Age-Related Evolution of the Professional Singing Voice

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Prevention, Voice Testing and Voice Therapy

By

Hugo Lycke

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FOREWORD

For many years I worked as a vocal coach/voice therapist in music conservatories and opera and musical theatres in Belgium and abroad, participating as a member of the jury at many castings, auditions, and rehearsals, testing voices, and providing therapeutic support for conservatory students and professional actors and singers (classic and commercial).

This creative, but rather exclusive and closed environment, the world of theatre, not easily accessible for scientific research, incited me to do my own research on the singing voice, based on voice testing by phonetograpy, and functional voice therapy,

I could observe that almost every voice problem, which occurred during the short but intensive rehearsals, and during the demanding performances afterwards, primarily had to do with **voice classification**. In my experience as a voice therapist, phonetographic analysis proved to be very helpful to all kinds of actors, singers, acting students, singing students, singing teachers, conductors, and directors of contemporary Opera and Musical Theatre.

This original viewpoint has been stated by this author, at many international scientific conferences and workshops, and finally resulted, many years later, in a Ph.D. thesis on 'Voice Classification by Phonetography'[11], based on *an experimental database of more than 1000 phonetograms, proving for the first time, the real existence of three specific natural voice groups for each gender* (2013).

Before and after the official defence of my doctoral thesis at the Catholic University of Louvain (Belgium), many conferences, papers, and workshops about voice classification by phonetography (Voice Range Profiling), were given at more than 100 international meetings and received much attention and appreciation from different audiences.

During the past 60 years of my professional activities, I could witness not only the changed world of scientific voice research, but I also became

aware of the different intra-and interindividual changes in vocal health and its impact on the professional activity of the singers and actors I had tested and guided many years before.

My long professional experience confronted me with the fact that the career of some professional singers and actors I had tested years before, had abruptly stopped, for one reason or another, while others continued their stage performances like before, even at an advanced age.

One must consider that, many years ago, the few scientific studies on aging were often overlapping. Moreover, studies on the evolution of the voice with aging were exclusively applied to the *speaking voice*. Even my Gerontology studies[8] were not very helpful in this respect.

In 1963, I graduated as a Speech-Voice-Language Therapist, at the H.R.P.B., A.Z. University of Ghent, on a rather atypical thesis: **"The Dysodia - Functional Disorders of the Singing Voice"**.[7]

Many years later, as a student of the first cohort of Gerontology students in Biomedical Sciences at the Free University of Brussels (1990), I learned about the increasing number of the aging population, and 'the need for information, orientation, and specialization concerning the aging process'.

According to the information prospectus of the university, the object of gerontology studies was described as 'the study of the physical and psychological (behaviour and experience) aging processes during getting older and being old, against the background of the entire life course'.

During my professional activity as a speech and voice therapist, I mostly had to do with children, adolescents, and young adults. Logopaedic interventions with elderly people were seldom dealt with, except for aphasia and laryngectomy patients.

With the appearance of the first issue of the American 'Journal of Voice' (1987), some articles on the aging process of the voice were published for the first time. This gave me the idea to do a follow-up functional voice analysis of the professional and amateur singers I had tested in 1963 for my logopaedic thesis. The objective was to investigate which items of my previous voice research had been changed over the years, to search for practical conclusions, in the context of the total lifecycle of the subjects.

The results of my first study on singers, made in 1963, were compared with the results of the same singers, 27 years later, in my gerontology thesis **"Functional Analysis of the Evolution of the Singing Voice in Adults"** (1990).[8] As a result, only a great intra-individual and inter-individual variability could be demonstrated.

Then followed a long-lasting study period, dedicated to the functional voice analysis of the earlier collected data of hundreds of singing students and professional singers and actors, applying a statistically balanced step-by-step procedure of voice classification by phonetography (Voice Range Profiling), resulting in the *elaboration of an extensive pattern card of the parameters of the human voice.*

In my first book, published in 2022 by Cambridge Scholars Publishing (U.K.): "**Voice Classification by Phonetography. A Manual for Voice Testing, Education, Therapy and Research**"[9], the analysis of a selection of longitudinal phonetograms also demonstrates that the evolution of the singing voice in a considerable lapse of time is greatly depending on a lot of complex factors.

While writing this first manual I became intrigued by the great diversity of the individual evolution of the professional singing voice. So, I decided to have a closer look at the more than 1000 phonetograms (Voice Range Profiles) I had taken during my professional life, hoping to find some evidence and explanation for this variable, but inevitable human phenomenon of vocal aging.

