

## THE CONNECTION BETWEEN A PROFESSIONAL SINGER'S INTONATION AND THE COORDINATION OF THE CYBERNETIC CIRCUITS OF THE EAR

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**SUMMARY.** This article is addressed to pedagogues, students, and professional singers and draws attention to the tight connection between the functionality of the larynx and the cybernetic circuits of the ear. During the training periods of a singer, and then throughout one's career, we deal with sound intonation flaws very many times. These are due not only to a flawed vocal technique or amusia<sup>3</sup>, but also to flaws of audio-vocal feedback circuits many times. If they are discovered and corrected, the voice can be completely regained. It is very important to be aware of the difference between hearing and listening, dealing with the listening posture when singing and the medical check of a specialized doctor in hearing impairment.

**Keywords:** voice, singer, connection between ear and voice, cybernetic circuits, audio-vocal feedback, control loop.

### Introduction

In his view, the ear plays a major part in vocal production, both as an organ regulating reception mechanisms of a vocal sound and as an organ that initiates the gestures necessary for a singing act. *Man is nothing else than an ear; an ear that speaks and sings*<sup>4</sup>.

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<sup>3</sup> Amusia is the inability to recognise musical tones or to reproduce them. Amusia can be congenital (present at birth) or be acquired sometime later in life (as from brain damage). Amusia is composed of a + musia and literally means the lack of music. Also commonly called tone deafness.

<sup>4</sup> Tomatis, Alfred A., *Come nasce e si sviluppa l'ascolto umano. Psicologia e neurofisiologia di una funzione vitale*, trad.it g Cimino, Como, RED, 2001, p.57.



All research conducted on patients who suffered from professional deafness, related to hearing traumatism, lead Tomatis to check the theory according to which there is a parallel between the auditory flaws and various alterations of the vocal function. It could be noted that there precisely lacked those frequencies from the voice spectrum of his patients, that the subject could not perceive any longer because of trauma they had suffered. From here, he formulated a principle called the 'Tomatis effect', according to which a voice can reproduce only those frequencies that the ear can perceive and where there is no damage at an organic level, the modification of hearing can determine an immediate and unconscious modification of the vocal emission.

According to Tomatis, the recoverable loss of frequency areas of hearing can derive, in fact, from unconscious mechanisms of self-protection that are triggered not only when an individual is assaulted and stressed in a concrete manner by forms of sound pollution, but also when they feel psychically menaced by certain sounds or voices. The ear, that is the brain, can thus decide not to listen, selecting the frequencies that it intends to exclude. In this case, we are dealing with a psychogenic deafness consisting of a lack of analysis at a cortical level of the rejected frequencies. Very often in his writings, Tomatis underlines the difference, that he considers fundamental, between **hearing**, which is a passive way of sound reception and **listening**, which is a conscious act that reveals the will and wish of a subject to communicate and so, to extract all possible information from a received acoustic message.

For this reason, singing needs a clearly defined wish for listening and any hearing impairment, regardless of its origin, will manifest in the voice as a weak quality of timbre or difficulties in intonation, expression, articulation, or as dysphonia. The ear participates in the singing act not only through the cochlea, with its activity of frequency analysis, but also through the vestibule, that controls verticality and balance as well as organization and coordination of muscles implied in the phono-respiratory act.

In comparison both with listening and singing, according to Tomatis, the labyrinth, that is the cochleo-vestibular ensemble that constitutes the inner ear is considered the only one responsible for its functionality. Activating listening and so, voice, implies preparing the body for reception, assuming a posture that favors the verticalization of the spine and the opening of the body towards the space, conditions considered necessary for the communication dynamics. In singing, the body is implied wholly. We know that in singing the instrument is made up of the human body and it is, undoubtedly, one of the most complex from the point of view of its structure. It is true that certain parts seem to be more strained than others;

nevertheless, these remain functionally integrated into a whole and do not reach the stage of performance unless they are integrated and act according to the dynamics of the entire body<sup>5</sup>.

### **1. Voice control through the cybernetic circuits of the ear**

If we look at the mechanisms through which the ear controls the instrument of the singer – the voice – we can extrapolate the fact that everything that exists, from the smallest cell to the entire universe, is coordinated and controlled. Cybernetics is the science that deals with control mechanisms. Even if it is considered a new science, it is based on some principles as old as the world. Plato guided himself with these laws in his writings about the govern. It is impossible to transgress as they are ageless.

