Διεπιστημονικές προσεγγίσεις των φωνητικών ιδιωμάτων στο τραγούδι με νέες τεχνολογίες

Interdisciplinary Approaches to Vocal Styles in Singing with New Technologies

Evangelos Angelakis

Singer, Singing Teacher MSc, PhD, PostDoc Researcher - UoA

Painting by Debra Hurd : http://debrahurd.blogspot.gr/

Laboratory of Music Acoustics and Technology
Music Studies Department, University of Athens, Greece

Athens 2025

«Singing is so much more than making a sound; it truly is a science. One who wishes to pursue it as a career must fully devote themselves to the study of the voice as a mechanism as well as its history and its place in music.»

(Bennett, 2017, p. 11)

1

SOUND PRINCIPLES

Our Voice and Sound

The human voice is:

A Natural Function of the Human Body

Primal Sound Production (sigh, laughter, cry)

Reflexive Vocal Reactions to External Stimuli (pain, fright)

Spontaneous Sound Production due to Intense Body Action (weight lifting, attack)

Emotion Expression (non verbal sounds-vocalizations)

Singing

Communication - Language

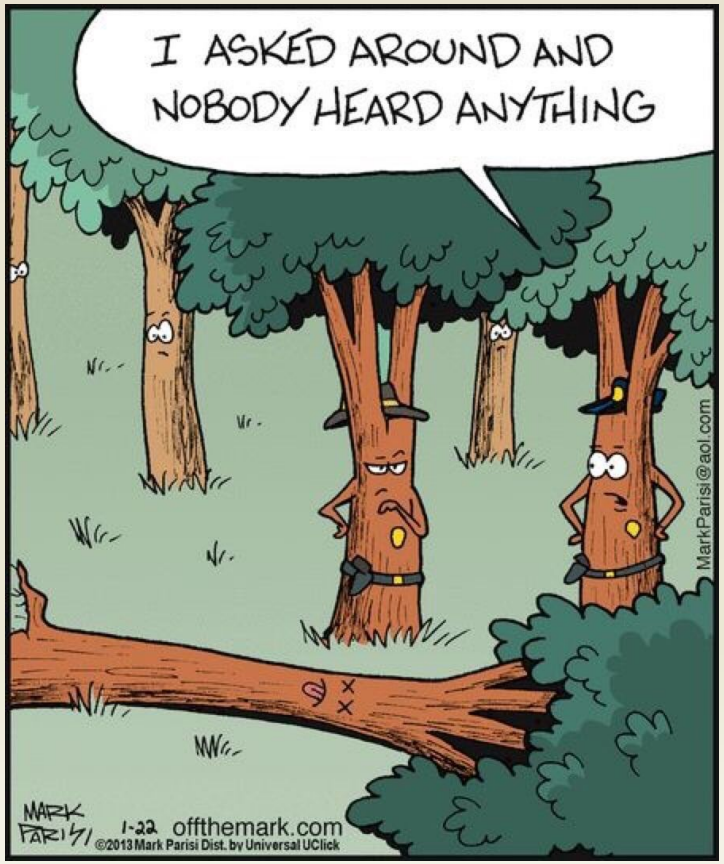
Art (music-theatre-poetry)

The Voice is Sound

What is Sound:

A tree falls in the forest and no-one is there to hear it

Does it make sound?

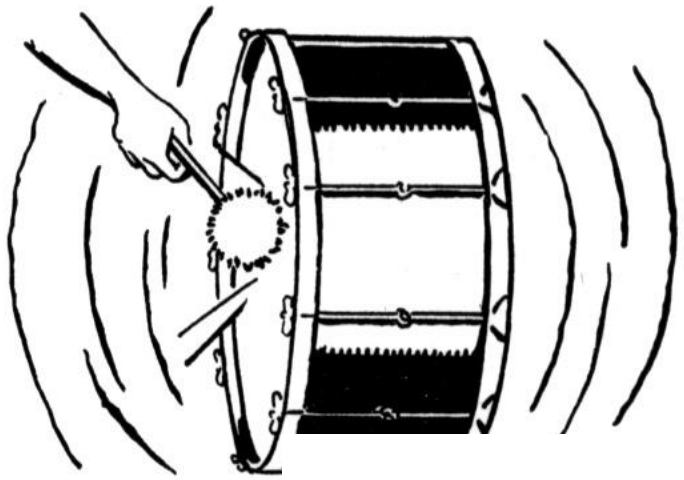


Yes!

It makes the same sound as when somebody is there to listen to it.

No!

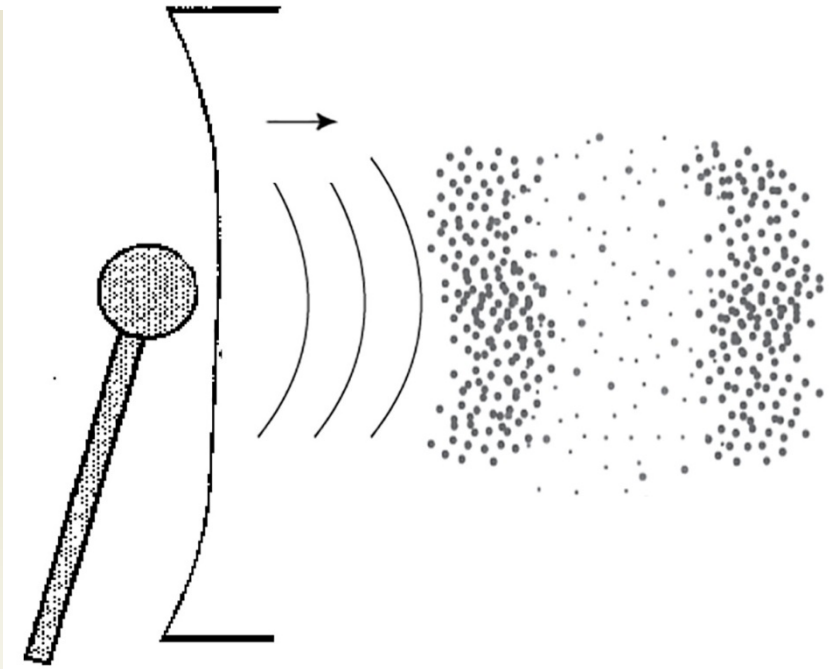
Sound is the sensation that is produced in the nervous system when the ear drum is oscillated by air molecules movement.

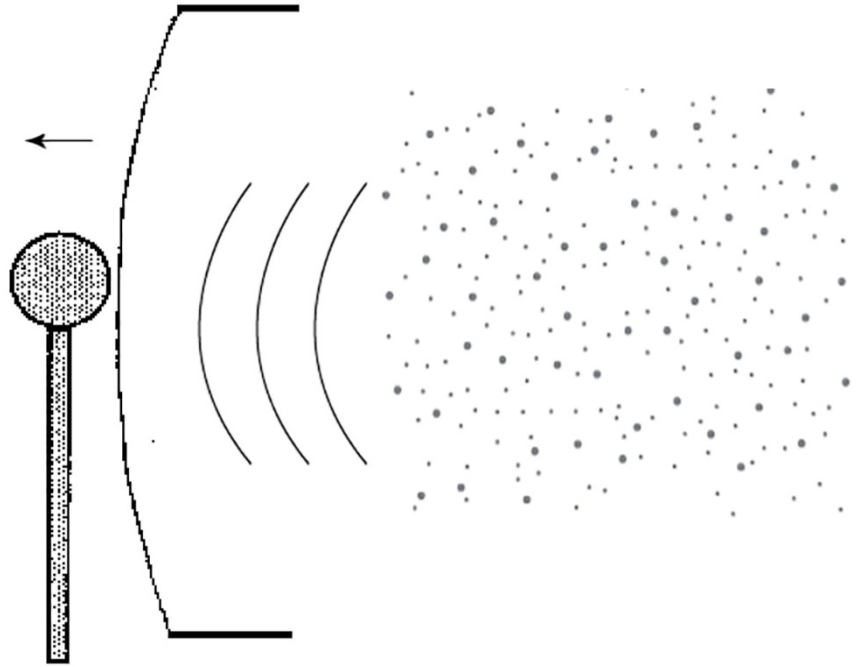


How is sound produced?

Sound needs movement(oscillation)!

It also needs…





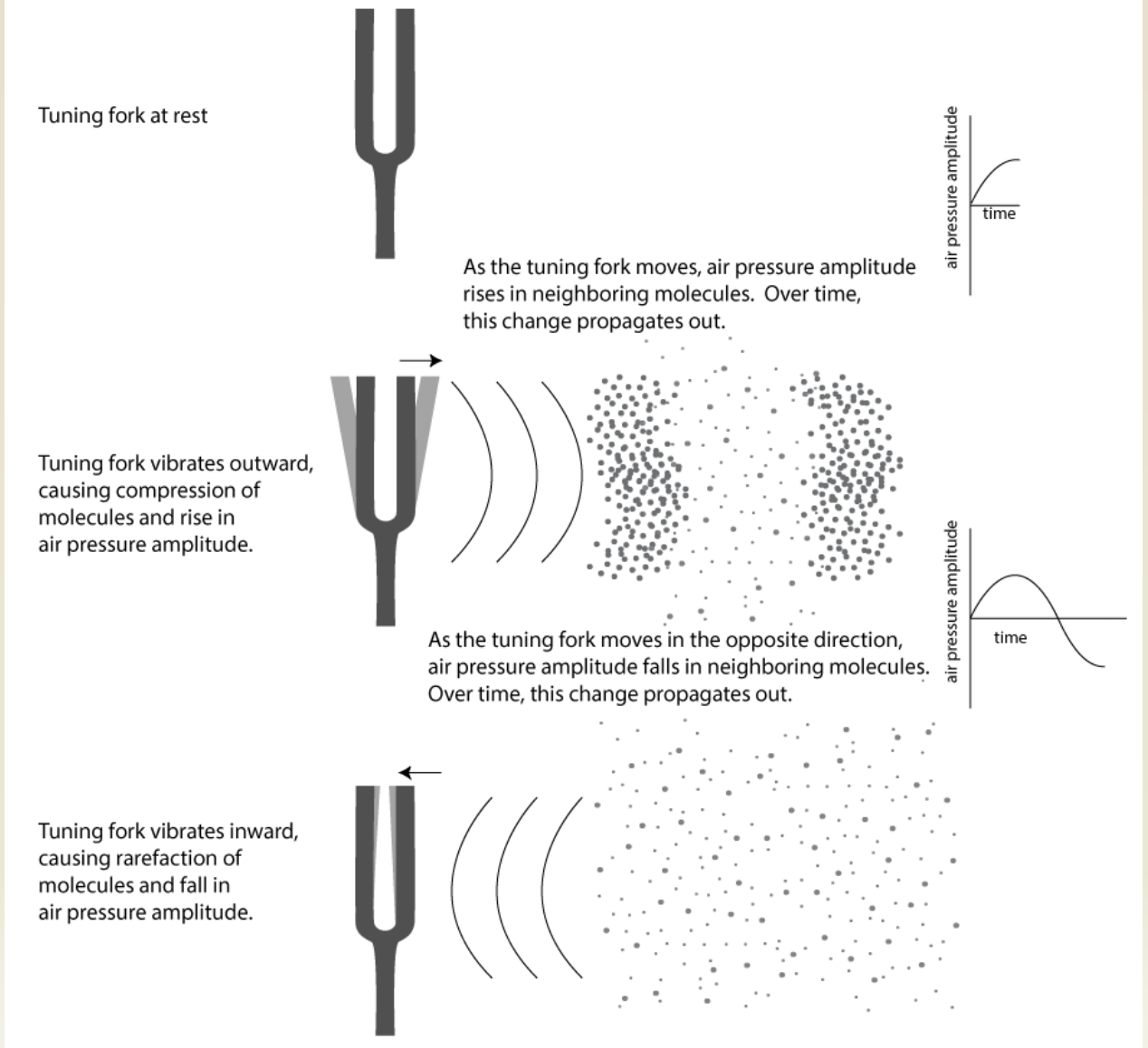
Sound needs a transfer medium (such as air):

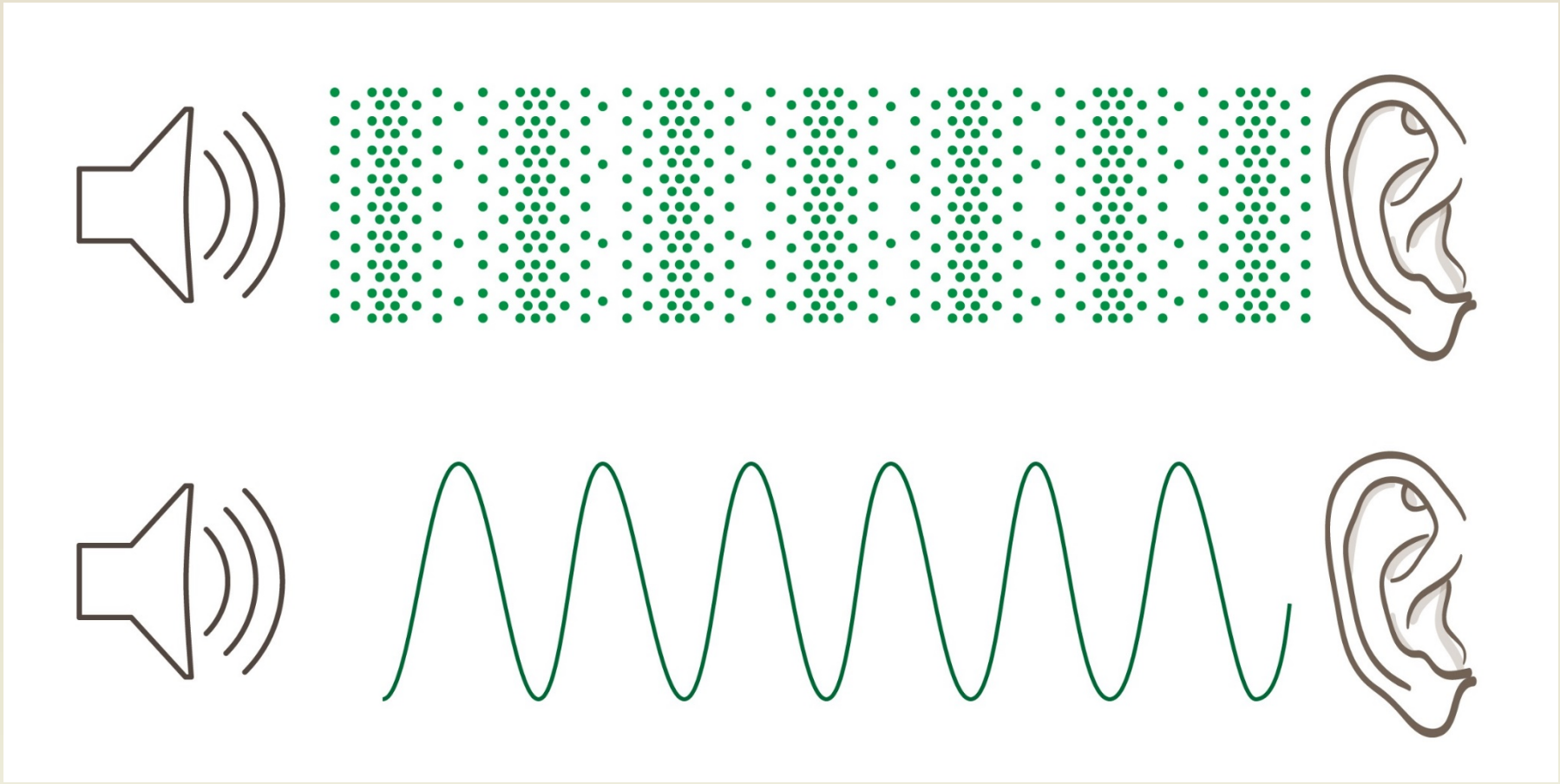
In space

there is only vacum,

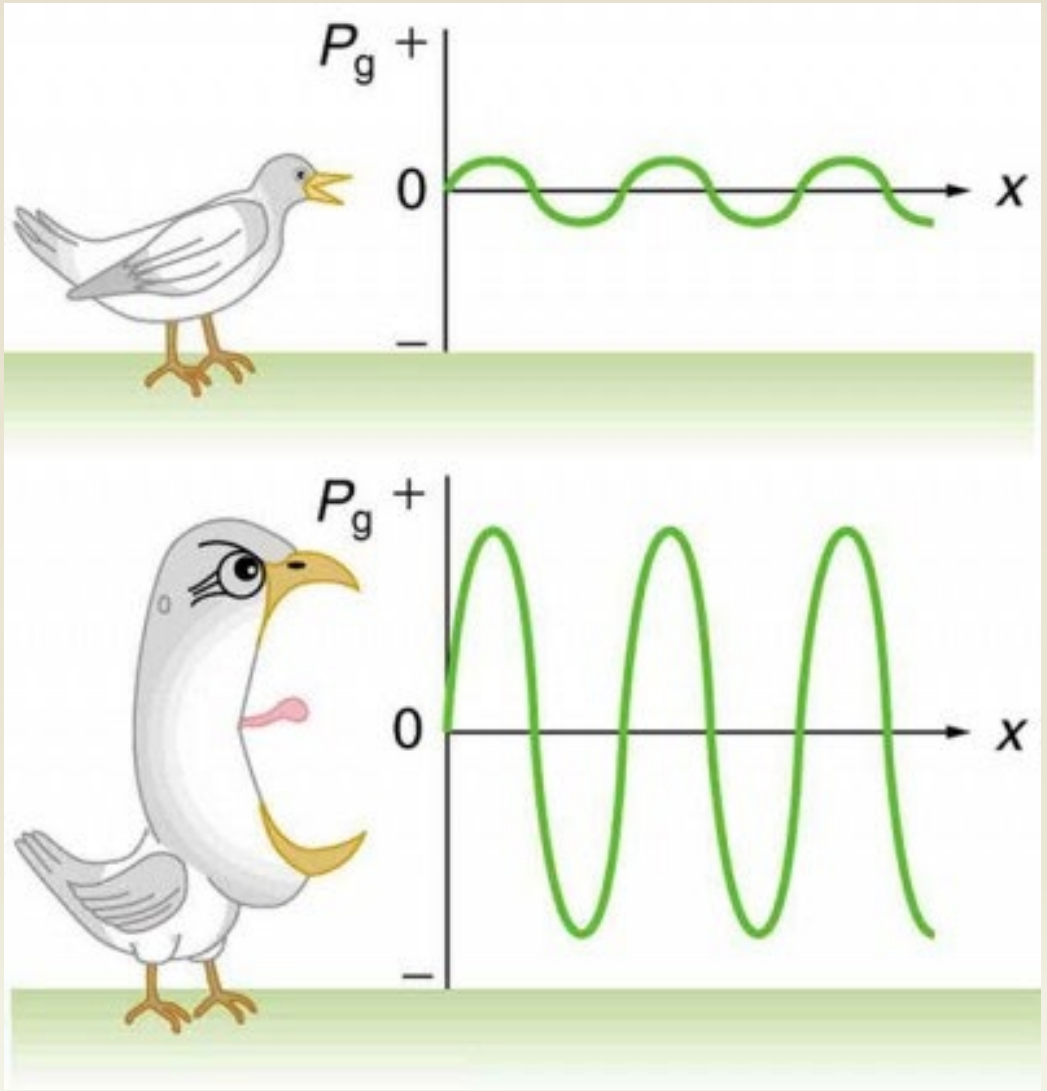
so there can be

No Sound!

