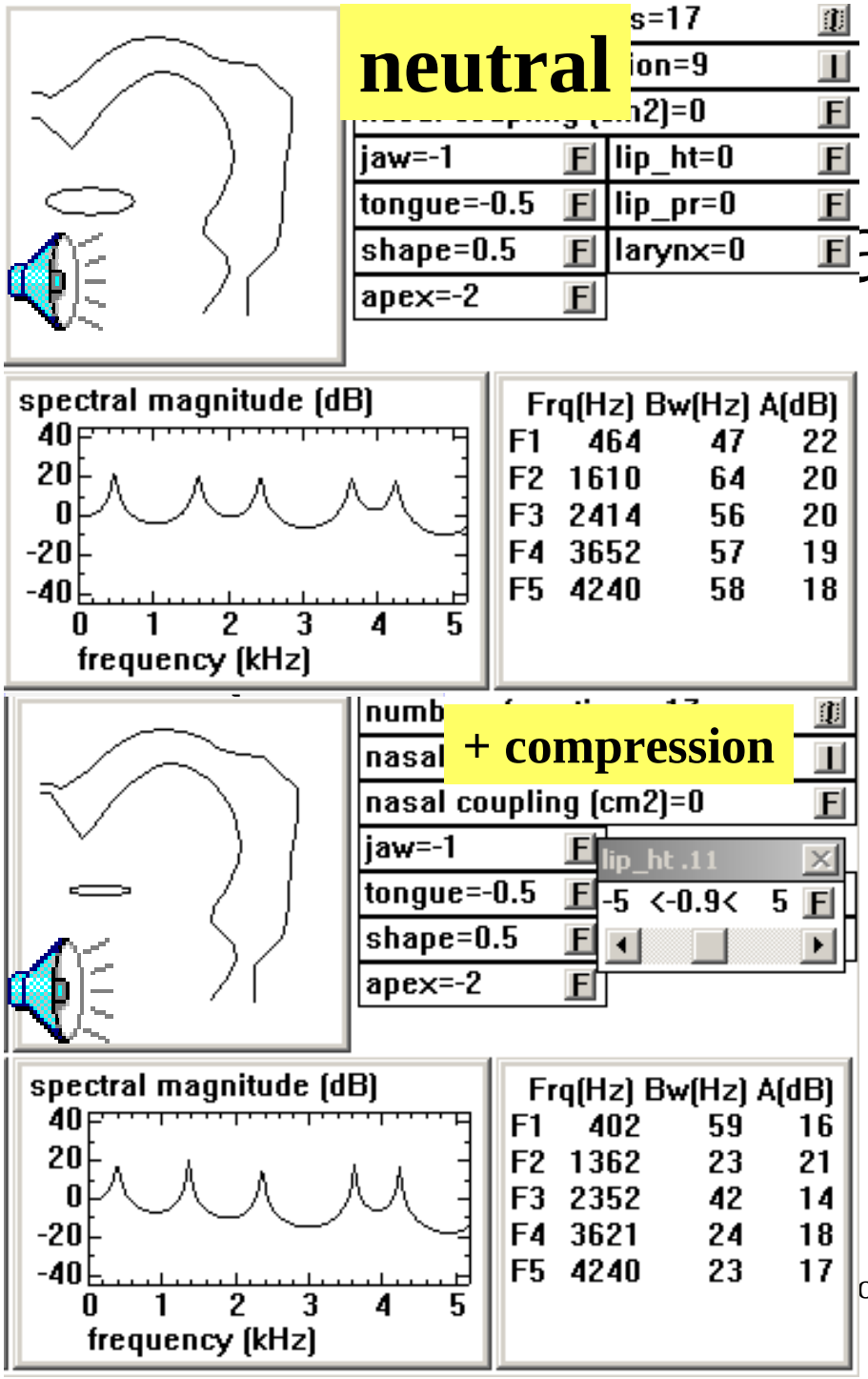


vowels
consonants

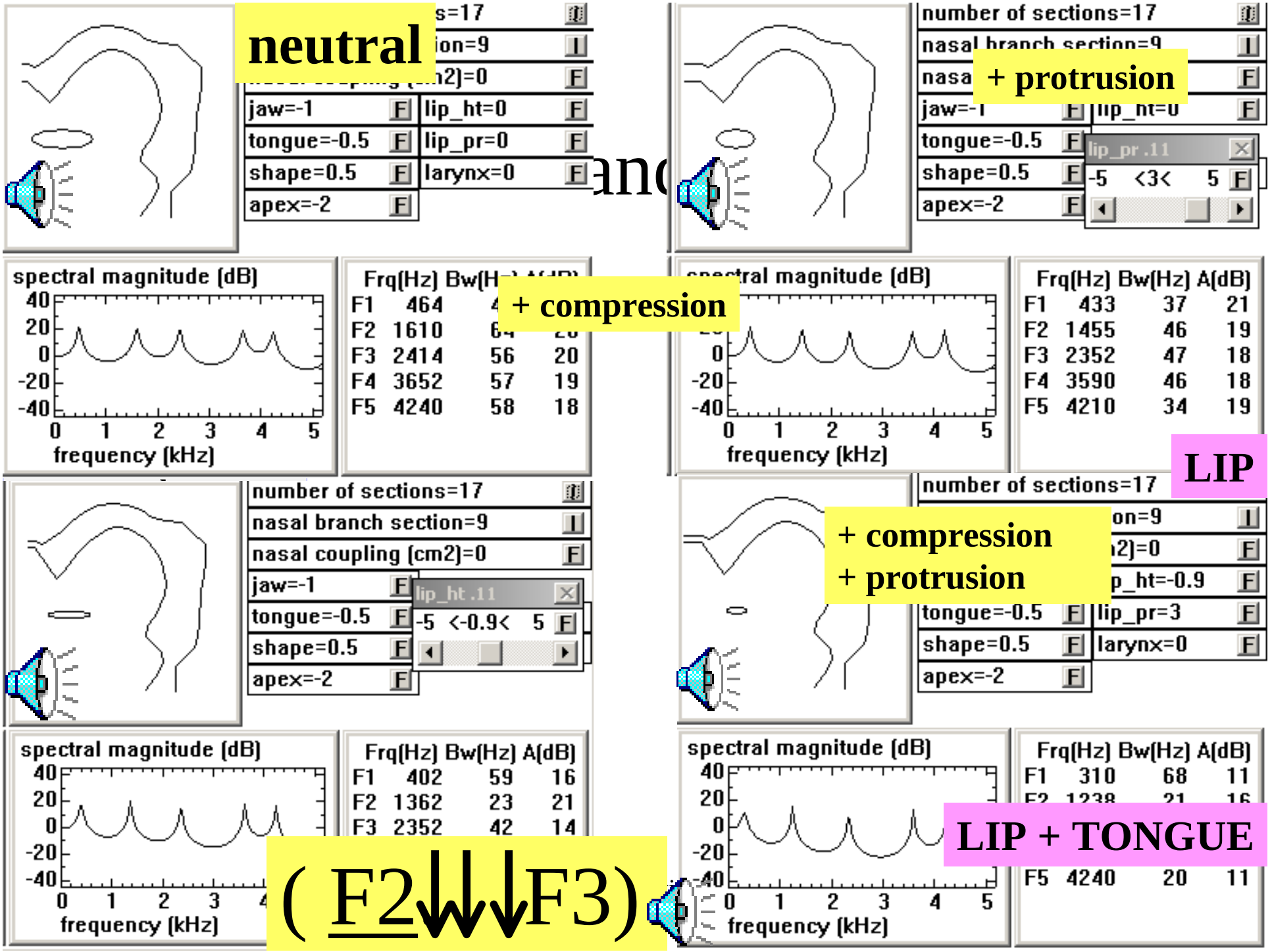
Other uses
- speaker anatomy
- speaker strategy
- singing formant
- inversion
- etc;