Hopefully, the data of this manuscript will provide the interested reader with more therapeutic insight and new ideas for his/her own practice with aging voices.

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Vocal Coach, Speech and Voice Therapist

INTRODUCTION

The human voice is an amazing phenomenon, comprising many psychological, sociological, artistic, and biological aspects. Vocal possibilities and limits are based on individual biological properties. Individual vocal qualities can give rise to optimal and even high-class artistic vocal performances, while vocal restraints can cause functional and organic voice disorders.

Professional voice users, e.g., singers and actors, using their voice as a primary tool, are especially prone to voice problems. Vocal nodules, for instance, most often based on *overload of the voice, e.g., due to an incorrect voice classification,* are well-known in clinical practice. Therefore, *it is important in voice and singing education to know the physiological limits of the voice and to carefully watch them.*

Studies on the aging voice are extremely rare. During my long professionally active period, many things changed in the scientific world concerning research on the (singing) voice. That's why, for practical reasons, *the whole text of this book is divided into 4 distinct periods*, which have not only to do with specific periods in the evolution of my own professional life, but which also coincide with specific periods in the evolution of scientific research on the (singing) voice. This way the interested reader can situate and compare my personal anecdotes, experiences, and therapeutic results with the knowledge and research progress of the same period.

In Chapter 1, a short survey is given of the period 1956 – 1963, in which the results of my first study, made as a young speech and voice therapist (1963), are reviewed.

Chapter 2 (period 1964 – 1990) gives a survey of an exciting new era of progress in voice research. For the first time, many scientific studies on voice were published, based on experiences with new devices, and amply promoted during international conferences and workshops, which I was lucky to attend. However, it was not easy to find useful references for my Gerontology thesis on the evolution of the singing voice in adults, and neither did I find clarifying answers by comparing the results of the voice

testing, anno 1963, with those of the voice testing of the same singers, 27 years later.[8]

For many years, I assisted as a special member of the jury, at all kinds of international auditions for opera companies (Amsterdam, Bayreuth, Brussels, Ghent, Helsinki, London, Milan, and Paris). Of course, most candidates for a major role were young adult singers. This was also the case for the students I tested in music and dance conservatories. As an expected result, specific age-related cases of early deterioration of the (singing) voice in this population could not be detected…

A breakthrough on the music scene happened when the Royal Ballet of Flanders at Antwerp started with a Musical Theatre Company, which successfully toured in Belgium and abroad for many years. For 12 years I assisted as a vocal coach on all auditions, judging thousands of candidates (this time, also older actors, singers, and dancers) from European countries, all trying to get an important role in a new musical production.

Voice testing with phonetographic analysis provided a more objective choice of the many candidates for a specific role in a musical comedy. I also assisted at the rehearsals and tried to help the singers, actors, and dancers with their often-occurring voice problems.

One must recall that in the eighties and the nineties, Musical Theatre became extremely popular in European countries, and I was so fortunate to assist at many interesting international workshops, e.g., the Workshop 'Musical Theatre' at the Oxford University, U.K., (1990) with Prof. Stephen Sondheim).

Chapter 3 (period 1991 – 2013) is mostly dedicated to my continuing research *to find a methodology for objective classification of the singing voice.*

At the Workshop 'Musical Theatre' at the Hürther Musikseminar, Erfurt, Germany (1991), and doing an extensive study tour in former Eastern Germany, shortly after the fall of the Berlin Wall (1992), I learned a lot about this popular medium, in full development in Europe.

Again, I was convinced about *the need for an objective voice classification method*, induced by the new vocal requirements for this popular singing theatre, depending on a special kind of performer who had *to sing, act, and*

dance all together. In my opinion, this situation also could open challenging possibilities for education and research.

After many years of technical ups and downs, primarily caused by the complex statistical analysis of the abundant data, the analysis of the numerous results provided in my Ph.D. thesis in Biomedical Sciences: **'Identification of Three Natural Voice Groups by Phonetography. A data-driven approach'**[11], finally could demonstrate *the real existence of three specific natural voice groups for each gender* (2013), thus providing a *new approach for testing, education, therapy, and research on the singing voice.*

In Chapter 4 (period 2014 – 2023), a survey is given of recent studies on voice, confirming the generally growing appreciation of the usefulness of phonetography in voice testing, education, therapy, and research. Studies on vocal aging, however, remain scarce.

