Theoretical and practical aspects of voice assessment

Baiba Trinite PhD, Liepaja University, Latvia
Our course will be about

- Diversity of voices
  - Gender: female/male
  - Age: children/adults/elderly
  - Profession: voice professions/non-voice professions
  - Health: normal or harmonic/pathological or disordered
- Voice assessment protocols and methods
  - Anamnesis collection
  - Aerodynamic assessment
  - Perceptual assessment
  - Acoustic assessment
  - Self-assessment protocols

Practical classes
- Lab: MDVP, VRP
- Group work: PRAAT
Voice is the sound produced by humans and other vertebrates using the lungs and the vocal folds in the larynx (NIDCD)

- Sound – a physical phenomena (sound is vibration of air particles)
- Humans and animals have voices
- The voice is produced by air flow passing through vocal folds (generator of vibrations)
Latin *persōna* ("mask; character") or *personare* ("to sound through")

*Voice = personality*

“The voice is closely associated with the soul”  
Aristotle
Voice ...

... is powerful communication and work tool

... is used for delivering the meaning of the message (7%-38%-55% Rule. Mehrabian, 1967)

... reflects our health condition, age, gender, and emotions

Baiba Trinite, PhD, Torino, 2017
Who is the speaker? A man or a woman?
Voice and gender

<table>
<thead>
<tr>
<th></th>
<th>Adult females</th>
<th>Adult males</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F0</strong></td>
<td>200-220 Hz</td>
<td>110-120 Hz</td>
</tr>
<tr>
<td><strong>Total vocal fold length</strong></td>
<td>11-15 mm</td>
<td>17-21 mm</td>
</tr>
<tr>
<td><strong>Thyroid cartilage angle</strong></td>
<td>110°</td>
<td>90°</td>
</tr>
<tr>
<td><strong>Cricoid level in the neck</strong></td>
<td>C6</td>
<td>C7</td>
</tr>
<tr>
<td><strong>Length of the vocal tract</strong></td>
<td>14.1 cm</td>
<td>16.9 cm</td>
</tr>
</tbody>
</table>
Voice and age

• Changes during the lifespan
  • Anatomical changes
  • Hormonal changes
Newborns’ & Children voices

- High voices F0: 500Hz-300Hz-250Hz
- No gender differences
- In newborns, the larynx is situated high in the neck (cricoid positioned at the level of C3 to C4)
- No identifiable layer structure of vocal folds until 11 months, 5 layer structure of lamina propria after puberty
- The length of vocal folds of boys and girls appears to be similar until age 10 (Hirano et al, 1983)
Puberty and voice changes

• Puberty period from 12 to 17 years, duration 2-5 years
• Voice changes occurs during 3-6 months, max 12 months
• Acoustic analysis can detect voice changes 5-7 month before perceptual perceptible signs. The acoustic evaluation is recommended for children choir singers for prevention of vocal fatigue and disorders (Fuchs et al, 2007)
• The male voice lower about 1 octave, female voice lowers 2 to 3 semitones (Curry, 1990)
• 80% of 14 old boys suffer of transient dysphonia (Curry, 1999)
• Acoustic analysis helps detect unstable vocal folds behavior after the acute period of voice changes.
Male: A-P growth of thyroid

Female: superior growth of thyroid
The changes of vocal folds’ length (female/male)

Kent, 2000
Adults: male / female

Hollien, 2011
Hormonal impact on voice (Abitbol et al, 1999)

- Females: estrogens, progesterons; Males: androgens
- Premenstrual vocal syndrome
  - Vocal fatigue
  - Decreased range
  - Loss of power
  - Loss of certain harmonics
- Menopausal vocal syndrome
  - Lowered vocal intensity
  - Vocal fatigue
  - Decreased range with loss of high tones
  - Loss of vocal quality
  - 17/100
  - Anatomically: vocal muscle atrophy, reduction in the thickness of mucosa, reduced mobility of cricoarytenoid joint
Geriatric voice changes

• Presbylaryngeus or aging larynx, presbyphonia or aging voice

• Anatomical/ histological changes:
  • intermediate layer of lamina propria becomes looser and thinner (insufficient vocal folds closure)
  • Morphological disorganization and loss of the collagen and elastin fibers (stiffness and decrease tissue elasticity)

