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EVTA SESSION HELSINKI

JUNE 06 – 10, 2012

evta
european voice teachers association

Education and Culture
Lifelong Learning Programme

Combined Real-Time Feedback in the singing studio

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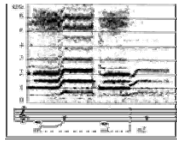
INTRODUCTION

OUTLINE



TEACHING SINGING AND TECHNOLOGY
Filipa Lã, 2012

A. Contextualizing feedback in singing pedagogy

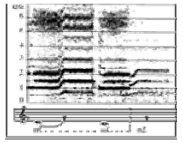
B. Different types of feedback which can be applied during singing lessons

C. Possible applications of combined real-time feedback in the singing studio:

Physiological parameters affecting voice quality

- Subglottal Pressure
- Tension and extension of the vocal folds
- Glottal adduction

A. Contextualizing feedback in singing pedagogy



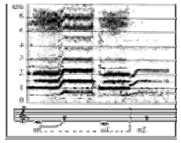
❑ Expected attributes of a singing teacher:

(Callaghan et al., 2001)

- ❖ well-informed guidance to modify incorrect neuromuscular behaviours
- ❖ observing, interpreting and understanding particular elements involved in singing (functional, musical and expressive)
- ❖ disentangling the underlying complexity of singing
- ❖ use of varied and up-to-date pedagogical tools
- ❖ sharing and discussing information with the student

The provision of meaningful feedback is fundamental to pedagogical encouragement of singing development

"Recent studies suggest that musical performance skills depend largely on practice and self-regulated learning, activities greatly assisted by feedback." (in Callaghan et al., 2001)

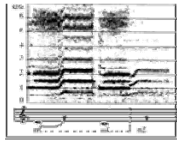


Feedback:

- *"(...) is the modification or control of a process or system by its results or effects"* (in Nair, 1999: 65)

CONTEXTUALIZATION

FEEDBACK AND TEACHING SINGING



- **Feedback** allows singers to learn how to control their vocal instrument (Welch, 1985)

  - **Sensations**
    - presentation and processing of a physical *stimuli*

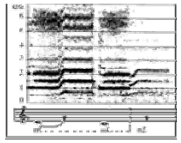
  - **Through:**
    - *interoceptive feedback*: organisation and interpretation of sensations
    - *proprioceptive feedback*: arising within the organism
    - *exteroceptive feedback*: arising from outside

  - **Perception**
    - organisation and interpretation of sensations

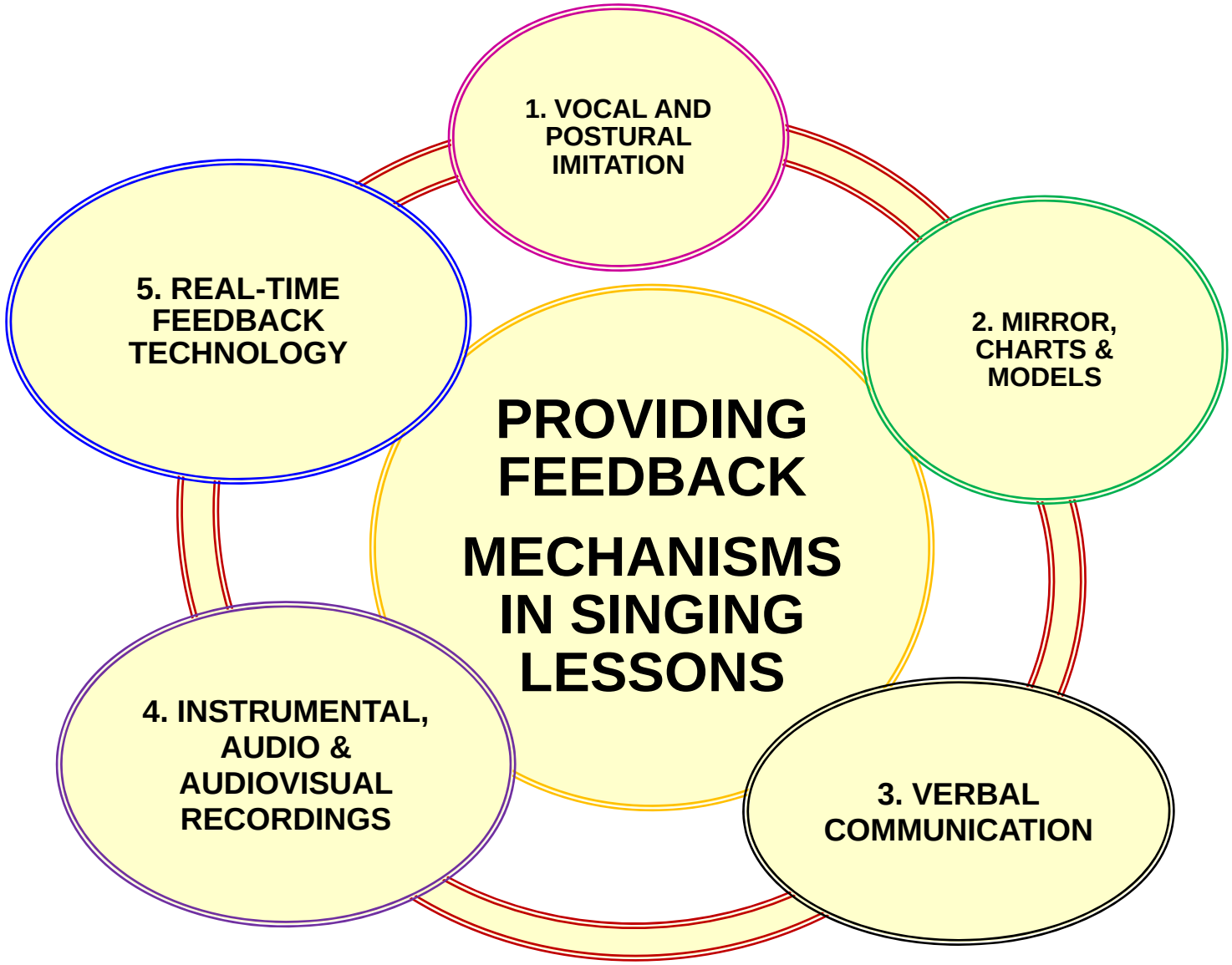
B. Different feedback tools which can be applied during singing lessons

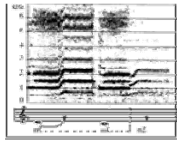
FEEDBACK

PROVIDING FEEDBACK IN SINGING LESSONS



TEACHING SINGING AND TECHNOLOGY
Filipa Lã, 2012



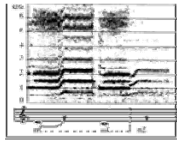


1. **Vocal and postural imitation:** teachers provide the model and the students imitate

- **Advantages**
  - The visual and auditory observation and imitation activates the ***mirror neurons:*** important for the learning process as they integrate sensorial meaningful stimuli, creating neural patterns necessary to the reproduction of the same stimuli even if these are absent

- **Disadvantages**
  - Student's internal perceptions of the model might be misleading
  - Imitation might lead to the acquisition of less correct habits
  - Imitation might decrease the capacity of developing a vocal individuality

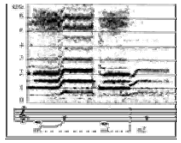
Photograph of a new born imitating human facial expressions.



2. **Mirror, charts and models**: the voice is a "*hidden instrument*" (Miller, 1995) - visual feedback is important to correct behaviours which, although sometimes not externally observable, may interfere with singing

- **Advantages**
  - for example, the **mirror** is important to increase neuromuscular behaviours of students with low kinaesthetic sensibility for, ex. tongue and jaw position, breathing behaviours
  - visualisation of the different elements that constitute the vocal instrument help the student to understand normal function in singing and optimising strategies (ex. charters, videos)
  - although external corrections are aiming at internal corrections, there is a correlation between certain external and internal gestures (ex. tension of the forehead has been related with tension in the soft palate (Nair, 1999))

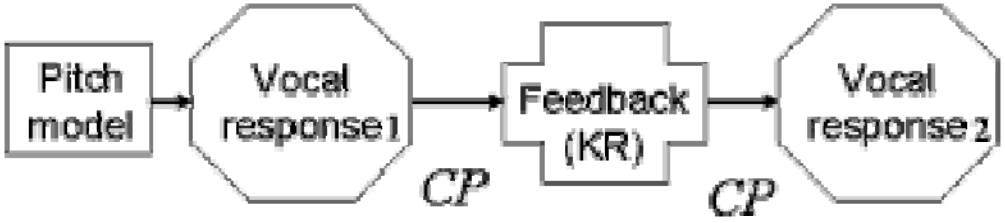
- **Disadvantages**
  - the feedback provided is only limited



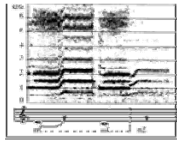
3. Verbal communication: teachers use metaphors to express kinaesthetic and visual images relying on previous experienced sensations and aural consciousness (Callaghan, 1998)

- **Advantages**
  - it is an easy and direct form of communication that will be interpreted and translated into a singing response

- **Disadvantages**
  - there is a dual possibility to misinterpret and mistranslating the information (Welch et al., 2005)

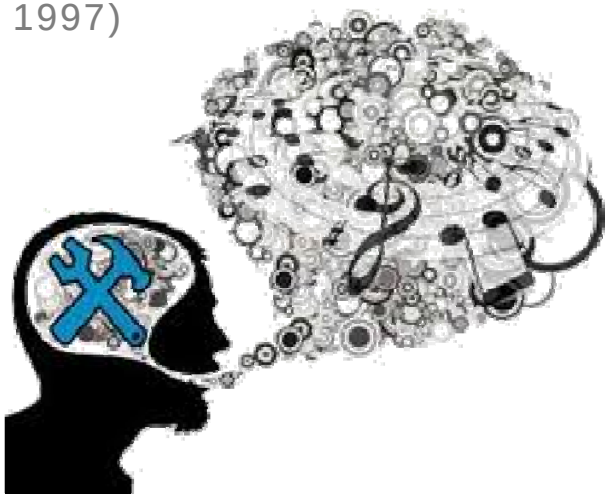


Traditional model of teacher's verbal feedback applied within a singing lesson (CP – critical points; KR knowledge of results) (adapted from Welch et al., 2005)

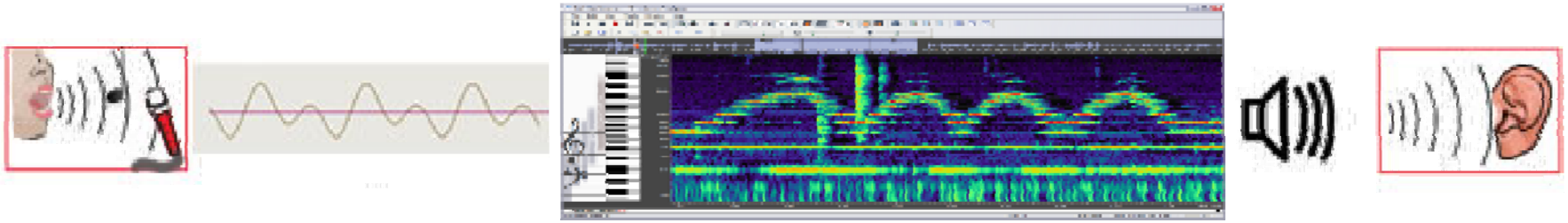


2. Verbal communication

- **Disadvantages (cont.)**
  - lack of correspondence between the metaphors used by the teacher and the underlying physiological behaviour
  - idiosyncrasy due to the reliance on the teacher's own experience and personal reflections and passed orally from one generation to the next (Mitchell, et al., 2003)
  - the lack of agreement of teacher's vocabulary (Callaghan, 1997)

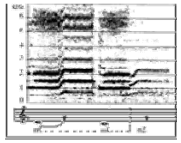


"(...) anything that can assist the learning process in the provision of more robust, less ambiguous and easily understandable feedback to both teacher and student would seem to be worthwhile." (in Welch et al., 2005: 227)



REAL-TIME FEEDBACK

APPLICATIONS IN SINGING LESSONS



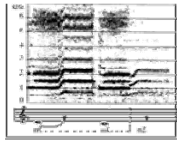
- **Real-time feedback** assists the teacher's diagnose of incorrect behaviours and application of effective correcting strategies (Miller, 1996)

- **Real-time feedback** promotes the development of a student's musical identity (Hargreaves et al., 2002)

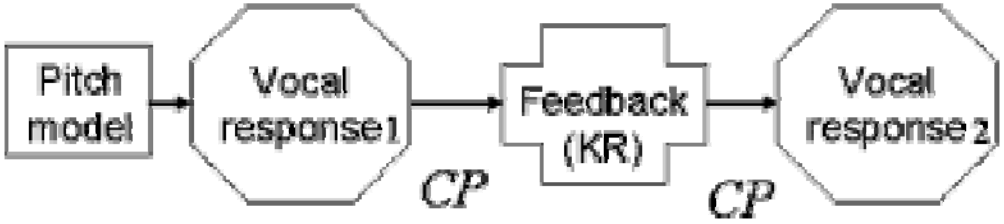
- **Real-time feedback** monitors the acquisition of correct practicing behaviours during practice and self-regulated learning, assisting cognitive and associative stages of learning (Anderson, 1982; Callaghan et al., 2001)

REAL-TIME FEEDBACK

APPLICATIONS IN SINGING LESSONS



- **Real-time feedback:** assists learning processes based on repetition - the student receives quantitative feedback concomitantly to his/her vocal behaviour, avoiding critical points in the teaching model as promotes subsequent responses (Howard, 2004)



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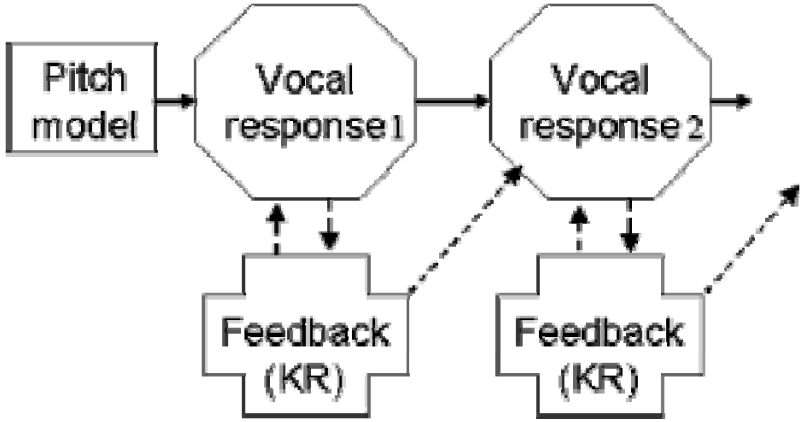

A real-time model feedback that can be used in a singing lesson (adapted from Welch et al., 2005)

REAL-TIME FEEDBACK

APPLICATIONS IN SINGING LESSONS

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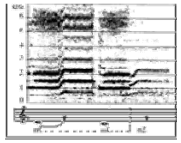
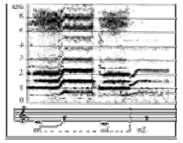


Real-time feedback: advantages

- when combined with verbal communication, becomes more effective than verbal feedback alone (Marks, 1978; Walker, 1981; Welch et al., 1989; Butler & Winne, 1995)
- it is beneficial on correcting melodic behaviour (Welch et al. 1989)
- increases attention and promotes emotional expressivity in performance (Welch et al., 1989)
- it confirms the auditory perception of the teacher with the visual feedback (Nair, 1999)
- there is a corresponding acoustic output of the sound generated, allowing a more accurate understanding of the physiological underlying mechanism (Nair, 1999)
- it helps the standardisation and clarification of terminology, establishing a bridge between science and vocal pedagogy (Nair, 1999)

REAL-TIME FEEDBACK

APPLICATIONS IN SINGING LESSONS



Real-time feedback: disadvantages

- **time consuming tool:**

(Welch et al., 2005)

  - for the teacher:
    - to be fully acquainted with technology
    - to understand and translate the displays
    - to organise time in the singing lesson
  - for the student:
    - learn how to use the same technology during individual practice

Should teachers really bother to learn about technology?

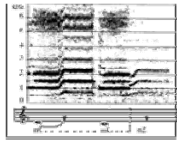
"The singing voice is an acoustic instrument that must be produced naturally in accordance with the laws of physics, and (...) the singing voice is primarily a physical instrument that obeys the laws of physical function."

(in Miller, 1986: 310)

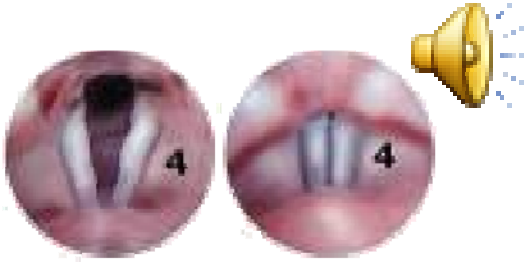
C. Possible applications of real-time feedback technology in the singing studio