In this actual manuscript, *many analyses of phonetograms from (famous) old singers and actors, who are still performing on the stage (up to 90 years old!),* are provided. With some of these artists, I have been in contact for many years, offering the possibility of doing a lot of follow-ups.

Because of deontological reasons concerning scientific studies, all featured cases in this manual are, of course, *anonymous.*

The analysis of the results of *an adapted voice guidance program for older performers*, also demonstrates what can be obtained in specific cases.

Anyhow, today everybody is confronted with attention-attracting publications from media and specialized gossip magazines, amply diffusing up-to-date news about cancelled performances or even definitive retirement of the stage, of young and older singers and actors, due to *'some persistent voice problems or even complex chirurgical interventions*', or because of many other vague causes. Moreover, statistics about the results of the nowadays abundant surgical interventions on singers, due to organic voice disorders, remain rather discrete…

Some pertinent examples of this peculiar phenomenon will be discussed at the end of this chapter.

CHAPTER 1. PERIOD 1956 – 1963

1.1. Introduction

As a young medical student, I was a member of many choirs, giving some solo performances (as a tenor). Taking singing lessons at the local music academy with some minor voice problems as an unexpected result, provided my first insight into the importance of an exact voice classification for an adequate singing education.

In my anatomy courses at the university, only 2 pages were dedicated to the subject of phonation. Concerning 'changes with aging', only a progressive ossification of the cartilago thyreoidea, followed by the cartilago cricoidea was mentioned.

As a fervent opera, operetta, and musical comedy lover, I attended many theatrical performances in different European countries. For many years I was an active member of 'Youth Opera', E.C.O.V. (European Centre for Opera and Vocal Arts), and the study-group "Musical Theatre", situated in my native city Ghent (Belgium). These experiences allowed me to be more and more in contact with the world of theatre and had a great impact on the choice of my future studies.

As a young speech and voice student, I continued my activities as a choir member, closely observing many singers, and asking a lot of technical questions, but without great success…

During the weekly rehearsals, I could observe, for instance, how one of the oldest (seated) singers of a male choir arose from his seat at the end of each song to be able to produce the highest notes as loudly as possible! The sight of his face with the heavily swollen blood vessels in his neck, and some manifest respiratory difficulties after this exceptional achievement, made me realize *the enormous physical effort needed to sing high frequencies with great intensity at a high age*!

Also intrigued about the many psychological aspects of performing, e.g., *stage fright*, I asked a well-known professional opera tenor what to do

before entering on stage. He gave me some invaluable advice: *'Have a good fuck'*!

My voice training as a future 'logopaedist' (speech therapist) was based on the 31st edition of the first Dutch 'Manual for Speech Techniques with Exercises' (published: 1886!) by A.M. Eldar (pseudonym for Anna Fles)[1]. Only 6 of the 213 pages were dedicated to so-called 'singing exercises', which were simply skipped by our young docent!

When I proposed to write my thesis on the disorders of the singing voice, the old professor O.R.L., in charge of the project, looked quite surprised and admitted he was not familiar with the subject of singing… However, I succeeded to find some interesting references.

At that time manuals on voice[2-4] were only dedicated to the speaking voice, while scientific literature was based on experiments on animals and corpses. Popular at that time was the neuro-chronactic theory of Husson, based on the measurement of the electric activity of the nervus recurrens. next to some studies on laryngoscopy, stroboscopy, and tomography.[5-6]

Tarneaud[6] considered 4 developmental stages of the voice: childhood, voice change in boys and girls, adult age, and old age. Concerning old age, he mentioned that male and female voices become less differentiated. The voice becomes gradually weaker and breaks because of joint stiffness, hyper calcification of the cartilages, and muscular hypotonicity caused by a deficiency of the endocrine glands.

1.2. Own procedure for voice testing

According to the few available test items at that time, it was not easy to make a compilation of appropriate voice testing procedures, certainly not for the singing voice, and this without the assistance of adequate measuring instruments!

However, I could make *a compilation of 38 items* for my own voice-testing procedure[7].

Next to a comprehensive anamnesis and status praesens, the most important test items were:

- Habitual pitch (= speaking fundamental frequency).
- Pitch according to the Pneumophonic Test (Tarneaud).

- Speaking voice range.
- Pitch at shouting.
- Vital capacity.
- Duration of tone in sec. at minimum, medium, and maximum voice intensity.
- Voice intensity at low and high pitches.
- Vocal range in singing.
- Location of registers.
- Test of Froeschels.
- Comparative test of Stern.
- Pressure test of Gutzmann.
- Lombard-Tarneaud test.
- Wicart test.