In cybernetic terms, a system is regulated when its function is subjected to control. Each organ of the human body controls a certain function. When intonational problems occur, this means that certain circuits and bodily reflexes are not well mastered cybernetically. As we head towards efficient listening, uncontrolled behavior occurs more rarely. Theoretically, singing does not imply anything complicated. Each sound emitted by a singer follows rules that are submitted to the listening function. Art and the ability to sing consist in abandoning the body that vibrates in the loops of the cybernetic circuits and of the regulating processes that work automatically. A cybernetic loop is a circuit that starts and finishes in the same place, the initial system determining a response that returns and conditions again (feedback).

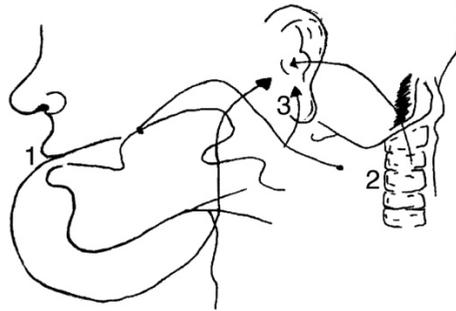
The act of singing is controlled by the ear through more circuits of this kind. They need to be identified, coordinated, and freed by the flaws installed through a use that attacks the larynx (for instance, through a flawed technique) or through different lesions to the hearing or the brain. Once we go back to the automatic and original functioning, these circuits will function without constraints, creating countless and infinite possibilities for the voice. At the same time, through correct functioning, the voice will stay healthy and protected.

Intonation in singing is controlled by the ear and the entire system is supervised by its listening function.

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<sup>5</sup> Tomatis, Alfred A., *The Ear and the Voice*, Maryland, Toronto, Oxford: The Scarecrow Press, Inc. Lanham, 2005, p. 67.

### Auditory vocal loops



1. From the mouth to the external ear through the auricle or pavilion.
  2. From the larynx to the cervical spine to the ear.
  3. From the mouth through the muscles and tendons to the ear.
- Ultimate control resides in the inner ear

E.g. 1 (Auditory vocal loops) shows how the intention to sing is processed by the brain and then, through feedback, determines the act of singing. Once we emit a sound, the auditory control is set to motion, collecting a part of the sound produced to maintain control.

In fact, the sound emitted by the subject mobilizes inner sensations and those of the mucous, even visceral tissues, more than the perception of a sound from the exterior could do. And due to conscious listening to these sensations, the singer can control and modify the vocal gesture. The awareness of being a body able to vibrate underlies the training of the vocal instrument, so that each experience that develops and intensifies this awareness has a priority value.

As we said, the ear selects the frequencies and transmits them to the brain so that singing unfolds according to the initial intention. In short, a feedback loop is configuring.

Sequentially, it takes place as follows:

- I intend to sing
- I sing

The ear tells me that I sing precisely what I wish to sing. I continue to sing and monitor myself. A continuous feedback loop is created. The auditory control is activated and fitted with the ability to select what a singer wishes to hear when he mentally previews what he will sing and knows to answer to what the brain planned.

In concerts, the ear acts together with the nervous system, which also requires auditory control, adding related motor impulses to guide the motor system. Each part of the body that is activated responds at a centralized level, so that the sensory-motor control complies with the requirements of the ear.

## 2. The Audio-Larynx Loop

This is the most important cybernetic circuit of the ear because the sound is formed in the larynx. All other circuits<sup>6</sup> depend on it functioning correctly. The artist who is a virtuosic handler of his body instrument improves the vocal production by adding various colors, inflexions, and modulations to it.