• Perceptual changes:
  • Roughness
  • Tremor
  • Reduced vocal loadness

43 years old man          69 years old man

Baiba Trinite, PhD, Torino, 2017
Voice and occupation

• Voice professions (singers, teachers, priests, call center operators, sellers, etc.)
• Non-voice professions (accountants, factory workers, shoes makers, etc.)
• The professional voice users are those who depend on a consistent, special or appealing voice quality as a primary tool of trade (Titze et al, 1997)
Levels of vocal use (Koufman, Isaacson, 1991)

<table>
<thead>
<tr>
<th>Level</th>
<th>Professional</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Elite Vocal Performer</td>
<td>Even the slightest voice problem impacts the professional performance and also constitute a hazard to the personal career. E.g.: professional singers and actors</td>
</tr>
<tr>
<td>II</td>
<td>Professional Voice User</td>
<td>Voice is part of the job performance; need to talk over long periods of time. E.g.: teachers, call center operators, priests</td>
</tr>
<tr>
<td>III</td>
<td>Nonvocal Professionals</td>
<td>Performance may be adversely affected by a moderate vocal problem, unable to perform activity when facing a severe problem. E.g.: doctors, lawyers, salesmen</td>
</tr>
<tr>
<td>IV</td>
<td>Nonvocal Nonprofessionals</td>
<td>The performance is not affected by a problem or vocal impairment. E.g.: shoemaker, factory workers, farmer</td>
</tr>
</tbody>
</table>

Baiba Trinite, PhD, Torino, 2017
Who are these professionals?
Voice problems in teachers’ profession

- 138 teachers were asked to answer a question “Have you ever had any voice problems?”
- increased vocal load
- Ignorance of voice hygiene
- Bad conditions of room acoustic
- presence of stress

Baiba Trinite, PhD, Torino, 2017
The aims of voice assessment

1. determine the presence of the deviant voice quality and determine the presence of disorder;
2. determine the etiological factors related to the disorder;
3. determine the disorder severity.
Voice disorders

• A **voice disorders** exist when quality, pitch, loudness or flexibility differs from the voices of others of similar age, sex, and cultural groups (Moore, 1971)

• No fixed standards of abnormal voice exists, just as no absolute criterion for normal voice can be established.
The social aspect of voice disorders

• A voice disorder is present when a person’s quality, pitch, and loudness differ from those of a person’s of similar age, gender, cultural background, and geographic location, or when an individual indicates that his or her voice is not sufficient to meet daily needs, even if it is not perceived as deviant by others (Colton & Casper, 1990)

• Abnormal voice is any voice that calls attention to itself, does not meet the occupational and social needs of the speaker (Aronson & Bless, 2009)
Symptoms of voice disorders

• abnormal pitch, loudness and vocal quality
• vocal fatigue,
• hoarseness,
• aphonia,
• weakness,
• strained harshness,
• poor pitch and loudness modulation,
• aesthetically unacceptable, resulting in severe personal, social, vocational, and economic penalties (Mattiske, Oates and Greenwood, 1998)
Causes of voice disorders

Voice ergonomics is awareness of work related risk factors, knowledge about how to improve voice production and speech intelligibility in different work environments to prevent occupational voice disorders.

Baiba Trinite, PhD, Torino, 2017
The basic protocol for functional assessment of voice pathology

• Committee on Phoniatrics of the European Laryngological Society in 2001 (Dejonckere et al., 2001)

• The aim of the project was to reach better agreement and uniformity concerning the basic methodology for functional assessment of voices.

• The protocol was based on the principle that voice is multidimensional phenomenon and following components were included in the assessment of dysphonia: perceptual and acoustic assessment of voice, videostroboscopy, aerodynamic measurements, and subjective rating of voice by patient.
Unità Operativa di Otorinolaringoiatria
Direttore: Prof. Delfo Casolino
Struttura Semplice di Foniatria e Fonochirurgia
Responsabile: Dott. Andrea Ricci Maccarini
The team work

• Professionally trained speech therapists can provide all types of assessment except endoscopic exam of the vocal folds. The instrumental assessment of vocal folds and upper airways and medical diagnosis of vocal fold pathology is carried out by otolaryngologists or phoniaticrians.

• It is highly recommended to work together speech therapists and physicians with involving neurologists, psychologists, and singing teachers.