REAL-TIME FEEDBACK

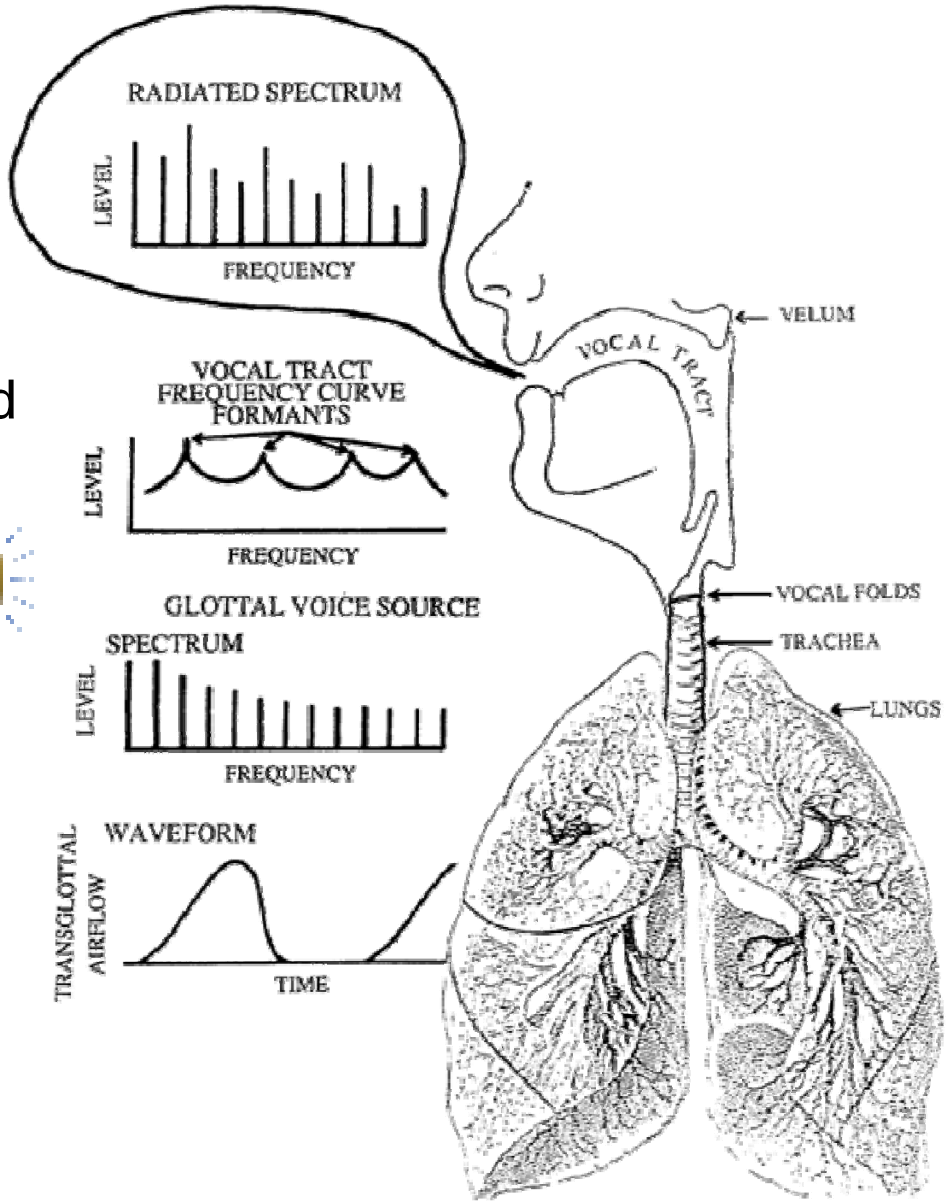
APPLICATIONS IN SINGING LESSONS



Radiated sound



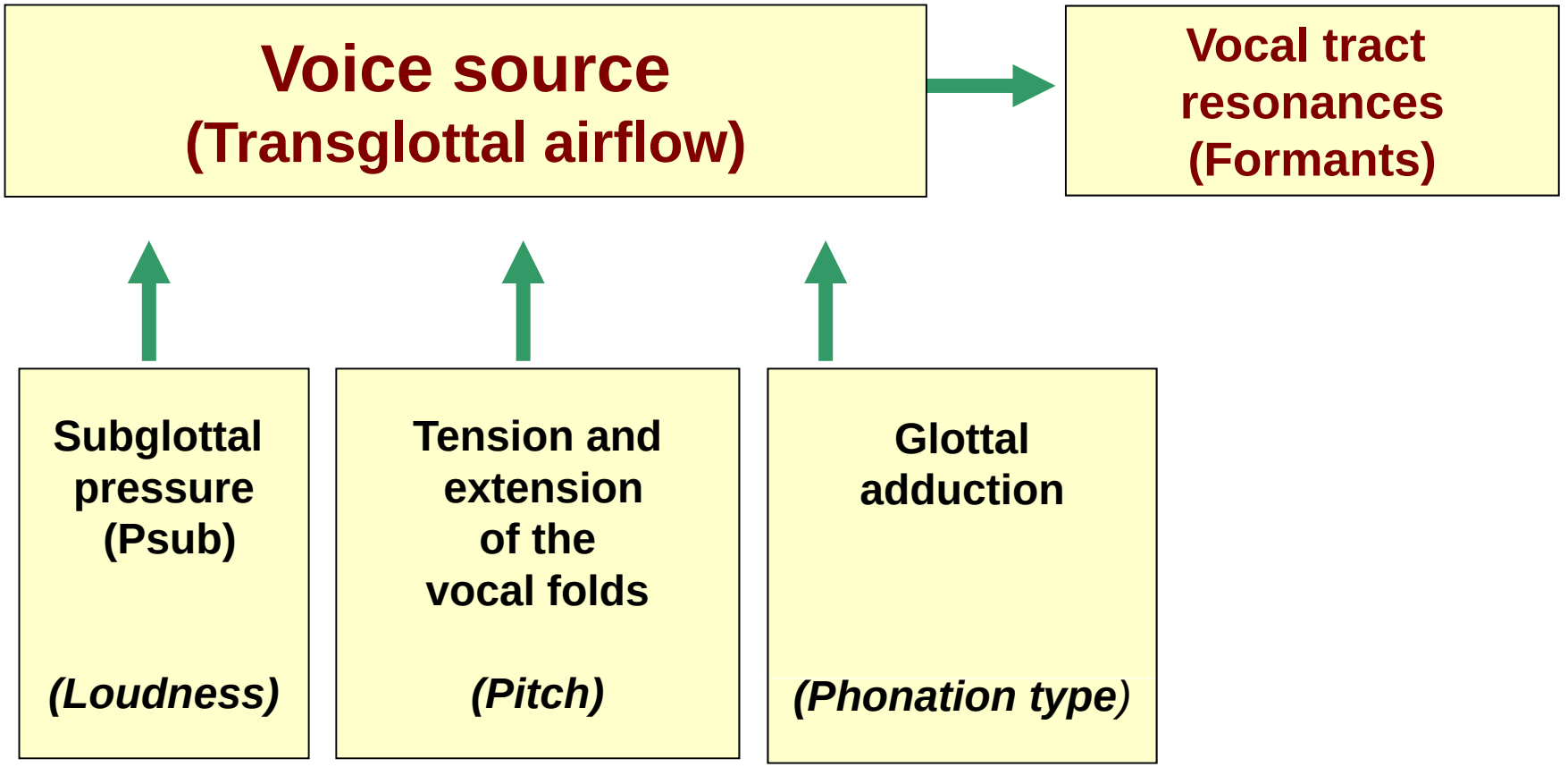
Voice source



(adapted from Sundberg, 1987)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING

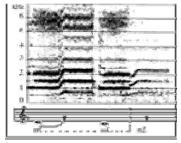


Physiological factors affecting voice quality

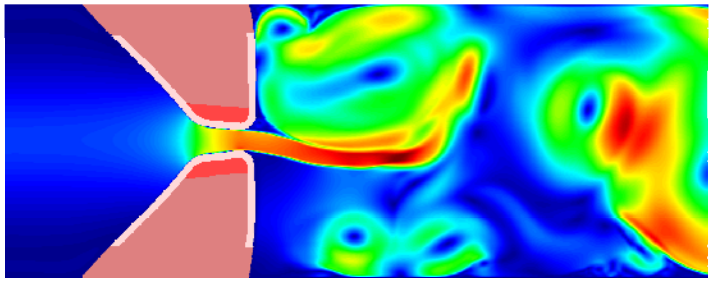
(adapted from Sundberg, 1987)

REAL-TIME FEEDBACK

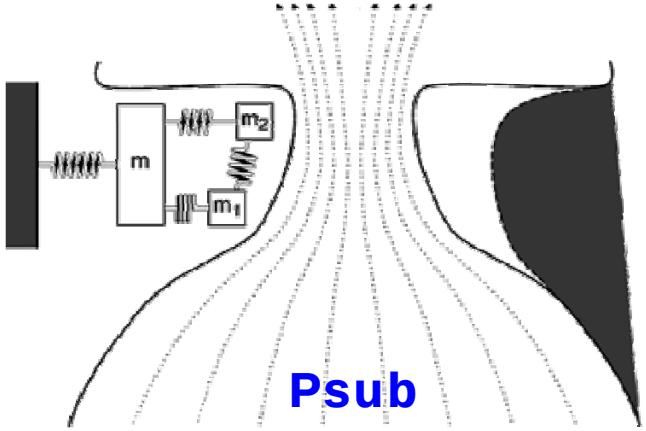
VOICE SOURCE MONITORING



❑ **Voice source:** vibration of the vocal folds

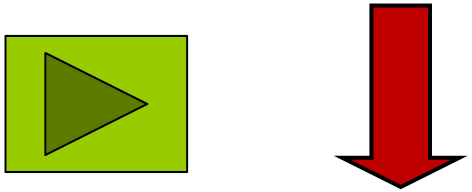


Transglottal airflow simulation (adapted from http://www.uni-klu.ac.at/tewi/13858.htm [in 5/12/10, 15:05])



Three mass model of vibration of the vocal folds by Titze (adapted from www.ncvs.org/.../voiceprod/tutorial/model.html [in21/07/09; 12:47])

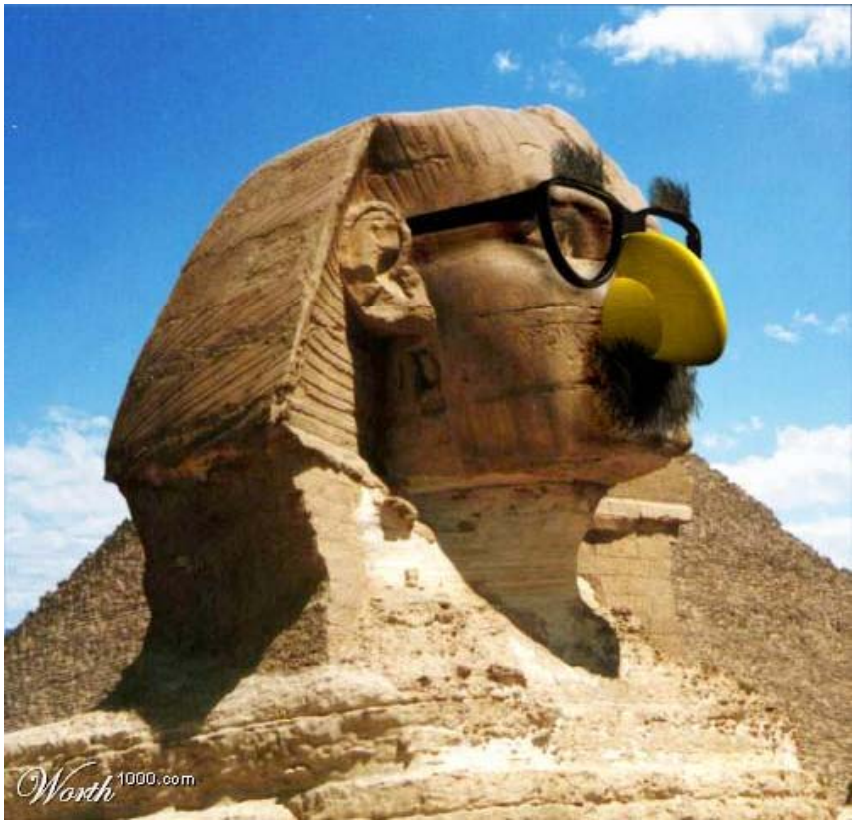
Tridimentional model– airflow induces vibration (Titze, 1988)



- different vocal fold's tissue layers (m, m1 & m2) have different myoelastic properties
- vocal tract inertia – asymetries in pressure

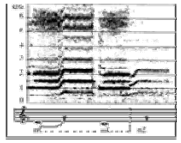
What technology is available as a teaching tool to assist on monitoring voice source?

Eg. An hybrid system



REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



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- Combination of digital Laryngograph microprocessor (1) and Glottal Enterprises MS-110 computer interface (2)

- Allows simultaneous recording of 4 channels digitized and sent into a PC:
  - Audio
  - ELG
  - Subglottal pressure (Psub)
  - Air flow

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING

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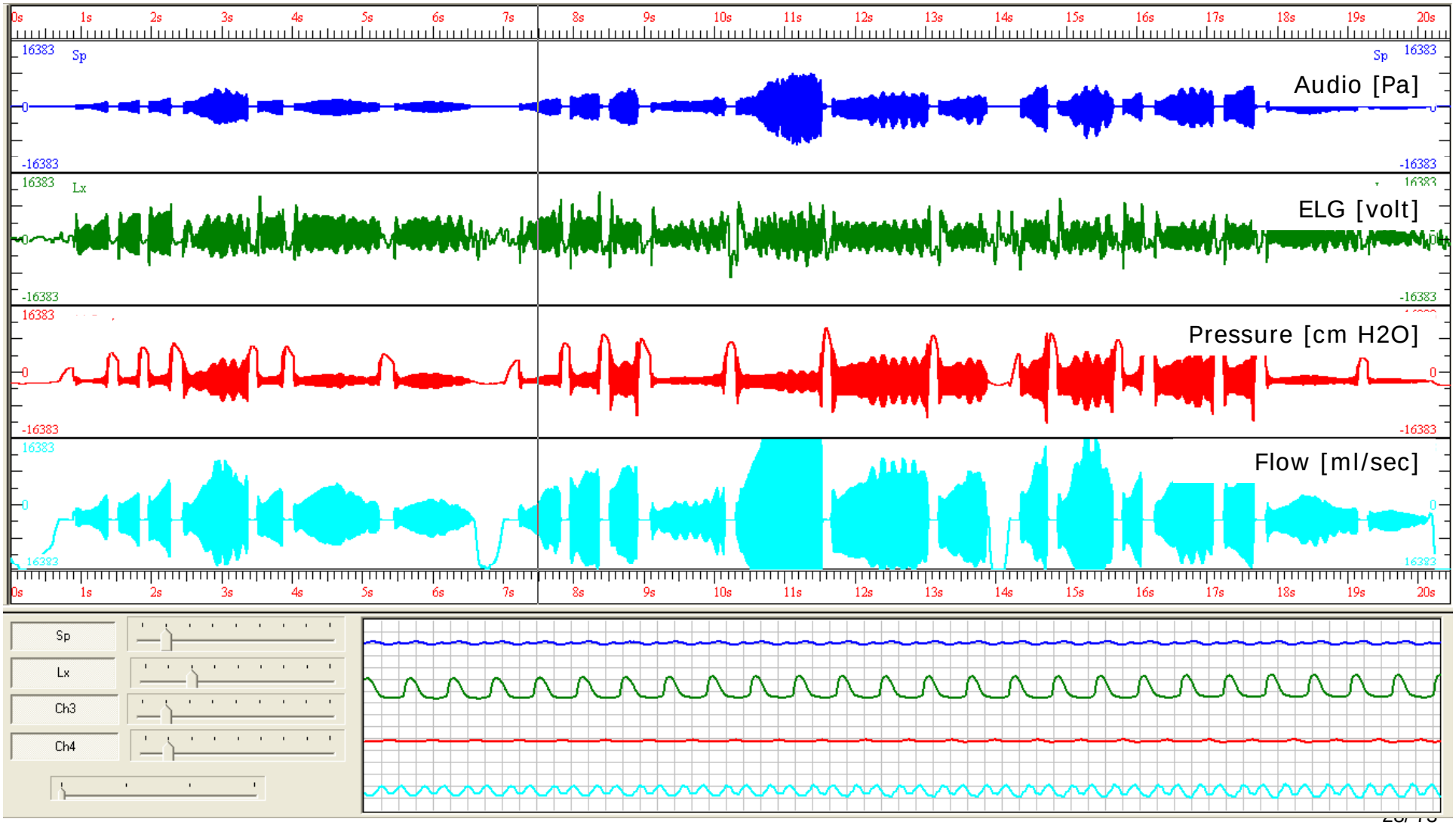
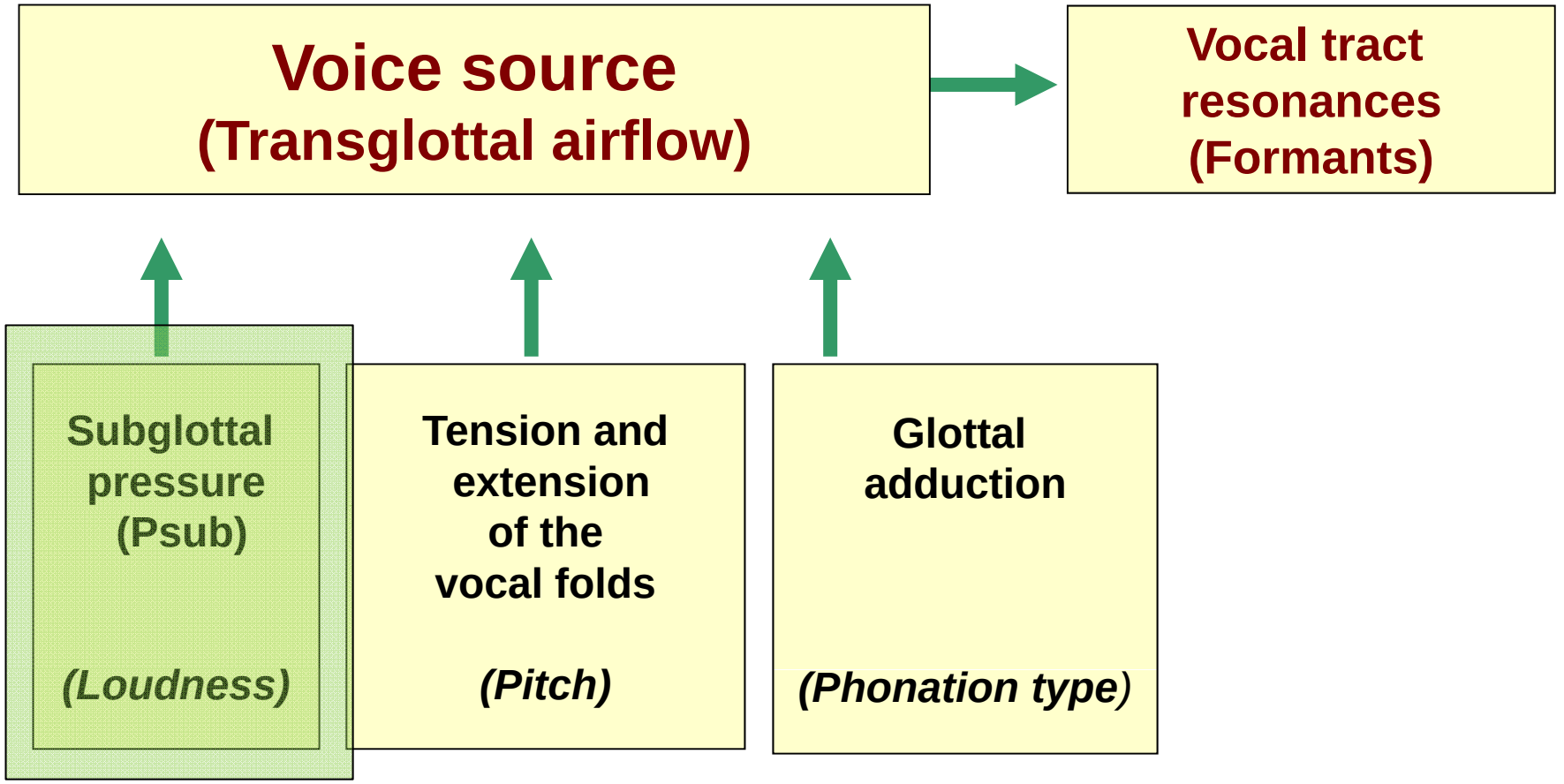
- **Real-time feedback** of different vocal elements



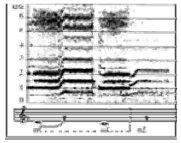
REAL-TIME FEEDBACK

VOICE SOURCE MONITORING

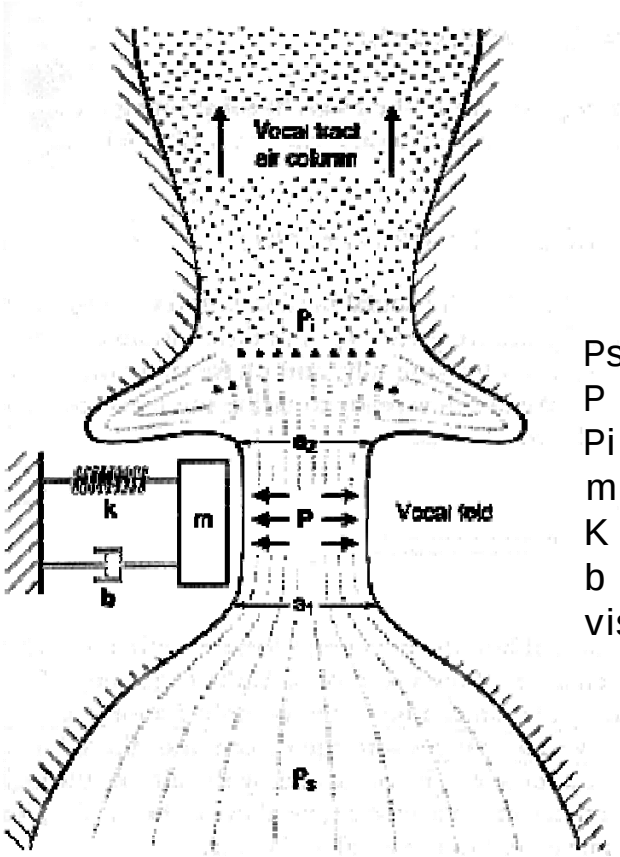


Physiological factors affecting voice quality

(adaptaded from Sundberg, 1987)



- **Subglottal Pressure (Psub):** "*the pressure by which the air pressure in the lungs exceeds the atmospheric pressure* " (Sundberg , 1987)

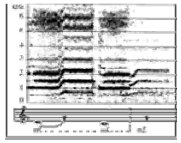


Ps = subglottal pressure
P = intraglottal pressure
Pi = supraglottal pressure
m = mass
K = effective stiffness of the fold layers
b = damping constant representing the viscosity of the tissue

(adapted from Titze, 1994)

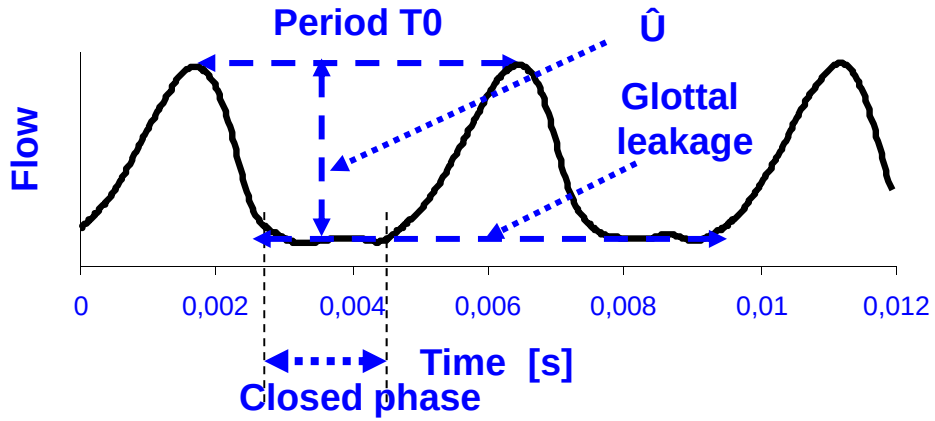
REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



