Walter Coppola

The Tomatis Effect with Professional Opera Singers. A Pilot Study

My research field is Audio-Psycho-Phonology (APP), a scientific discipline founded by Alfred Tomatis. It studies, on the one hand, the relationship between the ear and the voice, and on the other the relationship between the ear and the psychicism, defined as the sphere of spontaneous psychic activity which occurs irrespective of consciousness, attention and will.

Alfred Tomatis (1920-2001) was a French otolaryngologist, researcher and essayist. The specific nucleus of the discipline he founded is **listening**, a function he examined in its many facets, developing a theory, which draws on a range of fields:

- audiology
- neuropsychology
- phonology
- phoniatrics
- cybernetics

Audiology serves to define the sensory, anatomical and functional characteristics of hearing, and is used in the clinical assessment of hearing malfunctions. Neuropsychology enables us to investigate the cognitive and behavioural processes connected to hearing and their correlation with the configuration of the nervous system. Phonological analysis establishes the organisation of sounds as elements of a linguistic and communicative structure, while phoniatrics examines voice distortions in speech and singing and establishes methods for their correction. Lastly, cybernetics provides a functional self-regulation model, which is perfectly applicable to neuro-muscular mechanisms.

Tomatis was born in Nice to parents whose origins were in Piedmont and Romagna. Son of Humbert Tomatis (1898-1968), renowned *basse noble* of the Paris Opéra and the Toulouse Capitole, Alfred graduated in medicine and went on to specialise in otolaryngology, starting a private practice in which he treated colleagues of his father who were suffering from vocal pathologies and voice emission disorders. As he recounts in his autobiography *L'oreille et la vie*, his early

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clinical work conformed scrupulously to contemporary practice, which consisted largely of pharmacological treatments (such as the prescription of strychnine in cases of laryngeal hypotonia), though these often proved to be ineffective.

At the same time he was working as a consultant at the acoustic physiology laboratories of the French military aircraft industry, where he studied hearing disorders affecting workers who tested jet engines: an occupational hazard was difficulty in speech emission. Tomatis observed that the audiometric analyses of workers subjected to serious sound trauma showed results very similar to those of singers who had lost their voice. It should be remembered that the volume produced by a singer (such as a dramatic tenor) may reach an intensity of 130 decibels in the cranium, subjecting the hearing apparatus to high levels of repeated and damaging stress. He started on systematic comparisons of patients' spectrograms – a sort of photograph of the voice – and audiograms, which trace their hearing thresholds. Both tests produced identical sets of frequency deficits, on the strength of which Tomatis began to postulate that frequencies not perceived by the ear cannot be reproduced by the voice. He also identified the right ear as the "conductor" of sound control, since in anatomical and neurological terms it is directly connected to the left cerebral hemisphere, where the functions of language and communication are located.

How would it be possible to restore full use of vocal strength and range? The answer was to be found in retraining the ear, principally the right ear. To verify his unusual – and in some ways disconcerting – hypothesis, Tomatis had to subject his theoretical intuition to an experimental demonstration.

Tomatis believed that when damage is merely functional and not organic, the principal cause is the weakness and poor responses of the two muscles in the middle ear, those of the malleus and the stapes (Fig. 1). They are no longer able to perform their function, which is to protect the hearing apparatus from aggressive sound. How would it be possible to restore tone to muscles which are not only among the smallest in the human body, but also not directly accessible? After a number of attempts, Tomatis observed that these two muscles could be exercised by being exposed to music by means of a sound system, which was repeatedly switched on and off. The muscles tensed and relaxed continually in response to the sound stimulus.