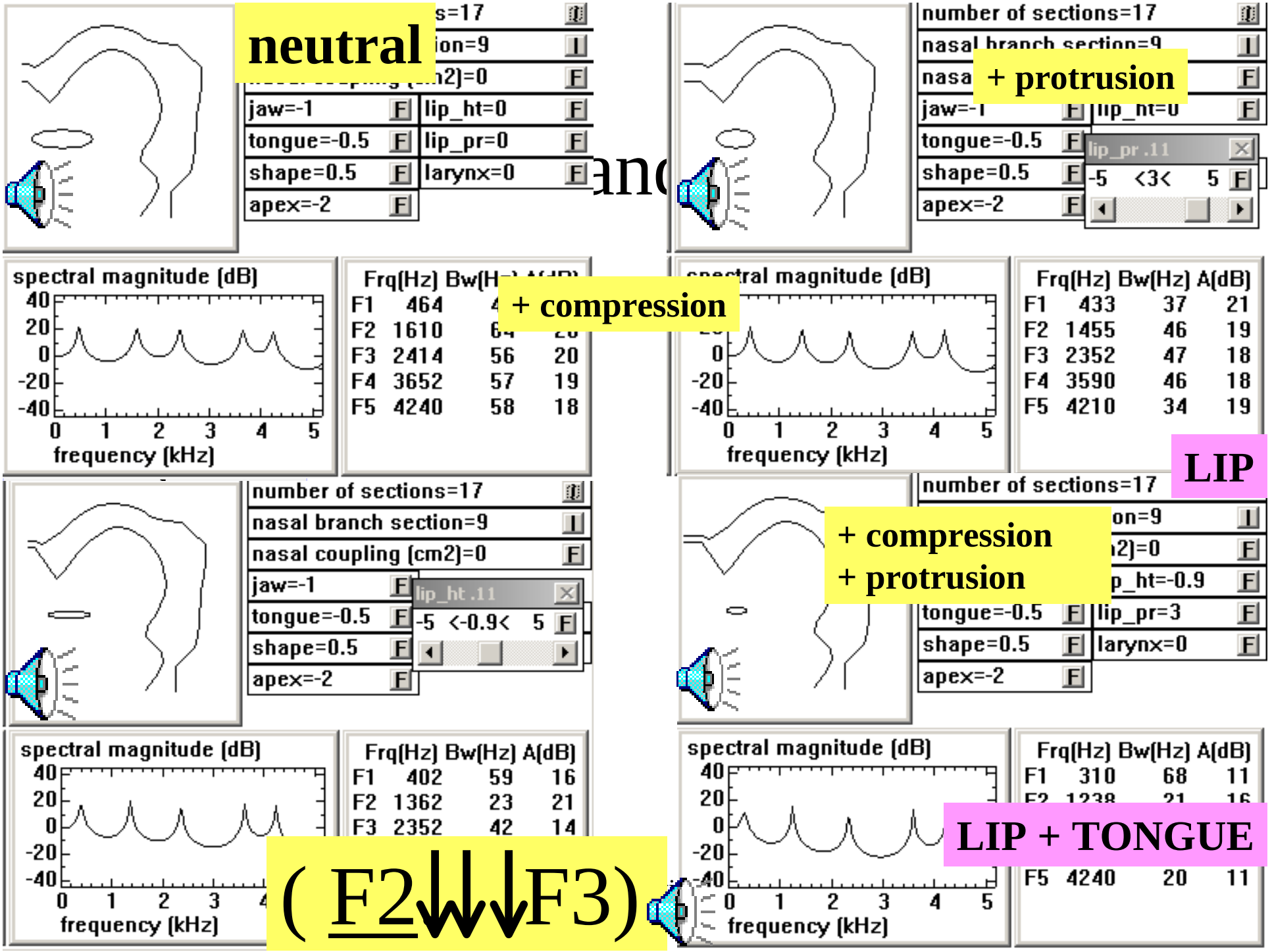
Need for reference vowels

(F2⇓⇓⇓F3)



Need for reference vowels


neutral
+ protrusion
+ compression
LIP
+ compression
+ protrusion
LIP + TONGUE
(F2⇓⇓F3)
number of sections=17
nasal branch section=9
nasal coupling (cm2)=0
jaw=-1
tongue=-0.5
shape=0.5
apex=-2
lip_ht=0
lip_pr=0
larynx=0
lip_pr .11
-5 <3< 5
lip_ht .11
-5 <-0.9< 5
spectral magnitude (dB)
frequency (kHz)
Frq(Hz) Bw(Hz) A(dB)
F1 464
F2 1610
F3 2414
F4 3652
F5 4240
F1 433 37 21
F2 1455 46 19
F3 2352 47 18
F4 3590 46 18
F5 4210 34 19
F1 402 59 16
F2 1362 23 21
F3 2352 42 14
F1 310 68 11
F5 4240 20 11


neutral
+ protrusion
+ compression
LIP
+ compression
+ protrusion
LIP + TONGUE
(F2⇓⇓F3)
number of sections=17
nasal branch section=9
nasal coupling (cm2)=0
jaw=-1
tongue=-0.5
shape=0.5
apex=-2
lip_ht=0
lip_pr=0
larynx=0
lip_pr .11
-5 <3< 5
lip_ht .11
-5 <-0.9< 5
spectral magnitude (dB)
frequency (kHz)
Frq(Hz) Bw(Hz) A(dB)
F1 464
F2 1610
F3 2414
F4 3652
F5 4240
F1 433 37 21
F2 1455 46 19
F3 2352 47 18
F4 3590 46 18
F5 4210 34 19
F1 402 59 16
F2 1362 23 21
F3 2352 42 14
F1 310 68 11
F5 4240 20 11

	Location of the constriction		
Lowest possible formant		**Highest possible formant**	
⇓F1	anterior part of the VT	⇑F1	posterior part of the VT
⇓F2	velar region + *lip rounding*	⇑F2	mid-palatal region + glottal region
⇓F3	pharyngeal region + *bunching of the tongue, retroflexion* + *lip rounding and lip protrusion*	⇑F3	apical and prepalatal regions + lip spreading + glottal region *(larynx lowering)*

Table 3: Tongue constriction position, lip configuration, tongue shape and F-pattern values: a summary.

2) For what concerns the vowels

a) Need for references vowels

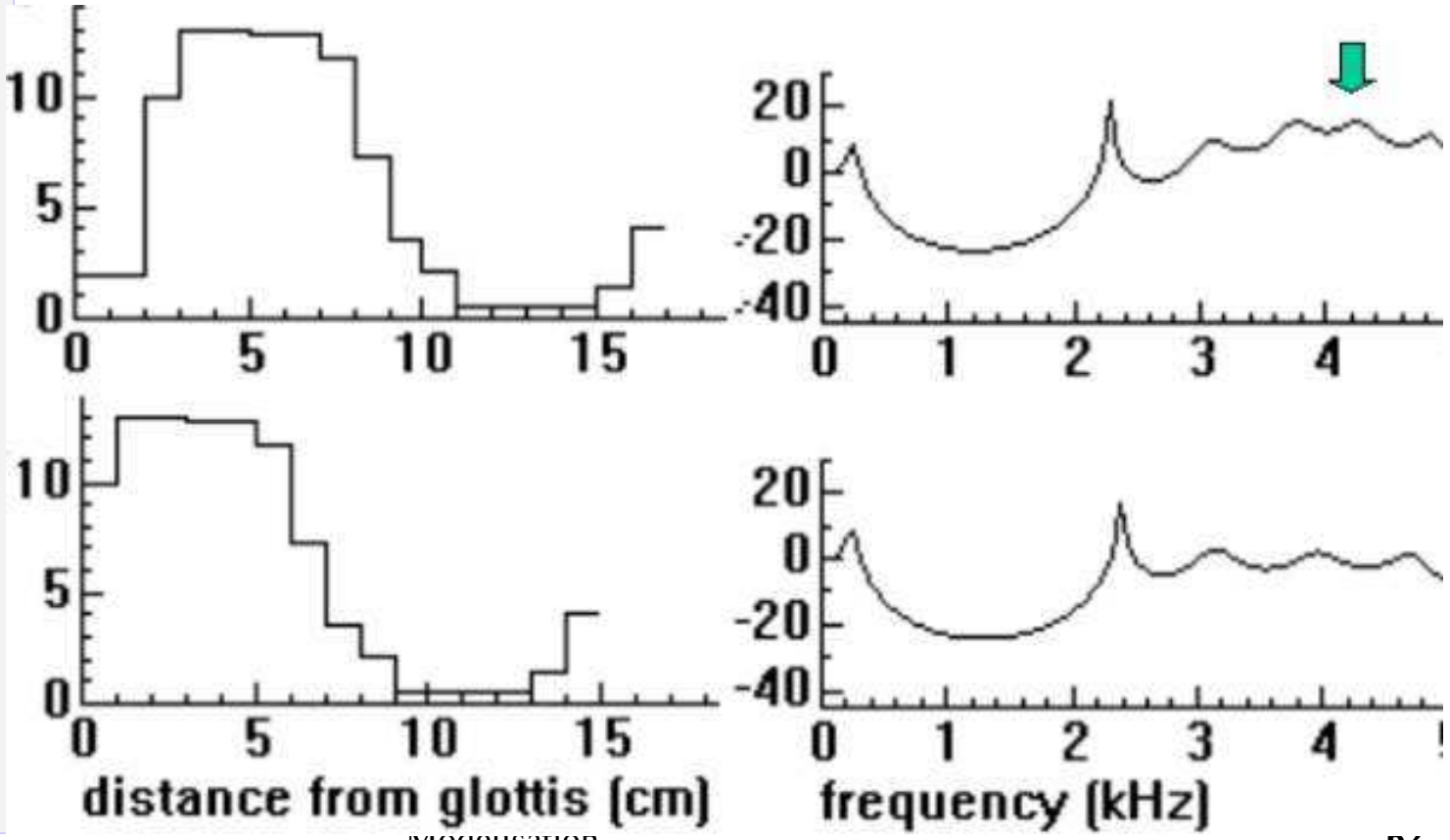
b) The rôle of anatomical details

- the laryngeal cavity for the vowels

- rôle of pharyngeal volume, etc.