Baiba Trinite, PhD, Torino, 2017
The voice evaluation process

• collecting of anamnesis;
• aerodynamic assessment;
• auditory-perceptual assessment;
• acoustic assessment;
• self-evaluation of voice function by client;
• diagnosis and recommendations.
Anamnesis

• **Client’s complaints about the voice.**

• **The initiation of the voice problems.**
  • Did voice problems start gradually or suddenly?
  • Did some additional changes observe in the speech (unintelligible articulation, hypernasality) or swallowing?
  • Did some significant factors be present in the history (emotional stress, illness of upper respiratory tract, surgery)?
Anamnesis

• **Characteristics of the symptoms.**
  • Do voice changes are permanent, periodically or unpredictable?
  • Does voice change during the day (the symptoms are more manifested in the morning or in the afternoon)?
  • Do voice changes are related to the vocal load? *It is important to know that physical tiredness and emotional stress increase all vocal symptoms regardless of its etiology.*
  • The presence of tiredness, tension, coughing and throat clearing, feeling of irritation and dryness in the larynx, heartburn can indicate the presence of other diseases.
Anamnesis

• **Information about the overall health**
  • laryngeal pathologies, chronic diseases of airways (chronic obstructive pulmonary disease, asthma),
  • gastroesophageal reflux disease,
  • neurological diseases (stroke, traumatic brain injury, pseudobulbar paresis, dystonia, Parkinson disease, amyotrophic lateral sclerosis, multiple sclerosis),
  • allergies,
  • endocrine disorders (hypo- and hyperthyroidism, hormonal disorders),
  • psychiatric disorders (depression, schizophrenia, acute or chronic anxiety),
  • hearing disorders,
  • oncological diseases.
Anamnesis

• Factors of voice ergonomics for representatives of voice professions (teachers, singers, actors, judges, and so forth).

• The environmental risk factors of voice disorders include:
  • noise and sound conditions, acoustics,
  • indoor air quality,
  • working postures,
  • working practice (Sala et al., 2009).
Output of anamnesis collection

Voice disorders

- age
- profession
- initiation symptoms regularity
- Harmful habits
- Possible causes
- References to other specialists
- Life style

Baiba Trinite, PhD, Torino, 2017
Aerodynamic assessment

• Maximal Phonation Time, MPT
  • Maximal phonation time is objective measure of phonatory ability that provides information about the control of respiratory function, glottal efficiency, and laryngeal control (Colton & Casper, 1990).
  • phonate sustained vowel /a/ at a modal or habitual pitch level for as long as possible after deep inspiration.
  • The measurement is repeated three times and the best score (greatest value) is recorded in the protocol.

• Norms
  • adult males is 25.89 s (SD 7.41),
  • adult females 21.34 s (SD 5.66) (Colton & Casper, 1990).
Auditory perceptual assessment

- Human auditory perceptual system + external rating system

Pitch
Loudness
Quality

Baiba Trinite, PhD, Torino, 2017
## Auditory perceptual assessment

**GIRBAS scale (Hirano, 1981)**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>G</strong> Grade</td>
<td>Overall grade of hoarseness</td>
</tr>
<tr>
<td><strong>R</strong> Roughness</td>
<td>Irregularity in the vibrations of the vocal folds</td>
</tr>
<tr>
<td><strong>B</strong> Breathiness</td>
<td>Audible turbulence such as a hiss, air leak at the glottis, a feeling of air in the voice</td>
</tr>
<tr>
<td><strong>A</strong> Asthenicity</td>
<td>Vocal weakness, loss of power, reduced vocal energy</td>
</tr>
<tr>
<td><strong>S</strong> Strain</td>
<td>Impression of hyperfunctional state, noise in the high frequencies of the spectrum</td>
</tr>
</tbody>
</table>

Baiba Trinite, PhD, Torino, 2017
GIRBAS (Hirano, 1981, 1989)

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal voice, absence of disorder</td>
</tr>
<tr>
<td>1</td>
<td>Mild disorder</td>
</tr>
<tr>
<td>2</td>
<td>Moderate disorder</td>
</tr>
<tr>
<td>3</td>
<td>Severe disorder</td>
</tr>
</tbody>
</table>

- G2 I0 R2 B2 A0 S0
- G1 I1 R0 B1 A0 S0

Baiba Trinite, PhD, Torino, 2017
Acoustic assessment

• Acoustic measures can provide objective and non-invasive analyses of vocal function.

• The acoustic analysis of voice allows obtain information about vocal fold physiology.