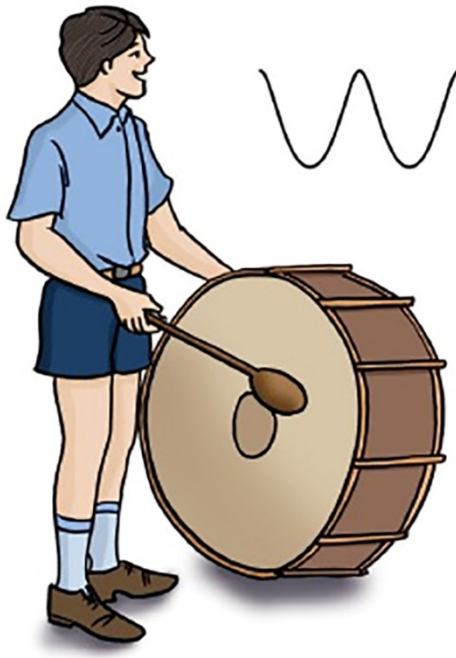

Tuning fork at rest
air pressure amplitude
time
As the tuning fork moves, air pressure amplitude rises in neighboring molecules. Over time, this change propagates out.
Tuning fork vibrates outward, causing compression of molecules and rise in air pressure amplitude.
air pressure amplitude
time
As the tuning fork moves in the opposite direction, air pressure amplitude falls in neighboring molecules. Over time, this change propagates out.
Tuning fork vibrates inward, causing rarefaction of molecules and fall in air pressure amplitude.



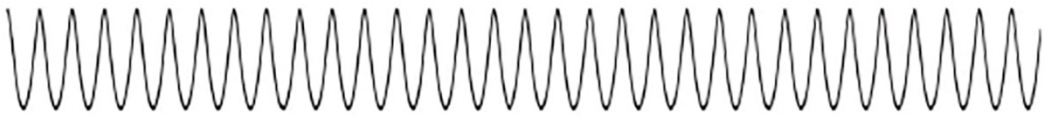
Sound Wave Amplitude (loudness)



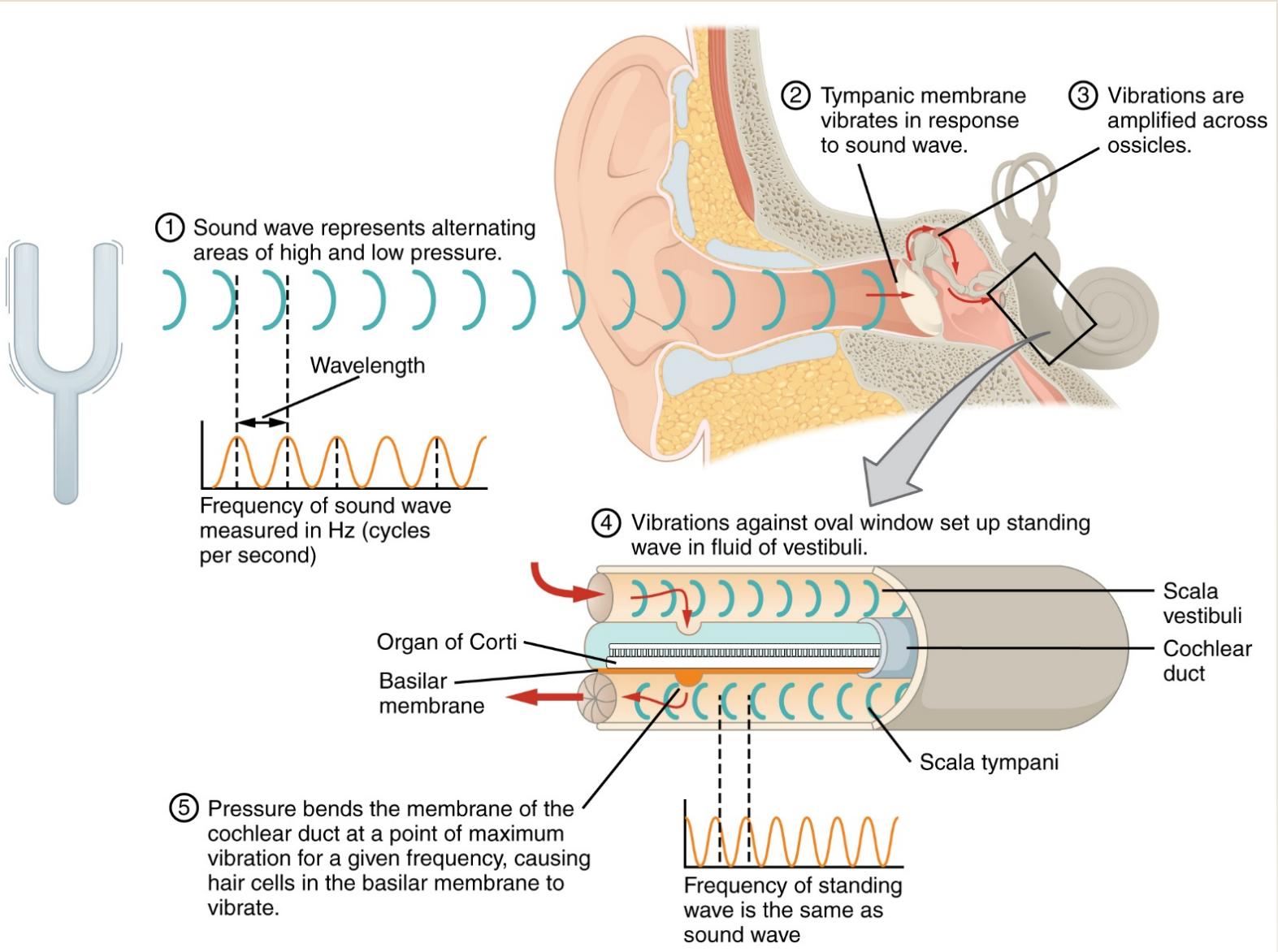
Sound wave length –Frequency (Tonality)



Low Frequency



High Frequency


1 Sound wave represents alternating areas of high and low pressure.
Wavelength
Frequency of sound wave measured in Hz (cycles per second)
2 Tympanic membrane vibrates in response to sound wave.
3 Vibrations are amplified across ossicles.
4 Vibrations against oval window set up standing wave in fluid of vestibuli.
Scala vestibuli
Cochlear duct
Organ of Corti
Basilar membrane
Scala tympani
5 Pressure bends the membrane of the cochlear duct at a point of maximum vibration for a given frequency, causing hair cells in the basilar membrane to vibrate.
Frequency of standing wave is the same as sound wave

2

INSTRUMENT MODELING

Discovering and Analyzing the Instruments' Mechanisms

Musical Instruments Parts

Sound is Movement!

1. So we need a part that moves/vibrates/oscillates to produce sound

This part it called an **«Oscillator»**

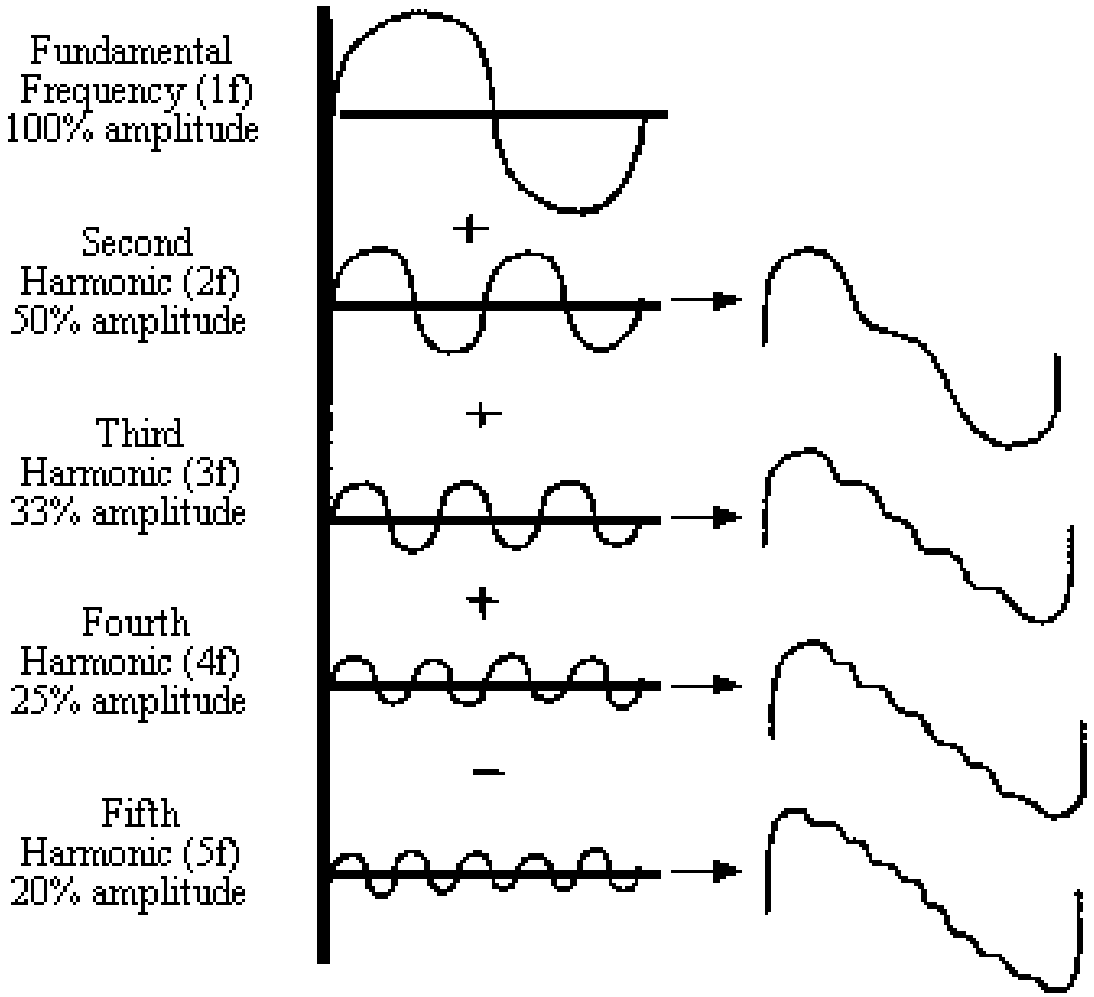
2. We also need some power source to start the movement of the Oscillator.

This part is called **«Exciter»**

3. The sound of instruments is shaped and amplified in their **«Resonator»**

Video Examples

https://youtu.be/9L9AOPxhZwY
https://www.youtube.com/watch?v=6JeyiM0YNo4
https://www.youtube.com/watch?v=14jPvnWhdNM

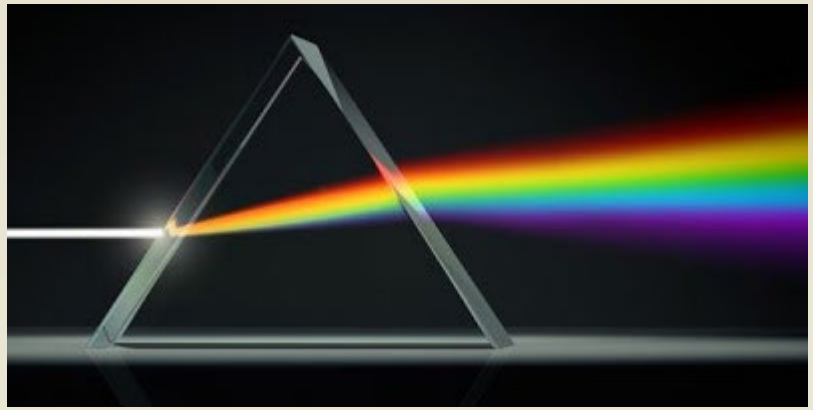


The Making of a Complex Waveform

Timbre

Sound is a wave – Just like light

Sound has a color– Just like light



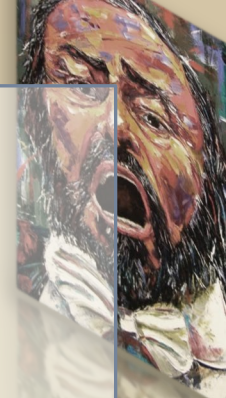
… which we can analyze

with a prism!

The same can be done with sound!

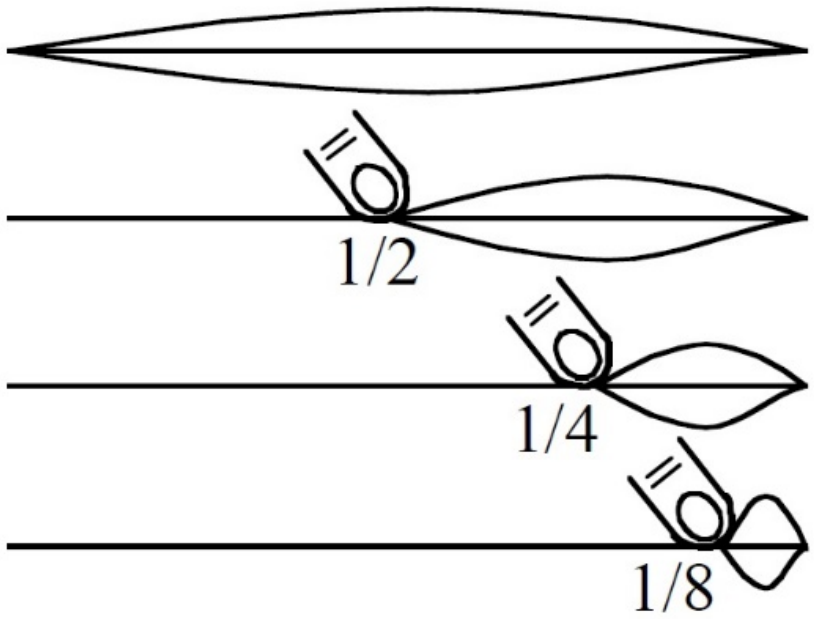
Light contains multiple frequencies

Video Examples

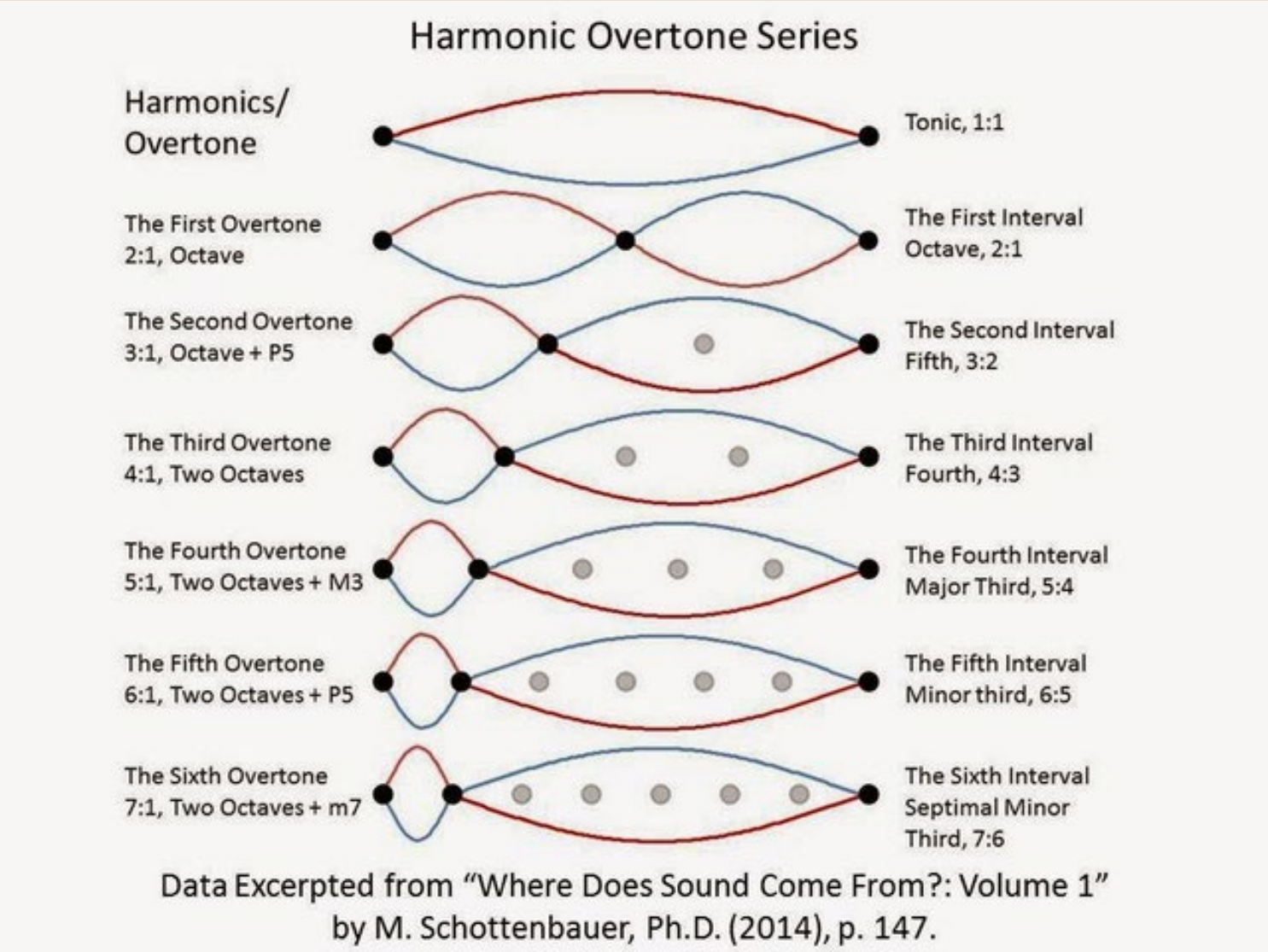


https://www.youtube.com/watch?v=VRAXK4QKJ1Q
https://www.youtube.com/watch?v=oZ38Y0K8e-Y&t=8s

Octave Frequencies

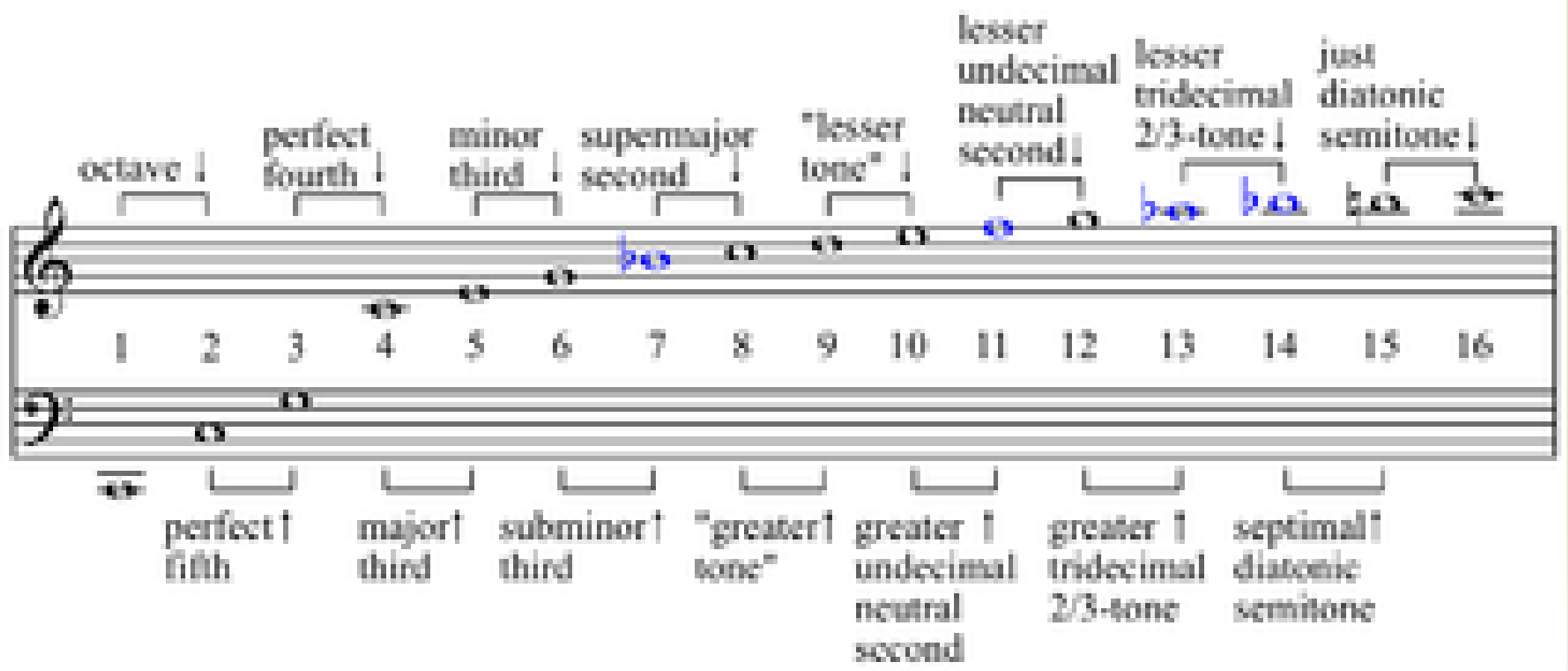
Note	Frequency	Diagram of vibrating string
low low low A	$f = 55$ Hz	
low low A	$f = 110$ Hz	
low A	$f = 220$ Hz	
middle A	$f = 440$ Hz	