Role of anatomical details

- What is a model?
- Why modelling?
- Which models?
- What is a useful model?
- How done?
- Demo
  - vowels
  - consonants
- Other uses
  - speaker anatomy
  - speaker strategy
  - singing formant
  - inversion
  - etc;



Role of anatomical details

2) For what concerns the vowels

a) Need for references vowels

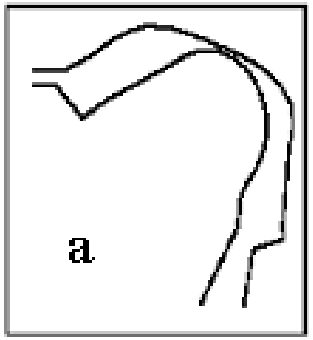
b) The rôle of anatomical details

c) The acoustic properties largely Prevail over articulation

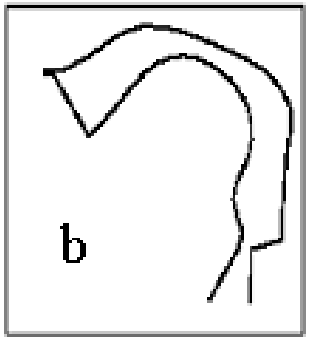
Perception prevails over articulation

- What is a mo
- Why modelli
- Which models?
- What is a useful model?
- How done?
- Demo
  - vowels
  - consonants
- Other uses
  - speaker anatomy
  - speaker strategy
  - singing formant
  - inversion
  - etc;

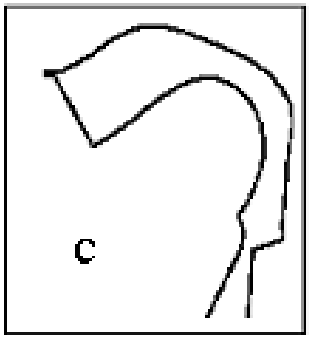
About the same sound (except the focal and extreme sounds can be obtained by Fairly different VT configuration



335 904 2150



341 986 2113



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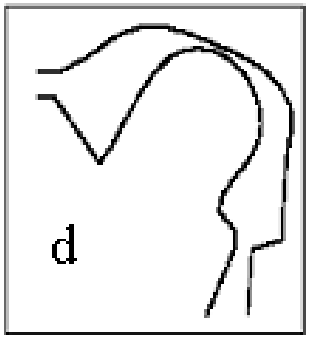


352 949 2112

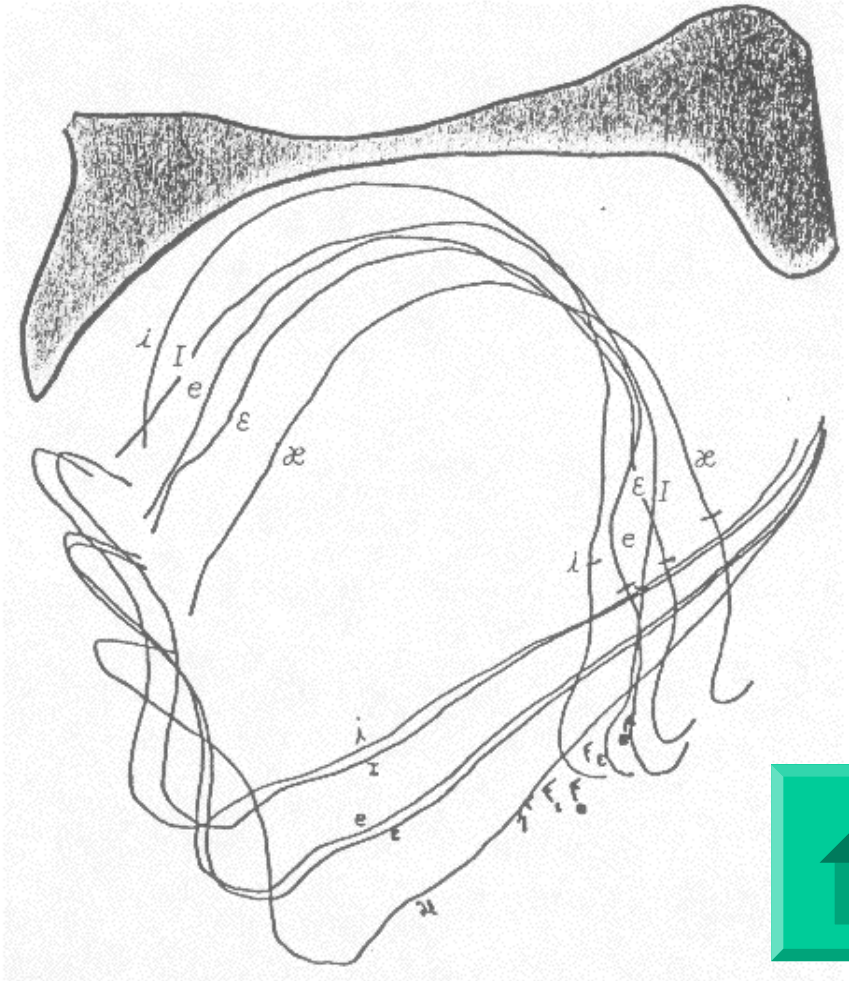
2) For what concerns the vowels

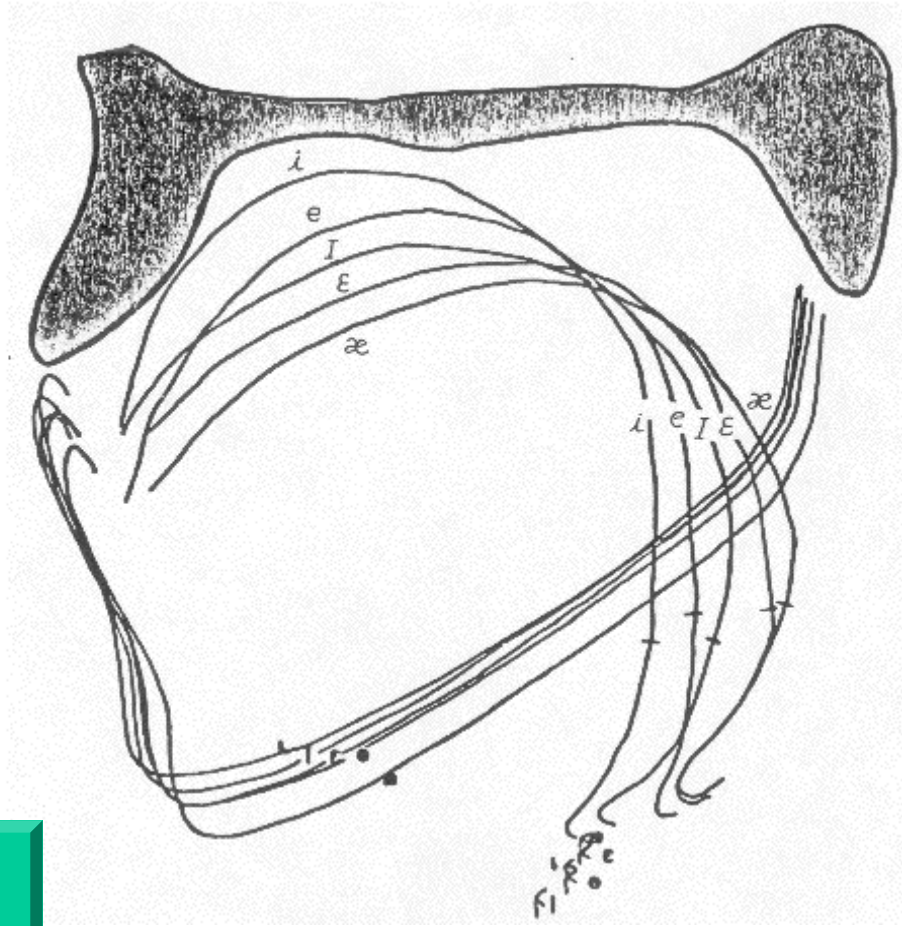
a) Need for reference vowels

b) The rôle of anatomical details

c) The acoustic properties largely Prevail over articulation

d) Different strategies can be modelled





inversion

Speaker different strategies

2) For what concerns the consonants

a) Simple concatenation works better than expected

2) For what concerns the consonants

a) Simple concatenation work than expected

b) The rôle of anatomical details: sublingual cavity

What is a model?