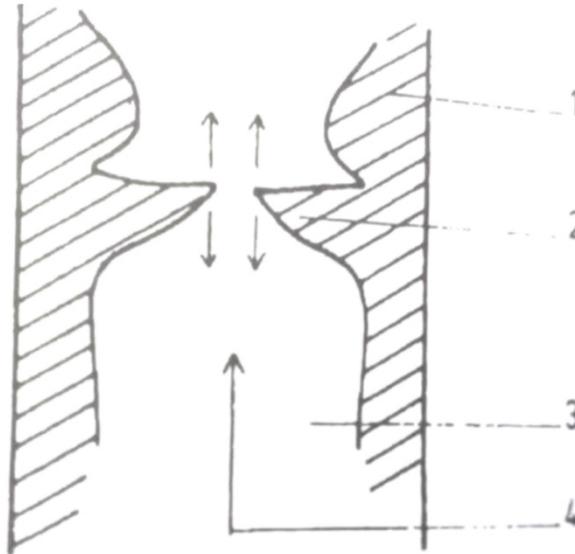
The larynx is a musculo-cartilaginous organ that sits at the top of the trachea. Although we can identify two sets of vocal cords, only the lower two are involved in singing. The upper cords are commonly called ventricular bands or false vocal cords. The two lower vocal cords are drawn together and vibrate throughout emission. The vibration is caused by air passing across the cords. The volume of air is so small that it seems almost spontaneous and automatic as with speech. The brain essentially regulates the tension of the vocal cords to keep the flow of air at a minimum, so that the vibration corresponds to the desired pitch<sup>7</sup>.

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<sup>6</sup> A. Tomatis describes eleven cybernetic circuits between the ear and audio-vocal tract: The Audio facial loop, The Audio-Mandibular Loop, The Audio Larynx Loop, The Audio Pharyngeal Loop, The Audio-Lingual Loop, The Audio-Thoracic Loop, The Audio Mouth & The Audio Nasal Loop, The Audio Recurrential Loop, The Audio-Lumbar Sacral Loop, The Audio-Cervical Loop, The Audio Corporeal Loop.

<sup>7</sup> Larsen, William J, *Anatomy: Development, Function, Clinical Correlation*. Philadelphia: Saunders, Elsevier Science, 2002, p.235

**E.g. 2**

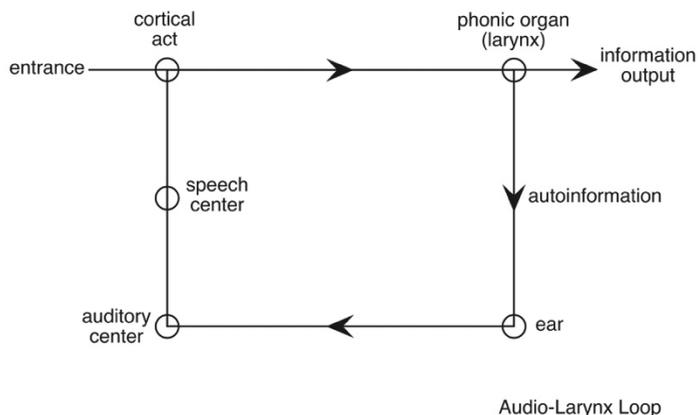


**Larynx (1. Ventricular bands of false cords;  
2. Lower vocal cords;  
3. Trachea;  
4. Puff of breath)**

There are many theories of phonation, but what helps a singer in the understanding of the process is the auditory awareness combined with skilled control of the air column through conscious breathing. This process is described at length in my PhD thesis 'Conscious breathing – the connection between repertoire versatility and vocal health'.

The sound produced in the larynx is immediately controlled by inner circuits of the ear. Two circuits are at work, one through bone conduction, the other through air conduction. These circuits meet in the ear, which can absorb both kinds of information, one devoted to articulation of consonants of words, the second essentially concerned with phonation of vowel sounds. The ear – larynx loop permits the regulation of audio-vocal reaction, which means that sound intonation is regulated here.

**E.g. 3**



### Audio-Larynx Loop

The stimulus for entering this cybernetic loop is the intention to sing. This decision sends an impulse to the phonation organs, especially the larynx, and when exiting the circuit, we benefit from the sound emitted by the system. However, part of the acoustic energy released is assigned to the organ of control, the ear. Its purpose is to send the information to the auditory center in the brain that controls phonation. The return impulse then produces singing.

Following his research, Tomatis postulates that „*The voice only contains what the ear can hear*“. This statement applies exclusively to the right ear; there are no exceptions.

So, any disorder of the right ear hearing, for various reasons, will determine intonation flaws and over time, voice deterioration. Maria Callas saw A. Tomatis, signaling the fact that she could no longer control singing with her right ear. The therapy for a minimum of three months was recommended to correct the situation. Unfortunately, she was not aware of the importance of the disorder of this circuit and left on a journey with Aristotle Onassis. Few people know that she lost voice control and her voice deteriorated because of the audio-larynx cybernetic loop.