The 54 tested subjects of both genders (35 males and 19 females, aged 17 – 65 years) were professional opera singers, including 11 soloists, and choir singers.

The interviews and voice testing were realized in difficult circumstances. The individual sessions generally took more than 2 hours, in different places, and according to the availability of the subjects.

Amateur singers were tested after the weekly choir rehearsals, between 21h. and 23 h. Professional opera singers were only available after rehearsals, between two acts in the theatre, or during the breaks, when their presence on the stage was not necessary. The sceptic director of the opera house agreed with this unusual (anonymous) experiment, and so did the subjects. Although nobody had ever been tested before this way, the professional opera singers generally appreciated the special efforts made by a young student to explore their voice in a brand-new way!

Note, that the main objective of the study was NOT voice classification, but only *detecting functional voice disorders in amateur and professional opera singers of both genders.* Because, at that time, most test items were inevitably subjective, because of the lack of existing measuring devices, the examiner was supposed to possess a good, musically trained ear'.[21] Although the results of this study have no statistical significance at all, these new empirical findings (anno 1963) were generally positively received as being instructive for future generations of researchers.

Unfortunately, the results of only 7 objective test items could be retained in view of comparing them with the results of the same tests, 27 years later:

Habitual Pitch (SFF), Speaking Vocal Range, Pitch at Shouting, Vital Capacity in l., Duration of Tone in Sec., Voice Intensity in dB(A), and Voice Range in Singing. Other popular tests used at that time can now be considered completely as obsolete…

1.3. Results

As expected, *the results of the voice tests were very divergent*. However, these limited data can give some interesting information when comparing them, according to the specific objectives of this book (vocal aging), with the results of the same persons, 27 years later (see Chapter 2. Period 1963 – 1990).[7,8]

At the time of the first voice testing, half of the tested subjects had taken singing lessons and 7 of them were still taking singing lessons! Curiously, the great majority of the singers were not satisfied with their singing lessons. In fact, for the status praesens, I noted that more than half of the subjects were complaining about voice problems like hoarseness after singing, (pseudo)phonasthenia, faulty voice classification, aphonia, hyperkinetic and hypokinetic dysphonia, voice breaks, tremolo's, dryness of the throat, much throat clearing after singing, coughing, intonation, and modulation disorders, register breaks, and so on.

In my opinion, many of these singing problems had to do with an incorrect voice classification, but, unfortunately, at that time, I was not yet able to scientifically prove this hypothesis …

Results

Generally, professional singers could be distinguished from amateur singers by better breath control and better voice placement.

The *Body Length* fluctuated between 1m60 and 1m85 in male singers and between 1,52m and 1,72m in female singers.

The *Body Weight* fluctuated between 58 kg and 97 kg in male singers and between 50kg and 78kg in female singers.

The *Habitual Pitch* of men fluctuated between G and gis and in women between g and e1.

The *Speaking Vocal Range* fluctuated between 3 and 9 tones in speaking, and between 3 and 11 tones in reading.

The *Shouting Pitch* varied between b and d2 in men, and between b and e2 in women, and was maximally situated 1 octave beyond the highest singing pitch.

The *Vital Capacity* of the subjects was also very divergent: between 1,7 l. and 4,5 l. in men, and between 1,9 l. and 3,5 l. in women. There was not much difference between the Vital Capacity of amateur singers and professional singers.

Tone Duration varied between 12 and 35 sec. in men, and between 10 and 26 sec. in women. There was practically no difference between the Tone Duration of amateur singers and professional singers.

Singing Voice Ranges were situated between 1 octave + 1 quint, and (exceptionally) 3 octaves.

Register changes were practically identical for a given voice type. The register changes were less noticeable in professional singers.

The *Maximum Vocal Intensities* were measured at a 1m distance, according to the instructions at that time: in amateur singers: between 65dB(A) and 87 dB(A) in chest register and between 90 dB(A) and 104 dB(A) in the head register. In professional singers: between 75 dB(A) and 82 dB(A) in the chest register and between 93 dB(A) and 108 dB(A) in the head register.