- Changes in **Psub** affect several voice source flow waveform parameters (Sundberg et al., 2005):

Flow glottogram



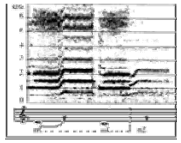
- Closed quotient (*Qclosed*)
  Q_{Closed} = Closed Phase / T0

- Peak-to-peak pulse amplitude ($\hat{U}$) ⇒ **Vocal loudness**

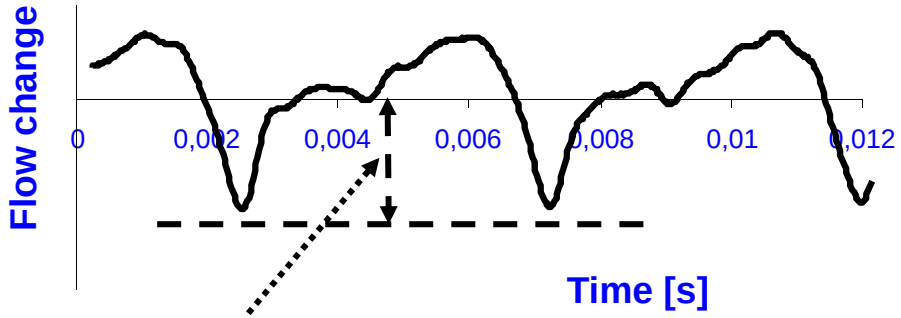
- *Glottal leakage*
  Mean airflow during the closed phase ($\hat{U}_{dc}$ flow)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



Derivative of flow glottogram

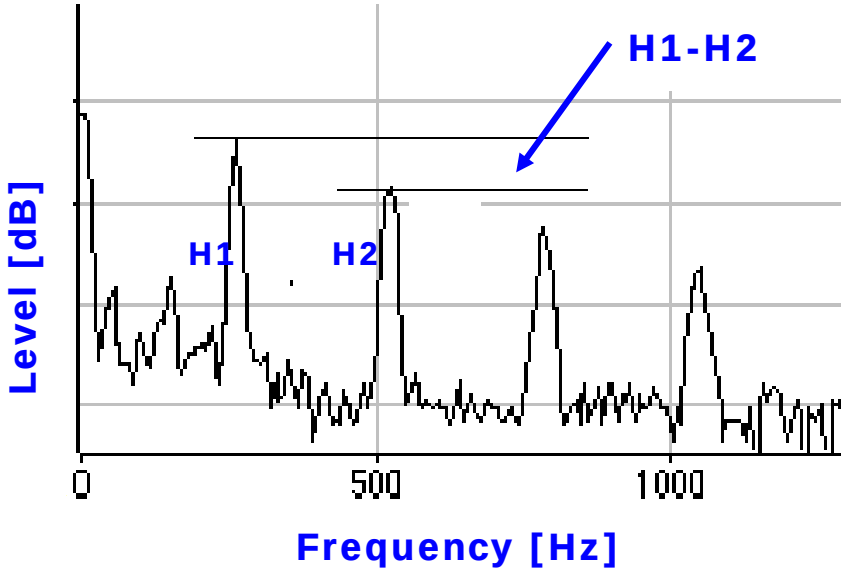


Max. Flow Declination Rate (MFDR)

❖ Maximum flow declination rate (MFDR), i.e. the negative peak amplitude of the differentiated glottogram **Acoustic energy and voice efficiency**

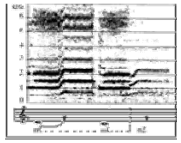
❖ Level difference *between the first and second partials* of the source spectrum (*H1-H2*) ⇒ **estimate of F0 dominance**

Madde (by Granqvist)

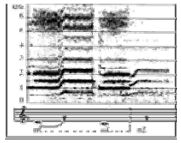


REAL-TIME FEEDBACK

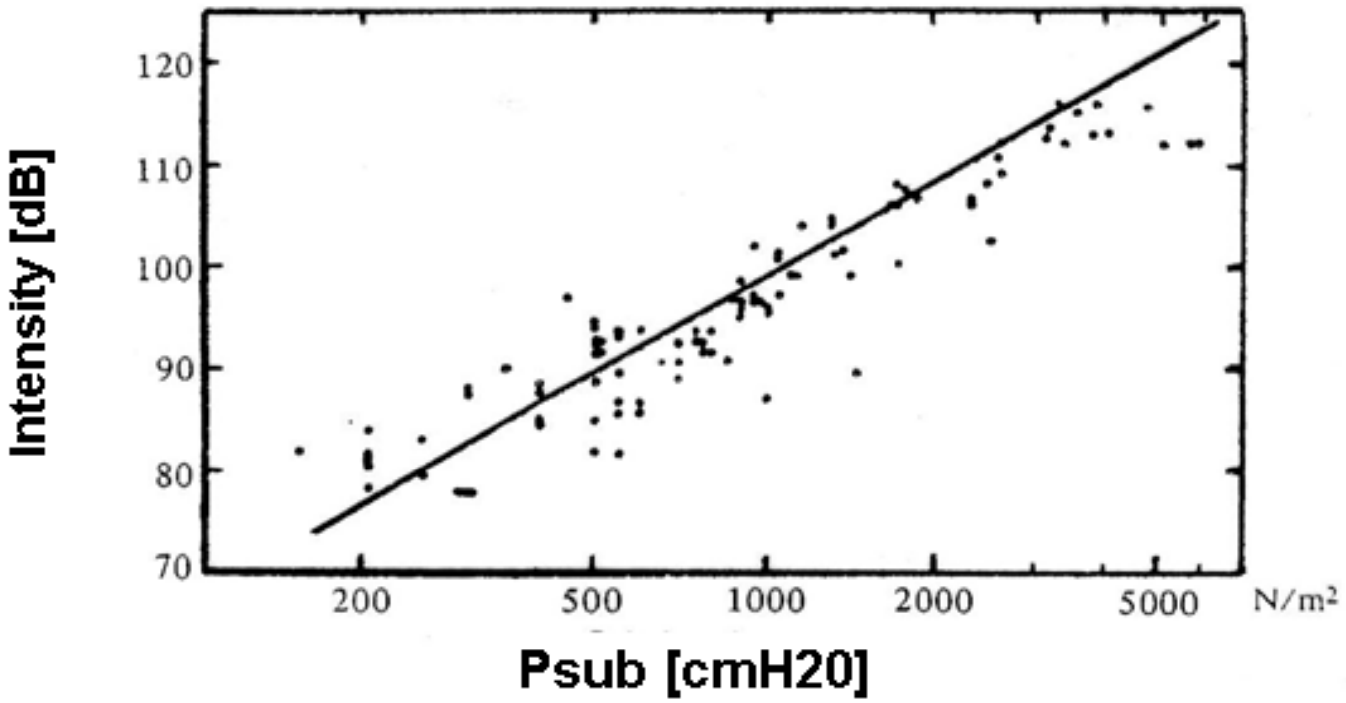
VOICE SOURCE MONITORING



- **Psub** is vital to pedagogical nurturing of singing development:
  - **It regulates changes in fundamental frequency (F0):** seem to be ***smallest in the high-pitched chest register***, ***greatest in the falsetto register*** and ***intermediate in the low-pitched chest register***, due to amplitude-dependent tension of the focal folds (Titze, 1989)
  - **Fine control of Psub** is crucial for the singer to sing in tune
  - **Psub is the primary variable for controlling vocal intensity** (Fant, 1983; Titze, 1988a): intensity and frequency are dependent



Psub is a measure of vocal loudness



Correlation between voice intensity and Psub
(adapted from Sundberg, 2008: Summer course)

REAL-TIME FEEDBACK

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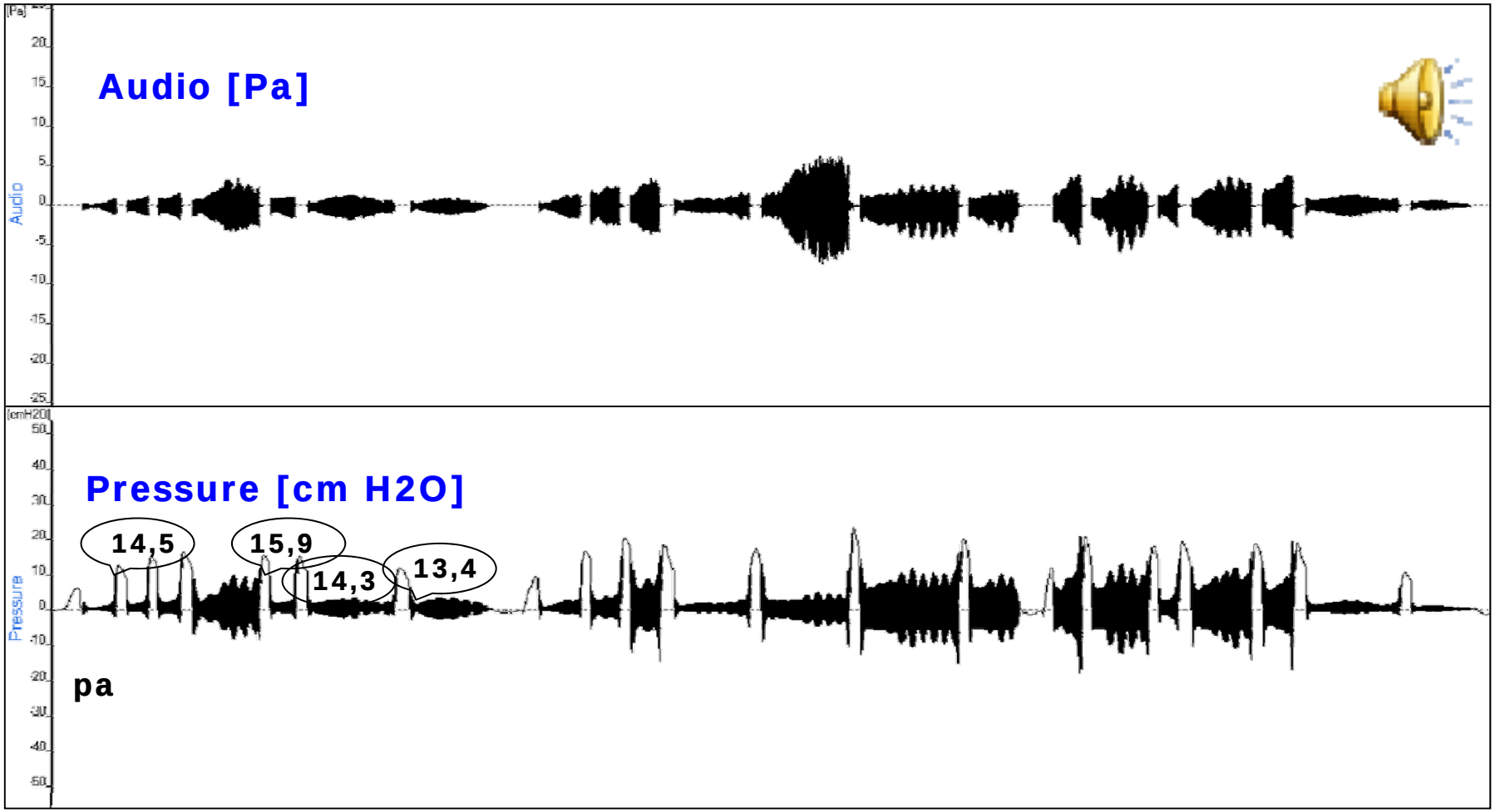
❑ Psub variations with F0

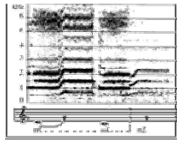


"O mio babbino caro" (by G. Puccini) sung substituting the lyrics with /pae/ syllables

Time [s]

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



- Learning to be at the right pressure for a specific vocal loudness and pitch before the tone starts is a key factor for efficient singing

- This pre-planned fine tuning is essential for the singer, as it allows the anticipation of what to expect under different conditions within different repertoire (Miller, 2006)

- One way of automatizing this ability is practicing staccato and arpeggio exercises (Welch & Sundberg, 2002)

REAL-TIME FEEDBACK

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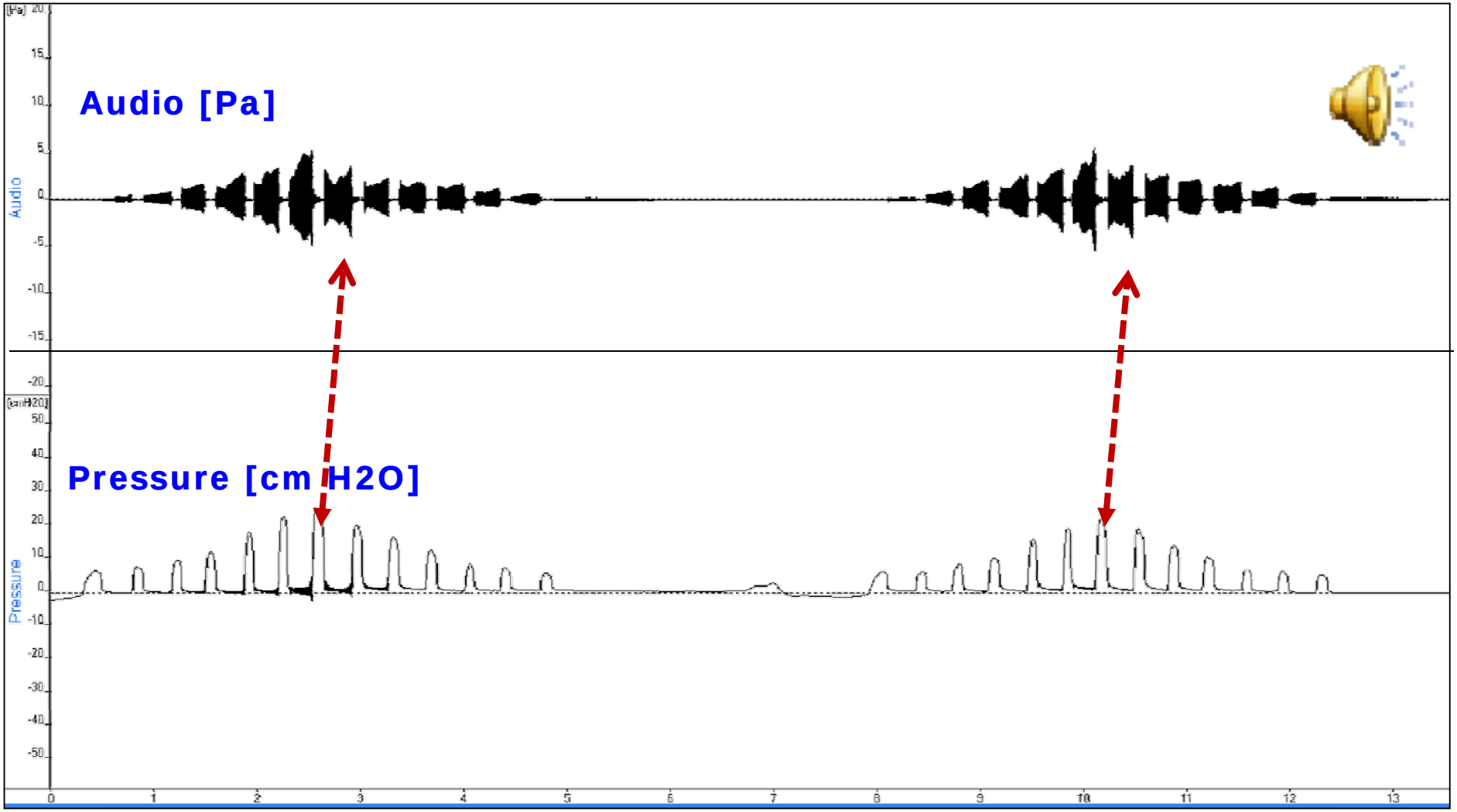
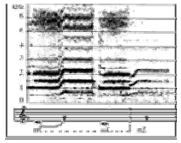
❑ Staccato and arpeggio repetitions