• The origin of voice disorders is change in vocal fold structure or vibratory characteristics and acoustic analysis helps identify and quantify these changes.
Acoustic assessment

• Frequency and frequency range
• Intensity & intensity range
• Short-term perturbations
  • Jitter – pitch perturbation
  • Shimmer – amplitude perturbation
• Harmonic-to-noise ratio
Softwares

- KayPENTAX Computerized Speech Lab, CSL
  - Multi-Dimensional Voice Programme (MDVP)
  - Voice Range Profile (VRP)
- WAVOSYS lingWaves
- PRAAT
Recording requirements

- Quiet room with ambient noise less than 35-37 dB
- Signal-to-noise ratio 42dB (recommended), 30dB (accepted), <30dB (nonaccepted) Deliyski et al, 2005
- Sound isolation booth
Recording requirements

• Lab
  • Microphone (15-20-30 cm, 45 degree)

• Smartphones

Smartphones Offer New Opportunities in Clinical Voice Research
C Manfredi et al. J Voice 31 (1), 111.e1-111.e7. 2016 Apr 07. more

Abstract
Smartphone technology provides new opportunities for recording standardized voice samples of patients and sending the files by e-mail to the voice laboratory. This drastically improves the collection of baseline data, as used in research on efficiency of voice treatments. However, the basic requirement is the suitability of smartphones for recording and digitizing pathologic voices (mainly characterized by period perturbations and noise) without significant distortion. In this experiment, two smartphones (a very inexpensive one and a high-level one) were tested and compared with direct microphone recordings in a soundproof room. The voice stimuli consisted in synthesized deviant voice samples (median of fundamental frequency: 120 and 200 Hz) with three levels of jitter and three levels of added noise. All voice samples were analyzed using PRAAT software. The results show high correlations between jitter, shimmer, and noise-to-harmonics ratio measured on the recordings via both smartphones, the microphone, and measured directly on the sound files from the synthesizer. Smartphones thus appear adequate for reliable recording and digitizing of pathologic voices.
Multi-Dimensional Voice Programme, MDVP

• MDVP
  • a sustained vowel /a/ at habitual, comfortable pitch, and constant loudness
    • demonstration by the examiner
    • multiple trials
    • the voice sample which is more relevant to the habitual client’s voice is using for the analysis
    • the 3-second midvowel portion is extracted from the chosen voice sample
  • A phonetically balanced standard passage
  • F0, Jitt, Shimm, HNR ... 33 voice parameters
Voice Range Profile or Phonetogram

- The VRP or phonetogram is a software program that assess both fundamental frequency and intensity at an individual’s absolute minimum and maximum capabilities.
- phonate a sustained vowel /a/ at the particular position (soft, low, high, loud)
- the low-high-low glide
- \( \text{INT}_{\text{min}} - \text{F0}_{\text{max}}, \text{INT range, F0 range} \)
Voice Range Profile

Baiba Trinite, PhD; Torino; 2017
Speech Range Profile

• Speech range profile (SRP) obtained during functional speech activity (by reading phonetically balanced text).

• Simplicity of the procedure and the shorter amount of time required compared to traditional VRP.

Baiba Trinite, PhD, Torino, 2017
Dysphonia Severity Index, DSI

• DSI reflects the overall vocal quality based on an integration of parameters of voice range profile, aerodynamic, and acoustic measurements (Wuyts et al., 2000).

• The DSI consists of a specific weighted combination of the highest F0, $INT_{\text{min}}$, MPT, and Jitt.

\[
DSI = 0.13MPT \text{ (s)} + 0.0053F0_{\text{max}} \text{ (Hz)} - 0.26I_{\text{min}} \text{ (dB)} - 1.18Jitt \text{ (%) } + 12.4.
\]
<table>
<thead>
<tr>
<th>Aerodynamic assessment</th>
<th>MPT(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acoustic assessment</td>
<td></td>
</tr>
<tr>
<td><strong>MDVP</strong></td>
<td></td>
</tr>
<tr>
<td>F₀(mean Hz)</td>
<td>Jit(%)</td>
</tr>
<tr>
<td><strong>VRP</strong></td>
<td>F₀ (Hz)</td>
</tr>
<tr>
<td></td>
<td>max</td>
</tr>
<tr>
<td></td>
<td>Hz</td>
</tr>
<tr>
<td><strong>SRP</strong></td>
<td>F₀ (Hz)</td>
</tr>
<tr>
<td></td>
<td>max</td>
</tr>
<tr>
<td></td>
<td>Hz</td>
</tr>
<tr>
<td>EGG</td>
<td>CQ:</td>
</tr>
<tr>
<td>DSI</td>
<td>0.13<em>MFL + 0.0053</em>F_max - 0.26<em>Int_min - 1.18</em>Jit + 12.4</td>
</tr>
</tbody>
</table>
PRAAT

• F0, F0 min, F0 max, F range
• Jitter
• INT, INT min, INT max, INT range
• Shimmer
• HNR
• AVQI
  • An objective method to quantify dysphonia severity.
  • connected speech + sustained vowel
• Etc.