Concerning the *important aspect of voice intensity measurements*, voice testing manuals at that time only mentioned if the voice was *normal, soft, or loud*. However, my first experiments with voice intensity measurements as a student (1963), using an old complex decibel meter, convinced me about *the huge importance of measuring vocal intensity in an objective way.*

So, after having carried out my first (incomplete) 'phonetograms', I strongly advised in my thesis that this method should be refined in future voice investigations, "**by measuring the voice intensity of each tone and each halftone of the whole voice range and of all vowels, to obtain a typical curve for each voice type, thus largely facilitating the troublesome "voice classification**."[7] This was quite a visionary statement from a young student at that time, years before the first scientific studies on phonetography were published!

As a general conclusion, I stressed my conviction that close cooperation between an E.N.T specialist, a singing teacher, and a logopaedist, was a *'condition sine qua non for an exact diagnosis and an adequate voice treatment'*.

This personal conviction has been expressed many times during conferences and workshops, introducing the term of a new kind of specialized speech and voice therapist as **'the missing link'**.[52,53, 296-302]

So, in 1963 I graduated as a Speech-Voice-Language Therapist, at the H.R.P.B., A.Z. University of Ghent, on a rather atypical thesis: **"The Dysodia - functional disorders of the singing voice"**.[7]

CHAPTER 2. PERIOD 1963 – 1990

2.1. Introduction

Of course, the bulk of the scientific data, provided in the present manuscript, is related to this long period of my professional activities. In the same period, *many scientific studies on voice appeared, based on experiences with new devices, and were amply promoted during international conferences and workshops*, which I was lucky to attend. This whole favourable creative atmosphere incited me to make my own research, based on testing and supporting artistic performers *in a rather exclusive and closed environment, the world of theatre, not easily accessible to scientific research*!

During this very active period in my professional life, many things changed in the scientific world, concerning studies on the (singing) voice. In this context, I refer to my first book **"Voice Classification by Phonetography. A Manual for Voice Testing, Education, Therapy and Research"** (Cambridge Scholars Publishing, 2022), including 152 figures and 72 tables.[9]

I specialized in *auditioning, casting, voice testing, education, and therapy for singers, and actors. and dancers*. As a vocal coach/speech and voice therapist, I worked for international music conservatories and dance academies. As a special member of the jury, I assisted at numerous auditions of thousands of candidates at international opera and musical companies, assisted at the rehearsals, and took care of the voices of the actors, singers, and dancers. This way I could introduce and freely experiment with my own methodology of voice classification by phonetography, including functional voice therapy.

Attending many international conferences on voice, I was a founding member of the "International Association for Experimental Research in Singing", San Francisco (USA), 1975, and wrote for 'Logopedie en Foniatrie' a report on the 'First International Conference on Experimental Research in Singing'[296]

I obtained master's degrees in leisure studies, cultural sciences, theatre sciences, dance research, and biomedical sciences (gerontology) at the Free University of Brussels, all with specific theses on voice.[8,10]

I founded a private cultural centre ("**Centre for Creative Communication**") at my homeplace, featuring more than a hundred international concerts and exhibitions, and founded a private record company ("**C.C.C. Records**"), producing classical, musical comedy, folk, and pop records. This way I also got some basic experience with recording studios.

I also organized 4 international conferences (1977 – 1981) on the singing voice at the same private cultural centre, inviting international famous voice specialists at that time, in the presence of phoniatricians, E.N.T -specialists, logopaedists, and singing and acting teachers with their students from different music conservatoria.

After a very long period of limited interest in the subject of voice classification, the scientific world finally realized the need for a correct voice classification, but the consensus of objective criteria on which voice classification should be based was still missing.

A correct classification of a singer's voice proved to be indispensable to achieve optimum performance and avoiding functional and organic voice disorders. However, at that time, no specific interpretation of VRP results regarding voice classification could be found in the scientific literature. Moreover, *I could not find age-related phonetograms of singers in the scientific literature, nor longitudinal phonetograms, providing clear indices of the evolution of the voice parameters in the same subjects*.

Gradually, phonetographic analysis of the speaking and singing voice has also been accepted as being of great help for the students and their teachers of drama and singing education.

With the arrival of computer technology, the ***objective and non-invasive method of Voice Range Profiling (Phonetography)*** *provided a clear image of all parameters of the speaking and singing voice,* ***visible in real-time on the computer screen***. Moreover*, longitudinal phonetograms offer the interesting possibility to document the evolution of a given voice,* ***providing sound technical advice for voice education and voice therapy.***

Based on my long professional experience, I could elaborate an ***age-related and gender-specific pattern card of the human voice***[9], *based on a step-by-step analysis of a database of more than 1000 phonetograms, which has been presented at more than 100 conferences, seminars, and workshops*.