C-Major Arpeggio repetitions sung using /pae/ syllables

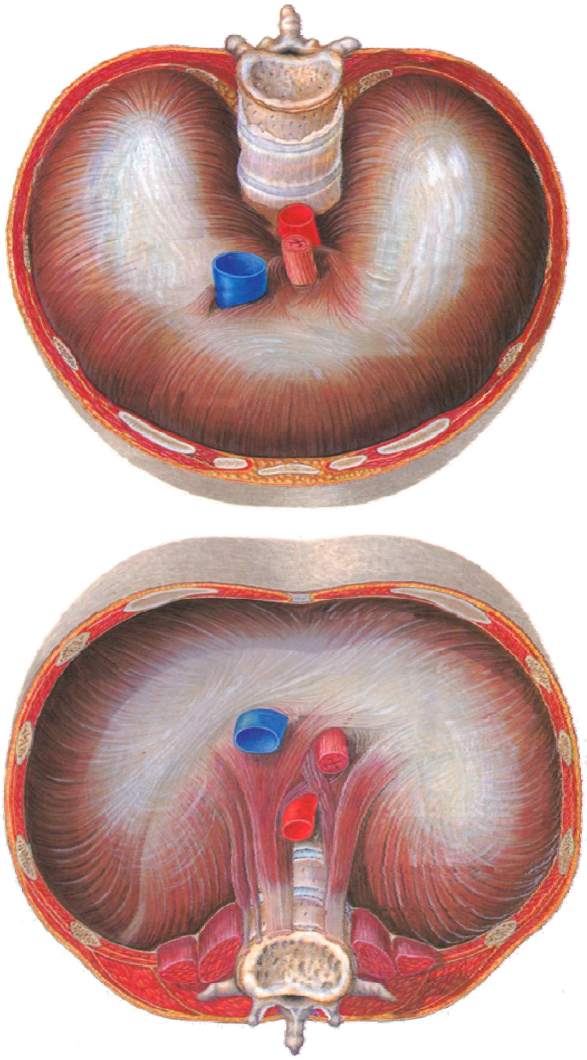
REAL-TIME FEEDBACK

VOICE SOURCE MONITORING

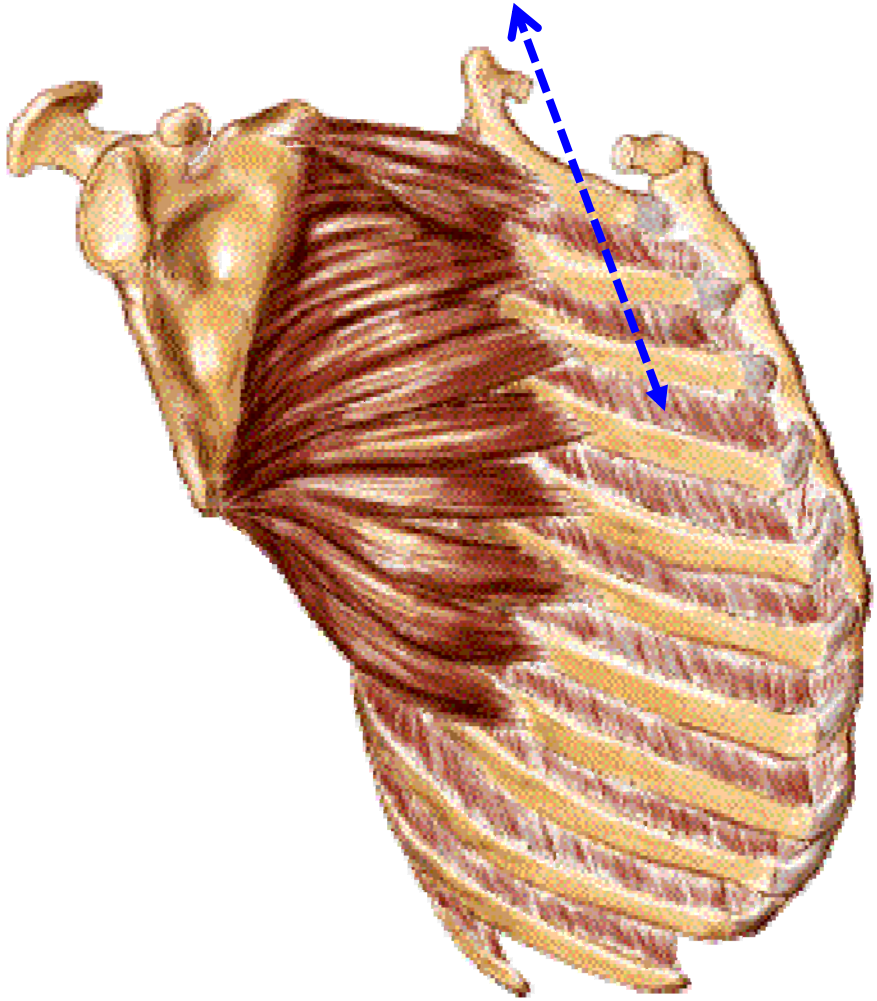


- **Breathing muscles: inhalatory muscles**

DIAPHRAGM

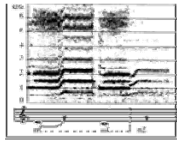


EXTERNAL INTERCOSTAL MUSCLES



REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



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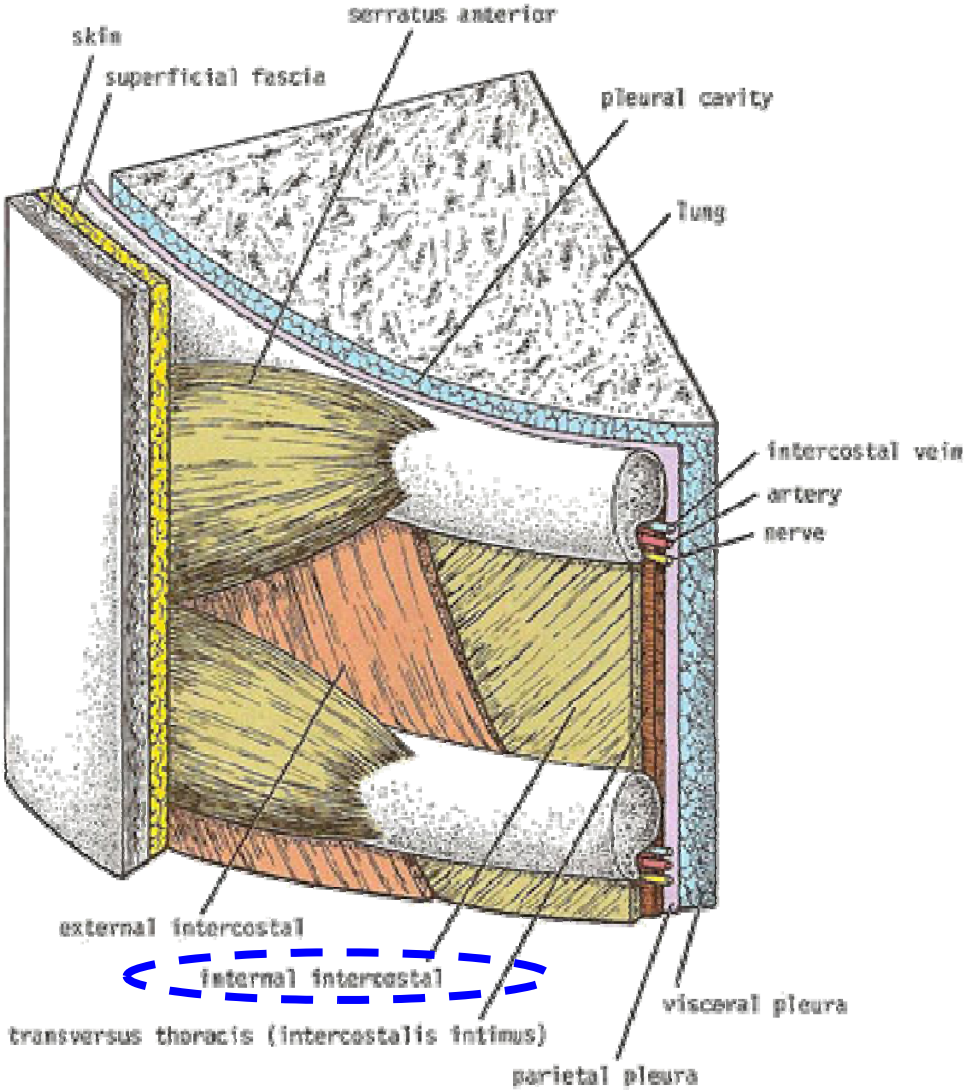
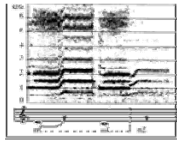
- **Breathing muscles: exhalatory muscles**

INTERNAL INTERCOSTAL MUSCLES



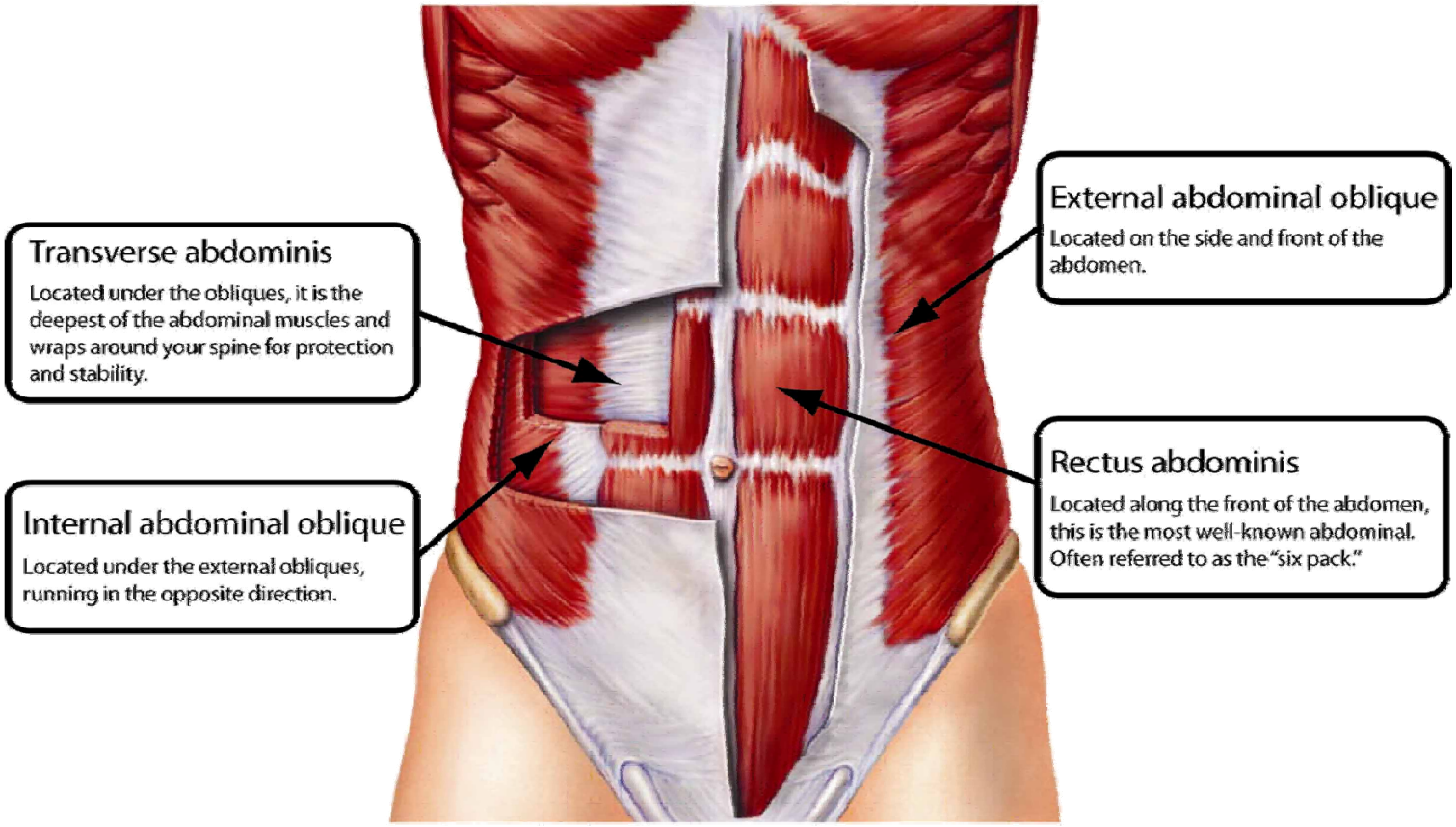
REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



- **Breathing muscles: exhalatory muscles**

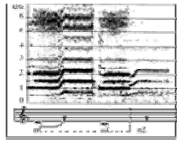
ABDOMINAL MUSCLES

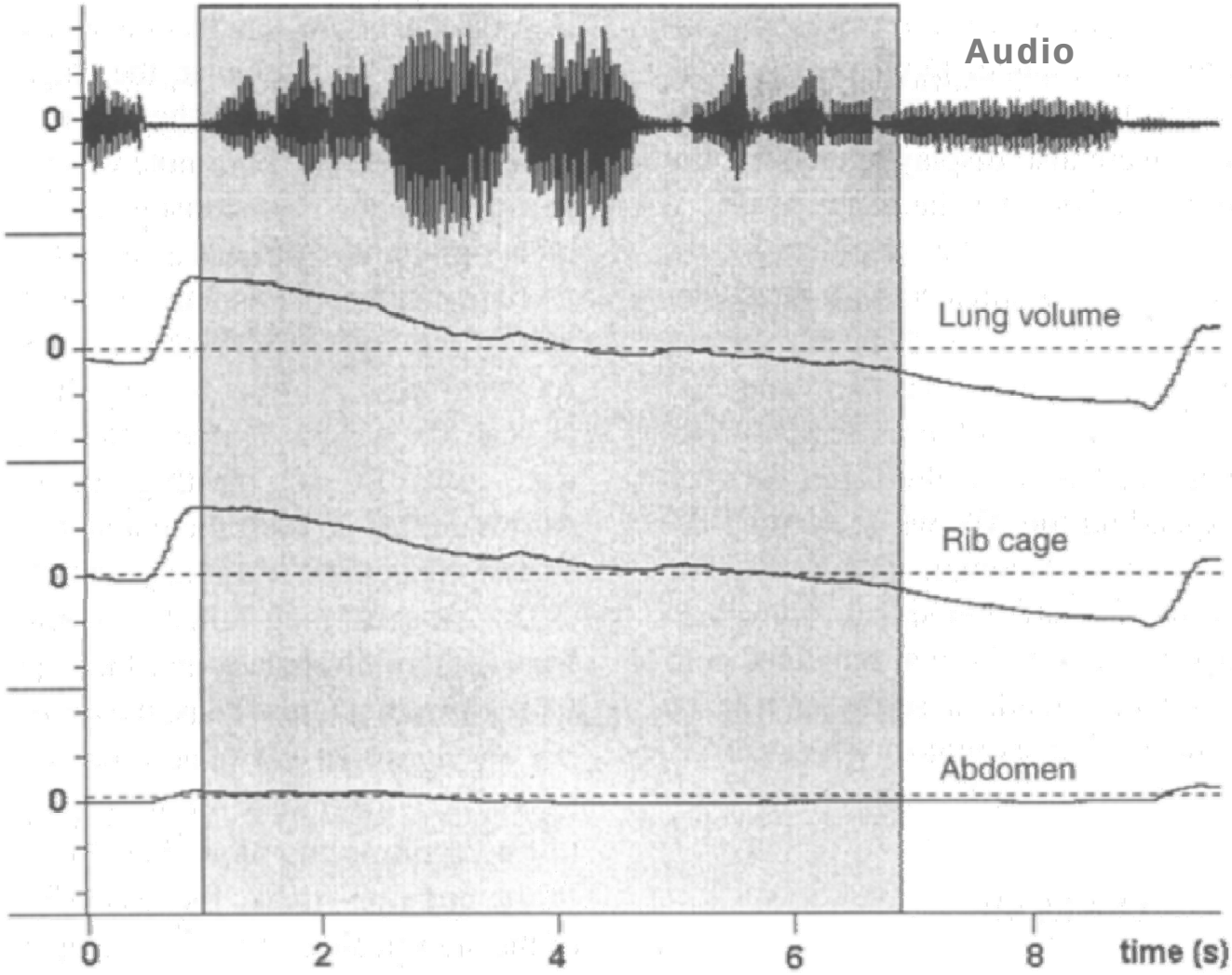


Exhalation occurs due to the elastic recoil of the lungs. The abdominal muscles and the internal and innermost intercostal muscles may assist during exhalation

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING

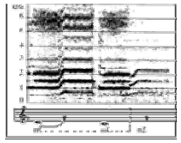




Signals recorded by Respitrace (Adapted from Thomasson & Sundberg, 1999)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



❑ Different singers use different breathing strategies (Thomasson & Sundberg, 1999)

- ❖ Variations of rib cage (RC) volume are commonly used by singers to change lung volume (LV) (and thus Psub) (Thomasson & Sundberg, 1999)

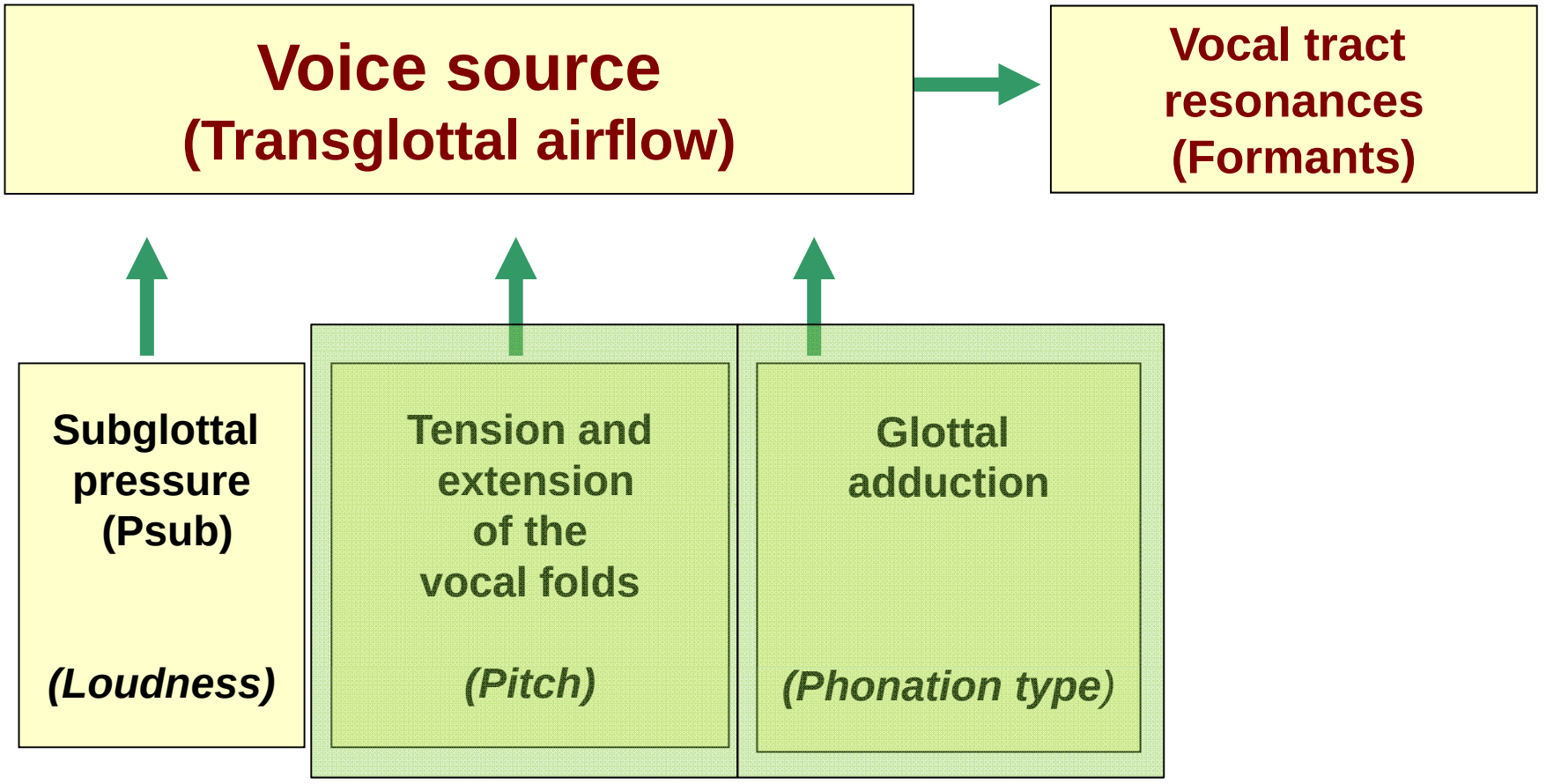
- ❖ Abdominal wall (AW) movements seem to belong to common breathing patterns of singers, participating in two possible ways: (i) assisting the RC in changing LV; (ii) as a stable platform for LV changes that are affected by RC (Thomasson & Sundberg, 1999)

- ❖ At the beginning of a phrase: LV is changed by movements of the AW (Watson & Hixon, 1985)

- ❖ At the end of a phrase: LV is changed by movements of the RC (Watson & Hixon, 1985)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



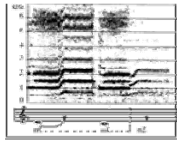
Physiological factors affecting voice quality

(adaptaded from Sundberg, 1987)

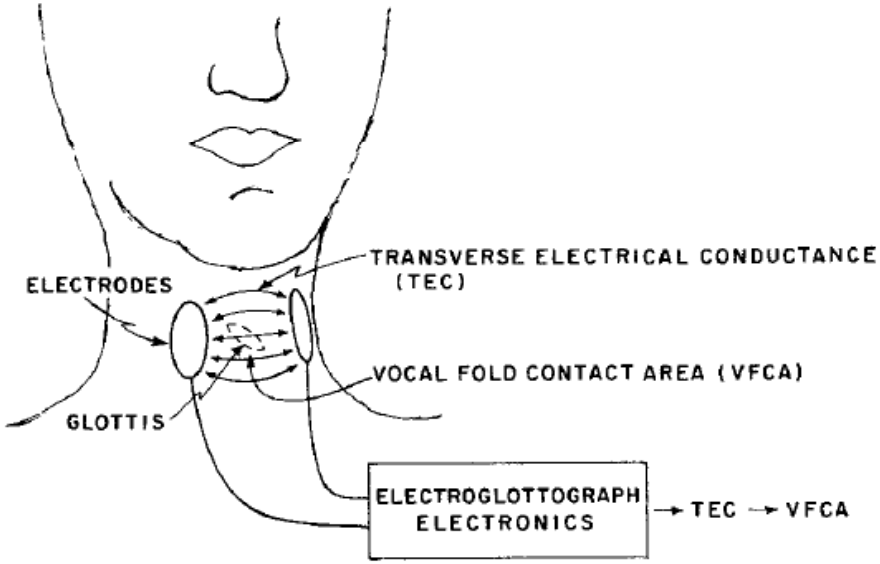
Eg. Electrolaryngograph

REAL-TIME FEEDBACK

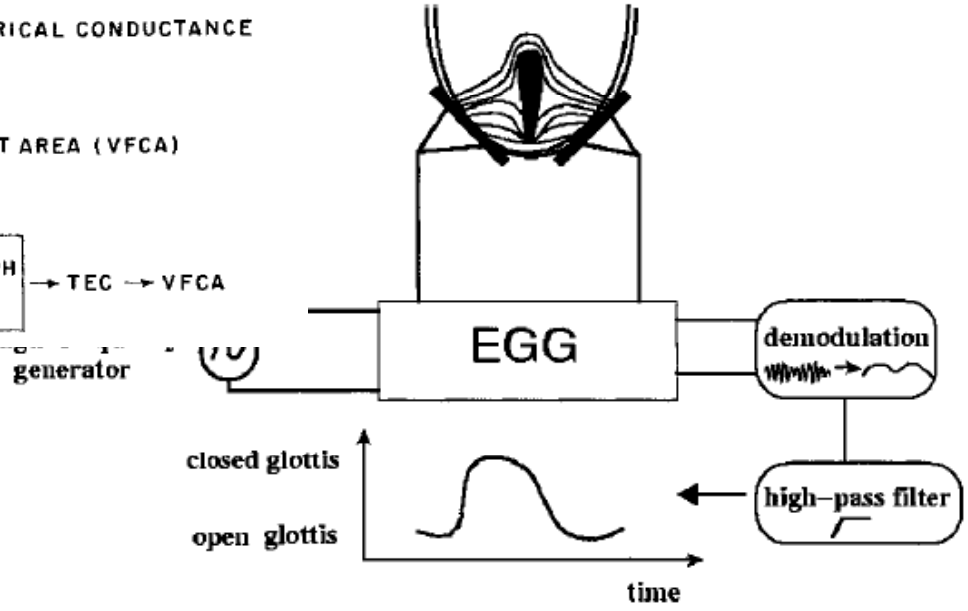
VOICE SOURCE MONITORING



❑ How can vocal folds tension and extension and glottal adduction be monitored?