Baiba Trinite, PhD, Torino, 2017
Self-evaluation of voice function by client

• The objective assessment methods provide data about the voice quality, structural and functional conditions of larynx, but do not give information about the functional impact of the voice disorder on the individual in daily life. **It is the patient who has to live with his/her voice** (Dejonckere et al., 2001)

• Voice Handicap Index, VHI (Jacobson et al., 1997)
  • three subscales: physical, functional, and emotional
  • A 5-point Likert scale is used to rate each statement as it reflects the client’s experience with the voice disorder.
**Voice Handicap Index**  (da Jacobson e Coll., modificato da Luppi)

| Impatto delle problematiche vocali sulle normali attività quotidiane | Data ____________ |
|---|---|---|---|---|
| | MAI | QUASI MAI | QUALCHE VOLTA | QUASI SEMPRE | SEMPRE |
| 1 | Mi sentono con difficoltà a causa della mia voce | | | | |
| 2 | Mi capiscono con difficoltà in un ambiente rumoroso | | | | |
| 3 | Mi capiscono con difficoltà anche in ambiente silenzioso | | | | |
| 4 | I membri della mia famiglia fanno fatica a sentirmi | | | | |
| 5 | Telefono meno spesso di quanto vorrei | | | | |
| 6 | Tendo ad evitare i gruppi numerosi per la mia voce | | | | |
| 7 | Parlo poco con amici parenti etc. a causa della mia voce | | | | |
| 8 | I miei problemi di voce limitano la mia vita sociale | | | | |
| 9 | Mi sento escluso/a dalle conversazioni per la mia voce | | | | |
| 10 | Se parlo a lungo mi gira la testa | | | | |

**Punteggio:** (punteggio massimo: 40) 0 1 2 3 4

**Impatto psicologico**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sono teso/a quando parlo con gli altri per la mia voce</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>La gente sembra irritata dalla mia voce</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Trovo che gli altri non comprendano il mio problema</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>I miei problemi di voce mi interroviscono</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sono meno socievole a causa dei miei problemi di voce</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Diagnosis and recommendations

• Summarizing of data
• Determination of prognosis for change,
• Making the decision regarding to voice diagnosis,
• Recommendations for intervention and support

• Presence of deviant voice quality
• Severity of disorder
• Etiological factors related to disorder
## Practical classes

<table>
<thead>
<tr>
<th>III ANNO</th>
<th>II ANNO</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.04. 2 pm-5 pm 10 students</td>
<td>27.03. 2 pm-5 pm 10 students</td>
</tr>
<tr>
<td>08.05. 2 pm-5pm 10 students</td>
<td>10.04. 2 pm-5pm 10 students</td>
</tr>
<tr>
<td>15.05. 2 pm-5 pm 10 students</td>
<td>21.04. 2 pm-5 pm 10 students</td>
</tr>
<tr>
<td>23.05. 2.30 pm-5.30 pm (?) all together/group presentations</td>
<td>31.05. 2.30 pm-5.30 pm (?) all together/group presentations</td>
</tr>
<tr>
<td>...? test</td>
<td>...? test</td>
</tr>
</tbody>
</table>
Student’s activities / group work

• 1 group: Voice & Occupation
• 2 group: Voice & Gender
• 3 group: Voice & Age
1. Collect the voice samples from healthy (without noticeable voice problems) people of different professions, age, and genders
   1. Use your smartphones
   2. Each student has to record at least three voice samples

2. Analyse the obtained voice samples.
   1. PRAAT
   2. The first consultation about the using of PRAAT during the first practical class if needed

3. Arrange a meeting with your group members. Bring together all voice reports (F0sv, F0cs, INTsv, INTcs, AVQI) and summary all individually obtained data
   1. Use the simple statistics

4. Prepare the group presentation about the group topic and present it at the final class.

Good luck!
Thank you for the attention!
See you in the practical classes!