2.2. The complex process of aging

Getting older can be seen as a complex process, involving changes on the molecular, cellular, and organic levels, resulting in a progressive and inevitable diminishing of the capacity of the body to react appropriately to disturbances of the homeostatic balance.[12]

Chodzkzo-Zajko and W.J., Ringel R.L.[12] made a comprehensive study concerning the structural changes and physiological adaptations in aging in cardiovascular, pulmonary, hormonal, immune, musculoskeletal, and central nervous systems.

Atrophy, dystrophy, and oedema are typical for aging on the cellular level and are often the precursors of more extended morphological changes such as decreased elasticity, compliance, demyelination, and neo-plasmatic growth. The functional consequences of these age-related structural changes are often profound. Aging organ systems usually are slower, and less accurate. They show not only a reduction of strength and stability but also a reduction of coordination and endurance.[12]

Although functional deterioration constitutes an inevitable result of aging, great individual differences exist concerning the fastness and extent of this decline. Many age-related changes appear to be affected by good nutrition, a healthy lifestyle, and exercise.

Functional analyses show that people in good physical condition demonstrate fewer sensory and motor deficiencies than people with poor health.

2.3. The aging process of the human phonation

2.3.1. Older data

As already mentioned in the Introduction of Chapter 1.1, at that time, publications on the aging of the voice were extremely rare. After the publication of my first thesis (1963), Murphy[13], for instance, only remarked

that, from the baby's first cry to the shaky voice of the old day, transitions of age are accompanied by changes in the voice.

Punt[14] reported a chronical senile myasthenia of the larynx because of degeneration of the larynx muscles, especially in case of misuse, during forcing high pitches, resulting in the end of a singing career.

Böhme and Hecker[15] corroborate the continuous shrinking of the vocal range in people over 60 years.

Mysak[33] reported that the quantity of words per minute gradually descends with age: from about 150 words per minute to 110 words per minute or less. The same with the phonation time ratio: there are more and more pauses in speaking with age.

Hanley[31] remarked that the habitual pitch of a middle-aged man only differs 3 halftones from the habitual pitch of an 80-year-old man.

I attended the Seventh Symposium "Care of the Professional Voice" of the Voice Foundation, New York, in 1978, dedicated to the **"Life-Span Changes in the Human Voice".** These conferences on the evolution and the involution of the human voice, with age-associated voice disorders, combined with interesting panel discussions, were revealing to me.

2.3.2. More recent research

More recent research demonstrated that efficient phonation depends on an intact respiratory and phonatory system. During the aging process, changes in muscles, cartilages, bones, and the innervation of these systems, can have a deteriorating effect on phonation. This aging process progresses in a strong variable way. Genetic factors, lifestyle, diet, and specific exercises can influence this aging process.[16]

However, many of these studies are overlapping. On closer inspection, it becomes clear that almost every study on voice exclusively applies to the ***speaking voice***. In two studies of Linville [17-18], no woman had any experience with singing or acting!

In my limited second study, almost one-half of the subjects were in their sixties and had a minimum of education in classical singing. This was an interesting group while it is generally accepted that *trained singers can deliver optimum vocal performances before their seventies.*[19-20]

Schutte[21] however, reminded us of the fact that *good definitions of 'singing' is still lacking*. The singer must have talent and personality and, next to this, develop a certain technique. Rightly, he stated that the kind of equipment used will determine the judgments of the singing techniques.

In this regard, I permanently stressed in my publications the huge importance of phonetography.

2.3.3. Age-related changes in the respiratory system

- Calcification of the rib cartilages.
- Arthritis of the vertebral joints.
- Structural changes due to modification of age-related positions in the vertebral column.
- Reduced muscle tonus.[19-20]
- Reduced mobility and elasticity of the lungs.
- Decreased vital capacity.
- Less adequate subglottal pressure.
- Decreased control of the breath stream.
- Problems with tune carrying, especially at loud vocalizing.
- Increase in wild air.
- Disturbed speaking rhythm: need for much breath and more pauses during speech.[22]
- Deterioration of the lungs caused by tissue changes, resulting in a gradual reduction of the capacity of the phonatory muscles, more expressed in men.
- Reduction of the mobility of the thorax caused by stiffness of the costovertebral joints.
- Lungs and bronchi shrink at high age and descend into a lower position in the thorax.
- Reduced sensitivity of the respiratory system with less coughing as a result.
- Increase of the residual volume: approximately 1,5l at the age of twenty; 2,2l in 60 years old men.
- Decrease of the expiratory air volume needed for phonation, which can be maintained by exercise and conscious control.
- The respiratory aspect can have a limited observed effect on speech but will be a distinct problem in singing.[23]