EGG placement to obtain an estimative of vocal fold contact (adapted from Rothenberg & Mashie, 1988: 339)



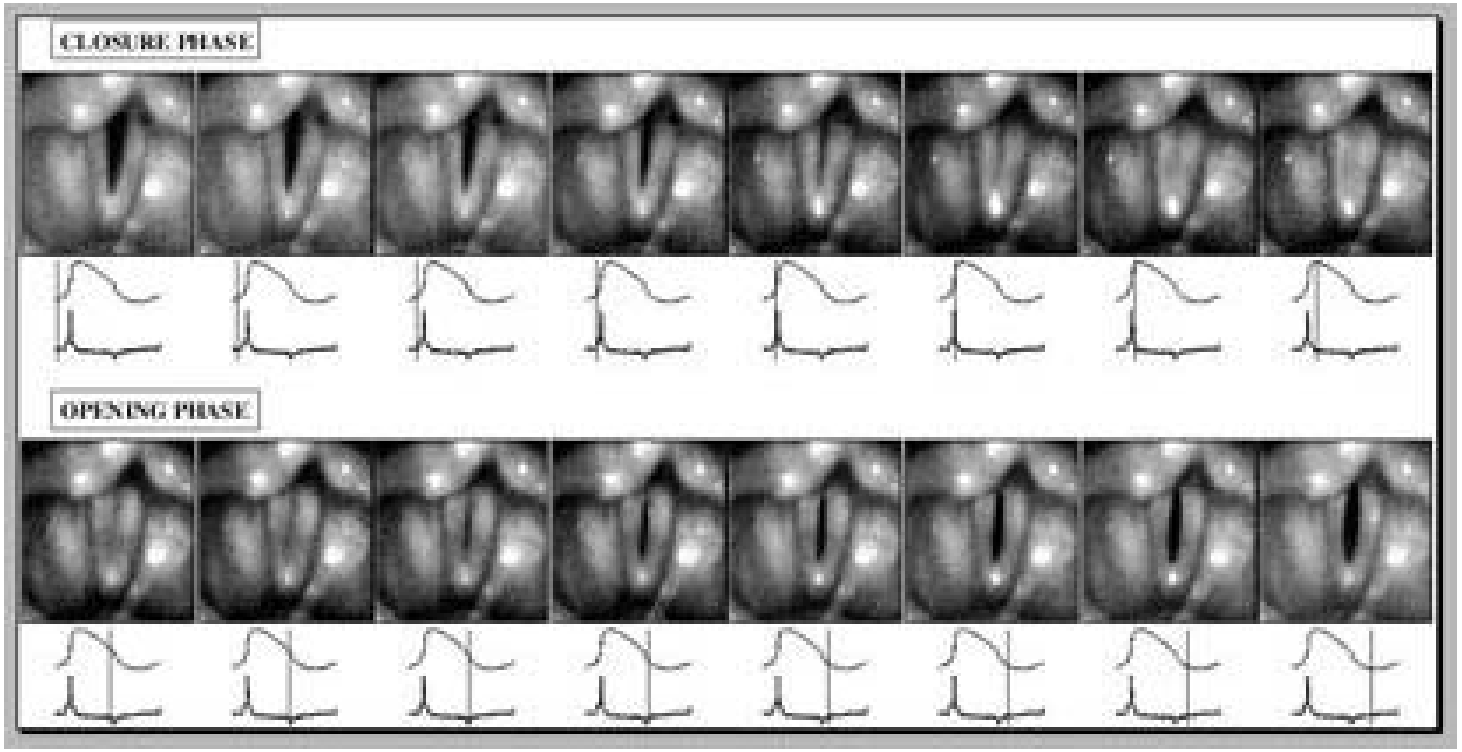
EGG signal is represented as a function of vocal-fold contact (adapted from Henrich, Doval & Castellengo, 2004: 1322)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING

Electroglotograph (EGG) (Fabre, 1957)

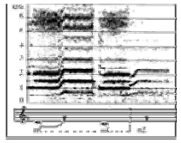
- Allows non-invasive monitoring of vocal fold vibration patterns



Comparison between the vibratory cycle displayed as a larayngographic waveform and the vocal fold vibratory cycle captured by videostroboscopy (adapted from Henrich, Doval & Castellengo, 2004: 1322)

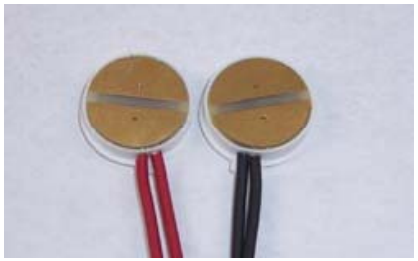
REAL-TIME FEEDBACK

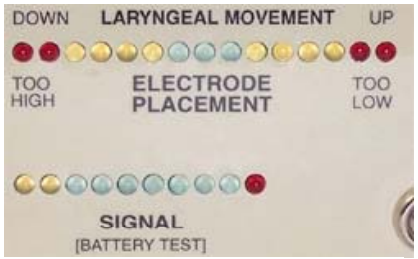
VOICE SOURCE MONITORING



VoceVista EGG

Glottal enterprises





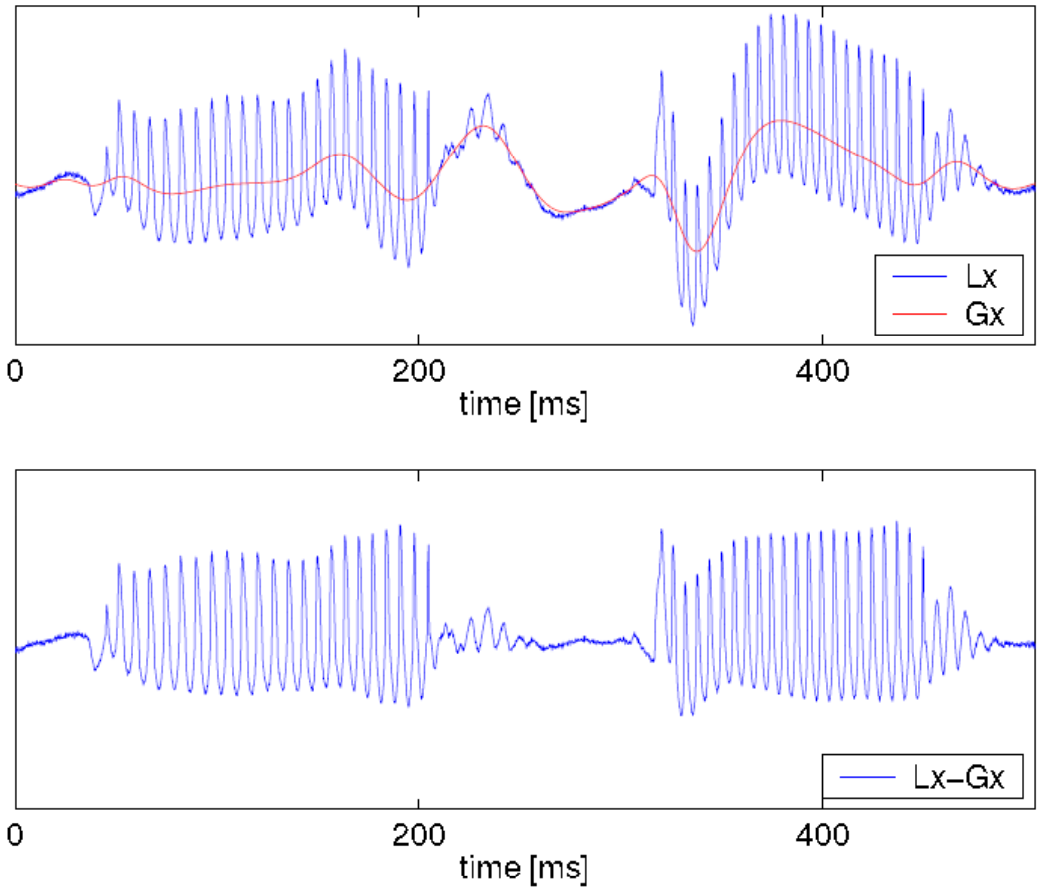
Allows monitoring of both vocal folds vibratory pattern and vertical laryngeal movement (Rothenberg)

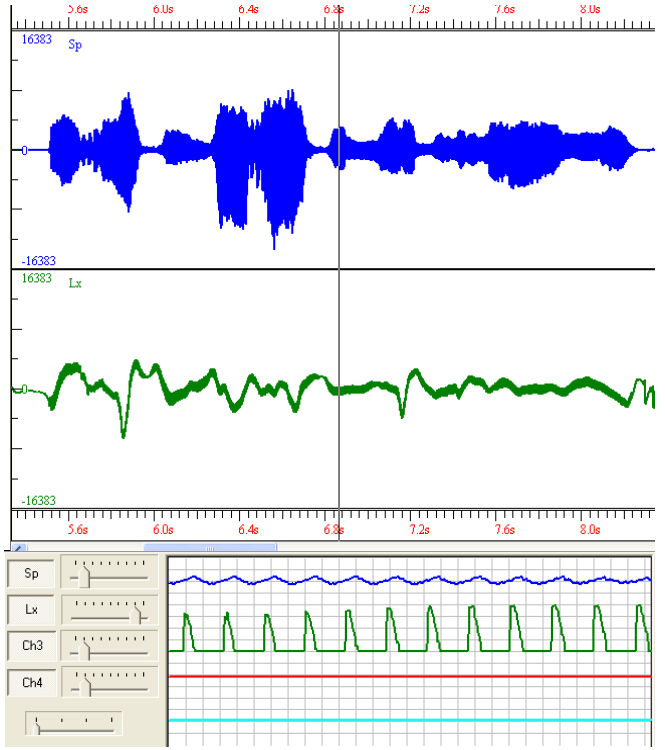
Laryngograph

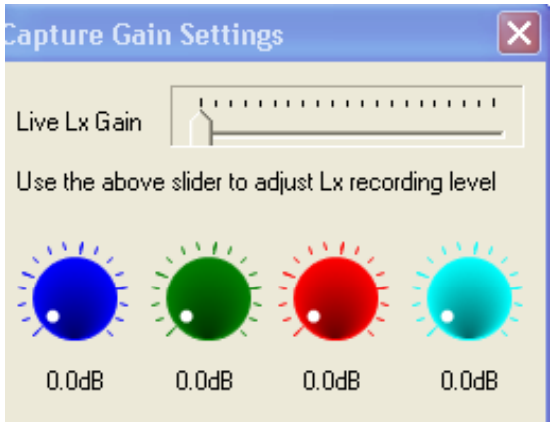
Electrolaryngograph (ELG) (Fourcin, 1974)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING





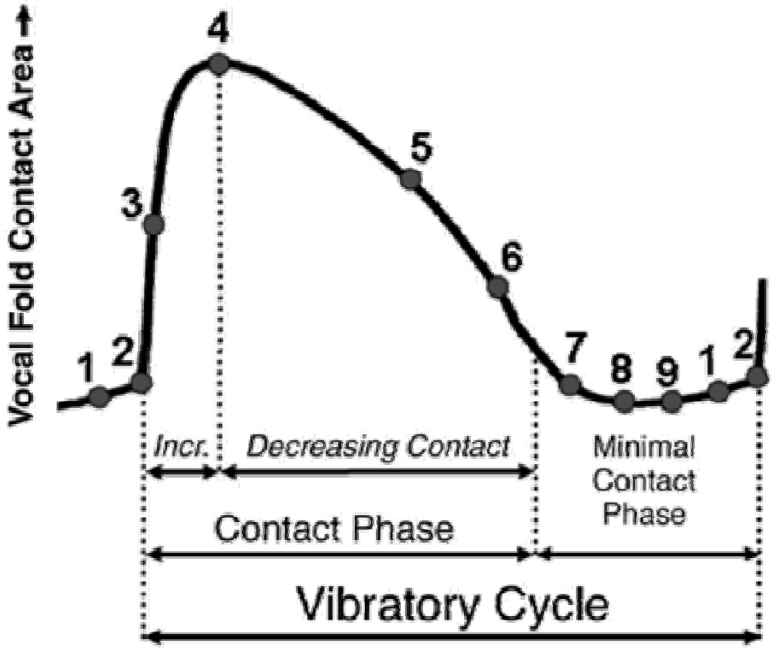


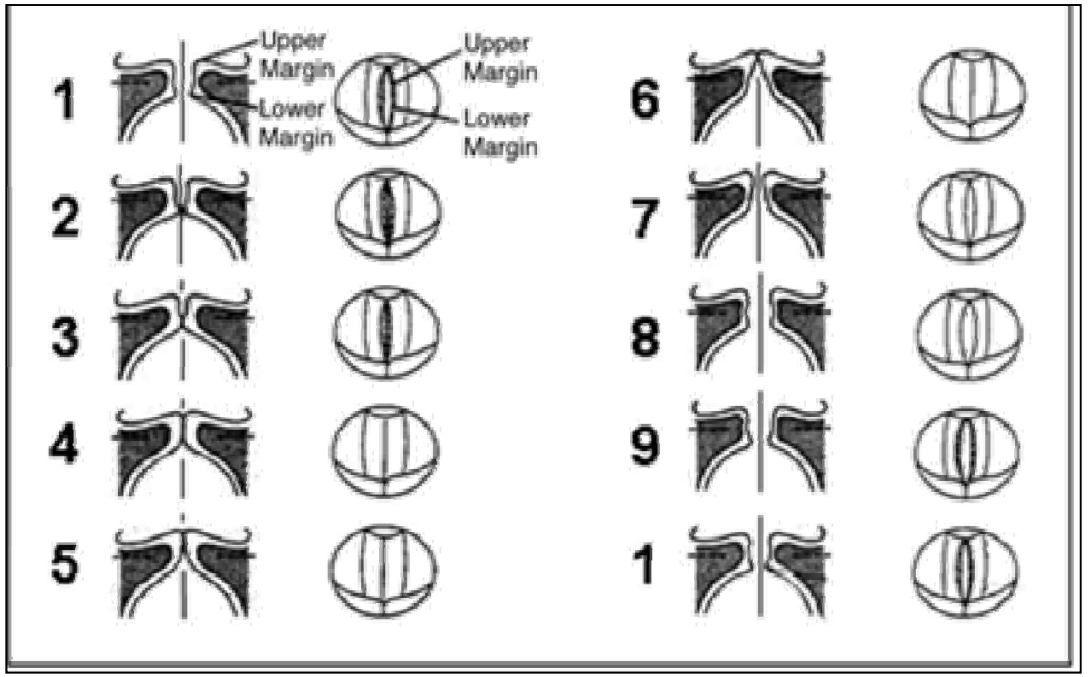
Top: Lx signal as it comes from the laryngograph, plotted along with the Gx signal (estimated using a 22Hz lowpass filter). **Bottom:** the Lx signal after removing the Gx signal (adapted from Menzer (2004) unpublished diploma thesis, Swiss Federal Institute of Technology, Lausanne).

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING

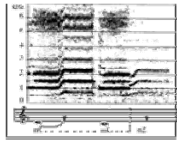
- Points in the ELG/ EGG signal correspond to different physiological events in the vibratory cycle of the vocal folds (e.g. changing registers and modifying phonation types)



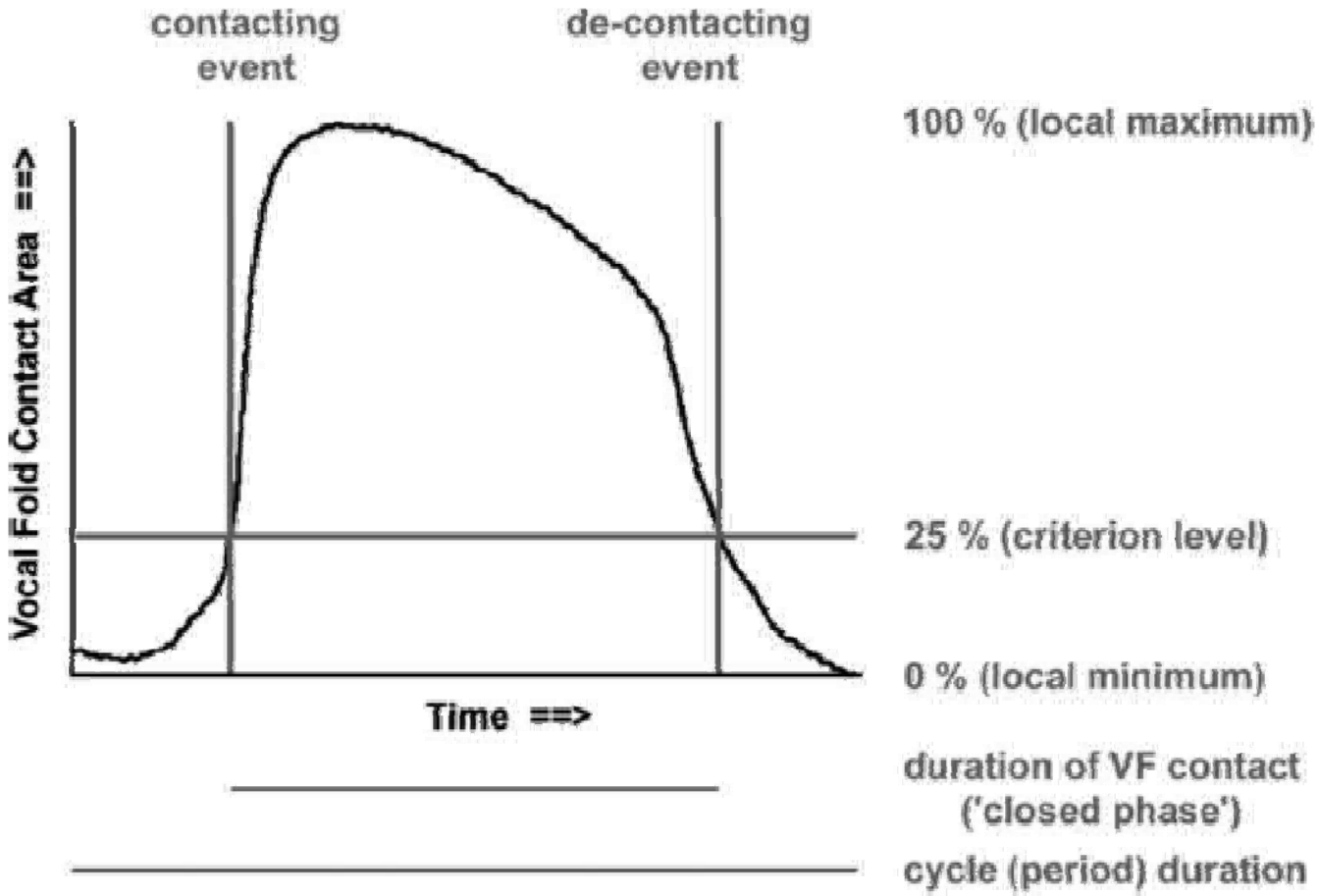


REAL-TIME FEEDBACK

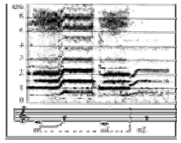
VOICE SOURCE MONITORING



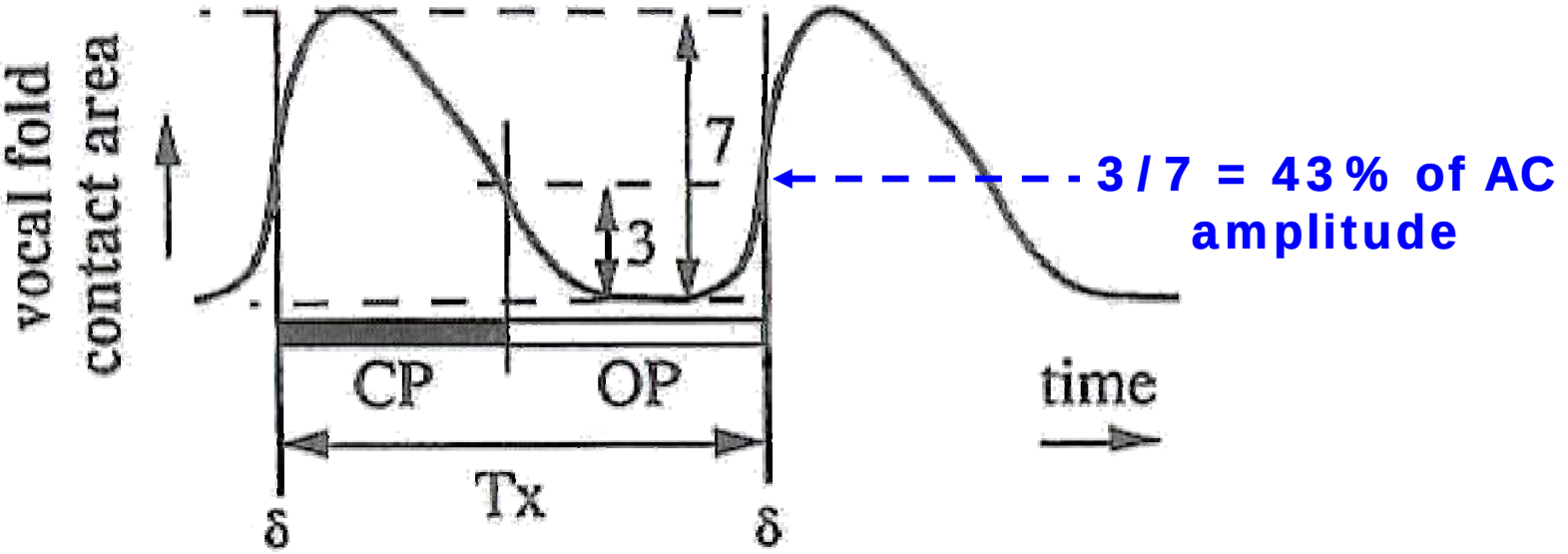
- EGG waveform



Contact and de-contact events, defining the contact quotient from EGG (adapted from Herbst & Ternström, 2006: 127)