Why modelling?

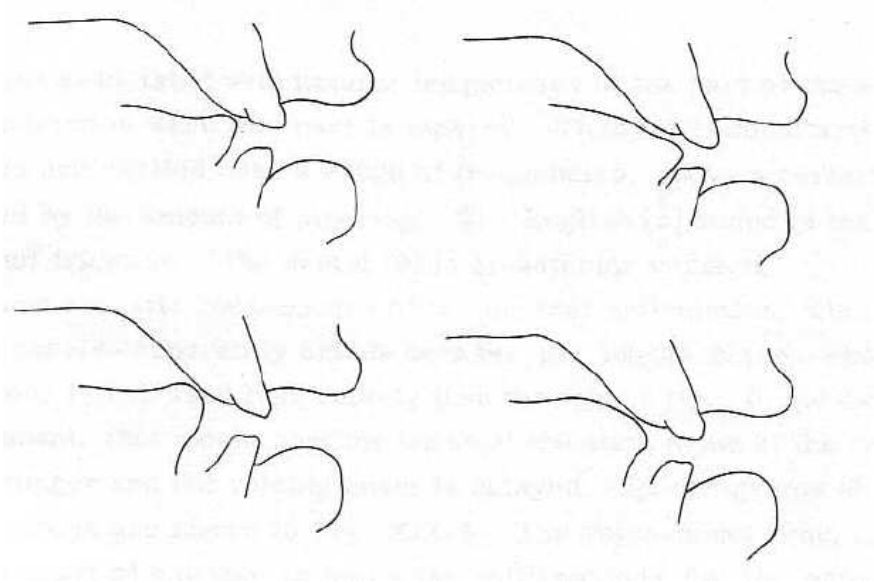
Which models?

What is a useful model?

How done?

Demo
- **vowels**
- **consonants**

Other uses
- speaker anatomy
- speaker strategy
- singing formant
- inversion
- etc;



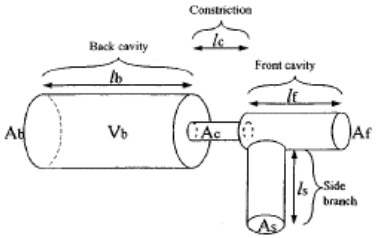
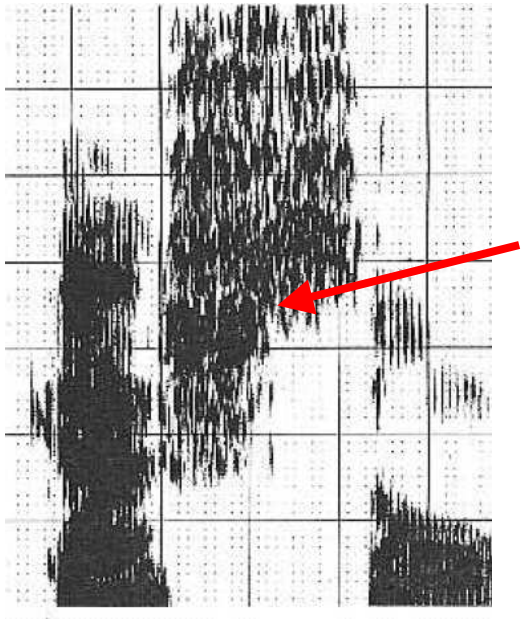


FIG. 5. The tube configuration simulated in the "weakly coupled" models.



sublingual cavity
Necessary
To recreate existing
Acoustic discontinuity

2) For what concerns the consonants

a) Simple concatenation work than expected

b) The rôle of anatomical details: sublingual cavity

c) The acoustic properties largely
Prevail over articulation: the velar

2) For what concerns the consonants

a) Simple concatenation work than expected

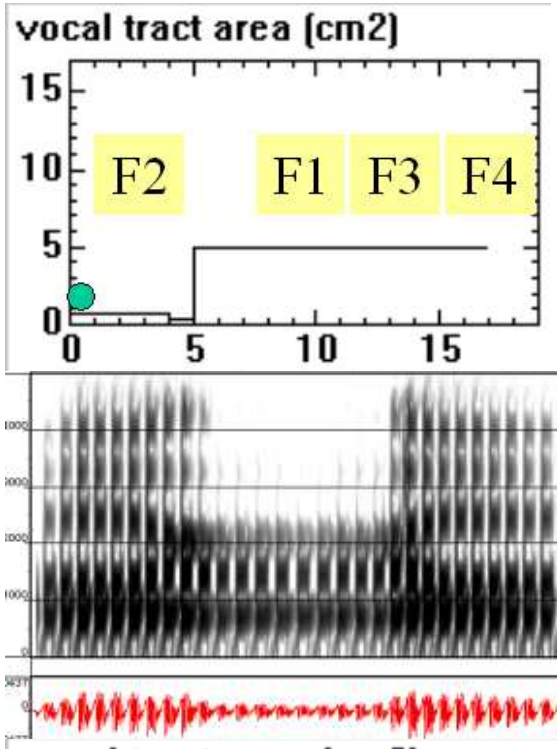
b) The rôle of anatomical details: sublingual cavity

c) The acoustic properties largely
Prevail over articulation: the velars

d) Exotic consonants may be easy to model

Non French consonants

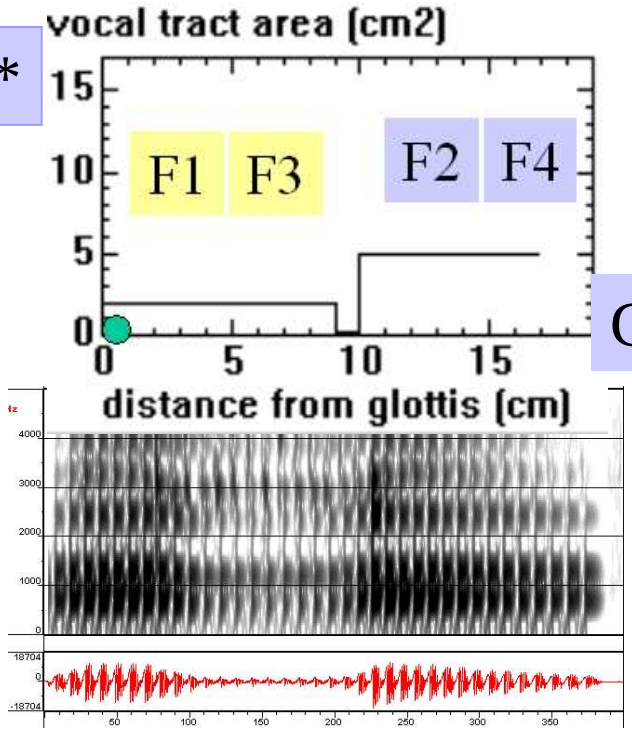
- Start from articulatory model for the flanking vowels
- Tube or area function for the consonant
- Examples: posterior arabic consonants
- (Mohamed Yeou's thesis)