### 3. The Concept of ordering

Singing responds to the need of expression and self-knowledge and allows man to have a dialogue with the environment through sound vibrations and acoustic feedback and due to the high frequency voice components helps nurture the nervous system, offering it sensory stimuli that are essential for its vitality. So, a beautiful voice is a voice that, due to its acoustics, especially high harmonics, offers well-being both to those emitting it and to those listening to it. The vocal function, in its complementarity with the listening function, contributes to the awareness of sensory and communication nature of man in the context of the environment and the universe.

Starting with the laws of synergism<sup>8</sup>, the Lichtenberg team from Institut für Gesang und Instrumental spiel, led by Gisella Rohmert<sup>9</sup>, studied the functionality of the singing voice, investigating the connections and methods of interaction between sound, body, psyche, sensory organs, and the environment.

Among the most significant aspects of Lichtenberg research, I would like to underline here especially that related to the **concept of ordering**, a fundamental synergy concept theorized by the physicist Hermann Haken. He states that in the processes of self-organization that characterize complex systems, various parts of the system known to let themselves guided by an invisible hand, but at the same time, the same parts are those that, in turn, by coordination, create this hand. This type of invisible entity is called **orderer**<sup>10</sup>. By applying this point of view to the singing system, Rohmert identifies the vocal sound as a potential orderer that, once produced through the coordinated action of the elements of the system, becomes an autonomous entity, able to guide and organize the system, optimizing its resources. As with the light in a laser (one of the physics models studied by Hasken), through the action of mirror reflection, feeds back with the electrons that generated it, thus nurturing its own energy, transferred then as a light concentrated and directed in the beam,

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<sup>8</sup> The term 'synergic' that literally means the science of combined effects was invented by Hermann Haken to indicate as study field that aims at discovering the laws that regulate the birth of ordering structures within complex systems.

<sup>9</sup> Gisella Rohmert, author of a canto method that is based on the idea that the whole body is an instrument that vibrates, and it is subjected to self-organisation and self-regulation rules.

<sup>10</sup> Haken, Herman, *Sinergetica, Il segreto del successo della natura*, trad.it. G. Longo, Torino: Boringhieri, 1983, p.125-127.

equally the voice sound, reflected against the walls of the resonance cavity, feeds back to the larynx, which, stimulated in its vibrational activity, is fed in its turn and receives quality and power with minimal energy loss. This phenomenon can take place when the air column is coordinated consciously with the help of breathing. It is also the phenomenon Husson talks about in 'The Voice in Singing', namely the impedance returned on the larynx<sup>11</sup>.

Essentially, it is a matter of triggering a virtuosic circuit due to which the larynx, through acoustic feedback, can use the sound energy to organize its own mechanism of sound production, thus saving the muscle and air energy. Of course, for this circuit to be activated, it is necessary that during emission, there should be certain particular conditions, namely no dispersion of sound energy in the vocal tract (and this depends on the setting of the oropharyngeal cavity of resonance) and that this energy be permanent.

According to Rohmert, a permanent sound energy can be guaranteed only through a frequency interval that remains stable, regardless of the pitch of the fundamental sound in singing. This stable frequency interval is identified throughout the auditory stimuli of the singer<sup>12</sup>. These are harmonic groups, situated around the value of 3000, 5000, and 8000 Hz, whose presence in the vocal sound manifest not as a superior supplementary voice, but as an energetic timbre quality, defined as the voice shine.

It is very important that those who train singers perceive the correspondence of these sounds, found by Lichtenberg researchers, with the frequencies of resonance of external ear cavities (3000 Hz), middle ear and inner ear cavities (5000 and 8000 Hz). In virtue of this correspondence, a vocal sound that contains these stimuli represents a biological key of access to the ear and through it, to the nervous system and so, to the entire body. Shining becomes thus a trait of the voice whose importance surpasses by far the aesthetic dimension and receives a functional value from the moment it assumes the role of orderer of the inner system of singing. Through its shining, the sound organizes its own inner structure, integrating harmoniously the other acoustic parameters (fundamental, vocal, and vibrato) and it influences positively the organization of the body, the breathing and articular activity on the psyche, and consequently, on the musical expression. In short, all functional levels are ordered with a self-regulation mechanism.

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<sup>11</sup> Husson, Raoul, *Vocea Cântată (The Voice in Singing)*, Bucharest: Editura Muzicală, 1968, p.92.

<sup>12</sup> Rohmert, Gisela, *Il cantante in cammino verso il suono*, Diaste Libri, 1995, p.29.