- Measures from ELG/ EGG signal

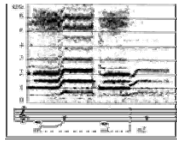


Closed Quotient = [(CP/ Tx) × 100] %

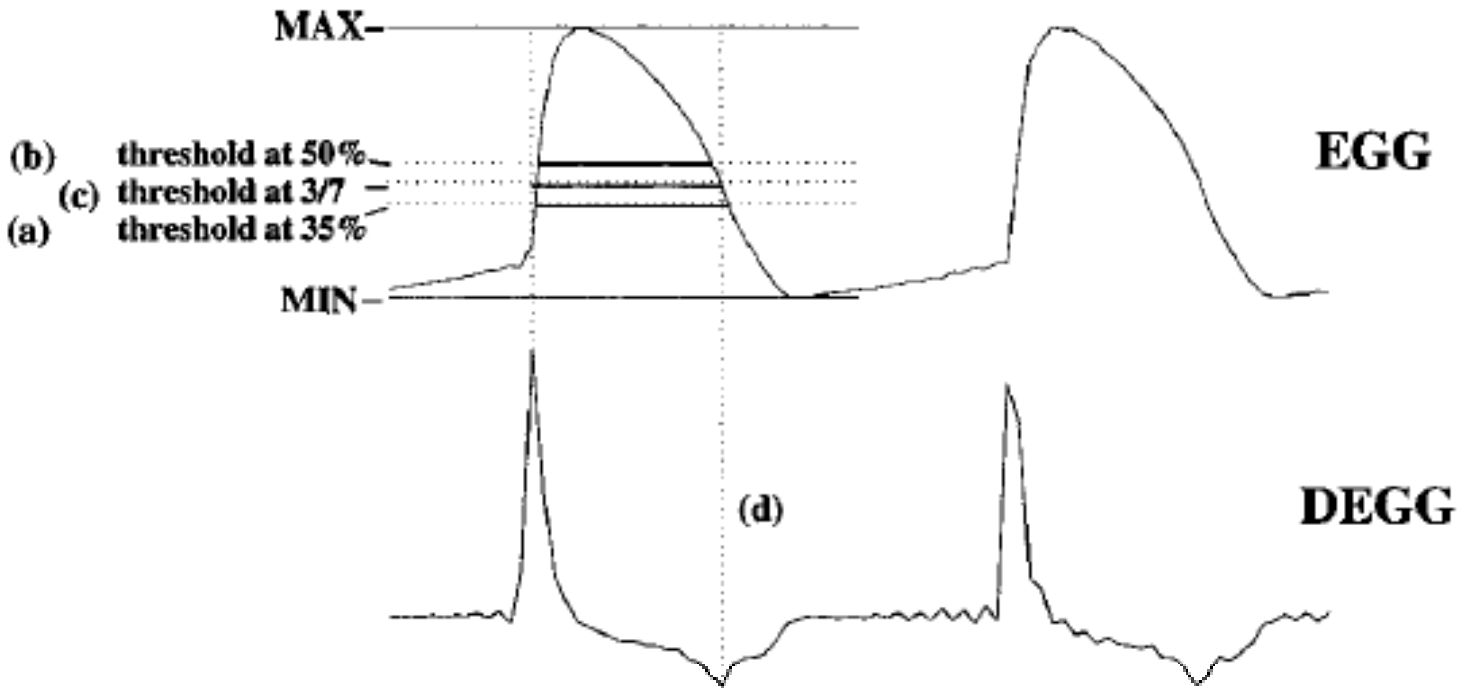
Lx waveform extraction of fundamental period (Tx), closed phase (CP) and open phase (OP). The CP ends when the negative going Lx crosses 3/7 of a cycle's peak-to-peak amplitude (7), and this point is the point at which OP starts (from Howard & Garner, 1992: 376)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



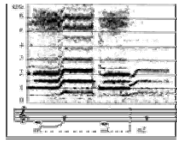
- Measures from ELG/ EGG signal



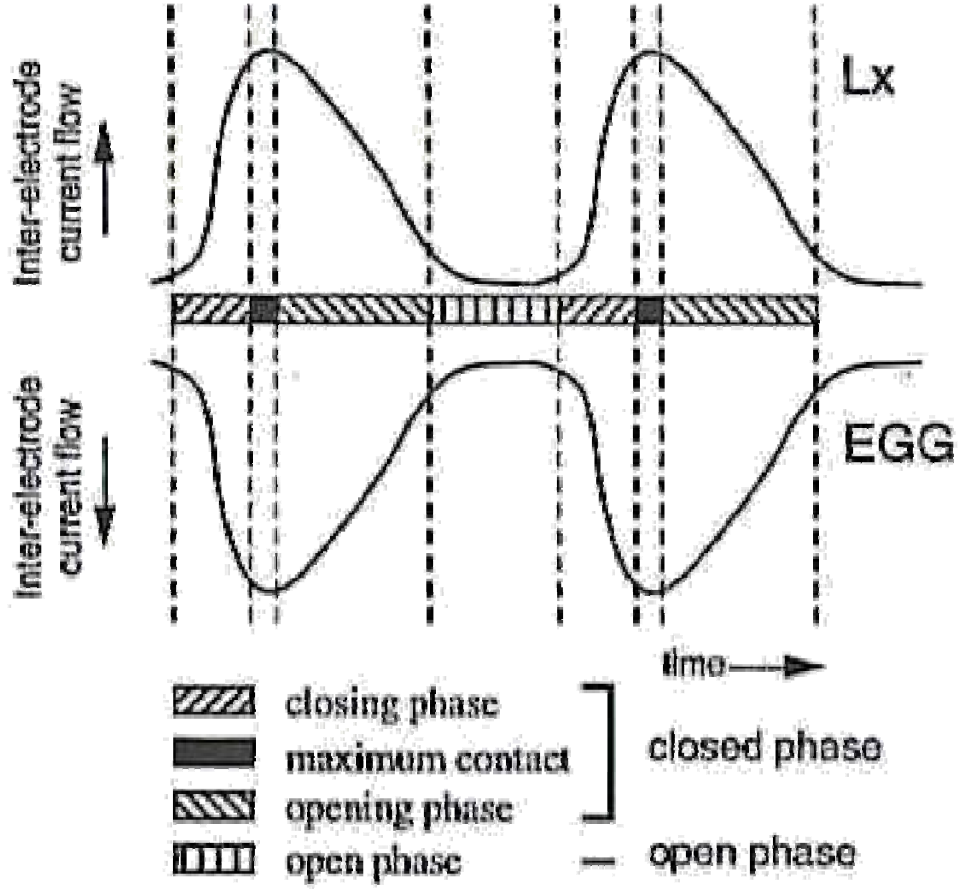
Different methods of extraction of open quotient (or equivalent, closed quotient) and its derivative, from an EGG signal (adapted from Henrich, Doval & Castellengo, 2004: 1323)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



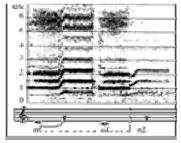
- ELG and EGG waveforms differ



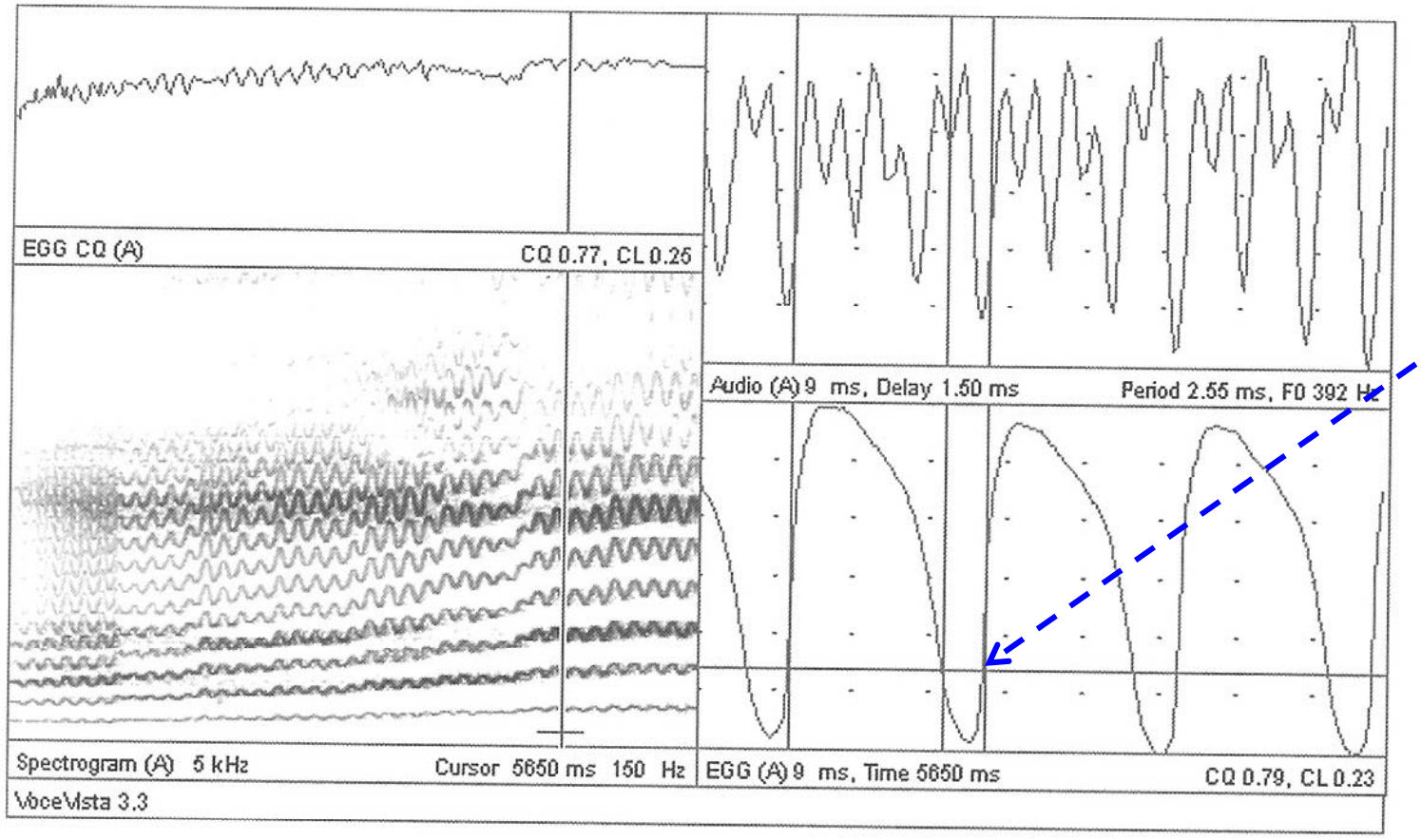
Comparison between Electrolaryngograph (ELG) and Electroglottograph (EGG) waveform outputs (adapted from Howard, 1998: 340)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



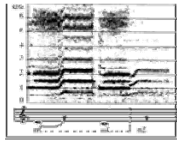
- EGG signal provided by VoceVista



Waveform (top left), Narrow band spectrogram (bottom left), Power-Spectrum (top right) and EGG signal displaied by Voce Vista for a tenor singing na octave scle ut to na A4, on the vowel /a/)

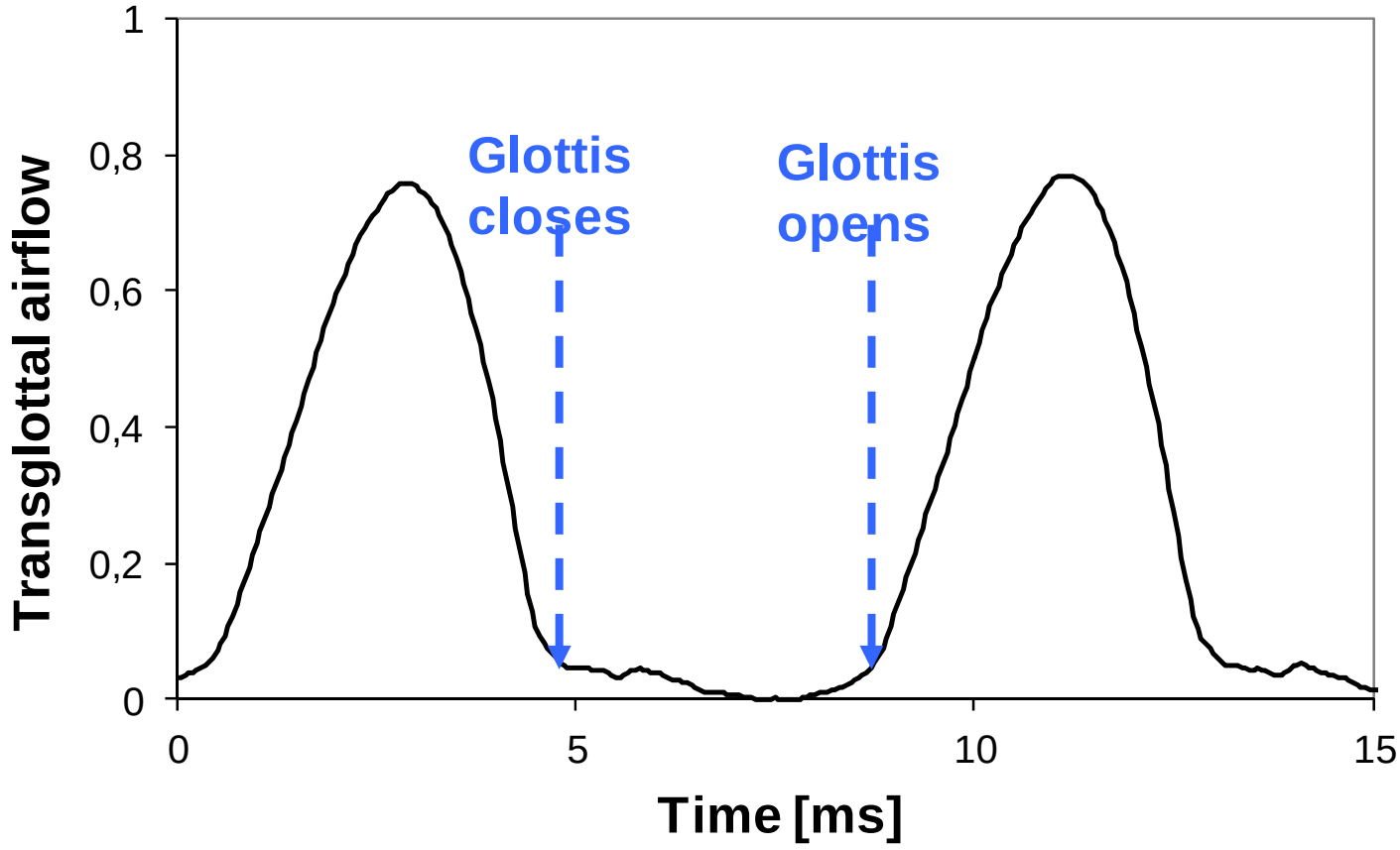
REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



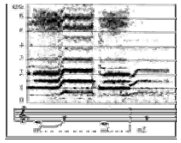
Some considerations

- ELG/ EGG signals amplitude is not directly correlated with vocal intensity



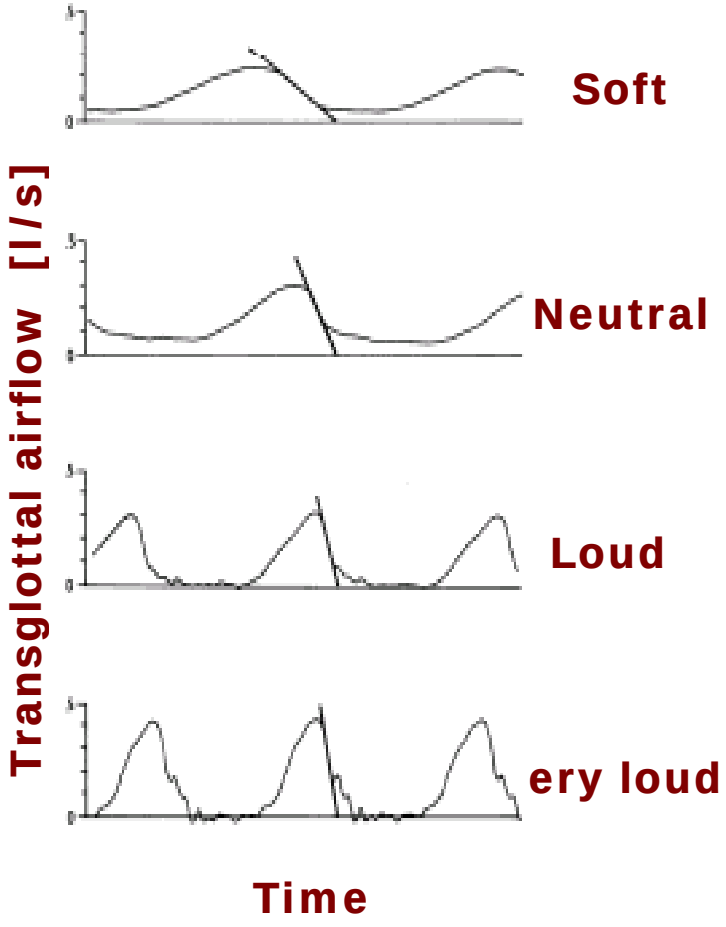
REAL-TIME FEEDBACK

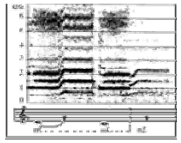
VOICE SOURCE MONITORING



Some considerations

- Real flow glottogram is directly correlated with vocal loudness





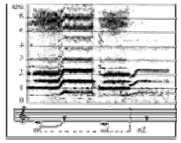
Some considerations

- Difficult to determine exact moment of glottal opening

Transglottal airflow can start, even if the folds are still partly in contact

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



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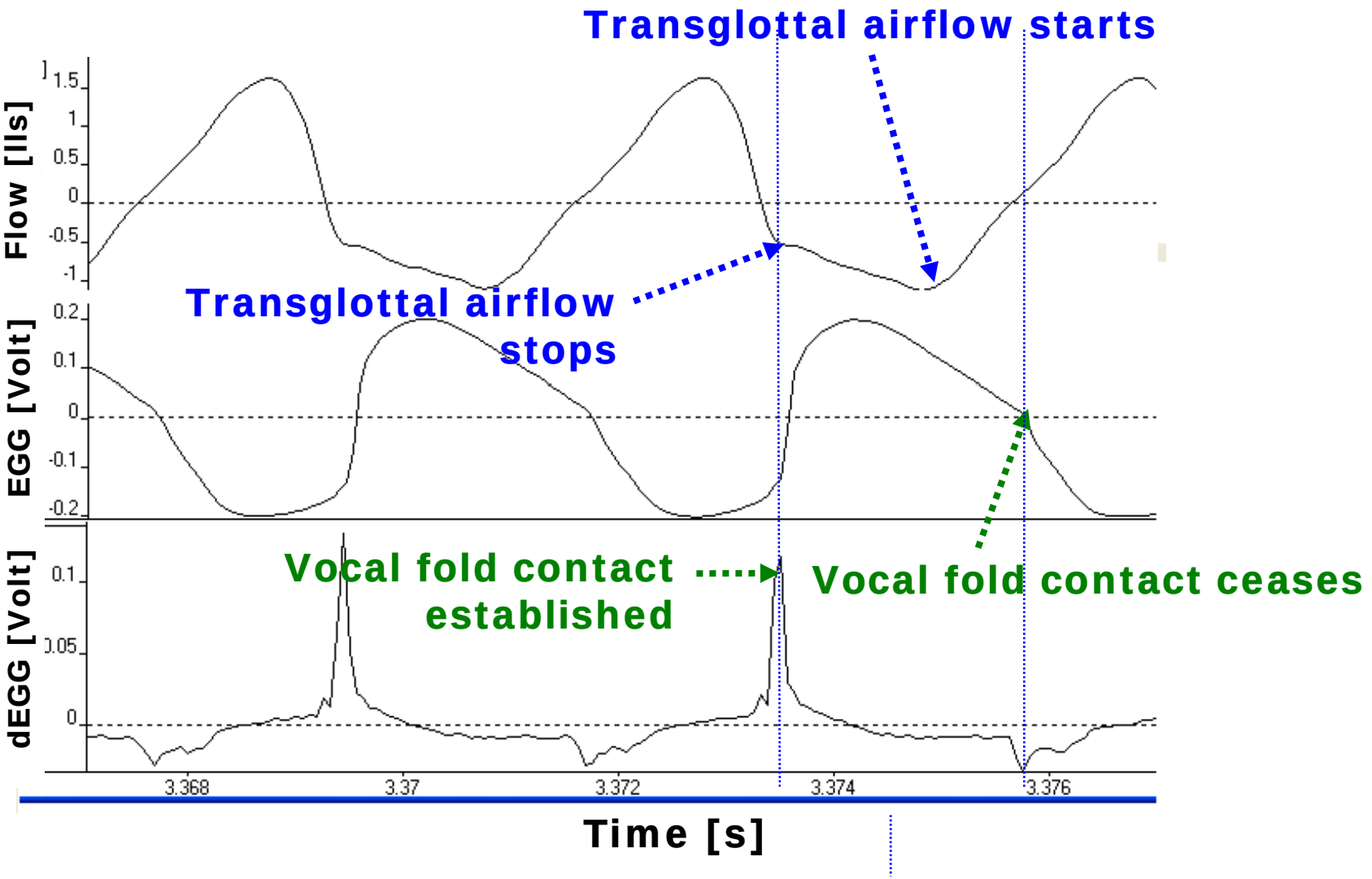
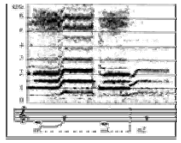
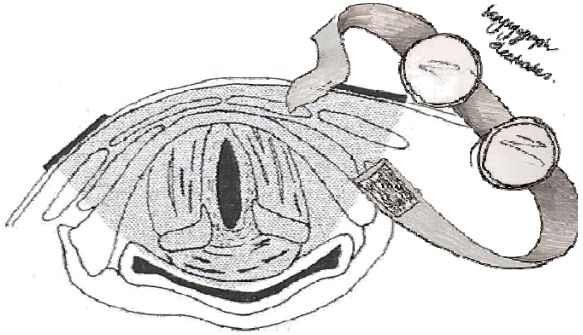