95%, 69*

ʕ

ħ ʕ



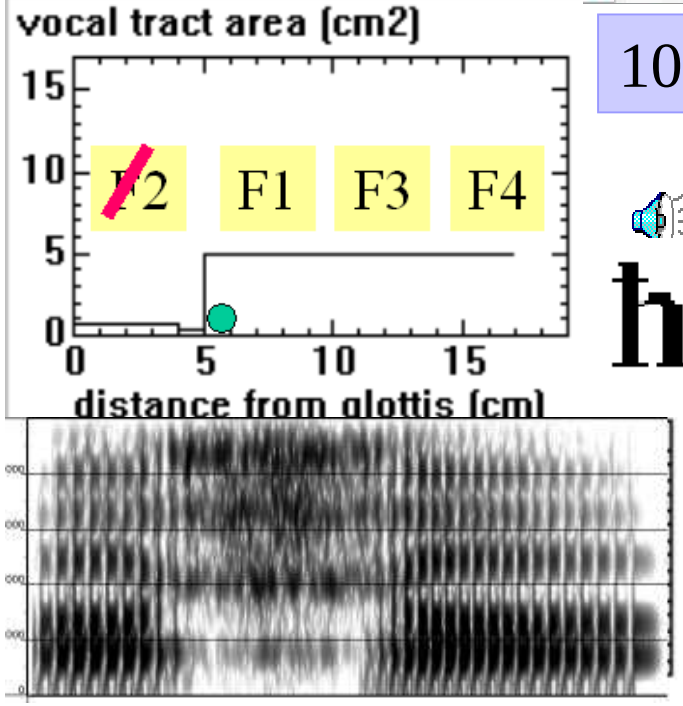
100%, 76

ʁ

0.35

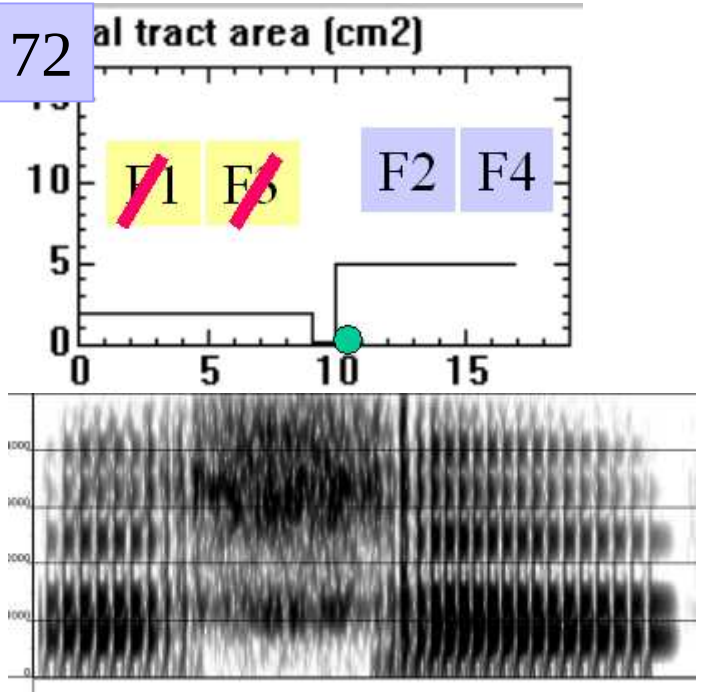
Glottis more open?

χ ʁ



100%, 72

ħ



100%, 79

0.20

χ

10 listeners
10 repetitions

*Alwan, 1989

Beans on a string synthesis

- Pharyngeal sourde
- 16.5
- 0.7 0.7 0.7 0.7 0.30 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0
-
- Pharyngeale sonore
- 16.5
- 0.7 0.7 0.7 0.7 0.35 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0
- [uvulaire sourde]
- 17
- 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 0.2 5.0 5.0 5.0 5.0 5.0 5.0 5.0
- [uvulaire sonore]
- 17
- 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 0.35 5.0 5.0 5.0 5.0 5.0 5.0 5.0
-

Ag = 0 cm2

Ag = 0.20-0.25 cm2

+ timing

2) For what concerns the consonants

a) Simple concatenation work than expected

b) The rôle of anatomical details: sublingual cavity

c) The acoustic properties largely
Prevail over articulation: the velars

d) Exotic consonants may be easy to model

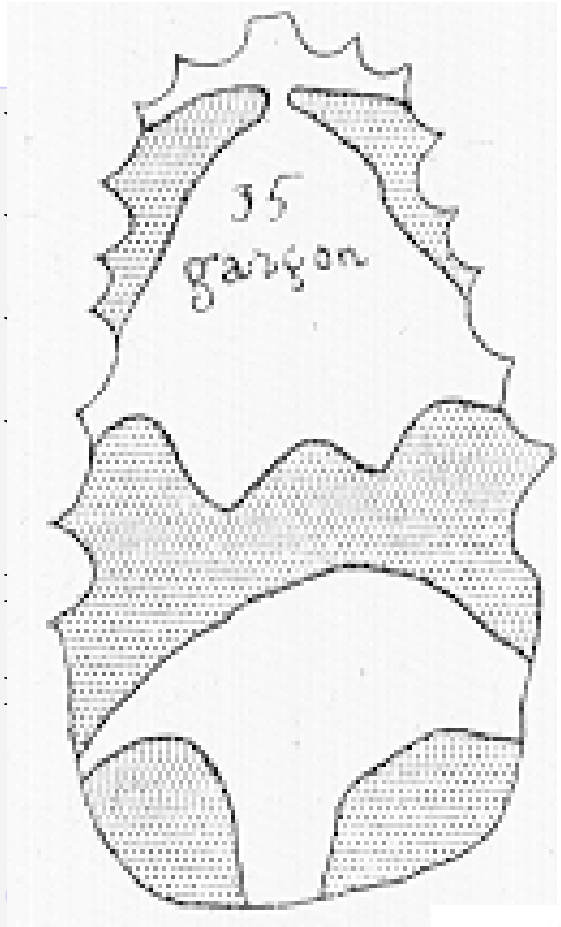
e) Lenition and fortition not difficult to model

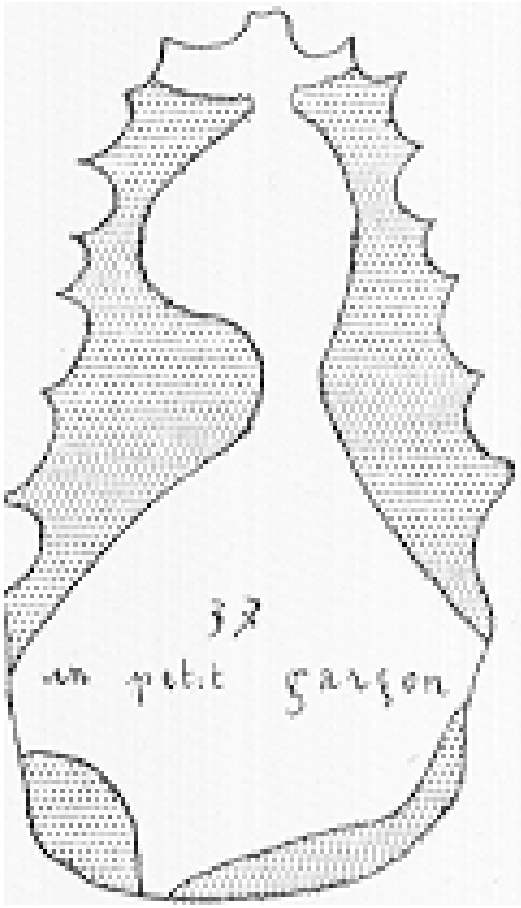
lenition

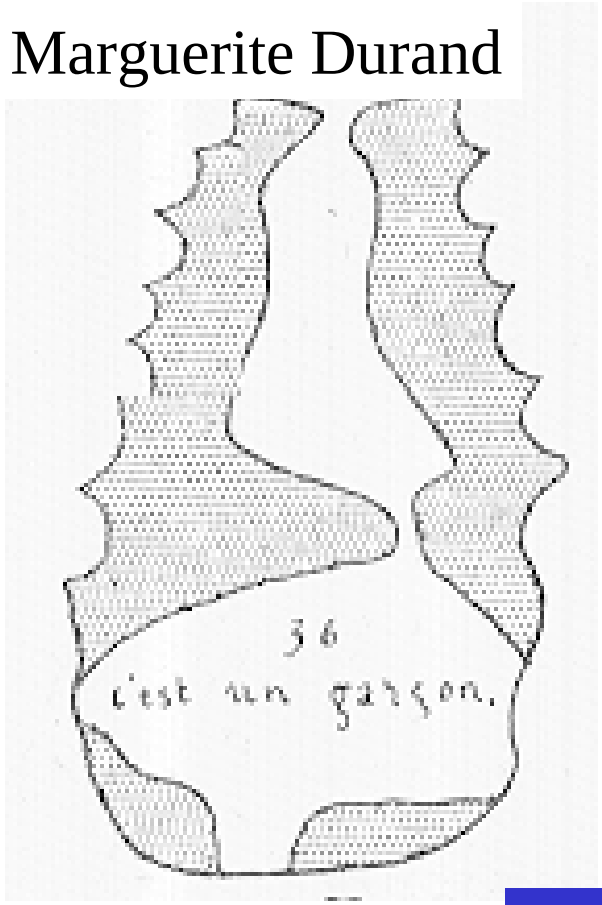
- **Less strong constriction**
- **More close glottis**

- Ration between the two areas may change, and to the category of the consonant
- But the underlying F-pattern is the same

Marguerite Durand







speaker anatomy
speaker strategy
singing formant
inversion
etc;

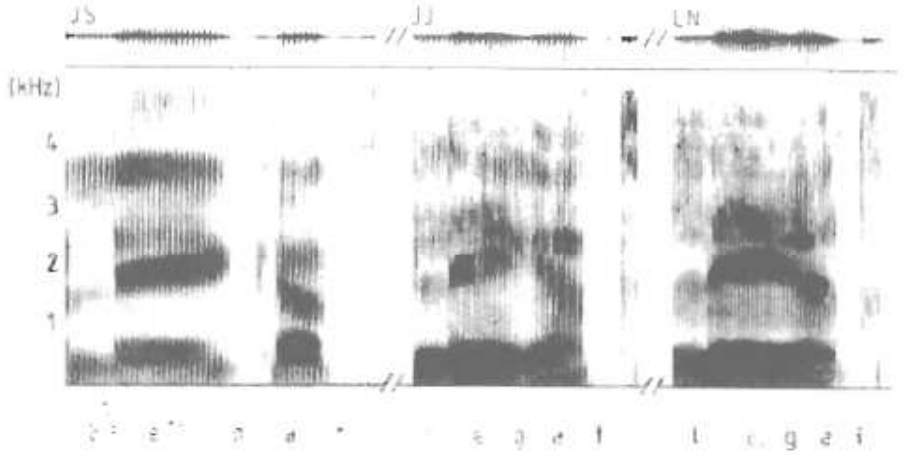


Figure 4.4.2 Normal and two degrees of target undershoot of a voiced stop.