Harmonics or Overtones



Harmonics or Overtones

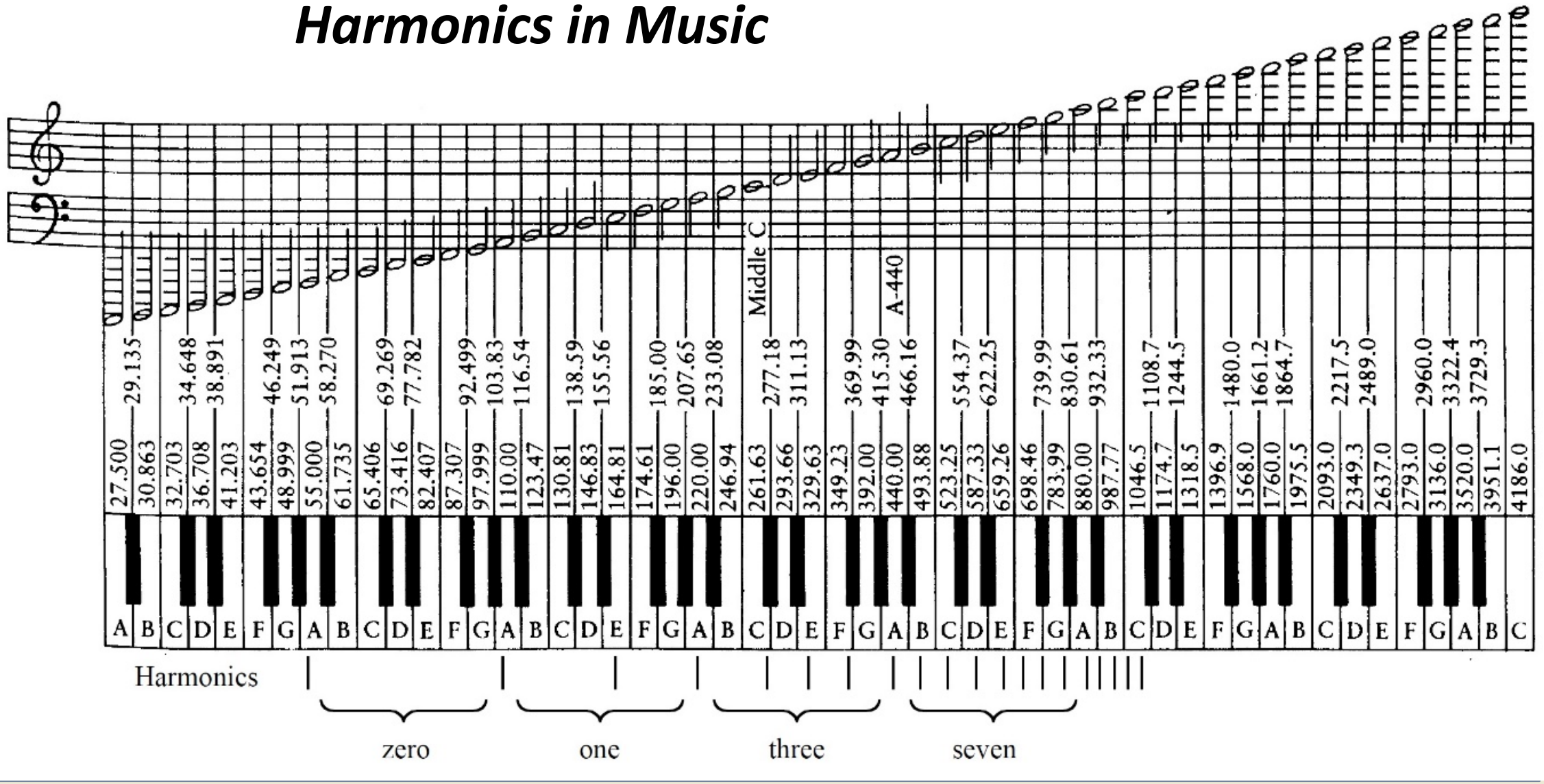
The harmonics series



Resonance in Musical Instruments

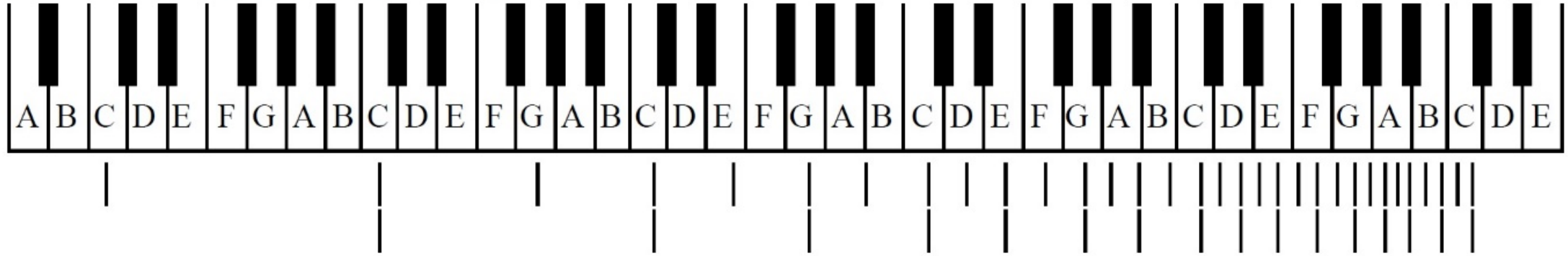
https://www.youtube.com/watch?v=sojjAyC5RzA

Harmonics in Music

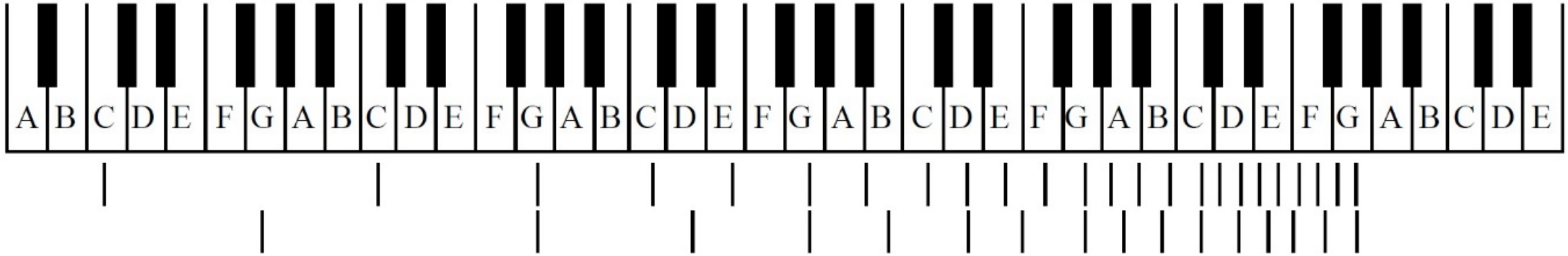


Harmonics in Music

Octaves Harmonics of low low C and low C. Octaves sound like the same note because all of their harmonics line up.



Fifth Harmonics of C and G. Here every other harmonic lines up while the others are not close enough to create beats. The interval of a fifth is very harmonious.



Free Software:

Madde, RTSect, Sopran, etc (https://www.tolvan.com/index.php?page=/main/home.php) –

NOTE: If any of the above ask you for registration **password**, close program, **"Run as Administrator",** and enter any characters.

VoceVista - free 30-days trial (https://www.vocevista.com/en/products/)

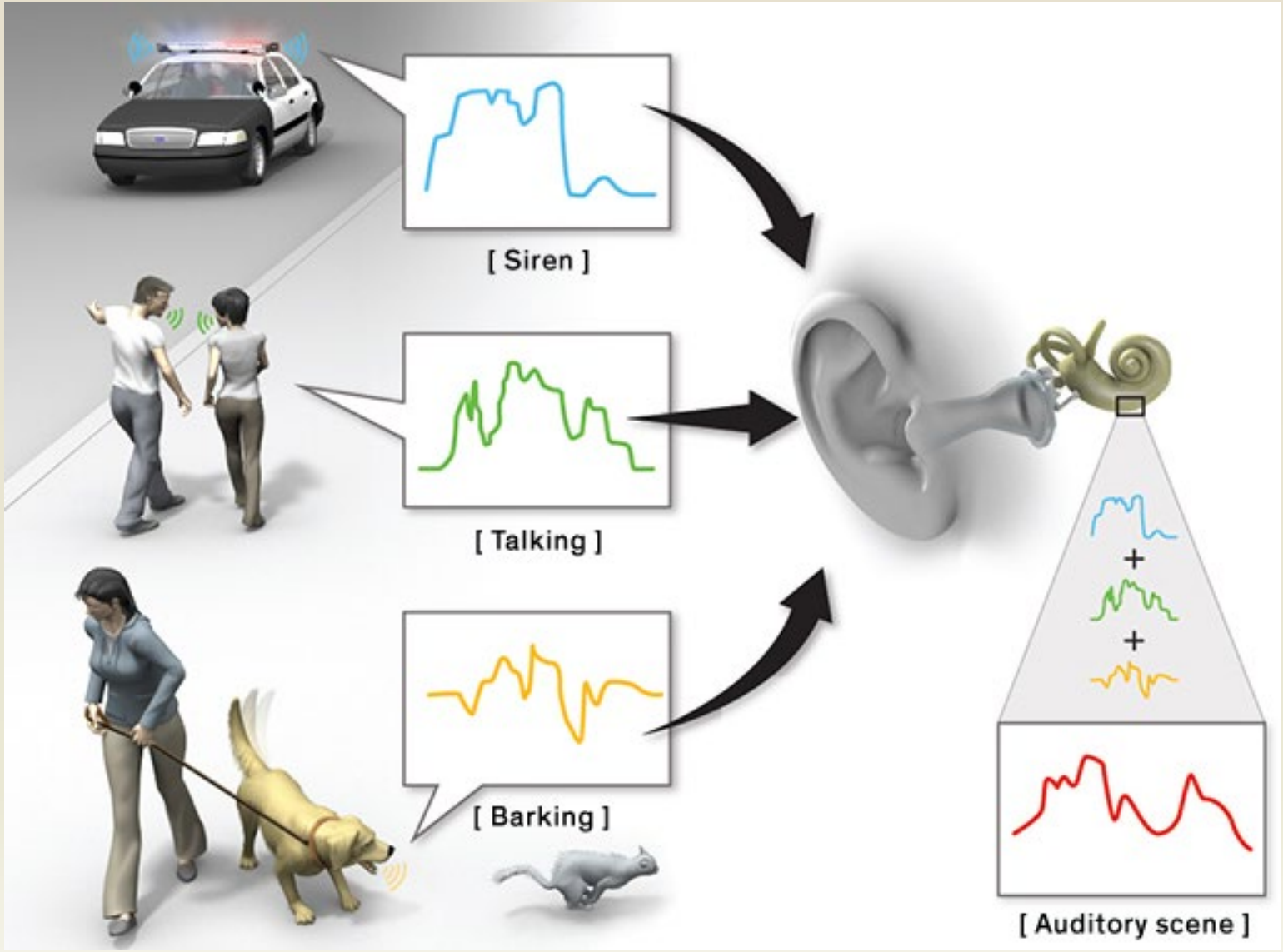
Audio Spectrum Analyser (http://www.techmind.org/audio/specanaly.html)

PinkTrombone (https://imaginary.github.io/pink-trombone/)

VocalTractLab – Try "Phonetic Parameters", "LF glottal flow" and more (https://www.vocaltractlab.de/index.php?page=vocaltractlab-download)

Praat (https://www.fon.hum.uva.nl/praat/)

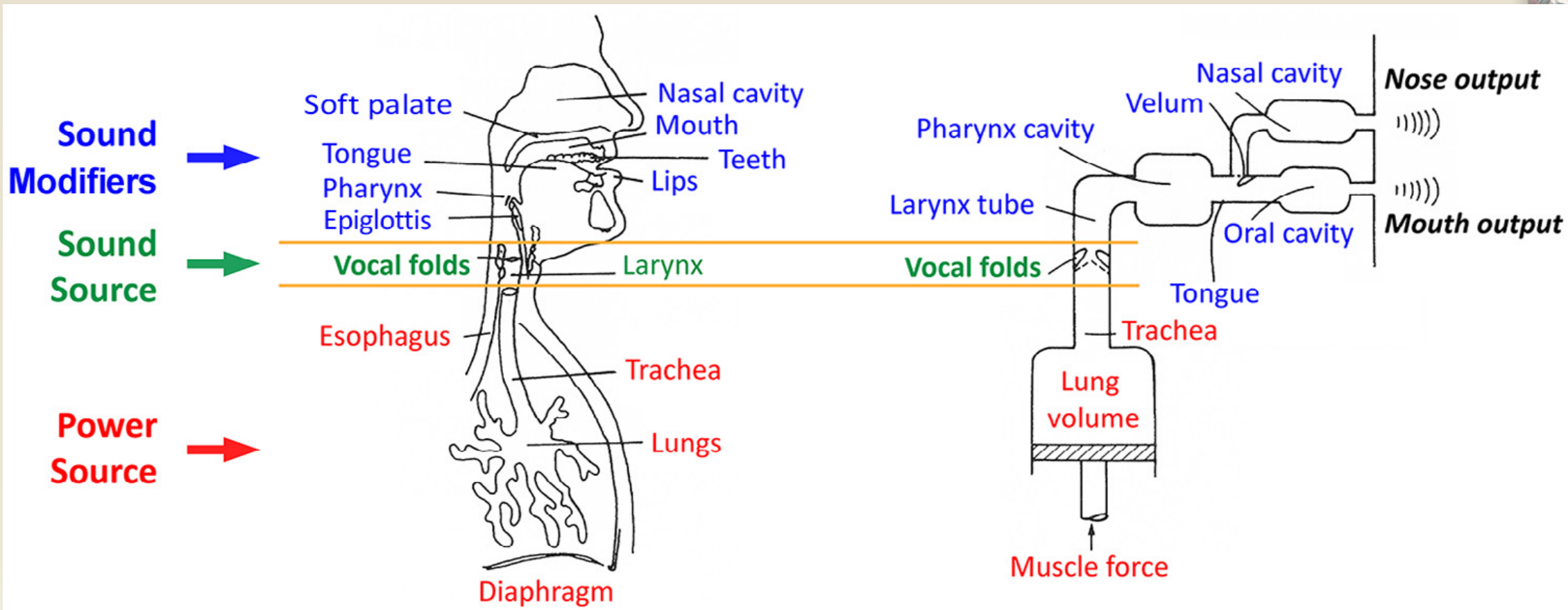
Audacity (https://www.audacityteam.org/download/)


[Siren]
[Talking]
[Barking]
[Auditory scene]

3

OUR VOICE

How it Works!


Sound Modifiers
Sound Source
Power Source
Soft palate
Nasal cavity
Mouth
Tongue
Teeth
Pharynx
Lips
Epiglottis
Vocal folds
Larynx
Esophagus
Trachea
Lungs
Diaphragm
Nasal cavity
Nose output
Velum
Pharynx cavity
Larynx tube
Oral cavity
Mouth output
Vocal folds
Tongue
Trachea
Lung volume
Muscle force

Voice is the result of Neuromuscular actions.

It requires the absolutely precise **coordination** of the parts of an extremely complex **motor mechanism**, which includes:

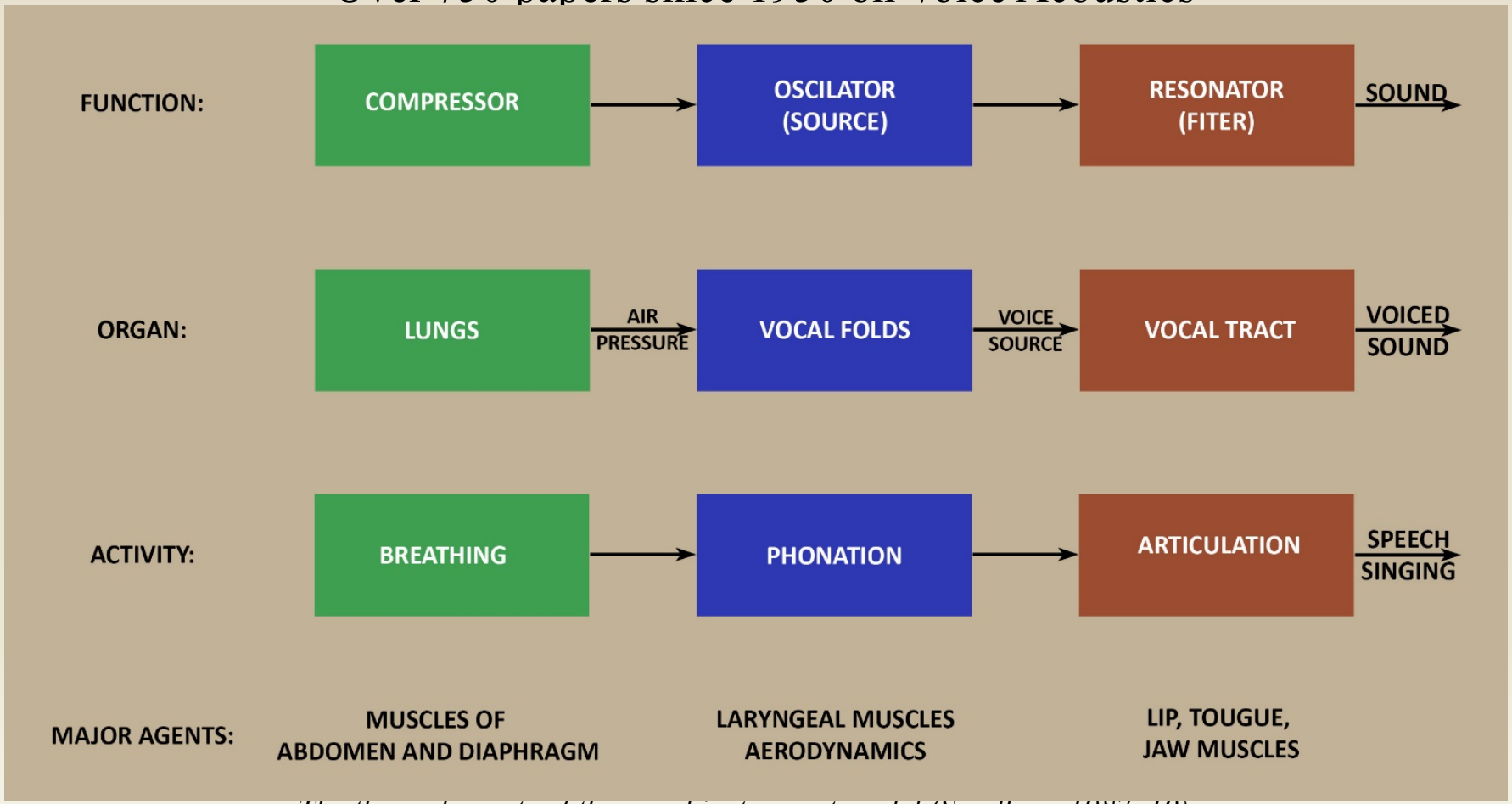
- The **Respiratory** System
- The **Larynx** with the Vocal Folds (chords)
- The Mechanism of **Articulation**