❑ Some considerations

❑ Variations of impedance shown by ELG only represent 1% to 2% of the impedance produced by the vocal folds (Baken, 1987)

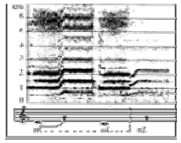


Electric current flow path in the neck (grey shading) between the two electrodes (adapted from Baken, 1992: 100)

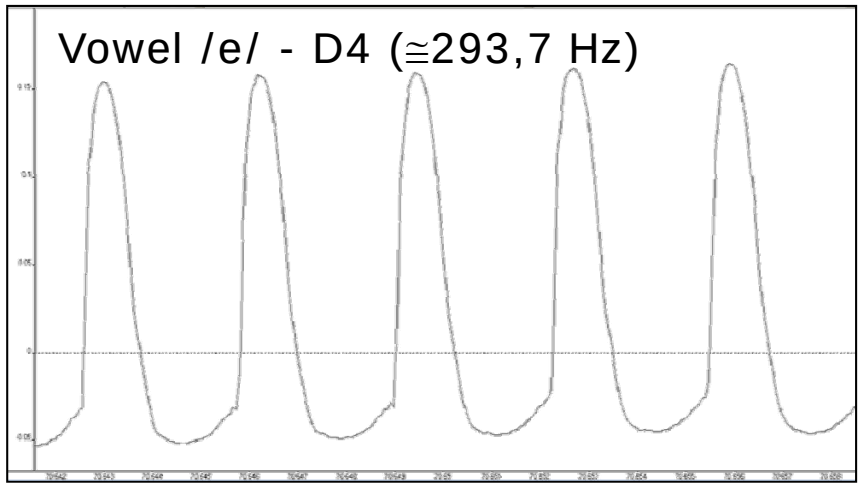
❑ ELG measures not only the transglottal impedance but also the impedance of all neck structures close to the electrodes (Baken, 1992)

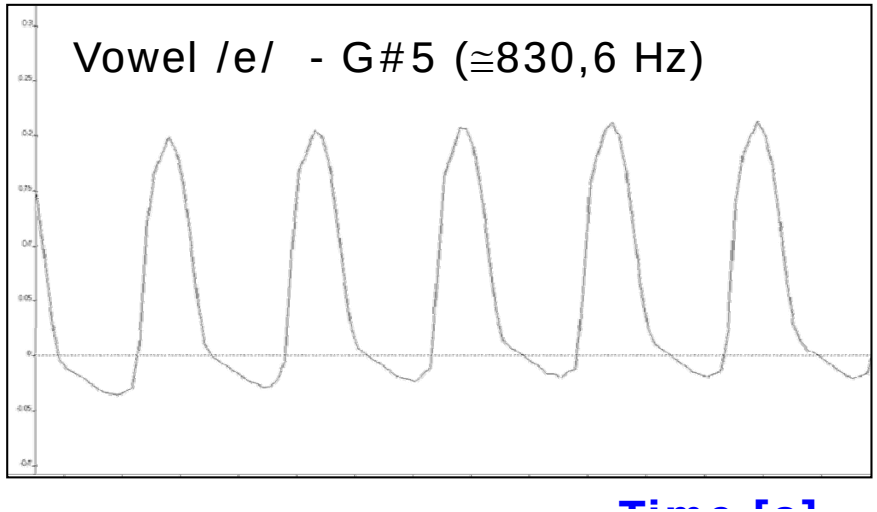
REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



- **ELG / EGG display assists in monitoring different pitches**





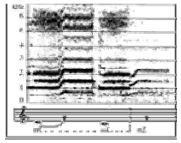
The amount of vibrating mass is different for different pitches

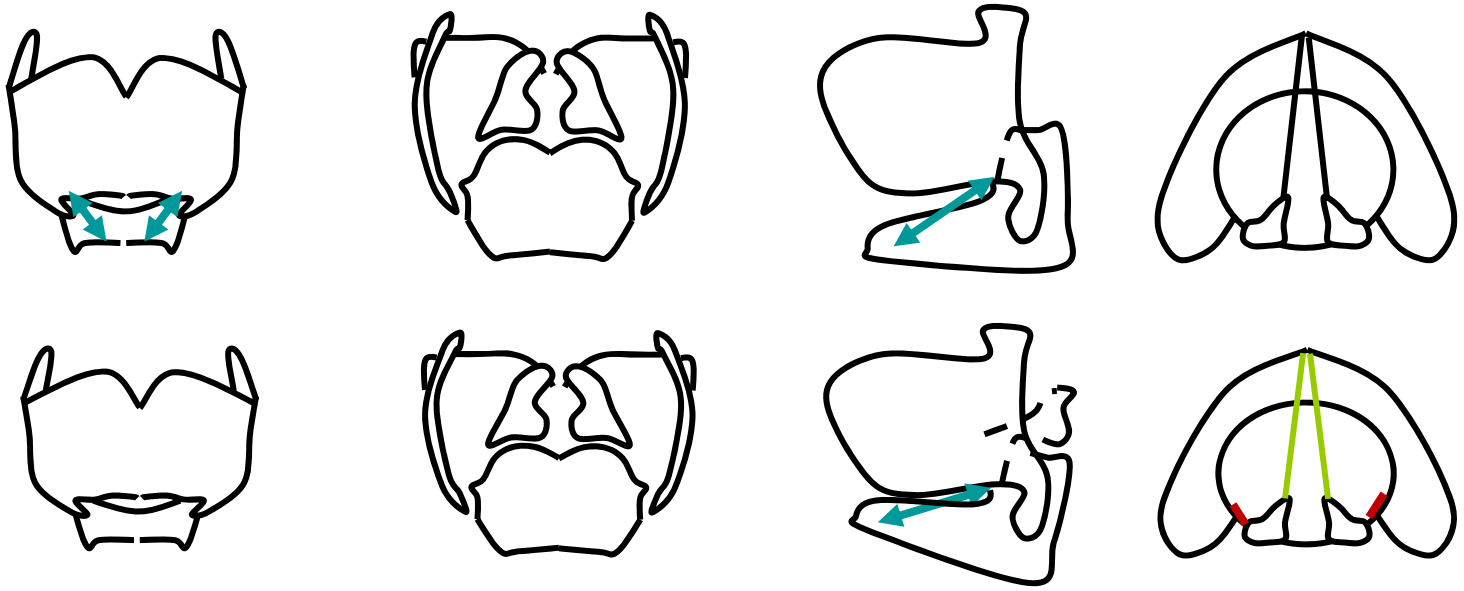
The ELG signal has a different shape

The student visualises different physiological phenomena with changing frequency

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING





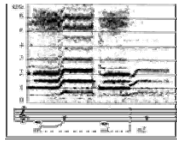
Frontal representation Posterior representation Lateral representation

- **Increasing frequency of phonation**: contraction of the **cricothyroid muscle** tenses longitudinally the vocal fold; contraction of the **lateral cricoarytenoid** muscle further elongates and thins the vocal fold, stiffening the vocal fold edge (Sataloff, 2007)

- **Decreasing frequency of phonation:** contraction of the **thyroarytnoid muscle** shortens and thickens the vocal fold, rounding the vocal fold edge (Sataloff, 2007)

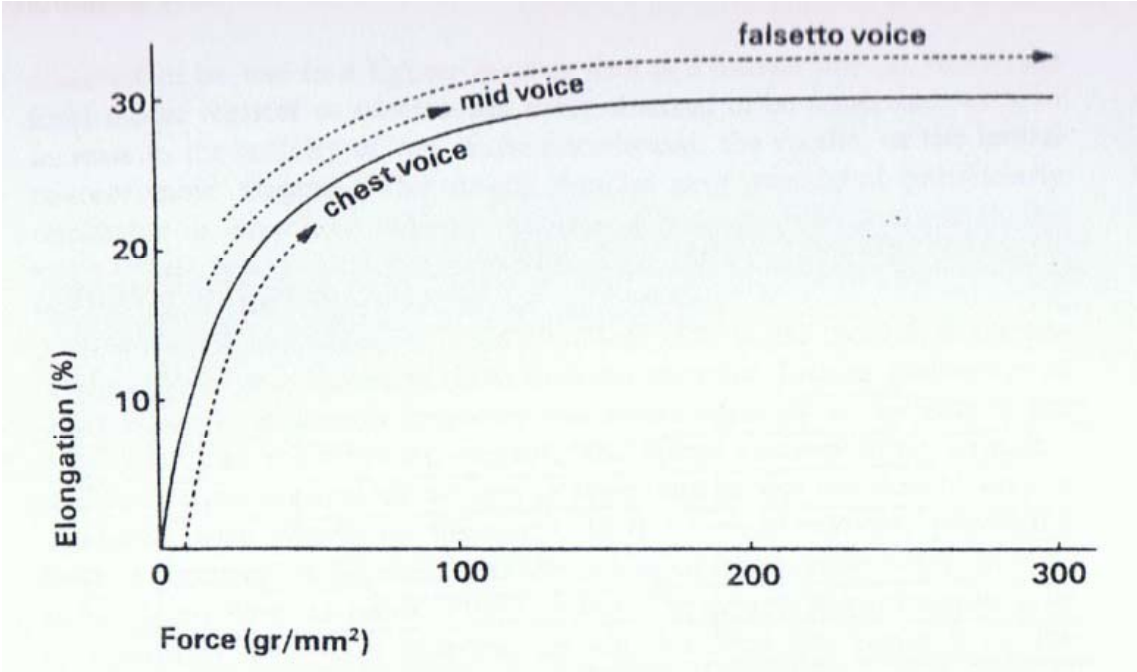
REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



❑ Changes in F0:

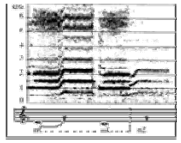
❖ Depend on glottal resistance, air flow, Psub and vocal registers



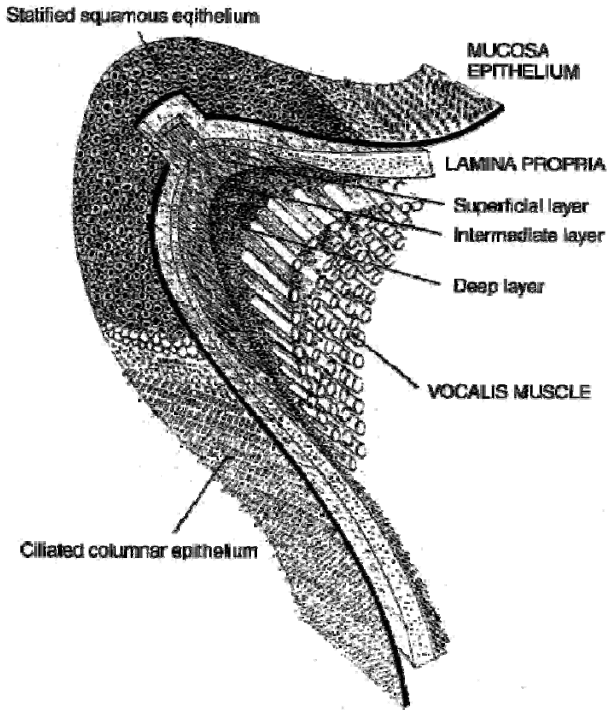
(adapted from Sundberg, 1987)

REAL-TIME FEEDBACK

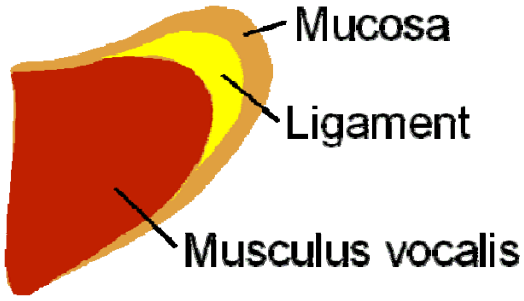
VOICE SOURCE MONITORING



❑ Changes in F0:



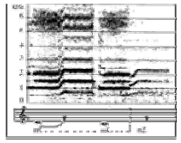
Tissues of the vocal folds (adpated from Maragos, 2008)



Vibratory motion in different frequencies (adapted from en.wikipedia.org/wiki/Chest_voice [in 20/07/09; 15:26])

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



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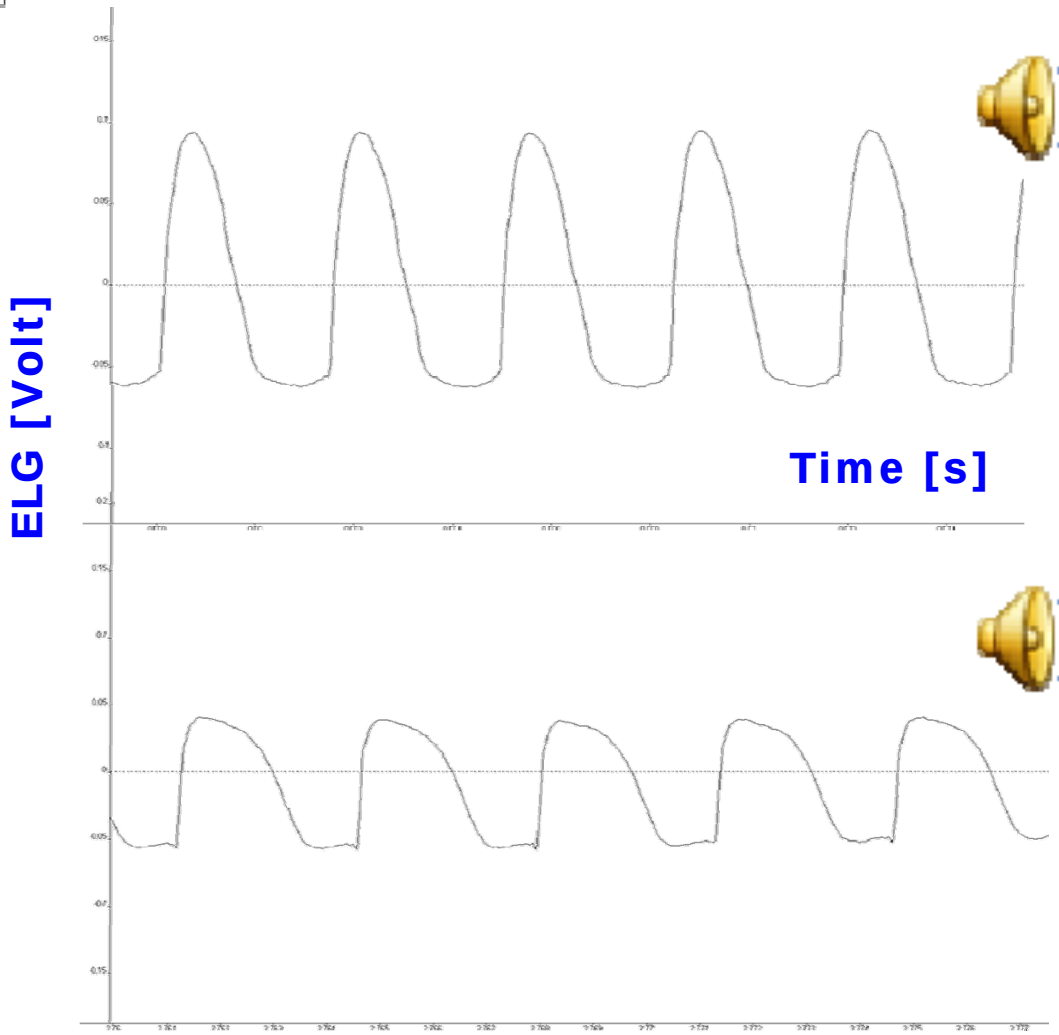
- **ELG / EGG display assist in monitoring registers**



Female middle register
- vowel /a/
(D4= 294Hz)

Female chest register
- vowel /a/
(D4= 294Hz)

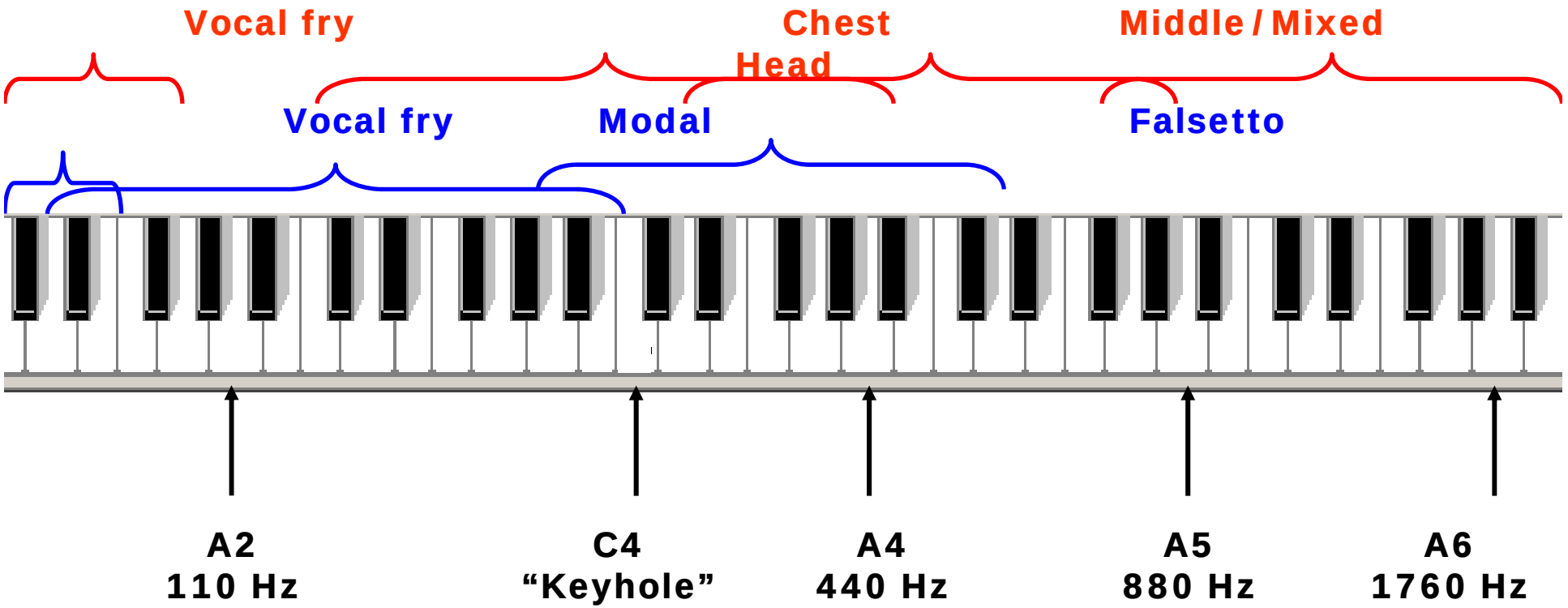
REAL-TIME FEEDBACK

VOICE SOURCE MONITORING

At least three registers, each with its own typical pitch range

(Courtesy of Prof. Sundberg, 2009: Summer course)