/g/

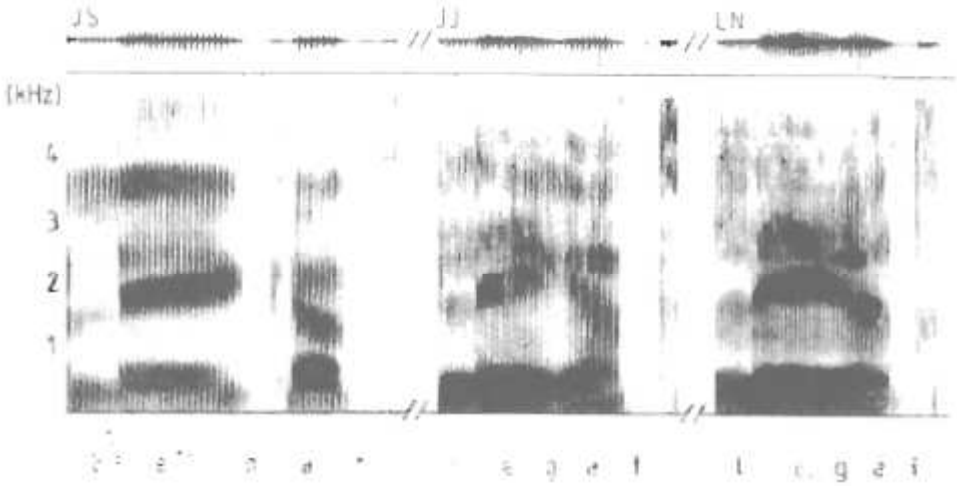
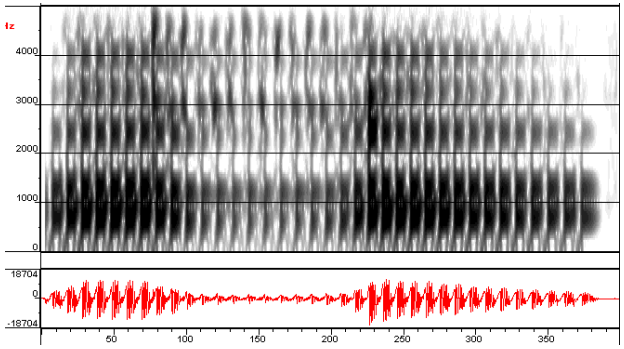
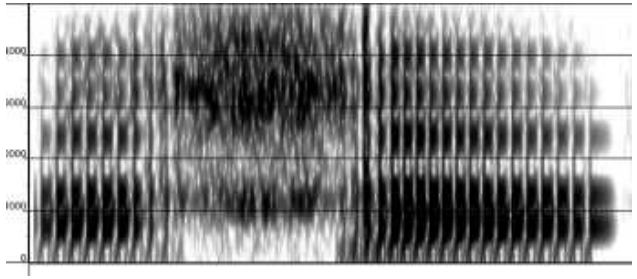


Figure 4.4.2 Normal and two degrees of target undershoot of a voiced stop.





Vt more close than vf

How done?

Demo

- **vowels**
- **consonants**

Other uses

- speaker anatomy
- speaker strategy
- singing formant
- inversion
- etc;

Less strong closure in the middle

Less vf opening

Stops> fricatives > sonantes

Voiceless > voiced

Noise created at the narrowest

2) For what concerns the consonants

a) Simple concatenation work than expected

b) The rôle of anatomical details: sublingual cavity

c) The acoustic properties largely
Prevail over articulation: the velars

d) Exotic consonants may be easy to model

e) Lenition and fortition not difficult to model

f) Shape of the tongue counts
more that exact place of constriction

What is a mo

Why modelli

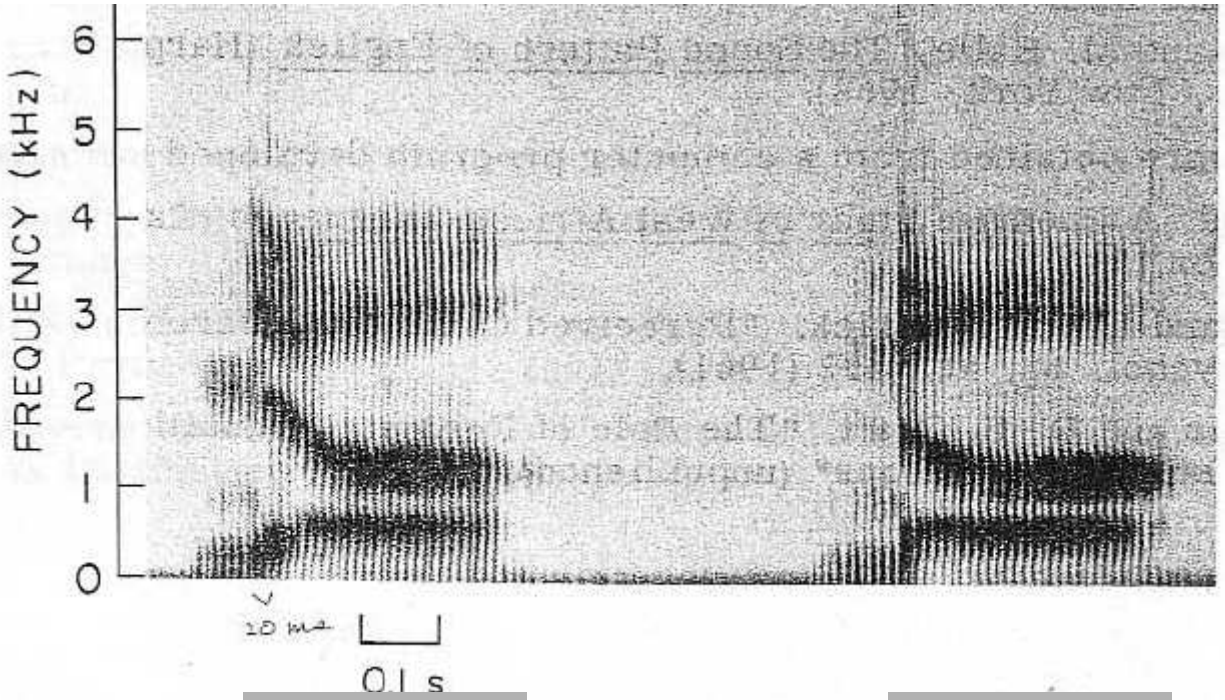
Which model

What is a use
model?

How done?

Demo
vowels
consona

Other uses
- speaker anatomy
- speaker strategy
- singing formant
- inversion
- etc;



laminal

apical

F2

And shape of the tongue is influenced by the vowels

2) For what concerns the consonants

a) Simple concatenation work than expected

b) The rôle of anatomical details: sublingual cavity

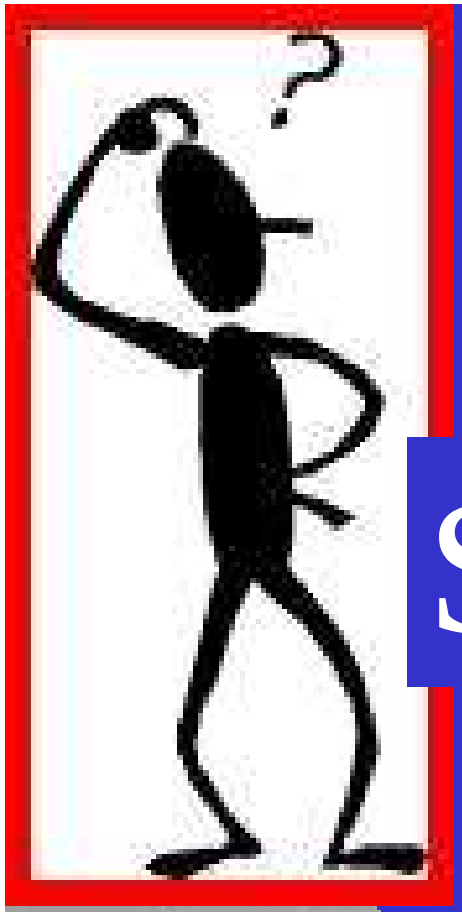
c) The acoustic properties largely
Prevail over articulation: the velars

d) Exotic consonants may be easy to model

e) Lenition and fortition not difficult to model

f) Shape of the tongue counts
more that exact place of constriction

g) Suppressing the coarticulation effect allows
to distangle the perceptual effects C to V and V to V



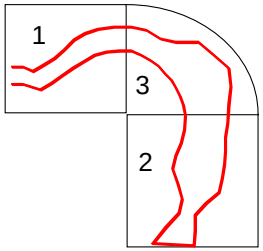
Speaker adapation .