These parts **are Controlled and Coordinated by the Brain**

Contemporary Scientific Voice Approaches

Physiology, Acoustics and Modeling of the Vocal Mechanism

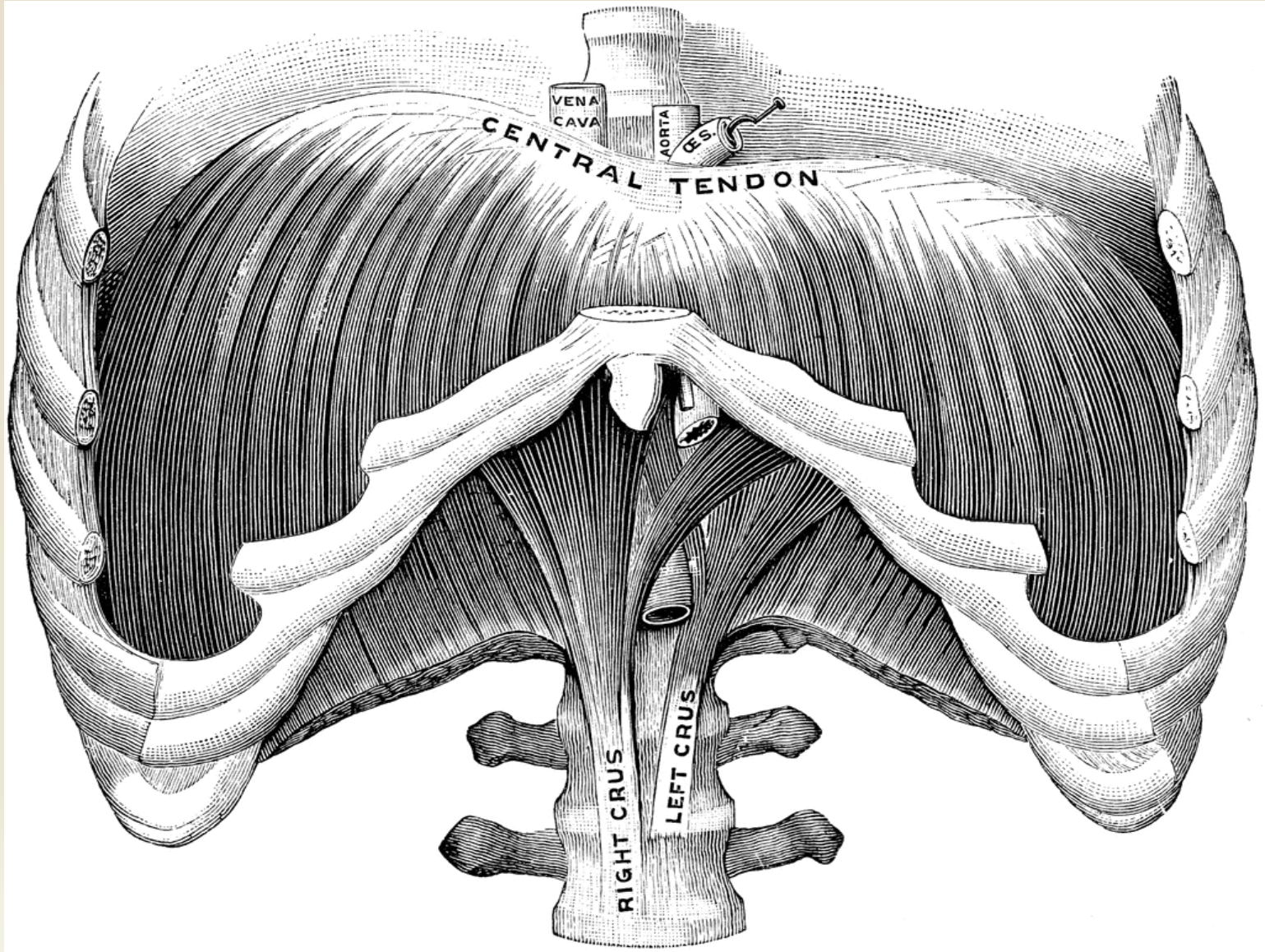
Over 750 papers since 1950 on Voice Acoustics



The three elements of the vocal instrument model (Sundberg 1987, 10)

BREATHING

The Voice's Power Source (exciter)


VENA CAVA
AORTA
ŒS.
CENTRAL TENDON
RIGHT CRUS
LEFT CRUS

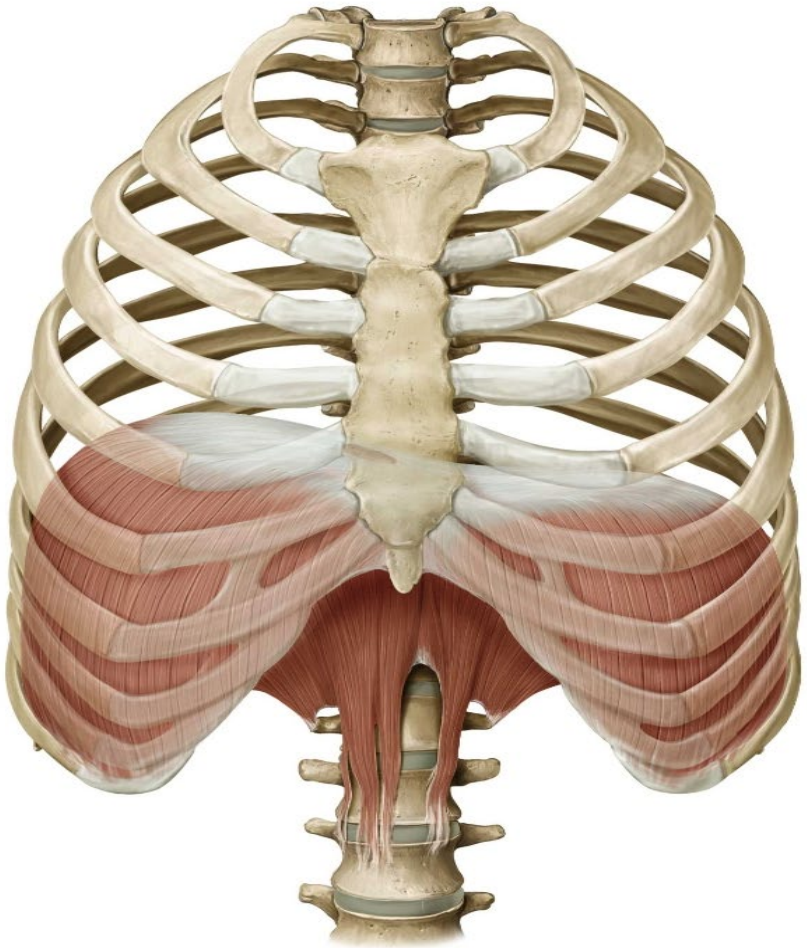
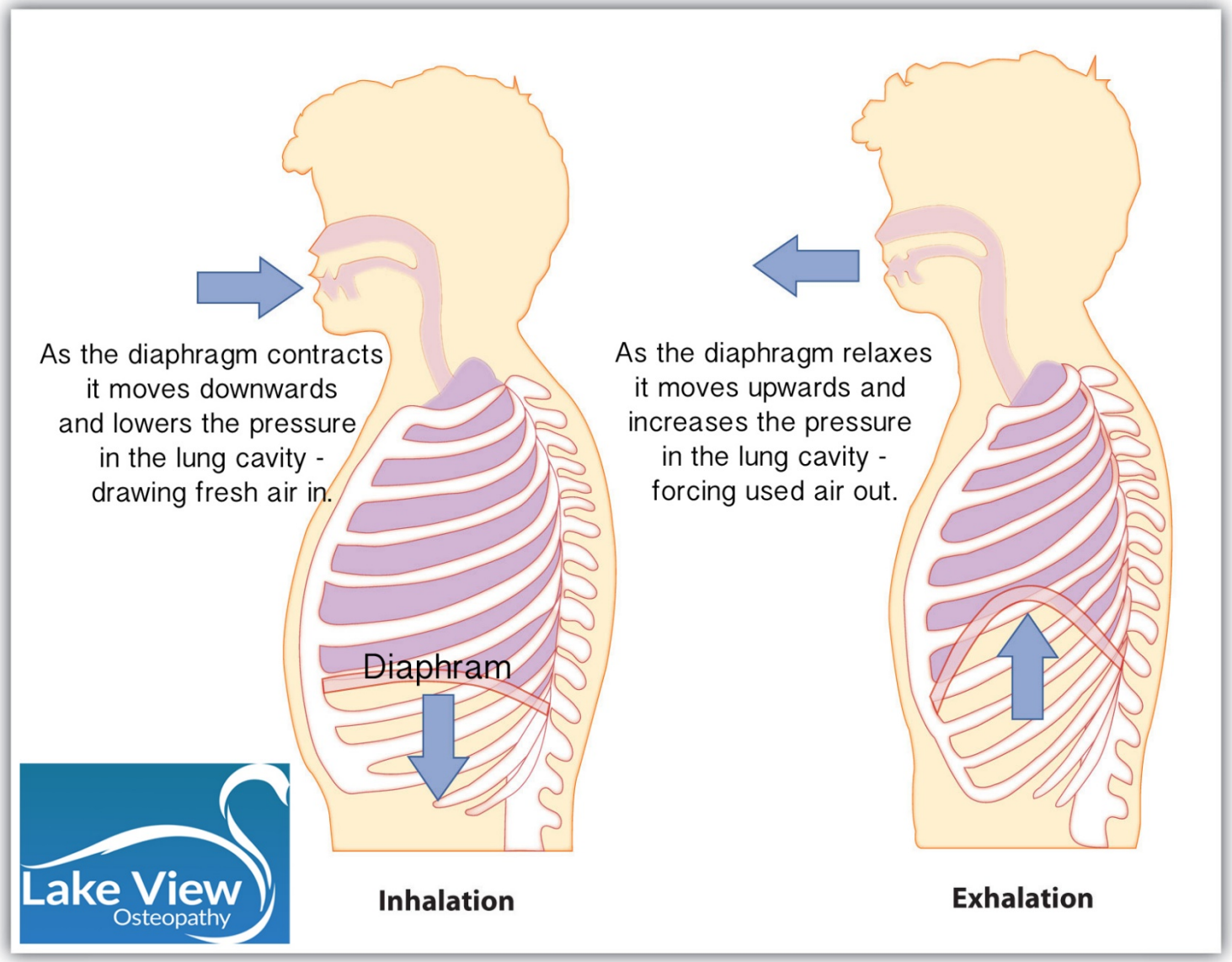


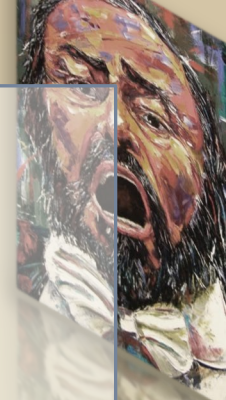
Fig. 5.12 A

Illustrator: Karl Wesker


As the diaphragm contracts it moves downwards and lowers the pressure in the lung cavity - drawing fresh air in.
Diaphram
As the diaphragm relaxes it moves upwards and increases the pressure in the lung cavity - forcing used air out.
Lake View Osteopathy
Inhalation
Exhalation

What Muscles Are Used for Forced Inspiration?

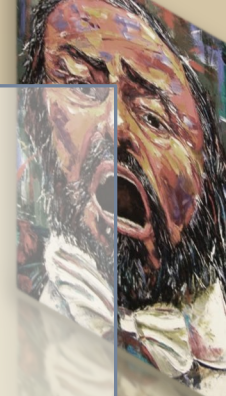
https://www.youtube.com/watch?v=FzITbKqMffU



Exercises in Classroom

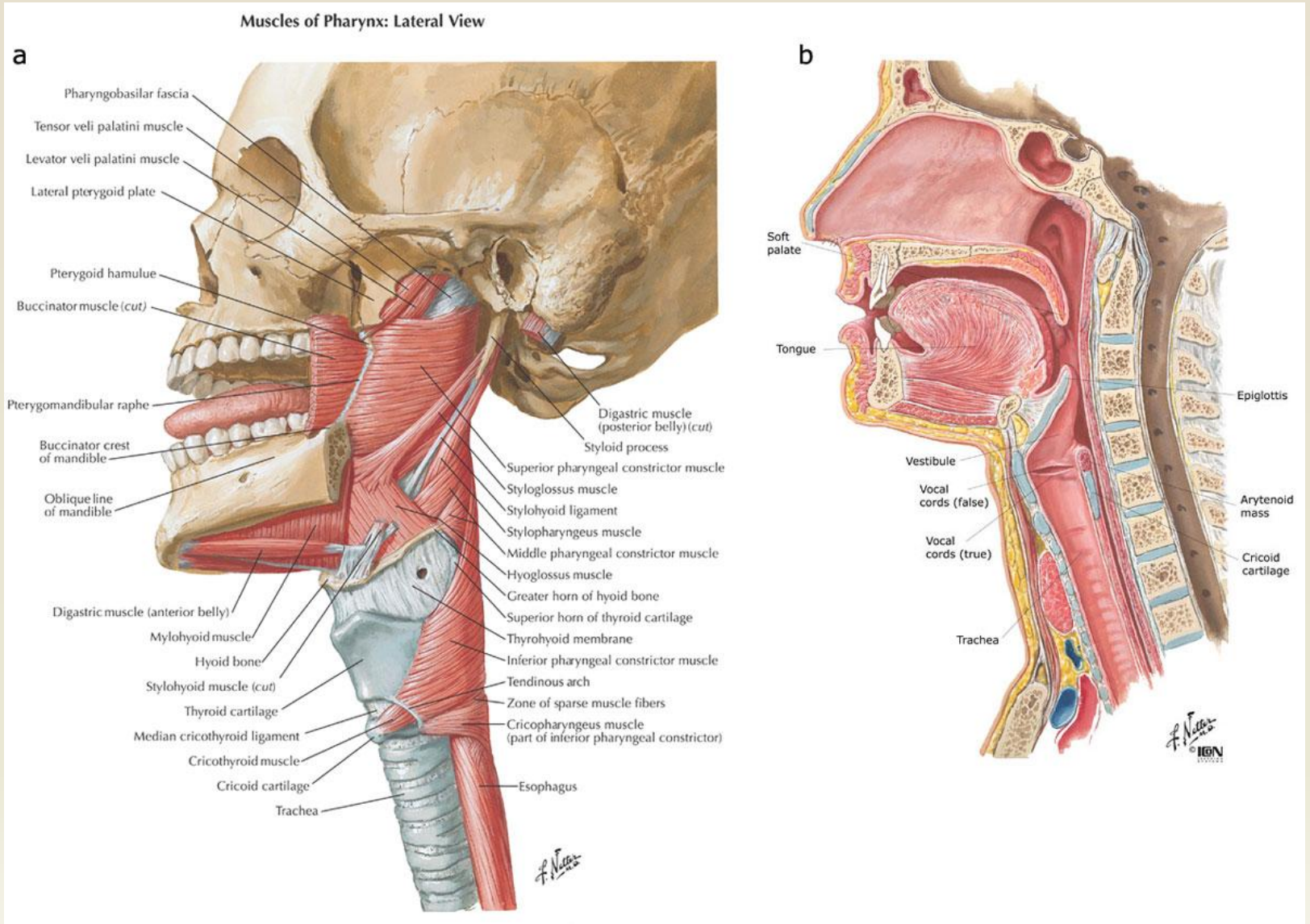
a. Forced diaphragmatic inspiration

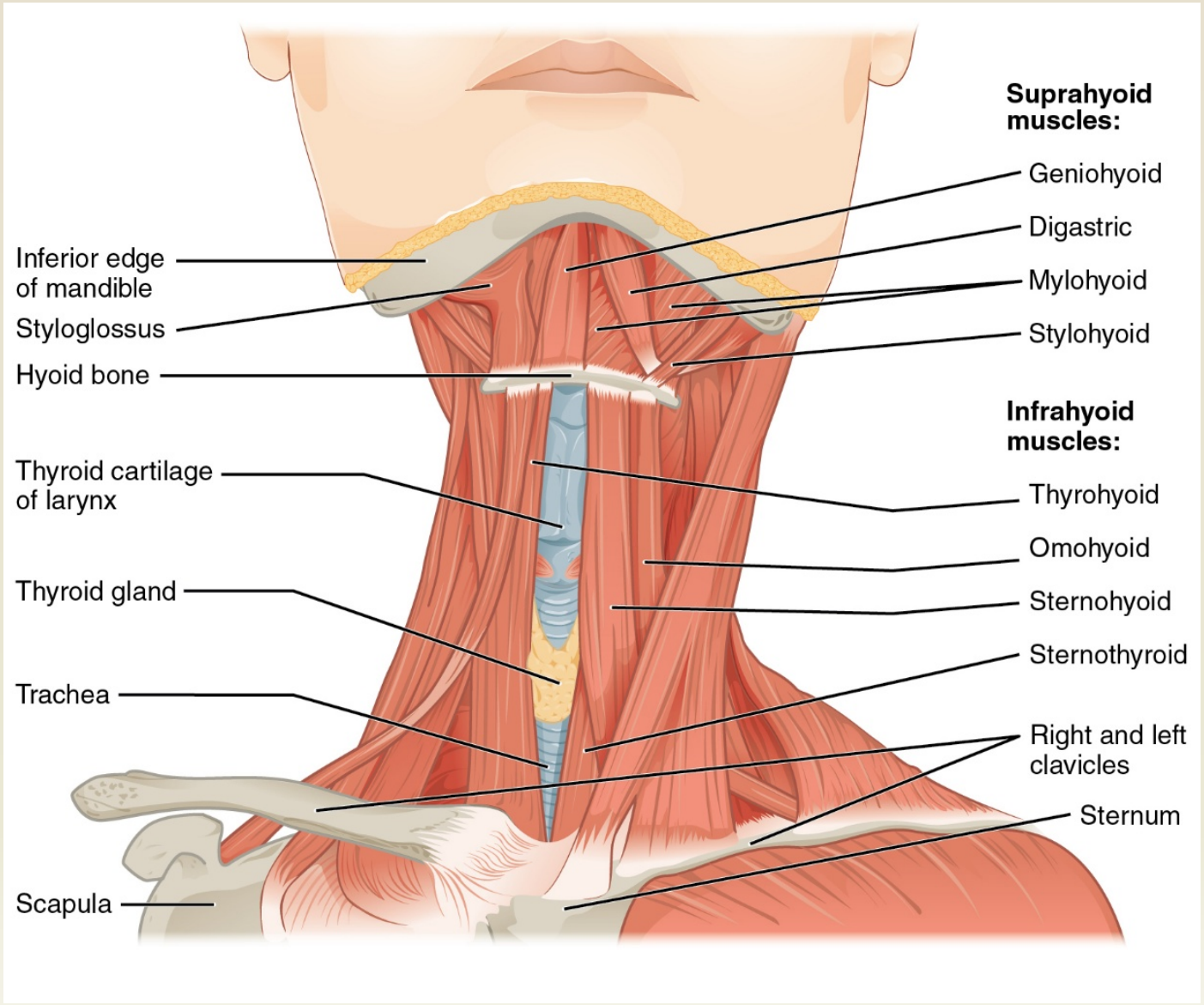
b. Full expiration – Relaxed inspiration