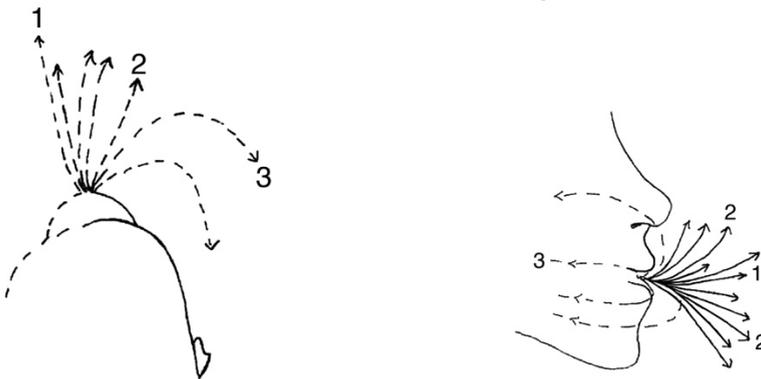
It is obvious that the identification of the auditory stimuli of a singer represents a development and a clarification of the theories of Tomatis regarding cortical recharging, to which Rohmert specifically refers. While the French physician talks in general about high frequencies, the research conducted by the Lichtenberg team mentioned exactly the frequency intervals and further developed the functional view of singing<sup>13</sup>.

Any emitted sound is very complex and contains both fundamental tones as well as the entire scale of associated harmonics. Once launched into the air, the sound is scattered and cannot be controlled any longer. High frequencies spread in a straight, directed line. Low frequencies, contained in all emitted sounds, propagate in a circular manner, bathing the outside of the ear. Therefore, when we hear our voice, we hear mainly the low frequencies of the sounds we emit.

Therefore, we are always surprised when we hear our recorded voice. While making sounds in the room with good reverberation, the feedback we get allows us to control high and medium frequencies as well as low ones.

E.g. 4

#### Production and Distribution of Frequencies



A: From above B: Profile  
1. Heights 2. Mediums 3. Lows

This is an example of cybernetic control when **hearing** becomes **listening**.

<sup>13</sup> Tosto, Ida Maria, *La voce musicale, orientamenti per l'educazione vocale*, Torino: EDTsrl, 2009, p. 11-12.

Not only is the importance of the ear and the listening function for the voice confirmed, but the sound itself becomes part of the singing system as an autonomous entity that interacts with the other elements that compose it. The role of the *auditory awareness* remains fundamental. In fact, Rohmert says about the auditory stimuli that only when singers listen to and recognize these elements in a conscious manner, can they then become new teachers.

#### **4. Pitch sound depends on listening posture and bone conduction**

*“A singer needs to accomplish the ability to move from pitch to pitch in the middle register without the throat moving. This needs to first be accomplished on a hum function.”*

*Giovanni Battista Lamperti*

An efficient alignment of the body activates listening, and the listening posture in the ear is the most important in singing. We can talk of a posture of the ear in full connection with the body posture.

The forward stretch of the sternum is the key to a healthy onset<sup>14</sup>.

Sounds are differentiated in the cochlear duct or organ of Corti. Each frequency is perceived in its own location along the duct, where it is distributed to the hair cells, which are specialized according to pitch. The vestibules use sounds, preparing the body to adjust the posture for listening. The cochlea breaks sound into its various elements and sends its analysis to the brain, thus extending its reach throughout the nervous system. The brain begins the process of differentiating the frequencies and sending them to pitch receptors. Then, after gathering in the temporal cortex, they are distributed throughout the most recent part of the brain. Finally, the entire information is redistributed to the whole body.

To sum up, the vestibule follows the directives of cochlea to achieve the best possible posture for efficient listening.

After we succeed in aligning the body according to physiological curves, relaxing the muscles of the face and mouth, we shall note that the sounds that we emit become purer, the timbre enlightens and the effort we make when singing diminishes. Your voice will acquire the resonance in the bones that is the mark of a great singer. Good posture reduces the impact of gravity, allowing muscles to work more efficiently.

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<sup>14</sup> Jones, David L., *A Modern Guide to Old World Singing*, Milton Keynes UK: Lightning source UK. Ltd, 2017, p.31.

In the singing posture, the larynx sends resonance to the bones that touch it. The spinal column then sets all structures that touch it into resonance. Once the bones begin to sing, they cause the cavities to vibrate. The voice becomes vibrant and more harmonious. It is resonance emanating from every bone in the body that causes this change.