2.3.4. Age-related changes in the mechanism of phonation

- Loss of the elasticity of the laryngeal cartilages due to progressive calcification.
- Loss of the mobility of the laryngeal joints due to arthritic changes or reduced elasticity of the ligaments.
- Atrophy of the ventricular folds.
- Almost permanent descent of the larynx.
- Atrophy of the intrinsic larynx musculature.
- The epithelium of the vocal cords gets thinner.
- Arterio-sclerotic changes of the laryngeal blood vessels.
- Increased fragility of the blood vessels causing submucosal hematomas.
- Increase in coughing and throat clearing because of possibly infectious causes.
- Changes in the oral cavity with influence on the dentition and maxilla-mandibular proportions.[19-20]
- Decrease of the elastic elements of the vocal cords and the muscular substance.
- Decrease of the quantity of secretion of the mucous glands in the ventricular folds and the Morgagni's ventricle.[24]
- Greasy tissue degeneration.
- Atrophy of the laryngeal mucous glands.
- Curved vocal cords.
- Atrophy or oedema of the vocal cords.
- Yellowish discoloration of the vocal cords.
- Stiffness of the laryngeal ligaments.
- Decreased blood supply to the laryngeal muscles.[22]
- Ossification of the thyroid cartilage starts at the lower horns and continues along the lower and back rands and subsequently along the front rand and corner.[26]

The hyaline cartilages of the larynx (thyroid, cricoid, and most of the arytenoids) undergo endochondral ossification involving the replacement of the pre-existent cartilage by bone which is laid down by bone cells called osteocytes.

- The epiglottis, the corniculate and cuneiform cartilages, and the vocal processes of the arytenoid cartilages never ossify.
- The extensive ossification of the laryngeal cartilages begins earlier in the male (3rd decennium) than in the female (4th decennium) and is greater in the male.

- The thyroid cartilage shows the earliest signs of ossification, followed by the cricoid and then the arytenoids.
- The ossification process ends around the 80th decennium and limits the flexibility of laryngeal cartilages.
- Oedema of the vocal folds can be considered a characteristic aging symptom in older women, resulting in a lowering of the frequency.
- The conus elasticus undergoes considerable changes in old men.
- The elastic filaments in the vocal ligament get thinner, especially in men.
- The changes in the fibrous components of the connective tissue of the vocal cords presumably contribute to pitch changes.
- The neuromotor control of the vocal cords depends on the coordination of the neuromuscular information from the respiratory and phonatory systems.[25-26]
- The hormonal imbalance during menopause can be held responsible for the swollen appearance of female vocal cords.[23]

Mueller et al[27] express themselves rather cautiously about anatomical and histological data concerning the vocal aging process They presume that compensatory and other factors play an important role, such as decreased blood circulation, changed lubrification of the vocal folds, decreased aerodynamic support, changed neuromuscular control and feedback, and a changed endocrine balance.[27]

The voice mechanism is strongly dependent on the integrity of the entire cardiovascular, respiratory, neurological, and skeletal systems. All these systems are completely dependent on the integrity of the body.[27] As Chodzko-Zajko formulated it: *"There is no such thing as an elderly individual who is disease free."*[29]

Based on the anatomy-physiological observations above, one can wonder to what extent these changes are in relation or not to the observed characteristics of the aging voice or the development of vocal pathology. Wilder[20], for instance, remarks that certain authors suggest that age-related changes of the voice are visible at the laryngoscopic examination, while others maintain not having observed laryngoscopic changes which count for observable changes in the sound. The same with age-related changes in the respiratory structure.

According to Greene and Mathiesen[23], calcification is not constant and can even be absent in older subjects. Presumably, there has been no calcification in singers and actors who have kept their voices in good condition.

Kahane[25], however, maintains that aging of the voice, without doubt, is correlated to de way and the extent of the tissue changes in the vocal apparatus.

Finally, Hollien[30] points to the fact that *research mainly has been made on clinical populations*. The decline must be considered a progressive reality, continuing till the end of life. Many aspects of communicative behaviour do not show the same deterioration as other physical and psychological factors.

2.3.5. Changes in the acoustical/perceptual features of phonation

Physical changes associated with physiological aging contribute to changes in the acoustical features of the vocal sound.