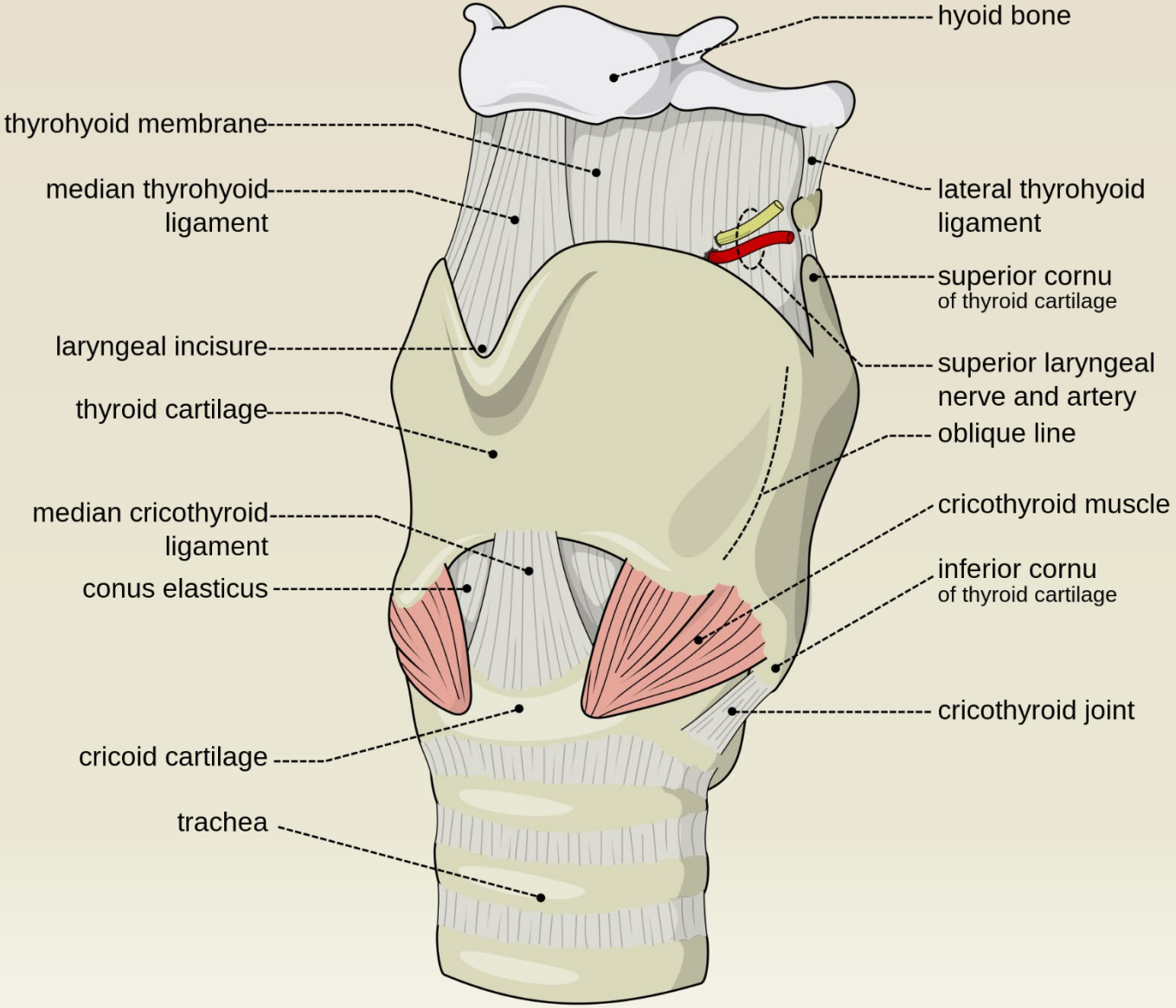


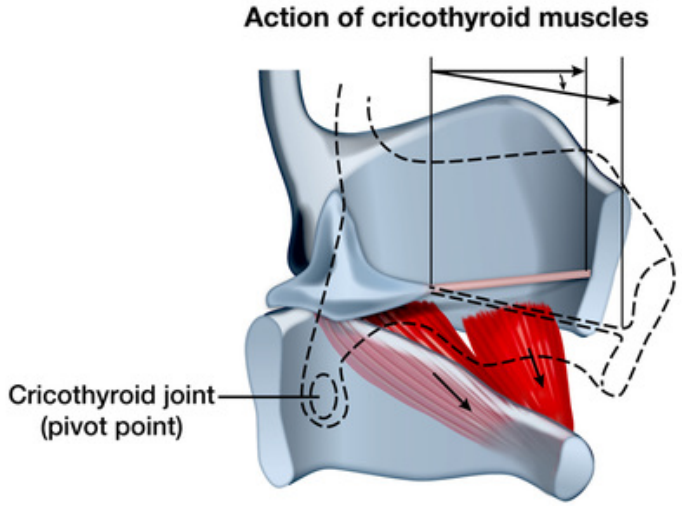
PHONATION

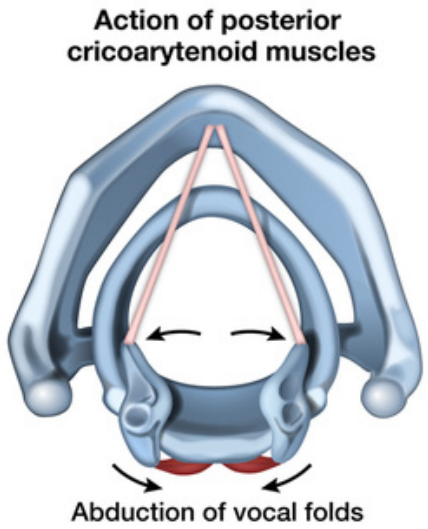
The Voice's Sound Source

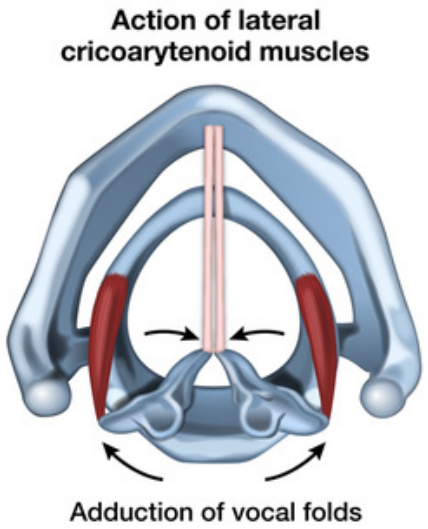

Muscles of Pharynx: Lateral View
a
Pharyngobasilar fascia
Tensor veli palatini muscle
Levator veli palatini muscle
Lateral pterygoid plate
Pterygoid hamulue
Buccinator muscle (cut)
Pterygomandibular raphe
Buccinator crest of mandible
Oblique line of mandible
Digastric muscle (anterior belly)
Mylohyoid muscle
Hyoid bone
Stylohyoid muscle (cut)
Thyroid cartilage
Median cricothyroid ligament
Cricothyroid muscle
Cricoid cartilage
Trachea
Digastric muscle (posterior belly) (cut)
Styloid process
Superior pharyngeal constrictor muscle
Styloglossus muscle
Stylohyoid ligament
Stylopharyngeus muscle
Middle pharyngeal constrictor muscle
Hyoglossus muscle
Greater horn of hyoid bone
Superior horn of thyroid cartilage
Thyrohyoid membrane
Inferior pharyngeal constrictor muscle
Tendinous arch
Zone of sparse muscle fibers
Cricopharyngeus muscle (part of inferior pharyngeal constrictor)
Esophagus
b
Soft palate
Tongue
Vestibule
Vocal cords (false)
Vocal cords (true)
Trachea
Epiglottis
Arytenoid mass
Cricoid cartilage

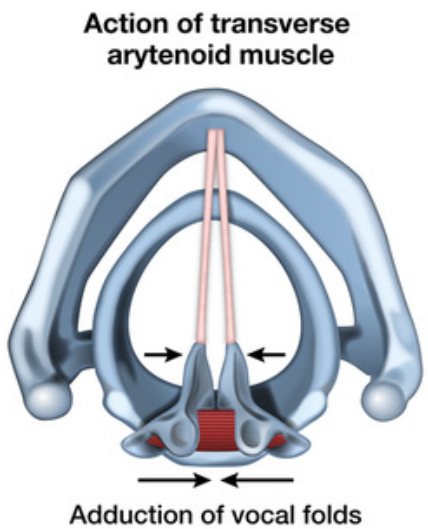

Suprahyoid muscles:
Geniohyoid
Digastric
Mylohyoid
Stylohyoid
Infrahyoid muscles:
Thyrohyoid
Omohyoid
Sternohyoid
Sternothyroid
Right and left clavicles
Sternum
Inferior edge of mandible
Styloglossus
Hyoid bone
Thyroid cartilage of larynx
Thyroid gland
Trachea
Scapula

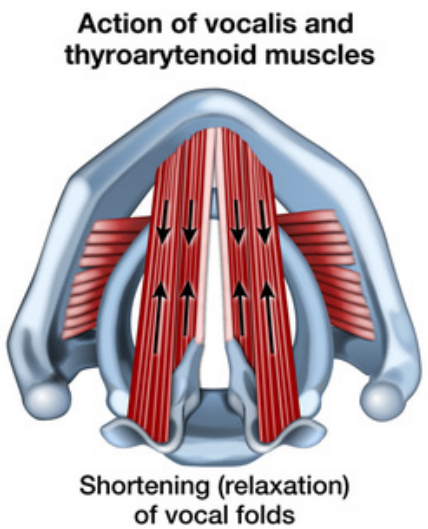

hyoid bone
thyrohyoid membrane
median thyrohyoid ligament
lateral thyrohyoid ligament
superior cornu of thyroid cartilage
laryngeal incisure
superior laryngeal nerve and artery
thyroid cartilage
oblique line
median cricothyroid ligament
cricothyroid muscle
conus elasticus
inferior cornu of thyroid cartilage
cricothyroid joint
cricoid cartilage
trachea

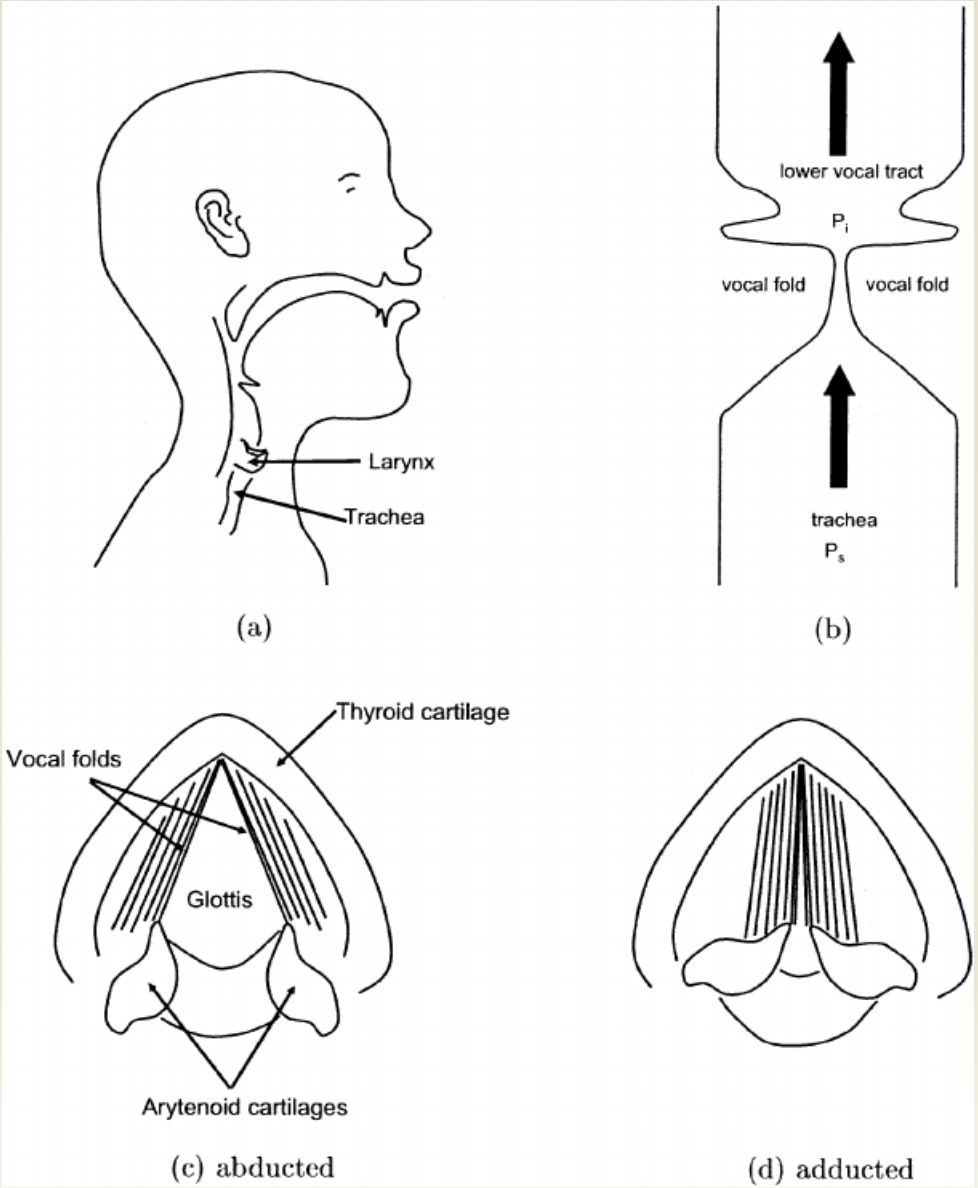

Action of cricothyroid muscles
Cricothyroid joint
(pivot point)
Lengthening (tension) of vocal folds