Laryngeal vibrations form fundamental tones, while the harmonic shower of sparks associated with the fundamentals, rich in higher frequencies and reinforcing the initial sound, considerably depends on the skeleton.

Once you can listen for highs you have to find your real voice the same way by seeking the high harmonics. This is very subtle and when you begin to perceive the voice this way, it is an entirely new experience. It feels as if you are far away from yourself with your **right ear** leading until you feel your sound emanating from a point located just behind the vertex – the center of the head – see E.g. 4<sup>15</sup>.

**E.g. 5**

### **Ear system**



**External ear**

**Middle ear**

**Internal ear**

I draw attention here to the vocal techniques that encourage the thickening of the voice by creating a supplementary open space towards the pharynx. Due to it, low harmonics of the sound will propagate towards the

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<sup>15</sup> Tomatis, Alfred A., *The Ear and the Voice*, Maryland, Toronto, Oxford: The Scarecrow Press, Inc. Lanham, 2005, p.68.

spine, and then, mainly towards the ear. A continuous stimulation of hearing through low harmonics will inevitably lead to increasingly impaired intonation over time.

As we have seen, the voice deprived of high harmonics does not represent a sufficiently good stimulus for the ear. Their lack of an interpreter's voice will determine over time a sound that amplifies under the optimum position of resonance. Therefore, it will be flat, but the ear will recognize it as being correct. The interpreter even avoids the sounds with high harmonics that he considers high-pitched<sup>16</sup>.

The conclusion is that if this habit is not corrected in time, the inner ear loses its capacity to generate correct sounds from an intonational point of view. One enters a loop circuit, in which a slightly dissonant sound will come to generate persistent pitch problems.

Also, the voices that sing a repertoire inappropriate to the vocal 'fach' are tempted to overbid the pressure that they exert on the air column to sound more consistent. The vocal cords on which too high air pressure is constantly exerted will prematurely become weary. Addressing a difficult repertoire when the breathing and vocal technique is not well mastered can cause muscle fatigue. If neglected, the fatigue of vocal cords will gradually turn into dysphonia.

Unnecessary efforts cause disharmony. The larynx moves around and makes habituation automatically, needing only the vigilant control of the right ear. Every muscle in the body, including the larynx, is under the control of the vestibule cochlear labyrinth.

Thus, the law according to which "*The larynx does not emit what the ear does not control*" is proved.

In Romania, the law of opera houses stipulates that all vocal soloists perform an audiogram at least once a year. It is much better to prevent the installation of flaws than to discover them too late.

A famous case of dysfunctionality of hearing that reflected in a disharmonious and falsetto voice over her entire career is that of the singer Florence Foster Jenkins. In her period of glory, she sold Carnegie Hall. She would address the most difficult opera arias, but she would sing falsetto badly, flat notes or even high-pitched ones. It is not clear if fans would like her despite her lack of musicality or precisely due to it. It is a typical case of amusia, described by Oliver Sacks in the chapter - 'Things Fall Apart: Amusia and Disharmonia' from the book *Musicophilia*<sup>17</sup>.

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<sup>16</sup> Leeds, Joshua, *The Power of Sound*, Rochester, VT: Healing Arts Press, 2001, p. 75.

<sup>17</sup> Sacks, Oliver, *Totul se destramă: amuzie și dizarmonie (Everything falls apart: Amusia and Disharmony)* from book *Muzicofilia (Musicophilia)*, Bucharest: Humanitas, 2009, p.114.

The awareness of listening and its coordination with an optimum subglottal pressure, that will not attack the larynx, will considerably extend the life of a professional singer, because *we sing with our ears*.

## Conclusions

- The ear coordinates all the other perceptions like the conductor of an orchestra, assembling and directing the many stimuli upon us into patterns that we can accurately perceive.
- Clearly singing is important. It energizes the singer as well as the listeners.
- The vocal sound works like an inner orderer of the audio-vocal system.
- Sound energy, transmitted through the audio-vocal circuit, makes an important contribution to peak function.
- It is important to be aware of the existence of the cybernetic circuits of the ear and the connection between them and the listening posture.
- The study of the voice must always be supervised by an external ear (of a teacher) or by regular recordings.
- A professional singer must perform an audiogram at least once a year to prevent the installation of flaws in the cybernetic circuits of the ear. This preventive act can save many voices from progressive deterioration.
- The larynx does not emit what the ear does not control.

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