	Females	Males
	Hz	Hz
Falsetto:	*300 - ?*	*250 - ?*
Modal:	*150 – 500*	*80 - 400*
Vocal fry:	*? – 100*	*? - 100*



REAL-TIME FEEDBACK

VOICE SOURCE MONITORING

universidade de aveiro
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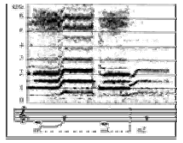


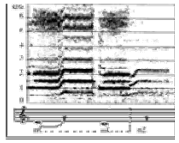
❑ ELG / EGG display assist in monitoring registers

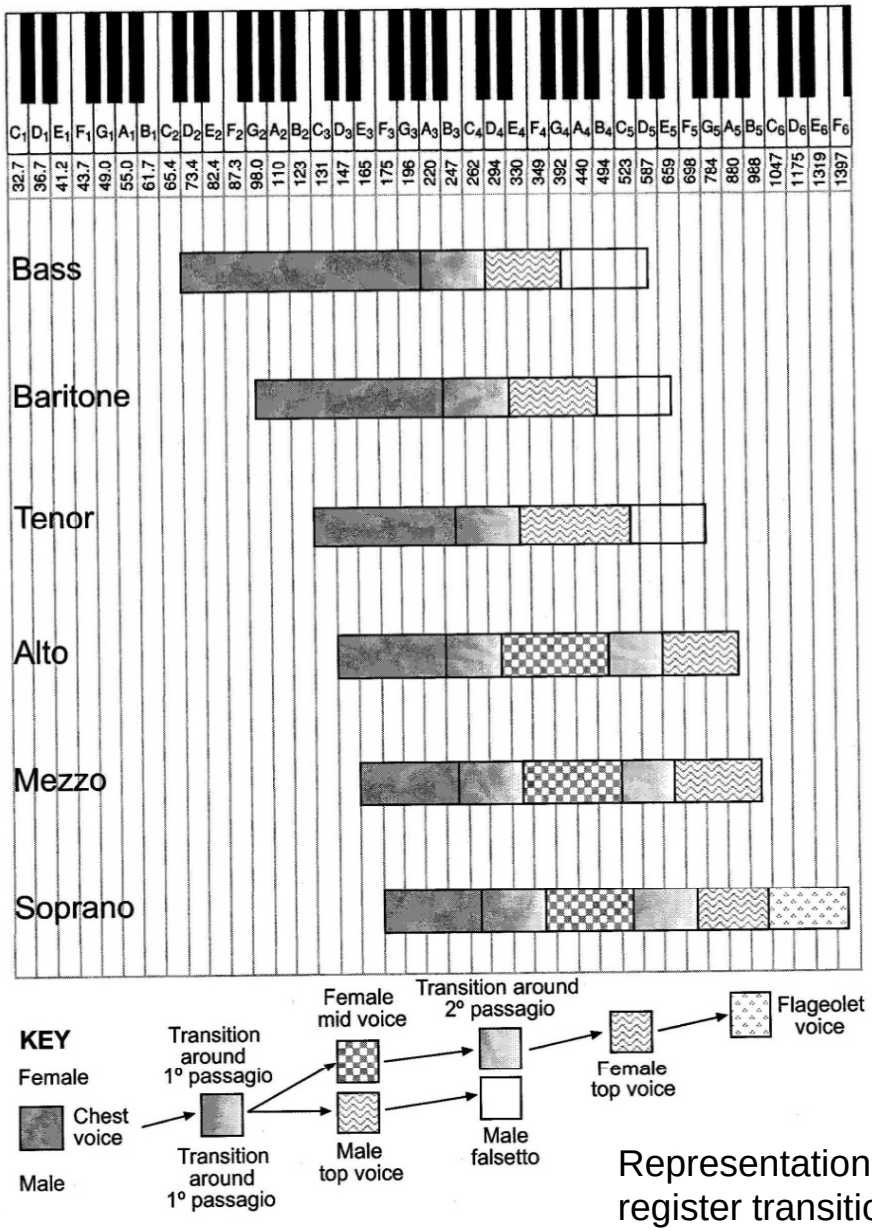
MECANISMS			
M0	M1	M2	M3
Fry	Modal	Falsetto	Whistle
Pulse	Normal	Head (M)	Flageolet
Strobass	Chest	Loft	Flute
Voix de Contrebasse	Heavy	Light	Sifflet
	Thick	Thin	
	Voix mixte (H)	Voix mixte (M)	
	Mixed (H)	Mixed (M)	
	Voce finta (H)		
	Head operatic (H)		

(adapted from Roubeau, Henrich & Castellengo, 2007)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



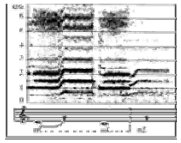


- **Register transitions assist teachers in classifying the student's voice and guide on repertoire choice**

Representation of vocal ranges registers and register transitions (adapted from Nair, 1999: 171)

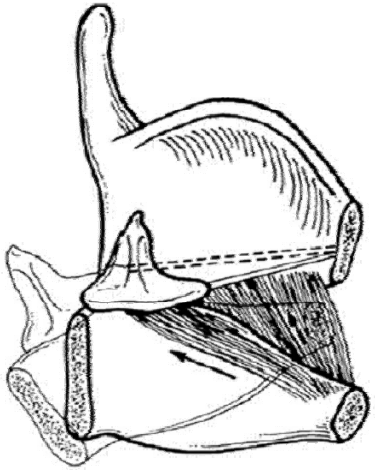
REAL-TIME FEEDBACK

VOICE SOURCE MONITORING

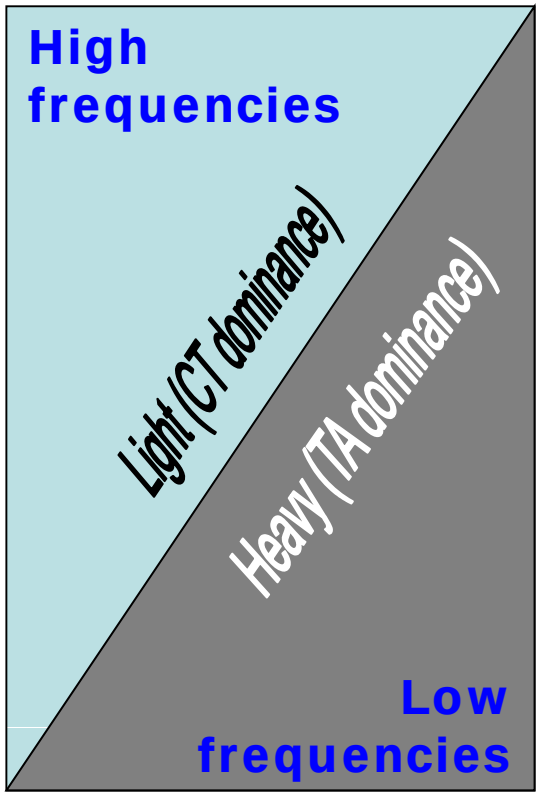


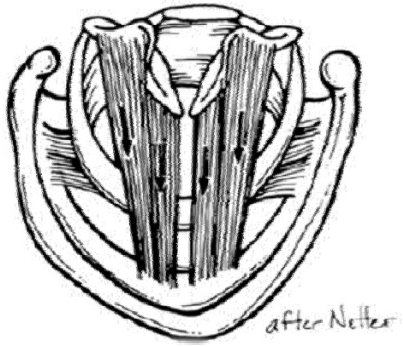
❑ ELG / EGG display assist in monitoring register transitions

❖ approximately continuous transition from TA dominance to CT dominance (old ideal model)



Action of cricothyroid muscle
(adapted from Sataloff et al., 2007)

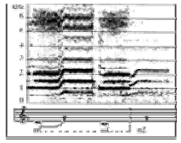




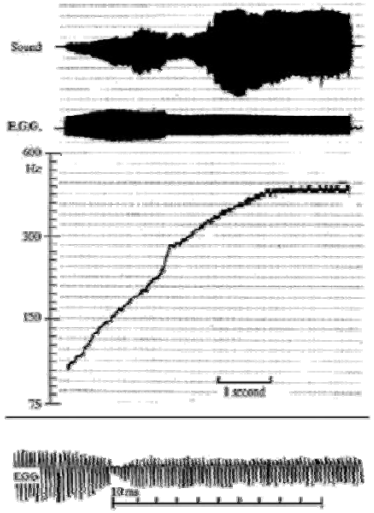
Action of vocalis and thyroarytenoid muscles
(adapted from Sataloff et al., 2007)

REAL-TIME FEEDBACK

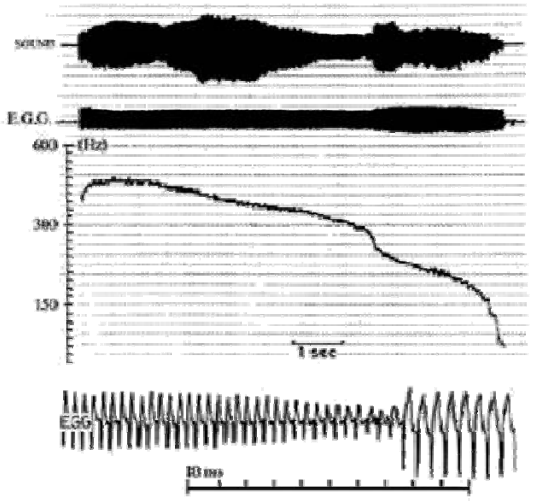
VOICE SOURCE MONITORING



❑ Register breaks are associated with:



Differences in audio, EGG and F0 displays for a male voice during the performance of an ascending glissando (adapted from Roubeau, Henrich & Castellengo, 2007)

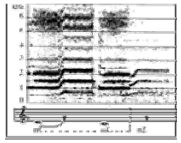


Differences in audio, EGG and F0 displays for a male voice during the performance of a descending glissando (adapted from Roubeau, Henrich & Castellengo, 2007)

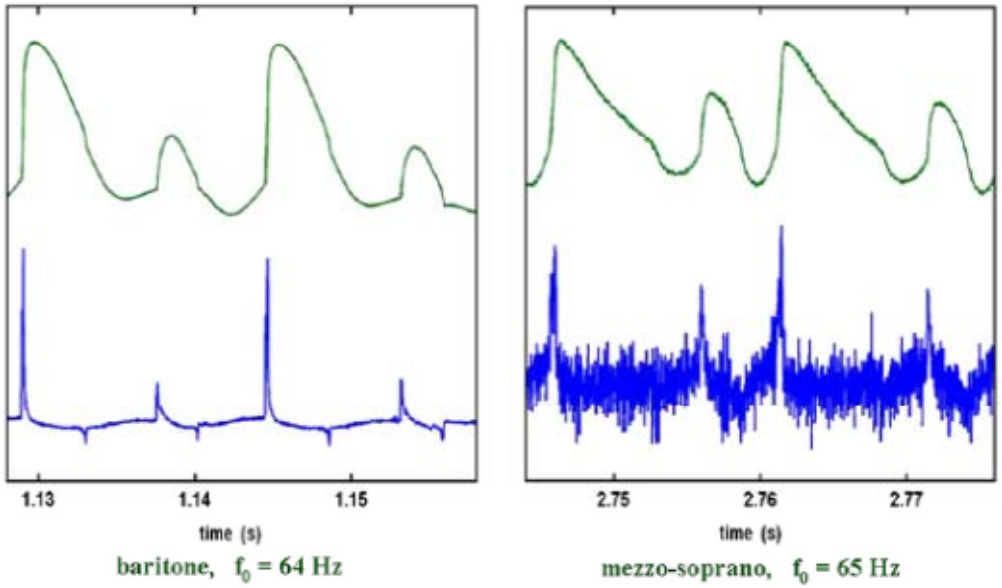
- an increase/ decrease of F0
- a reduction in ELG/ EGG signal amplitude (there is less contact between the vocal folds dues to a reduction of the number of mucosal laryers set into vibration)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



❑ Vocal fry (M0):



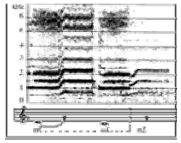
EGG and dEGG signals for vocal fry (M0), during 2 vibratory cycles of a baritone (left) and a mezzo soprano (right) (adapted from Roubeau, Henrich & Castellengo, 2007)

- the vocal folds are short
- there are more mucosal tissue layers involved in phonation
- the duration of the closing phase is high in relation to the total time of the vibratory cycle
- there is aperiodicity in the vibration of the vocal folds

Ingressive vocal fry can be used to assist the student in producing the correct vocal tract shape for a given vowel

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



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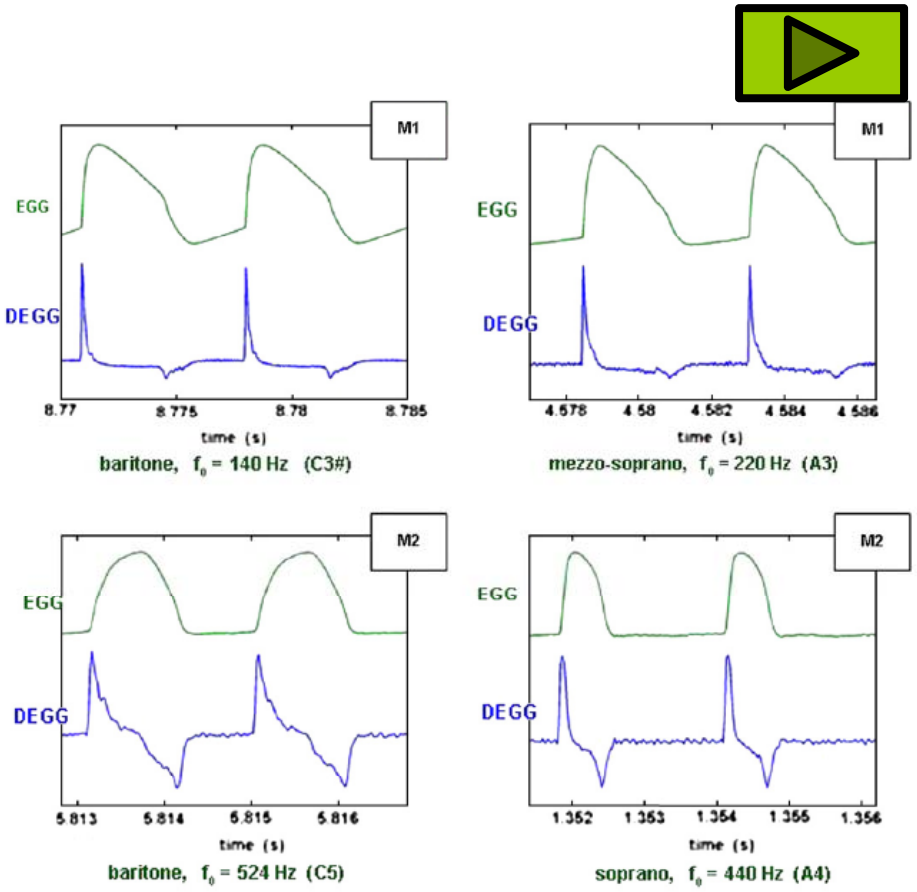
❑ Modal (M1) and falsetto (M2) voice:

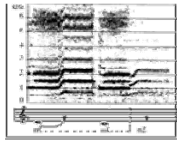


EGG and dEGG signals for modal (M1) and falsetoo (M2), during 2 vibratory cycles of a baritone (left) and a mezzo soprano (right) (adapted from Roubeau, Henrich & Castellengo, 2007)

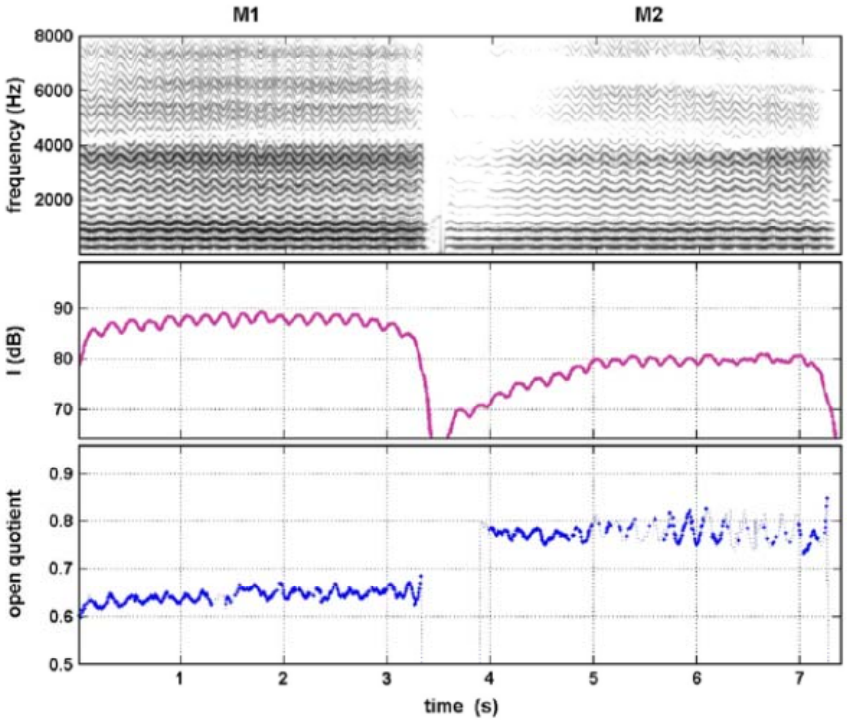
- Modal voice (M1) presents a high amplitude of vibration, higher than for fasetto voice (M2)
- Modal voice the contacting phase is longer and the conctacting quicker than for fasletto voice (M2)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



❑ Modal (M1) and falsetto (M2) voice:



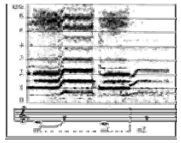
Relationship between registers (M1 y M2) and open quotient for D4 sung by a counter-tenor, first in M1 and secondly in M2 (adapted from Roubeau, Henrich & Castellengo, 2007)

❖ In M1, the opening quotient is smaller than in M2, for a same F0

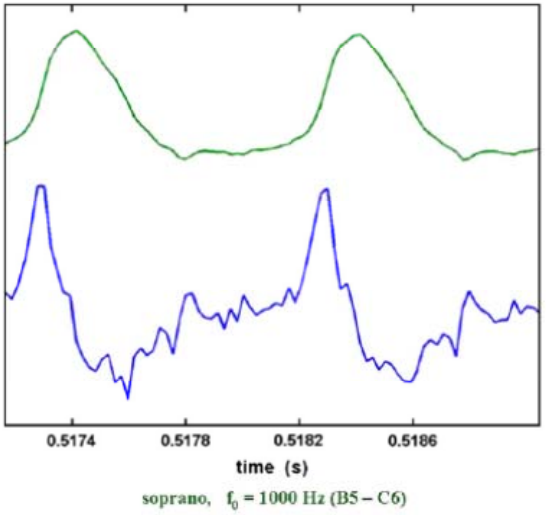
Example in changing M1 and M2 for a tenor singing D4 with an /a/ vowel (adapted from Castellengo, 2002)

REAL-TIME FEEDBACK

VOICE SOURCE MONITORING



❑ Whistle (M3) voice:



EGG and dEGG signals for whistle (M3), during 2 vibratory cycles of a soprano (adapted from Roubeau, Henrich & Castellengo, 2007)

- The vocal folds are extremelly enlogated and tense, so that the vibrating layer is very thin
- the glottal opening is extremely reduced
- It is possible that there is no contact of the vocal folds