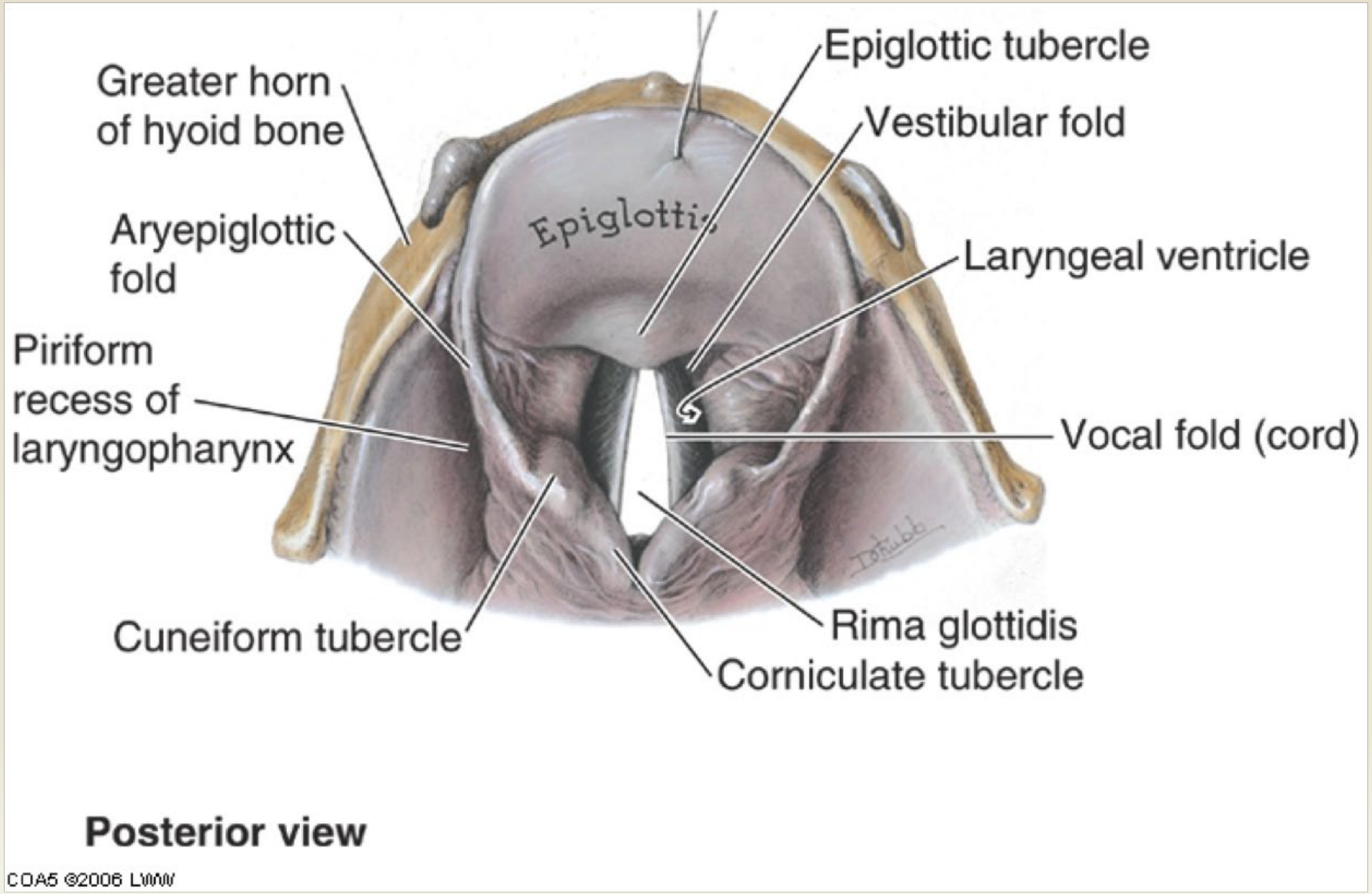

Action of posterior
cricoarytenoid muscles
Abduction of vocal folds

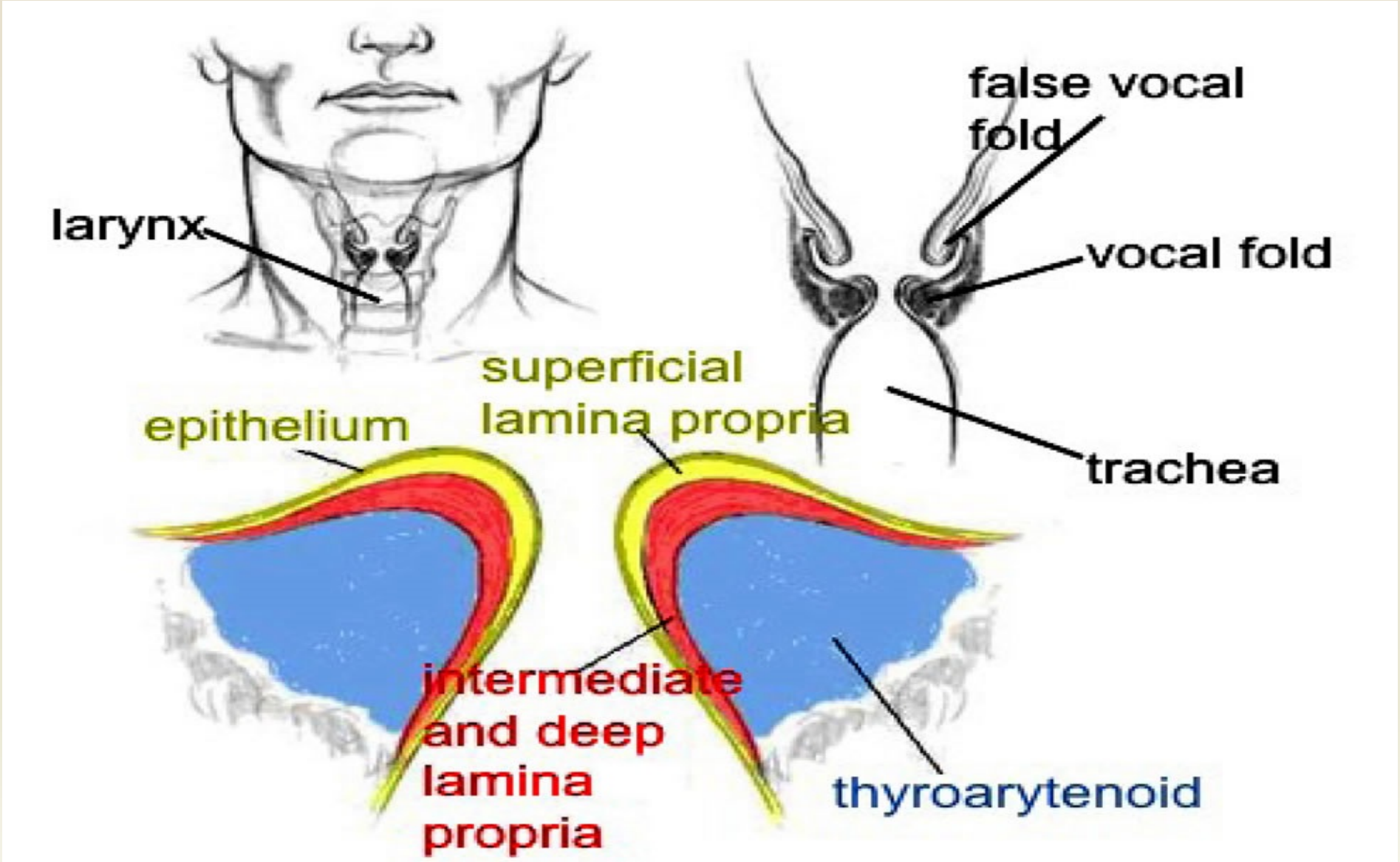

Action of lateral
cricoarytenoid muscles
Adduction of vocal folds

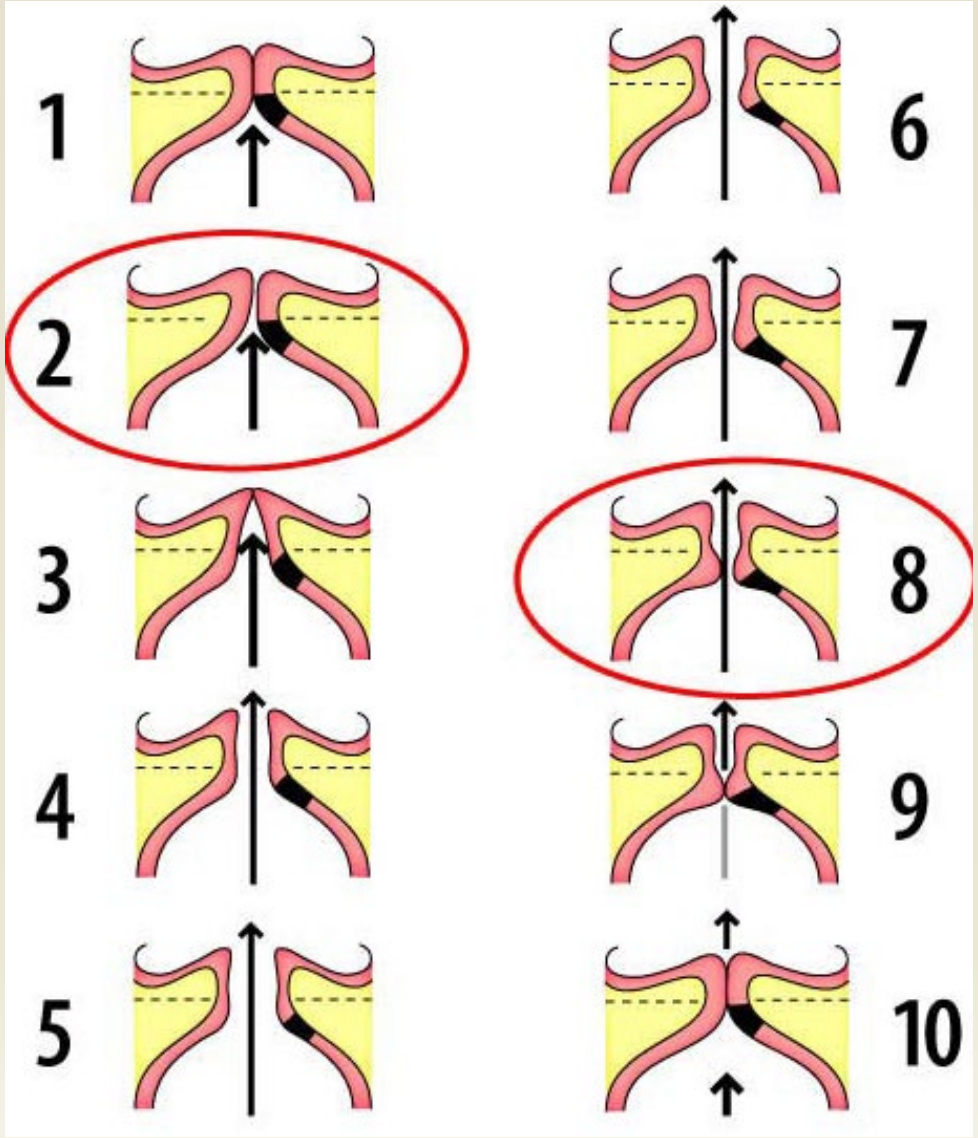

Action of transverse
arytenoid muscle
Adduction of vocal folds


Action of vocalis and
thyroarytenoid muscles
Shortening (relaxation)
of vocal folds


Larynx
Trachea
(a)
lower vocal tract
P_i
vocal fold
vocal fold
trachea
P_s
(b)
Thyroid cartilage
Vocal folds
Glottis
Arytenoid cartilages
(c) abducted
(d) adducted


Greater horn of hyoid bone
Aryepiglottic fold
Piriform recess of laryngopharynx
Cuneiform tubercle
Epiglottic tubercle
Vestibular fold
Laryngeal ventricle
Vocal fold (cord)
Rima glottidis
Corniculate tubercle
Posterior view
COA5 ©2006 LWW


larynx
false vocal fold
vocal fold
trachea
superficial lamina propria
epithelium
intermediate and deep lamina propria
thyroarytenoid


1
2
3
4
5
6
7
8
9
10

Exercises in Classroom

a. Glottis (weight & laughter)

b. Attacks (singing & speaking)

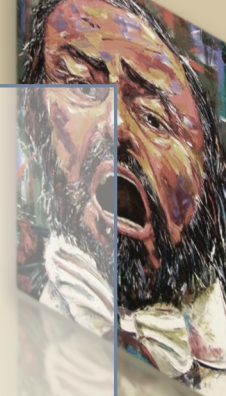
c. Phonation and open quotient

d. Balloon demonstration

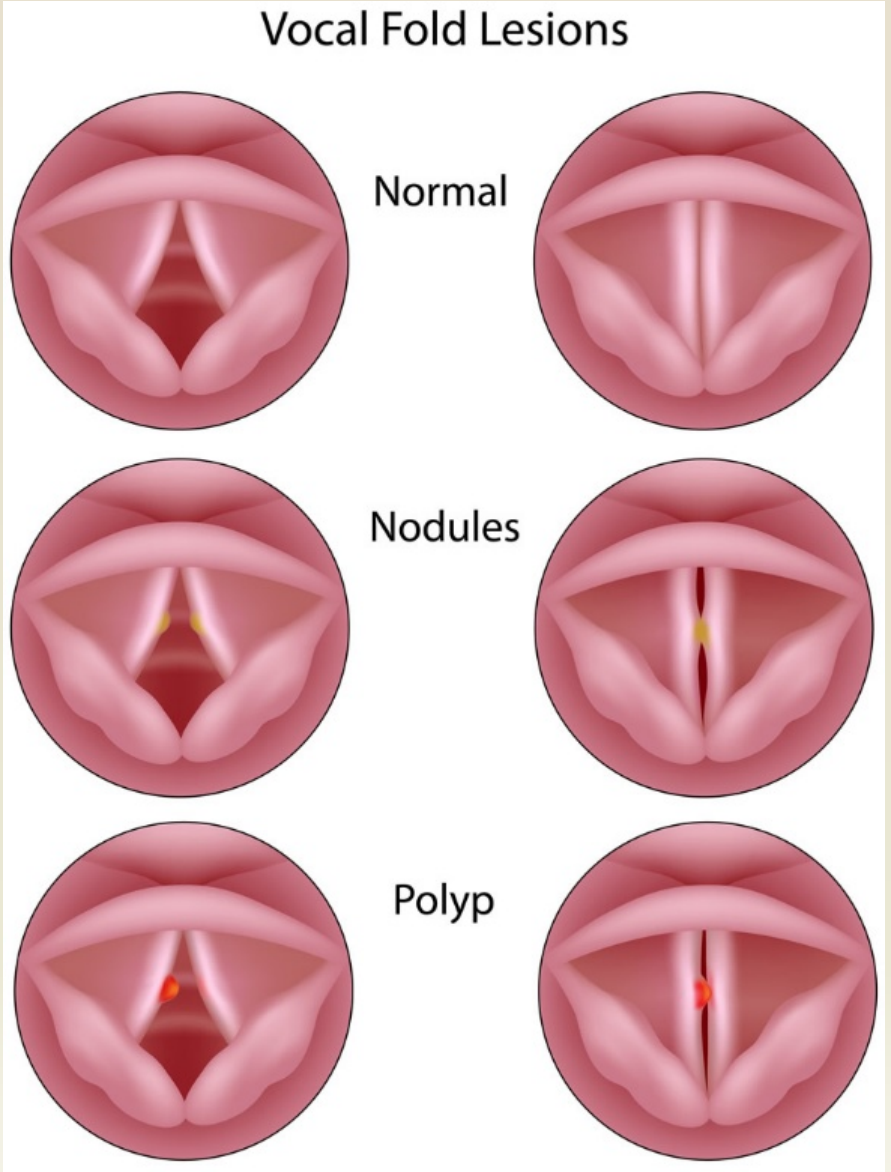
e. Flame experiment

f. Experiments with software

Video Examples



https://www.youtube.com/watch?v=Aoa_N1vQS4M
https://youtu.be/b89RSYCaUBo?list=PLdawQFyF0jAmobzS38cAxuaNl2365V4T9
https://www.youtube.com/watch?v=9Tlpkdq8a8c
https://www.youtube.com/watch?v=A8JFz04EmvY
https://www.youtube.com/watch?v=5rJ8nCTgZ2Q&t=1s


Vocal Fold Lesions
Normal
Nodules
Polyp

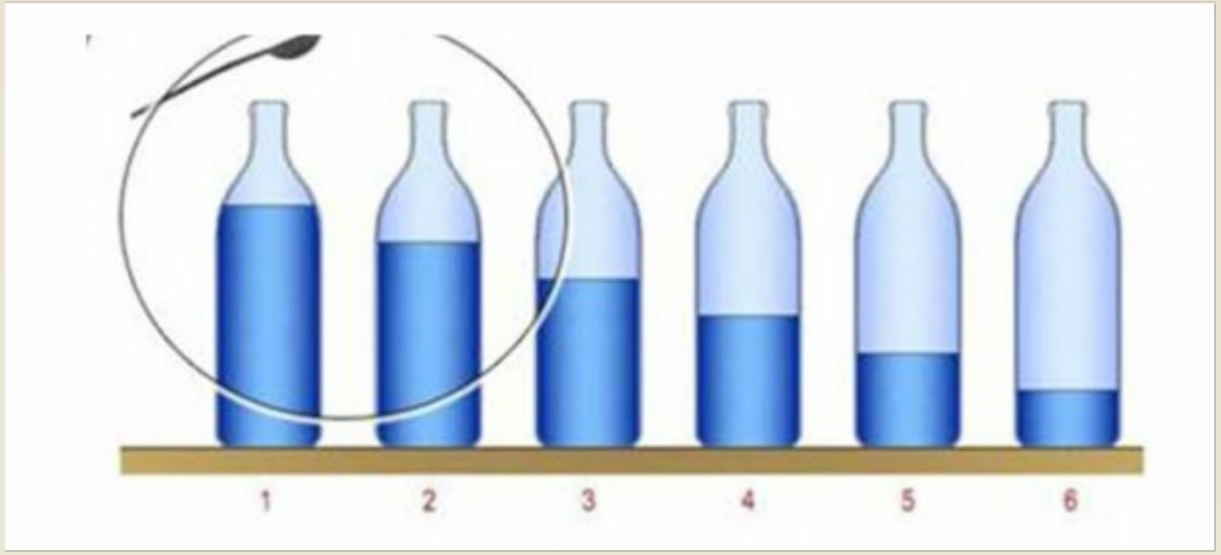
SOUND MODIFICATION

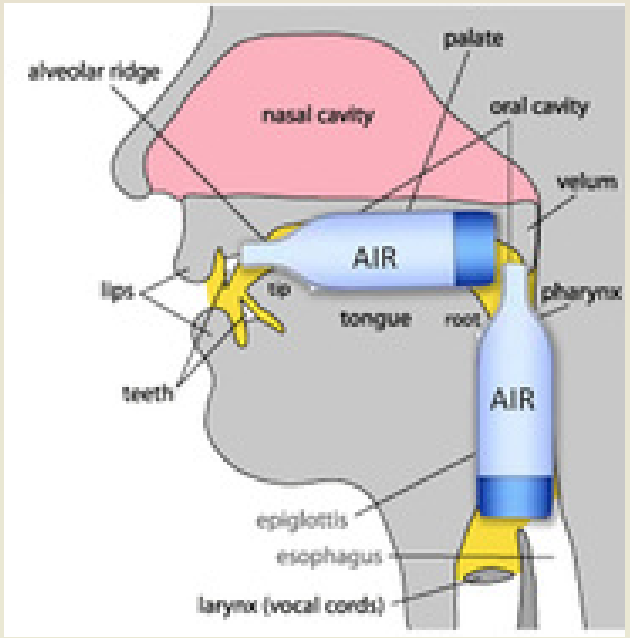
RESONANCE & ARTICULATION

The Voice's Sound Filter

Evangelos Angelakis
Laboratory of Music Acoustics and Technology - University of Athens

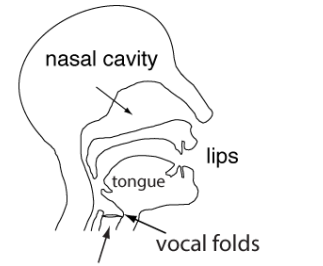
Formants and the Vocal Tract





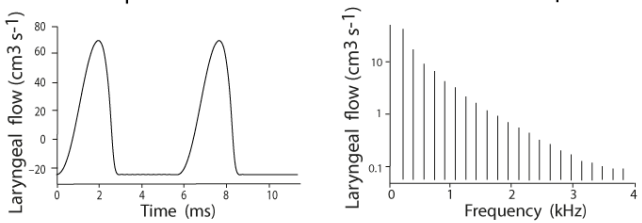
SOURCE

The vocal folds undergo auto- oscillation and produce a pulsed laryngeal flow through the glottis, the oscillating gap between the folds



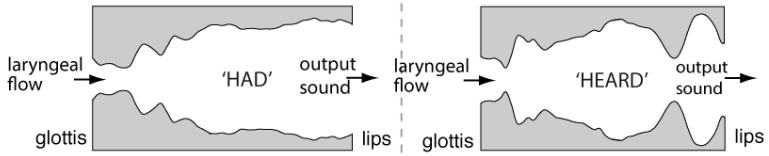
steady airflow from lungs via trachea provides energy source

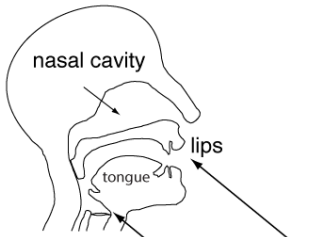
periodic flow → harmonic spectrum



The periodic laryngeal flow then enters the downstream vocal tract
Two different configurations show how the radius varies with distance along the tract. They correspond to the vowels in 'had' and 'heard'..

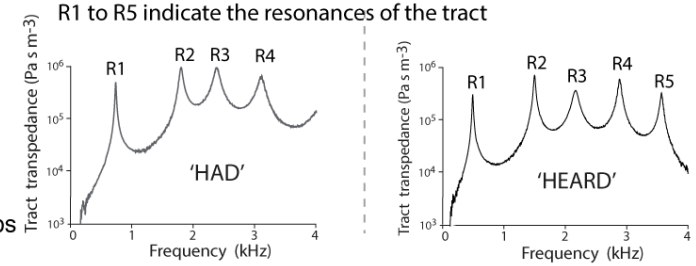
FILTER



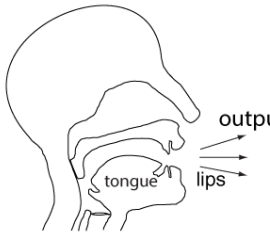


region from the vocal folds to the lips defines the vocal tract

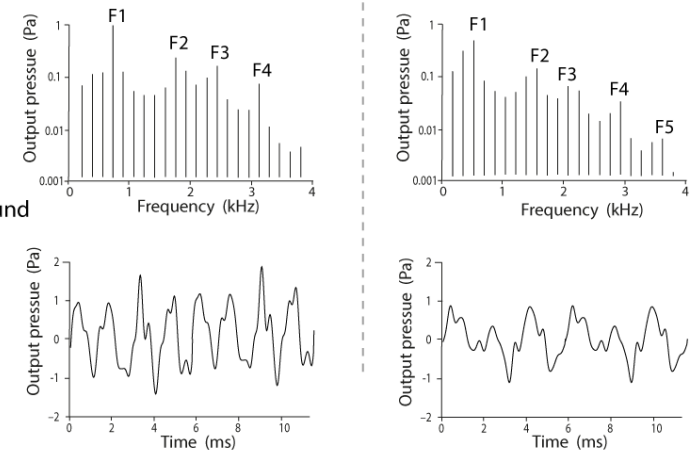
The 2 vocal tract models have the measured transpedances shown below.
R1 to R5 indicate the resonances of the tract