- What is a model?
- Why modelling?
- Which models?
- What is a useful model?
- How done?
- Demo
  - vowels
  - consonants
- Other uses
  - speaker anatomy
  - speaker strategy
  - singing formant
  - inversion
  - etc;

VLAM (Maeda, 1994)

Variable Linear Articulatory Model

lip, jaw, tongue, larynx



The Larynx Height Index variation is introduced by modifying the longitudinal dimension of the vocal-tract according to 2 scaling factors and 3 zones:

(1) for the anterior part of the vocal-tract

(2) for the pharynx

(3) interpolating the zone in-between

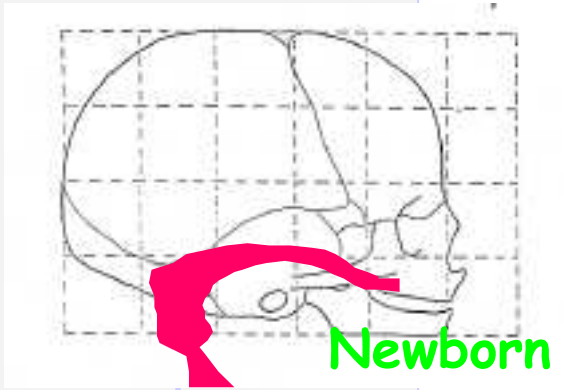
See the work at ICP Grenoble (web)

Babies
Neanderthal
monkey

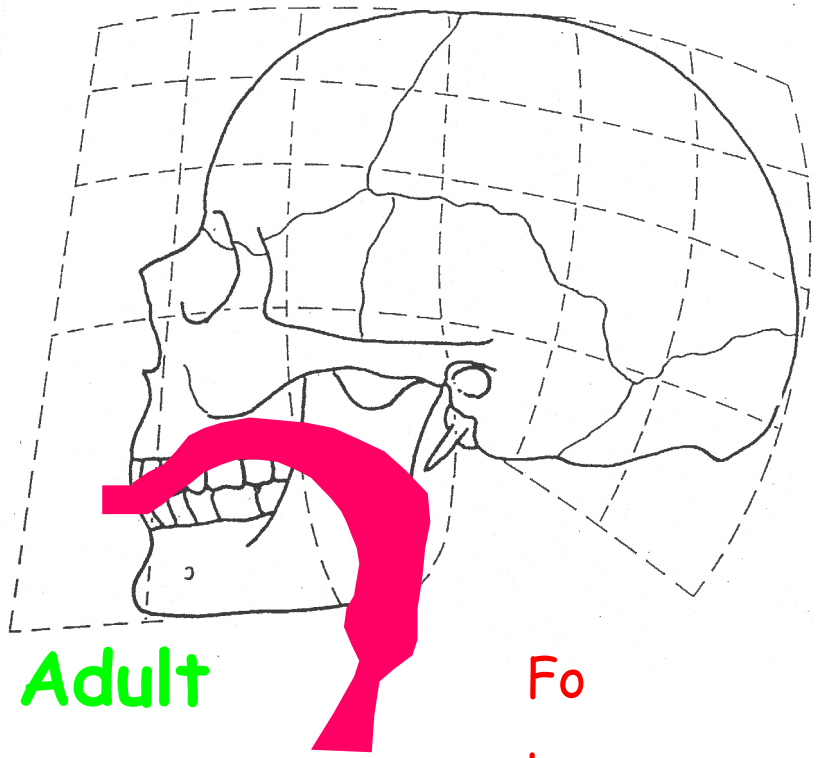
Vowel prototypes for ontogenesis

Which models?

What is a useful model?



Ontogenesis



speaker anatomy
speaker strategy
singing formant
inversion
etc;

See the work at ICP Grenoble (web) with Maeda

Babies
Neanderthal
monkey

- What is a model?
- Why modelling?
- Which models?
- What is a useful model?
- How done?
- Demo
  - vowels
  - consonants
- Other uses
  - speaker anatomy
  - speaker strategy
  - singing formant
  - inversion
  - etc;

Larynx Height Index

1.00 0.95 0.88 0.79 0.61 0.55

Man Woman Child (10y 4y) Newborn

Ape

Newborn Adult

Neandertal

La Ferrassie La Chapelle-aux-Saints

See the work at ICP Grenoble (web), Boé, etc. with Maeda

Babies
Neanderthal
monkey

What is a model?

Why modelling?

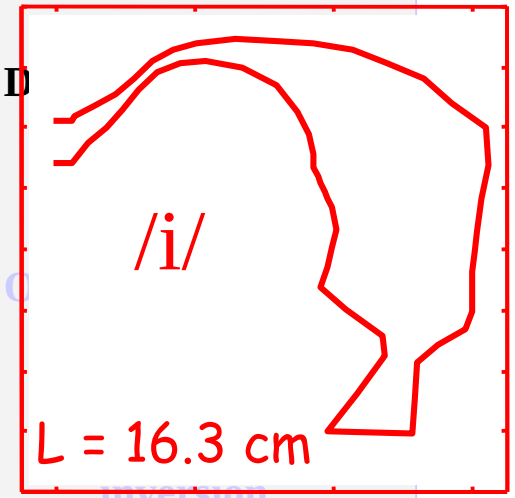
Which models?

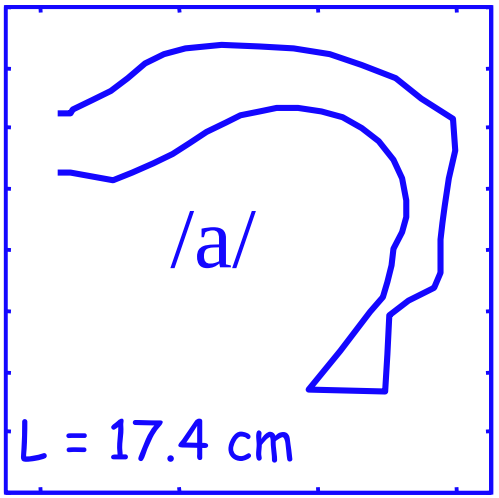
What is a useful model?

How done?

D

Vowel prototypes (adult man)





See the work at ICP Grenoble (web) with Maeda

Babies
Neanderthal
monkey

Why r

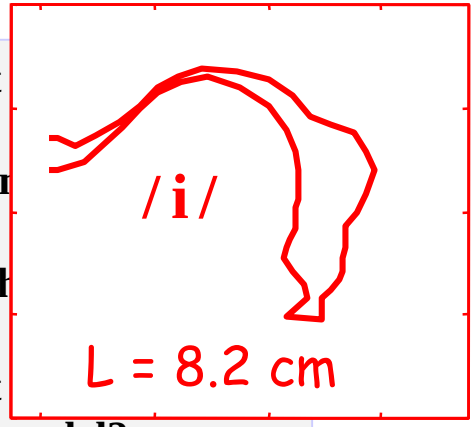
Which

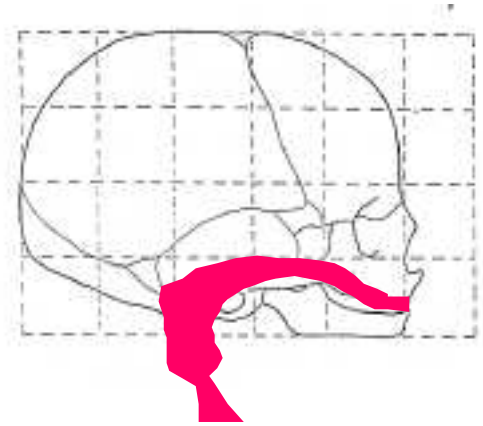
What
model?

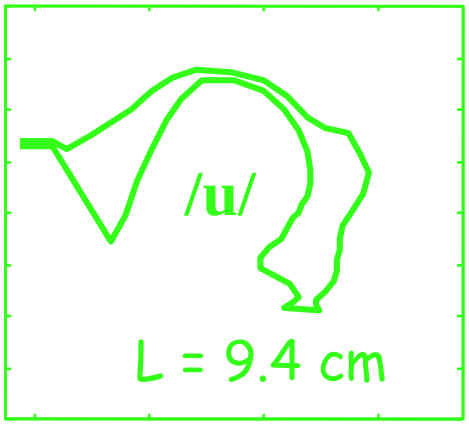
How done?