One can wonder if there exist parameters allowing one to discern the sound of adult subjects of different ages. According to Hanley et al.[34], a trend of decreasing efficiency could be manifested which is, however, *not immediately perceptually detectable*.

It is commonly accepted that there is something like a typical speech of elderly persons or "*vocal senility*".[32] Moreover, physiological age can be unrelated to chronological age, mostly among trained professionals, which explains that *many singers keep their voice at concert level beyond 70 years*.[20]

Correct judgment increases with the age of the listener.[23,32] Eventually, a variety of studies show that some components adequately can predict vocal age: tremor, blurred consonants, laryngeal tension, slow tempo of articulation, mean fundamental frequency…[20]

Next to anatomy-physiological studies and comparative listener judgment, there exists a third method for collecting data on the elderly voice, namely the *measurement of the fundamental frequency, phonation time, aerodynamics, and other acoustical and physiological parameters*.[27]

Studies before 1980 mostly paid attention to:

- pitch (fundamental frequency).
- loudness (vocal intensity).
- pitch usage: speaking fundamental frequency (SFF), habitual pitch, mean habitual pitch.

- pitch perturbations: jitter.
- pathological voice conditions; voice disorders.
- pitch variability.
- reduced vocal range.
- vocal fry.
- tremor.

Studies on the rising of the mean fundamental frequency only concern speech.[20] Usually, the vocal range is not great, while a singer extremely enlarges his/her vocal range. According to Mc Glone R.[35], *a singer phonates in various ways in singing or in speaking, while a non-singer speaks and sings in the same way*.

Studies between 1980 and 1990 are rather sceptical concerning earlier studies, raising new questions.

Speech requires a motor performance, associated with auditory and kinaesthetic perception and feedback. An increase in reaction time could be in connection with a decreased efficiency of the sensory process.[36]

Research data demonstrated that autonomic movements are less deteriorated by aging than less frequently performed movements. Speech, as a frequently repeated motor skill, would therefore be less susceptible to aging effects. Let us think about denervation symptoms of certain muscle fibres of unknown cause. *The diaphragm, featuring constant movement, shows no denervation*.

Generally accepted is the fact that the speech of older people is characterized by a reduced speaking tempo and longer pauses.[33] *The speech and voice parameters most affected by the aging process are tempo of speech and voice intensity*.[36]

Age-related effects on the rate of speech can be induced by a reduced speed of the transmission of nerve impulses or a decline of muscular strength and reduced elasticity of the mucosa. Age-related changes in the pulmonary and laryngeal systems can influence the efficiency of the system, resulting in a loss of air, accompanied by reduced air pressure and intensity, with a reduced carrying capacity of the voice.[37] However, the female subjects in this Morris and Brown study belonged to two extreme age groups: 25 women aged between 20 and 25 (called: 'young adults') and 25 women above 75 years (called: 'old adults'). Young adult speakers showed a greater maximum intensity range than old adult speakers. However, there were no

statistically significant differences between the two age groups at the level of conversation.

According to Mueller et al., [27] the diversity in selection procedures and instrumentation contributes to certain discrepancies in several studies.

Frequent voice complaints of elderly people are:

- changed pitch.
- shrunk vocal range.
- decreased control.
- changed vocal quality.

Several authors stress the *importance of the distinction between normal, primary aging, and disabilities due to illness, misuse, or psychopathology when treating voice disorders of elderly people.*

Habermann[24] claims that the vocal range of elderly women shifts downward, and in old men upward, with a loss of the chest voice, while Hollien[30] cites a possible influence on vocal quality by extreme hyper-and hypothyroidism and menopausal effects and virilization effects by androgens in adult women.

Studies in the period between 1980 -1990 pay more attention to jitter and shimmer as direct correlations of vocal roughness in older persons.

To Hollien[30], age-related changes in respiratory structure and function are not severe enough to influence vocal output in speech. The influence of senile kyphosis on breathing is not known. But how do singers experience these changes in the thorax, considering the huge importance of a correct body position in singing pedagogy? Popular at that time, for instance, was the Alexander Technique [38] and the study of Brouw N.A.B.[39], even underlining the importance of the action of the little (not constantly existing), pyramidal muscle!

Strangely enough, *even when considering the 3 basic parameters of vocal sound, namely: pitch, vocal intensity, and vocal quality (timbre), the analyses of studies of the period 1980 – 1990 are not very similar.*