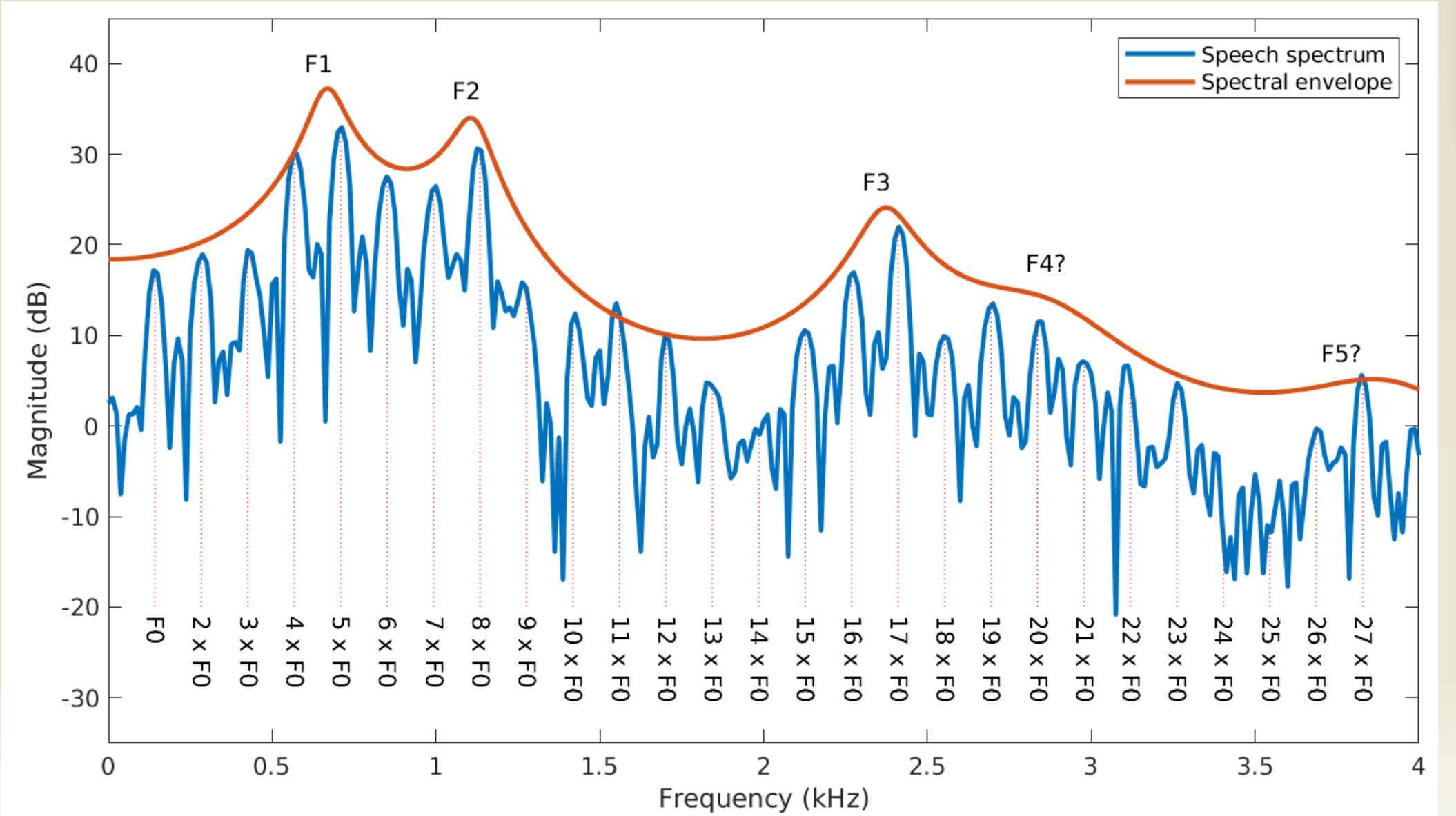
OUTPUT SOUND



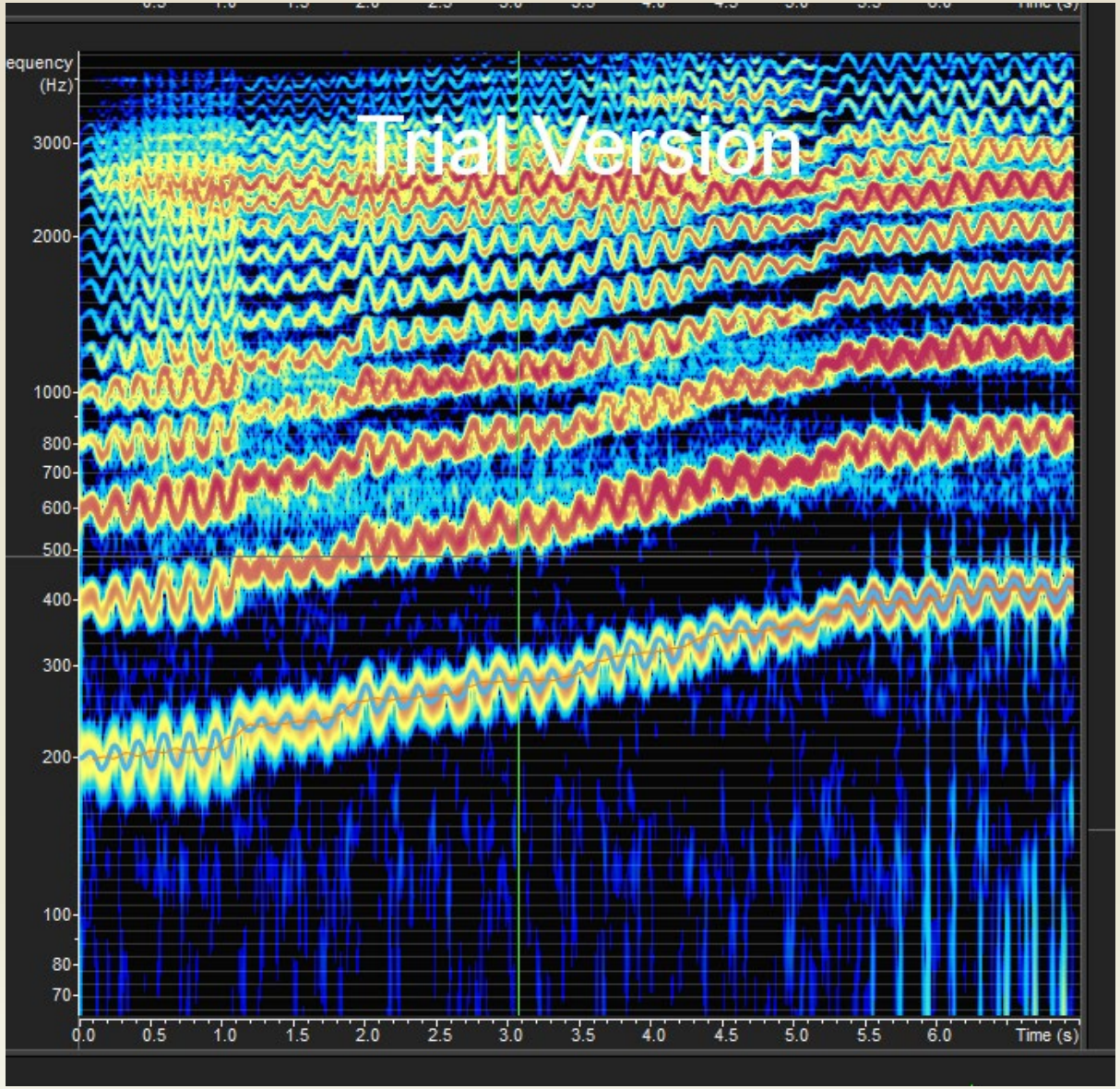
In a linear system the output sounds are the product of the source function and the filter function and will have the pressure spectra and waveforms shown below



Vocal Sound Spectrum and Envelope



Voice Spectrogram

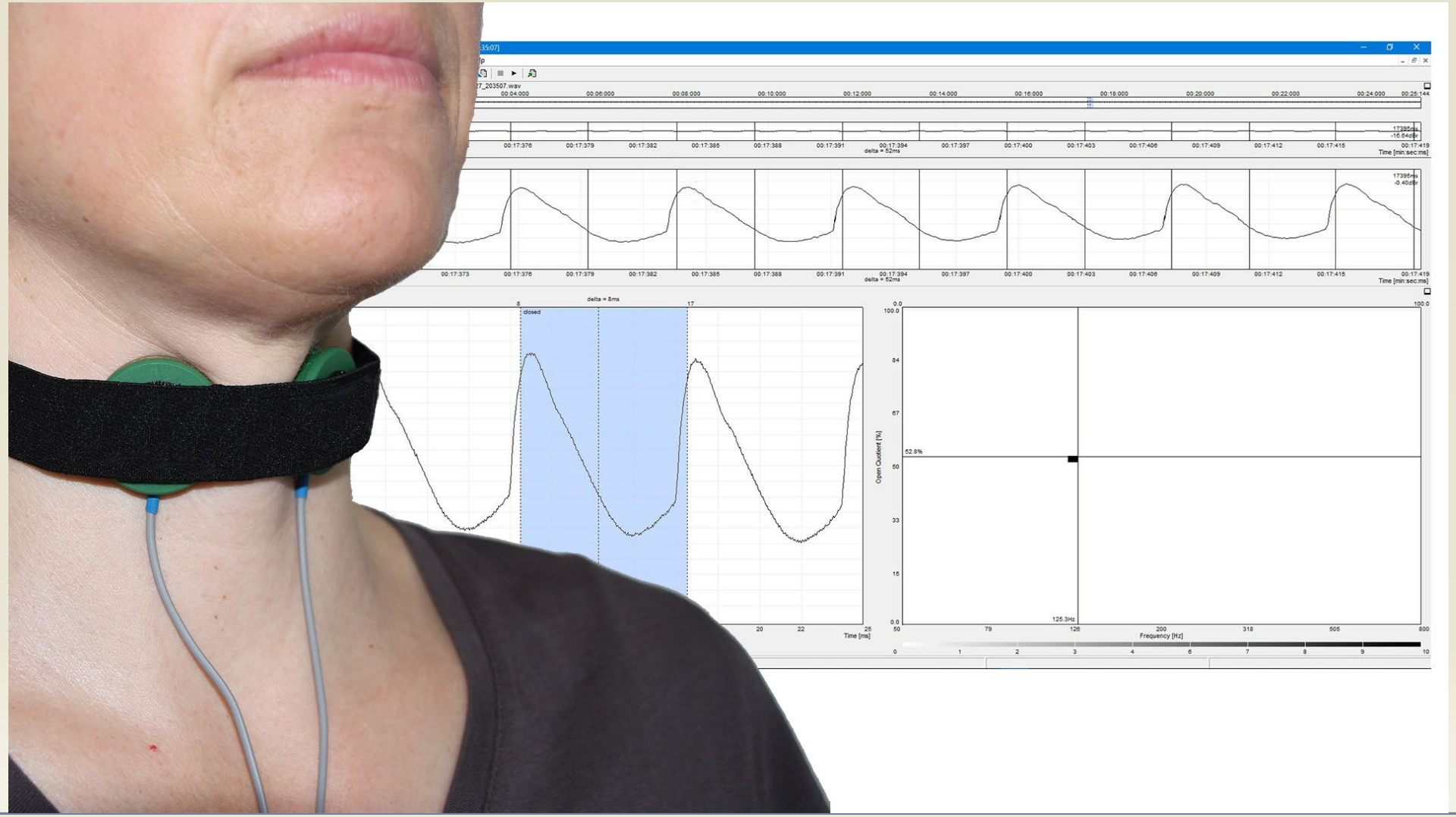


Evangelos Angelakis
Laboratory of Music Acoustics and Technology - University of Athens

Athens 2025

Vocal Folds Oscillogram

Oscillation - Vibration



Exercises in Classroom

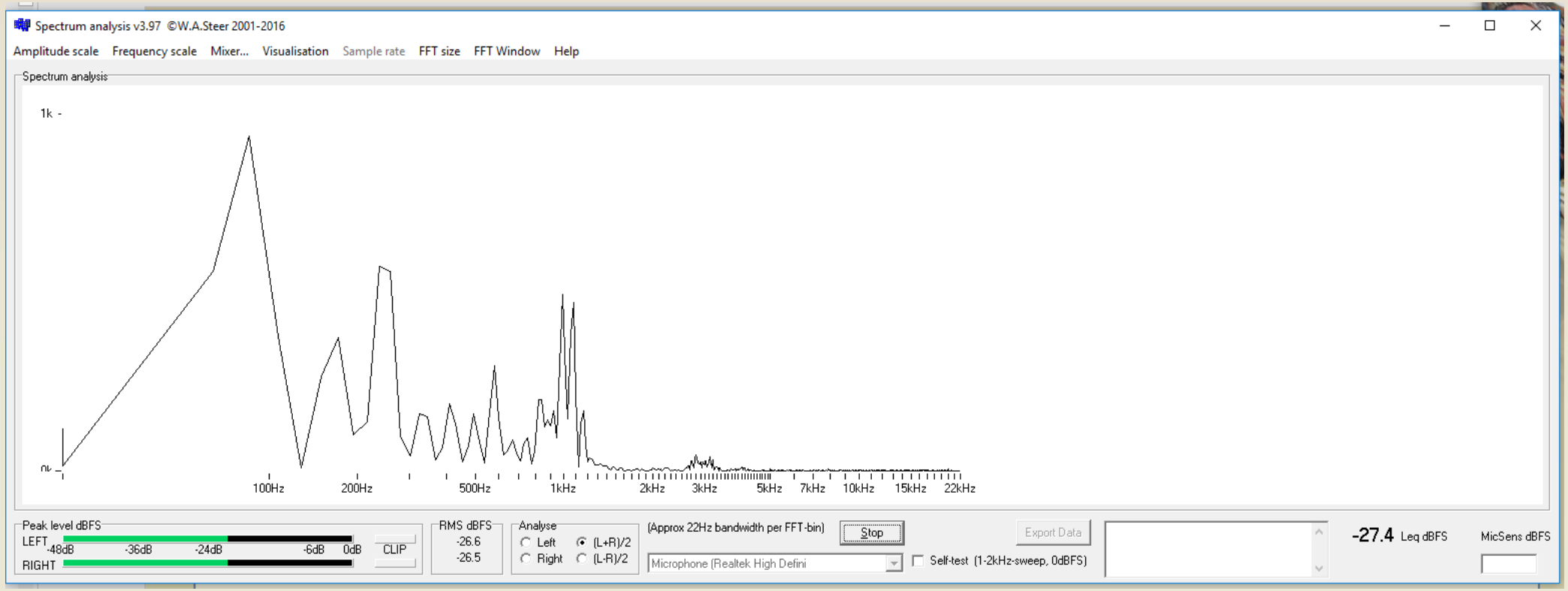
a. Speaking and Singing Differences

b. Speaking and Singing in Various Distances / Spaces

c. Singing Styles (Socio-political Conditions & Technology)

d. Hands Sound Modification

Formants and Vowels

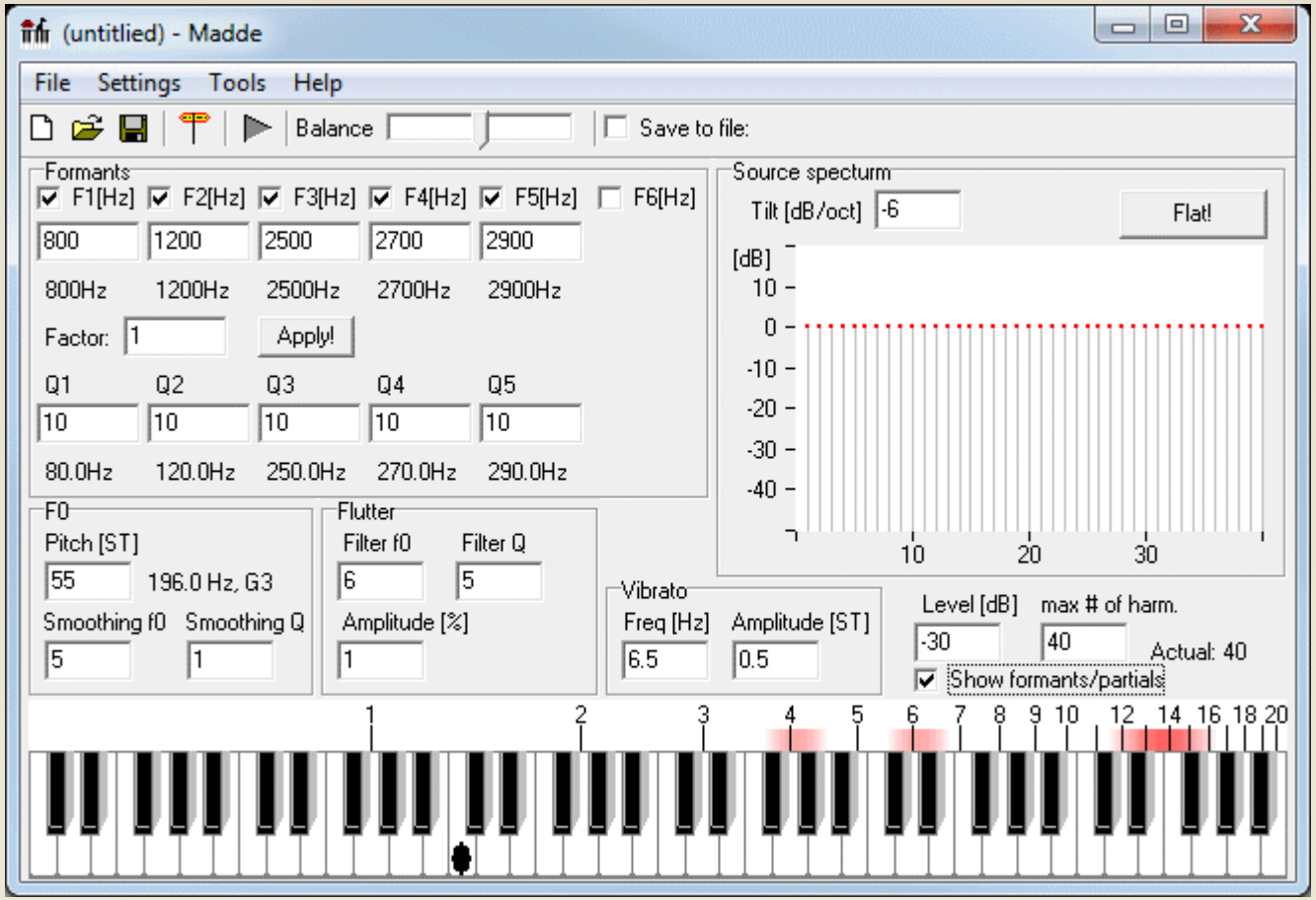


http://www.techmind.org/audio/specanaly.html

use a suitable “Amplitude scale” (try to find one that doesn’t peak) – and a Logarithmic “Frequency scale”

Video Examples

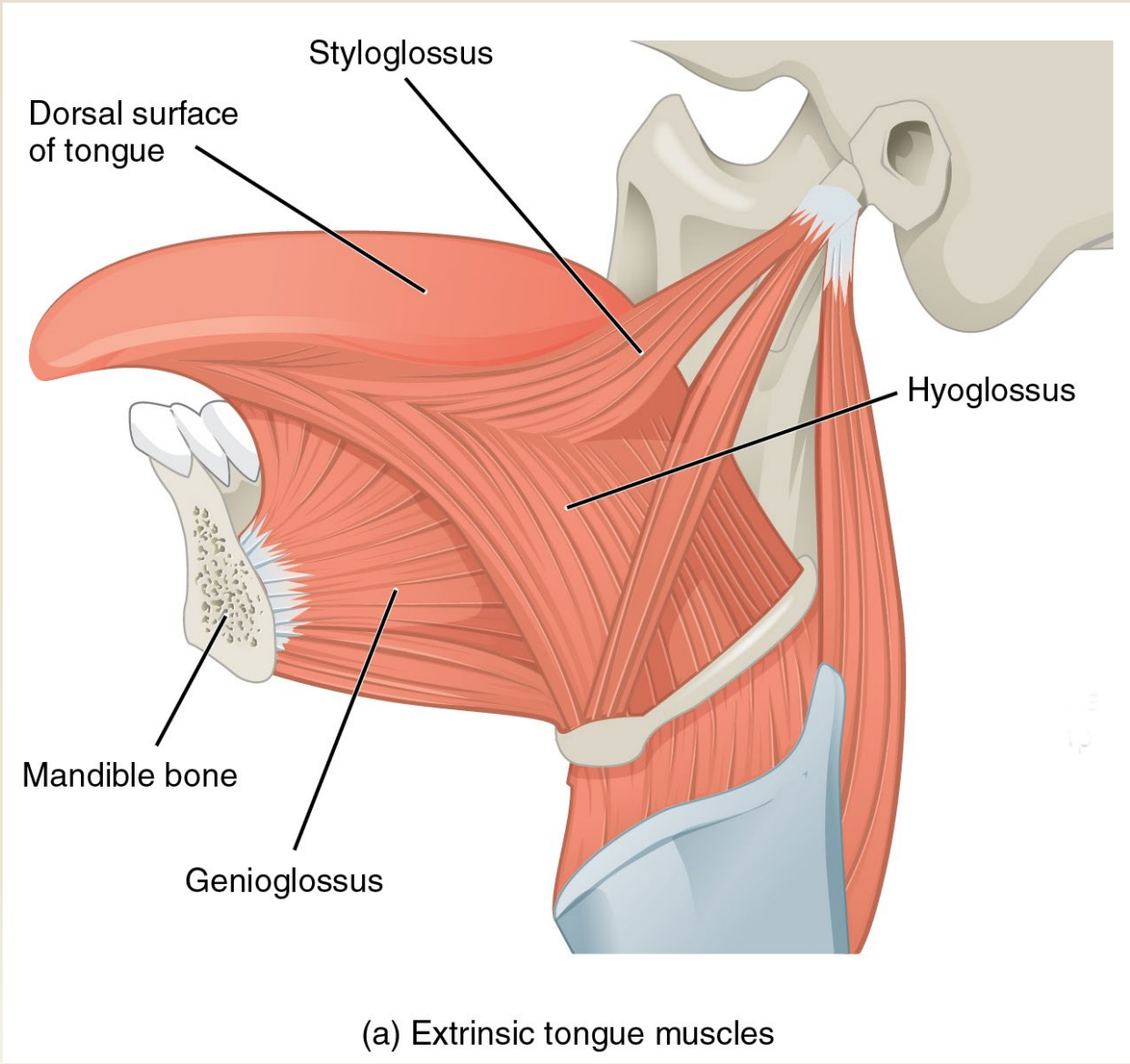
https://www.youtube.com/watch?v=QvzvFj0qEAc&t=19s
https://www.youtube.com/watch?v=wR41CRbIjV4