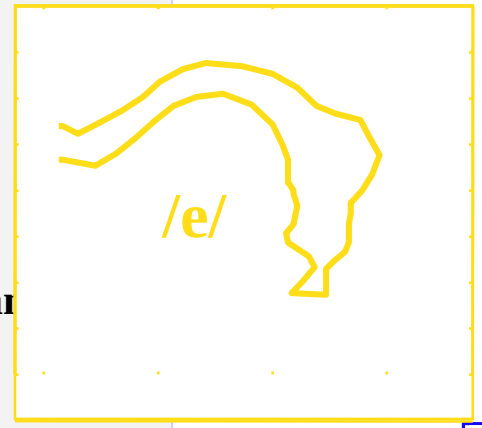
Demo
vowels
consonar

Other uses
- speaker anatomy
- speaker strategy
- singing formant
- inversion
- etc;

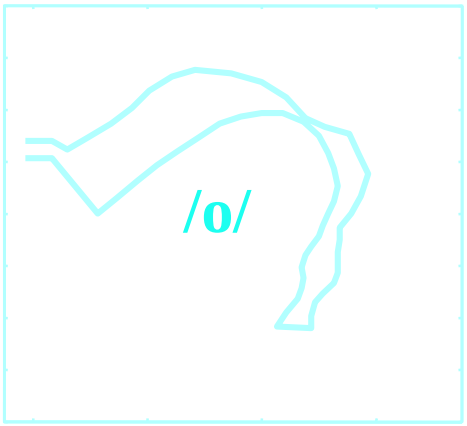


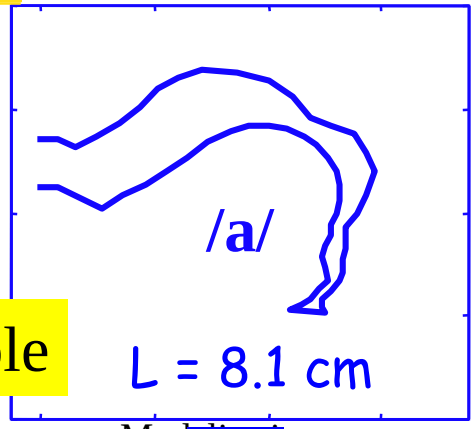






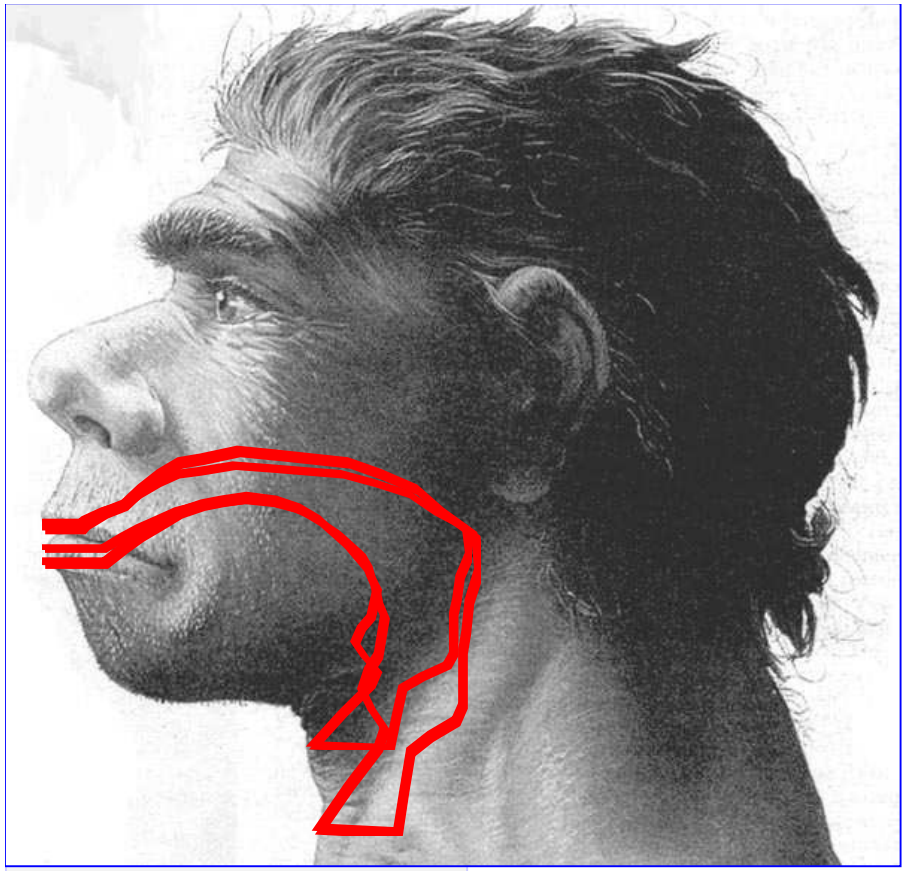
4 months

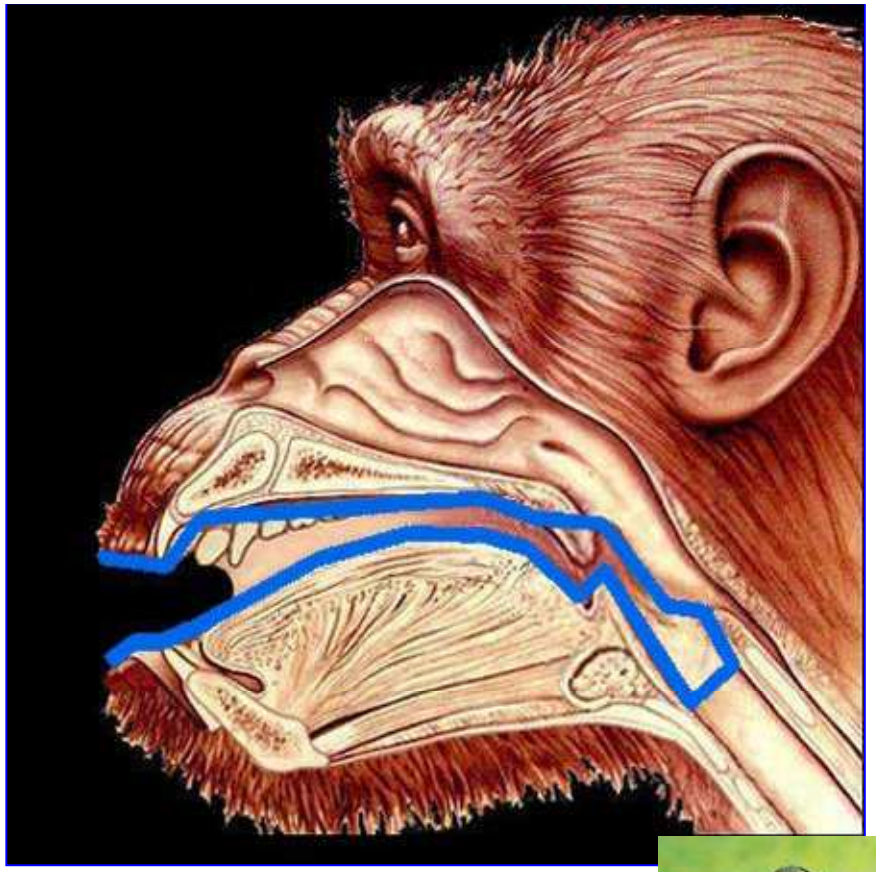




Maeda + ICP-Grenoble

Mod ion





Other uses

- speaker anatomy
- speaker strategy
- singing formant
- inve
- etc;

Contra Lieberman & Crelin

Modelisation of the differences suggests that the neandertals were no more vocally handicapped than children at birth are

Babies
Neanderthal
monkey

Maeda + ICP-Grenoble

Modelisation

Conclusions?

- AM is a very useful research and teaching tool
  - Essential as a plateform for discussions between phoneticians and engineers
- As a complement of other instrumentations such as EMMA, echograph, IRM, etc.
- Still in progress (a third cavity)
- New thesis coming in fricatives in different languages (Toda/Maeda), MRI, ATR

Conclusions?

- **limits**

1. /l/ and many other sounds not yet done

(as presented in this congress)

1. Register/Phonation types/laryngeal region area and Fo/quality interaction not included (could replace the actual 3 parameters)
2. Aerodynamic contrains increase when VT very close
3. mid-saggital profile conversion to area function not straightful process (3D)
4. New X-ray difficult to obtain (MRI and new instrumentation)

What is a model?

Why modelling?

Which models?

What

How

Demo

Other

- The corresponding paper with references are available.

Bon anniversaire !