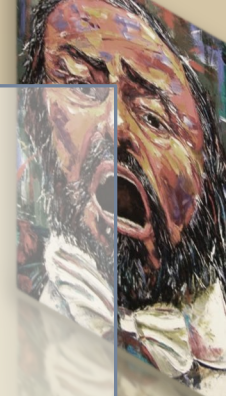
http://www.tolvan.com/index.php?page=/madde/madde.php

Vowel Formants 1-3 Mean Frequencies

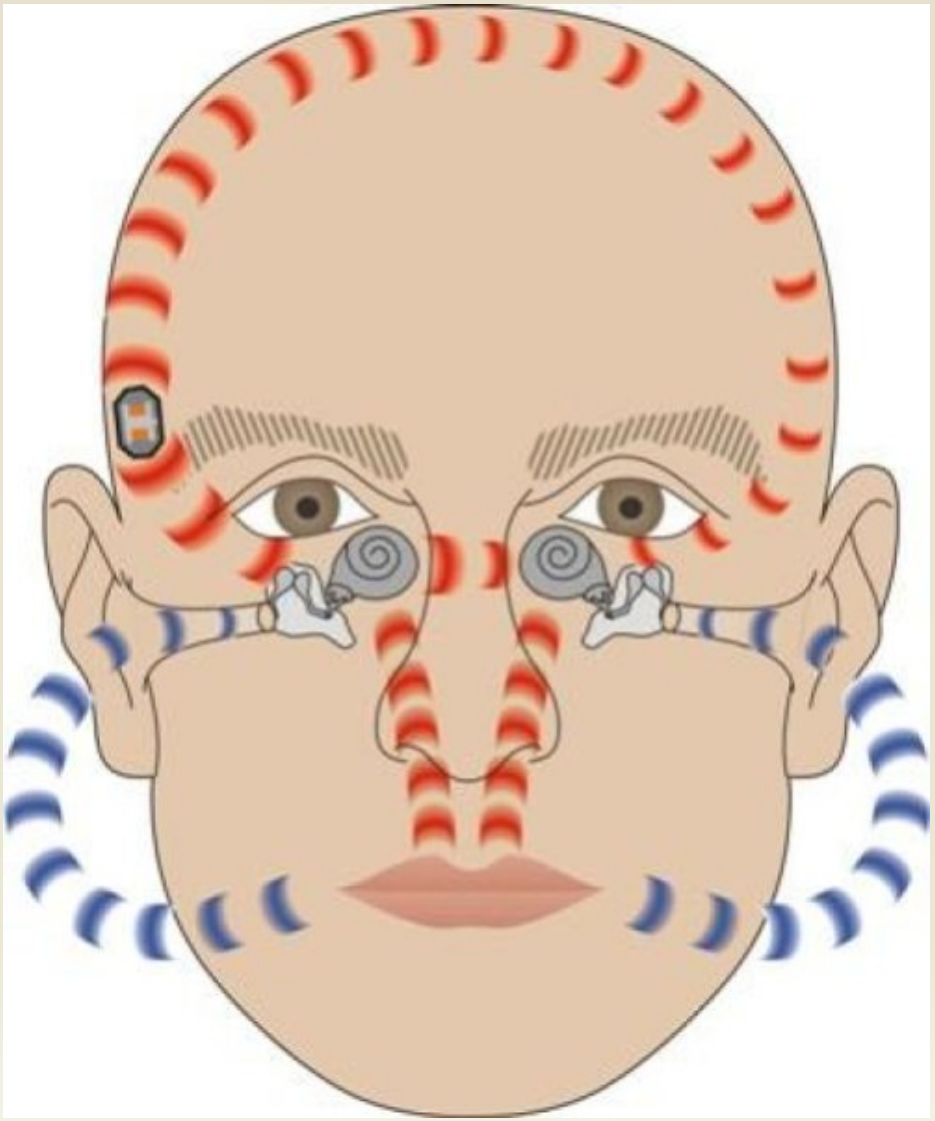
	Men			Women			Children		
Vowel in	F1	F2	F3	F1	F2	F3	F1	F2	F3
beat	270	2300	3000	300	2800	3300	370	3200	3700
bit	400	2000	2550	430	2500	3100	530	2750	3600
bet	530	1850	2500	600	2350	3000	700	2600	3550
bat	660	1700	2400	860	2050	2850	1000	2300	3300
part	730	1100	2450	850	1200	2800	1030	1350	3200
pot	570	850	2400	590	900	2700	680	1050	3200
boot	440	1000	2250	470	1150	2700	560	1400	3300
book	300	850	2250	370	950	2650	430	1150	3250
but	640	1200	2400	760	1400	2800	850	1600	3350
pert	490	1350	1700	500	1650	1950	560	1650	2150



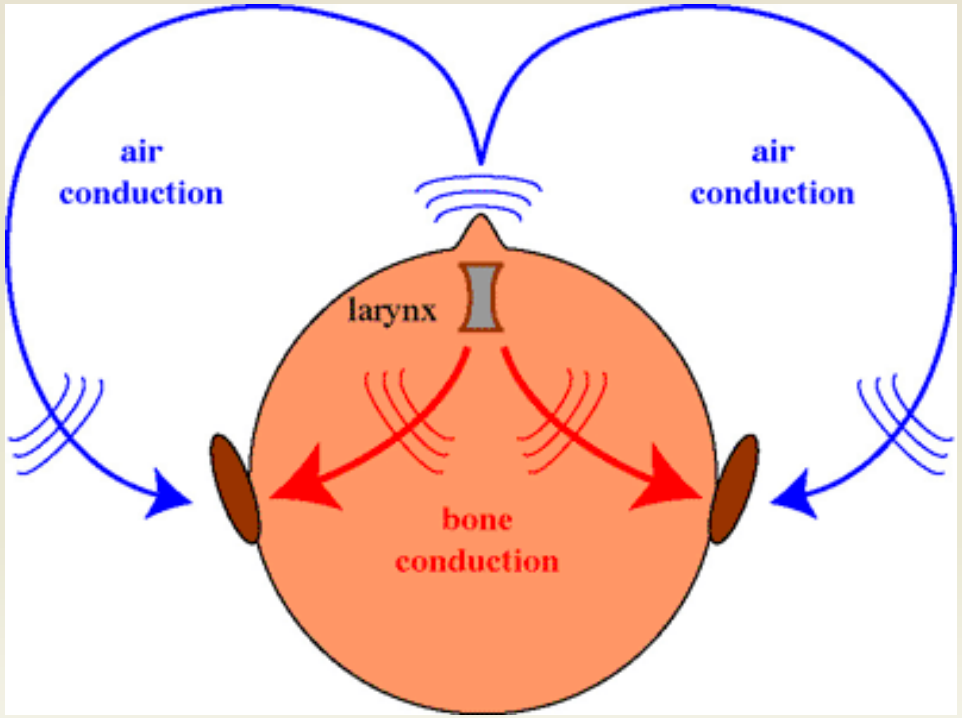
(a) Extrinsic tongue muscles



https://www.youtube.com/watch?v=mB468Jh9aAY



Air conducted hearing
and
Bone conducted hearing



Somatosensory Voice Control

Successful professional operatic singers :

- have a particularly large **kinesthetic perception** of the "vocal instrument"

(Kleber , Veit , Birbaumer , Gruzelier , & Lotze , 2009)

- they gradually learn to **rely more on somatosensory**, rather than on the auditory feedback of the voice

(Kleber et et al ., 2009; Kleber , Zeitouni , Friberg , & Zatorre , 2013; Zarate and Zatorre , 2008; Zarate , Wood, & Zatorre , 2010; Zarate , 2013) .

- the above increases **with experience and level of education**

(Zarate , 2013)

Sensors for Voice Analysis:

Acoustic analysis:

Various voice signal acoustical properties can be realized with data from such sensors, such as pitch estimation, formant analysis, singers' formant, spectral energy, sound pressure level (SPL) (Švec & Granqvist, 2018), harmonics-to-noise-ratio (HNR), jitter and shimmer (Teixeira et al., 2013). In all the above cases the sensor used is the microphone (Švec & Granqvist, 2010), while different types of microphones are used to better suit the conditions of each study (condenser and dynamic microphones, piezoelectric contact microphone). Accelerometers have also been used for some of these metrics, such as pitch estimation (Cortés et al., 2018), but also for metrics like SPL, cepstral peak prominence (CPP), and f_o (Cantor-Cutiva et al., 2025).

Voice acoustic analysis has found application in fields such as voice analysis for singers (Sangiorgi et al., 2005), children voice education (Wallace, 2020; Welch et al., 1989), clinical evaluation (Manfredi et al., 2017), and voice research (Manfredi et al., 2019).

Motor functions (mostly respiratory): accelerometers (Blanco-Almazán et al., 2019), electromyograph (Titze et al., 1989; A. H. D. Watson et al., 2012), mechanomyograph (Ramli et al., 2019), plethysmograph (Wlodarczak, 2019), magnetometers (P. J. Watson & Hixon, 1985b), linear response transducer (Konno & Mead, 1967)., RespTrack System (Heldner et al., 2019), wearable surface electromyography collar (Reed et al., 2022).

A formant is a spectral peak of complex sound, including a range of frequencies. The maximum frequency within this range is the formant frequency.

Spectral energy, or spectral energy distribution of a vocal sound, is the distribution plot graph of energy, as a function of frequency, for all the different frequencies present in this vocal sound.

Sound pressure level (SPL) of a vocal sound is the level of pressure change to the ambient (usually atmospheric) pressure, caused by the wave of said sound. It can be measured through the movement it causes to a microphone membrane.

Shimmer and Jitter are deviations on the f_o between wave cycles. Shimmer is a disturbance in amplitude values and Jitter in frequency values.

Sensors for Voice Analysis:

Postural and kinetic analysis: A special category of kinetic analysis systems is used for the estimation of body movement and skeleton tracking, which can be realized with the use of cameras with depth assessment capabilities, which utilize multiple 2D cameras, or specialized equipment with integrated time of flight, structured light and synchronized cameras technology (Cippitelli et al., 2015; Clark et al., 2019; Li et al., 2020; Ning, 2018; Xu et al., 2019).
Respiratory air volume and speed: spirometers (Ksinopoulou, H., Hatzoglou, C., Daniil, Z., Gourgoulianis, K., & Karetsi, 2016), pneumotachograph mask (Rothenberg, 1977), Accelerometers (Cortés et al., 2018).
Air Pressure: pressure sensors (D. Miller & Schutte, 1984).
Articulators tracking: electromagnetic articulograph (Dromey et al., 2018), imaging camera (Chawah et al., 2014; Yanagisawa et al., 1990), MRI (Nair et al., 2016), and ultrasound (Nair et al., 2016), electronic glossographer, X-ray tomography (Stulova, 2021).
Vocal Tract / Tongue Contour: ultrasound probe (Chawah et al., 2014).
Blood/tissue oxygenation: near infrared spectroscopy (NIRS), pulse oximetry (Kyriacou et al., 2018).
Glottal Activity: electroglottograph (EGG) (Herbst, 2020a), video-endoscope (Yanagisawa et al., 1990), kymography (Kumar & Švec, 2019), laryngoscope, oscilloscope, stroboscope (Stulova, 2021), accelerometers (Cortés et al., 2018).
Brain activity: functional magnetic resonance imaging – fMRI (Kleber et al., 2009, 2016; Zarate, 2013), electroencephalogram – EEG (Kleber et al., 2008).
New generation of sensors: During the last years there have been groundbreaking advancements in material science, allowing for the creation of new types of wearable sensors. These are usually made from newly-developed flexible and stretchable electronics and materials, and some even are nanomaterial-enabled (Yao et al., 2020). Such “Bio-integrated wearable systems can measure a broad range of biophysical, biochemical, and environmental signals to provide critical insights into overall health status and to quantify human performance” (Ray et al., 2019).

Voice Aesthetic Foundations: Why ‘Human’ Matters

Evangelos Angelakis
Laboratory of Music Acoustics and Technology - University of Athens

Aesthetics and The “Human” Element in Opera

- *"Paradoxically enough, the public does not seem to want the 'perfect' voice, but rather, the ‘**human’ voice**." (Cooke, 1921, p. 10)*
- *Distinction between flawless technical execution and the emotive, 'human’ quality in operatic performance*
- *Public preference for individuality and **identity in a voice***
- *Maria Callas – known for a distinctive timbre yet considered one of the most influential opera singers.*
- *“**Una grande vociaccia**” (Tulio Serafin) Translation: A Great, Rough/Coarse Voice”*
- *Opera's **roots in Ancient Greek drama** and the emphasis on **catharsis** through dramatic representation.*

Tragedy and Catharsis

Tragedy is the imitation [mimesis] of an action that is heroic, complete, and of a certain size [...] accomplishing with pity and fear the ***catharsis of these emotions****."*

(Aristotle, as translated by Pabst Battin, 1975, p. 294)

Technique as a Means to an End: “Empathy!”

- *“drama **purifies the feelings of the audience**” (Huibin, 2017, p. 618)*
- *Role of **empathetic psychological phenomena, body resonance, and mirror neurons** in **connecting performers with the audience**.*

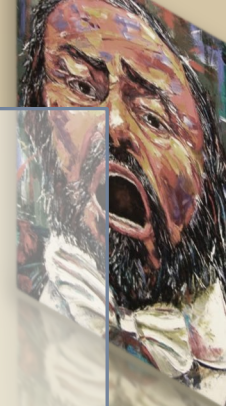
  (Brown, 1996a; Mansouri & Madison, 2022; Blair, 2019)
- ***Neuroscience** research supports the **engagement of the mirror neuron system during opera performances**. (Tanaka, 2021, p. 1)*
- *Opera singing techniques aim not just for aesthetic beauty but for **emotional resonance with the audience***

Vocal Function and Immitation

- Mirror Neurons **-> Neurons that are activated**
  both when we do an action and when we observe a third party doing that action
- Auditory mirror neurons -> **Imitation of sound action**
  (Gazzola V, Aziz-Zadeh L, Keysers C (2006) *Empathy and the somatotopic auditory mirror system in humans* . Current Biology 16)
- Many linguists argue that **imitation of sounds** plays an important role in **learning to use language** (Kymissis , E., & Poulson , CL (1990). The history of imitation in learning theory: The language acquisition process. Journal of the Experimental Analysis of Behavior , 54(2), 113-127
- Singing lessons (**imitating a teacher**) with subjective acoustic self-feedback
- But, "[…] if **imitation** should come to be the **sole resource** of lyric artists it would **disparage the art of singing**" Charles Battaille (1864): Pioneer in Vocal Science and the Teaching of Singing p.165
- Learning the different Music (and Vocal) Genre styles authentically through "Personal experience»

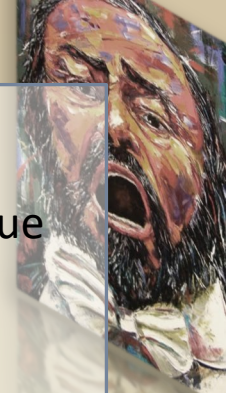
Effects of Mastery and Simplicity in Technique

- ✓ *"When I hear **great singing**, it is as though I were listening to a **marvelous animal**. I believe this is why audiences are so **deeply moved** by great singing. At a subconscious level, **empathy** takes place when a singer shares his or her **primal sound**."* (Brown, 1996a, p. 4)
- ✓ *"Singing is such a stylized art form. Like ballet is to walking, [operatic] singing is to talking. In essence, it **is a cultivated scream**."* (LaBouff, 2008, p. vii)
- ✓ *"Singing is as demanding a performance art as any other. Simplicity is possible only when the **performance has become 'simplified'** through reliance **on well-programmed technical foundations**."* (Miller, 2011, p. 45)
- ✓ ***Great Opera artists'** singing "brings **tears** to our eyes or puts us on the **edge of our seats** in suspense. **We empathetically groan, moan, laugh, cringe, lament, rejoice, or become exhausted with despair**."* (Brown, 1996a, p. 5)



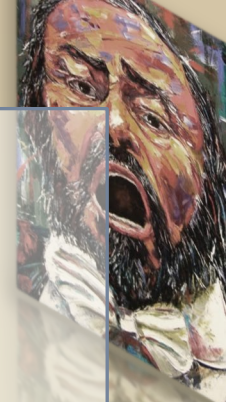
Singing as a Balance:

- ✓ *Discipline & Freedom*
- ✓ *Conscious technique supports unconscious reflexes*
- ✓ *Artist must feel free, not constrained by method*
- ✓ *Audience should not perceive difficulty → only expression*
- ✓ *True artistry = making the extraordinary seem simple*



A Few Examples of voices with the **empathetic "Human" Element** of Freedom and Simplicity **Through** Technique From Various Genres

Callas (https://www.ertecho.gr/radio/trito/category/trito-afieromata/ondemand/1161776/giati-i-kallas-me-ton-ari-xristofelli-02-12-2025/)
Del Monaco (https://youtu.be/EOk9AXRfe68?t=1158)
Gigli (https://www.youtube.com/watch?v=SiWa5S-1UrQ)
Freddie Mercury (https://www.youtube.com/watch?v=b0cBzrjw4zE)
Sinatra (https://www.youtube.com/watch?v=w019MzRosmk)
Luis Armstrong and Dean Martin (https://www.youtube.com/watch?v=4pTsWkCvACs)
Celine Dion (https://www.youtube.com/watch?v=epqYft12nV4)
Κατίνα Παξινού (https://www.youtube.com/watch?v=VJYSONVk7U0)
Χρόνης Αηδονίδης (https://www.youtube.com/watch?v=B7ovSoyQlfg)
Ρόζα Εσκενάζυ (https://www.youtube.com/watch?v=4Luxw7Lfqls)



Practical Experimentation in the Classroom

- ✓ *Experiments with Software*
- ✓ *Experiments with Actual Singing*
- ✓ *Experiments with Sensors*