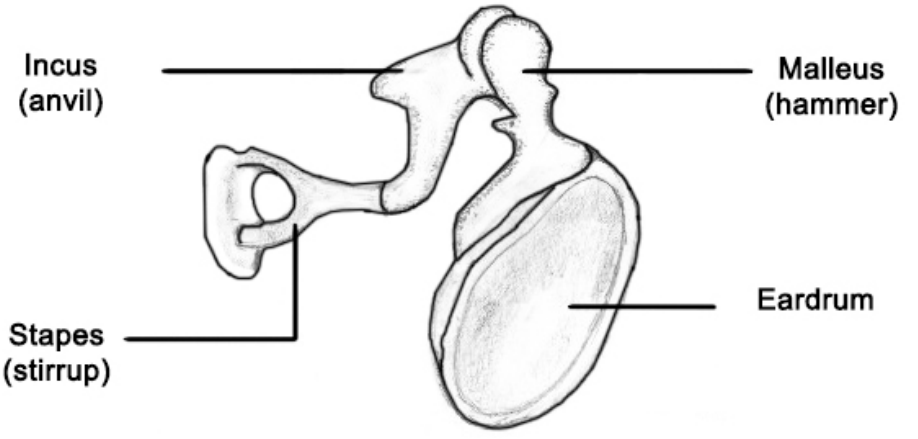


Fig. 1 The ossicular chain

This was the 1950s, when electronics was extremely primitive compared to current levels of sophistication. With the material available to him, however, Tomatis was able to build rudimentary equipment, which served his purposes. Subsequently, instead of alternating music and silence, he tried alternating music through two channels: from the first, where low frequencies were emphasised, to the second, which amplified high frequencies, and vice-versa. With this form of "micro-gymnastics" which compelled the muscles to tune in to set frequencies, progress was much more rapid. By means of a series of electronic weighbridges and sound filters, the muscle functions of the middle ear were retrained and patients were able gradually to reacquire perception of the frequencies they had lost. The result was an immediate and spontaneous improvement in their vocal emission.

In 1957 the theory was experimentally corroborated by a team led by Professor Raoul Husson in the Functional Physiology Laboratory at the Sorbonne in Paris: it was certified as the **Tomatis Effect**. The three laws underpinning his theory may be summed up as follows:

- the voice is able to reproduce only the frequencies that the ear can perceive;
- if listening is modified, the voice is also immediately and unconsciously modified;
- when auditory stimulation is maintained over a length of time, phonation undergoes lasting modification.

This is a very brief summary of how Tomatis developed his theories. Since then, they have undergone continuous evolution and have been successfully applied in a wide variety of fields. Witness to this is the range of his writings, which comprise perceptual neurophysiology, vocal techniques, learning difficulties

in the formative years, pathologies such as dyslexia and vertigo, intra-uterine listening and ethno-linguistics. Today his methods are applied in hundreds of centres all over the world. Doctors, psychologists, teachers, trainers and musicians, each in their own field, use listening retraining in the treatment of a large number of personality and behavioural disorders, in foreign language teaching and in the development of musical sensitivity, in the reacquisition of the capacity to communicate and the joy of communicating.

Listening retraining is accomplished by means of a device known as the **Electronic Ear**. Having first developed and then patented it, Tomatis presented his invention at Expo '58 in Brussels. Over the years it has undergone a great many modifications and technological and functional developments, benefiting from the enormous progress made in electronics.

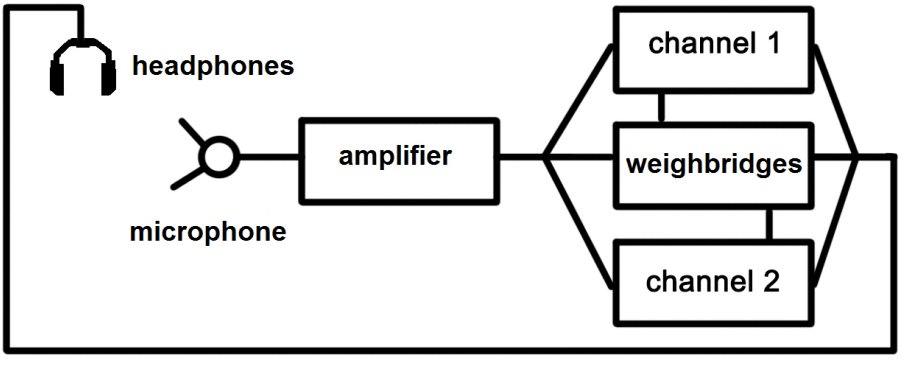


Fig. 2 The Electronic Ear structure

The Electronic Ear is based on a series of amplifiers, filters, weighbridges and electronic controls which receive the sound emitted by a source, process it and send it to the subject through a special headset, which in addition to normal earpieces is fitted with a bone vibration transducer (Fig. 2).

The electronic **weighbridge** stimulates the work of contraction and relaxation in the muscles of the middle ear; regulation of **latency** affects the speed with which our acoustic sensor accommodates sound messages, while the control of **precession** – the predictive mechanism located in the inner ear – acts on the relationship between air conduction and bone conduction; lastly, the stimulation of **laterality** enhances the dominant function of the right ear.

In terms of voice training, a subject sings into a microphone, which picks up the sound and sends it to the device (Fig. 3).

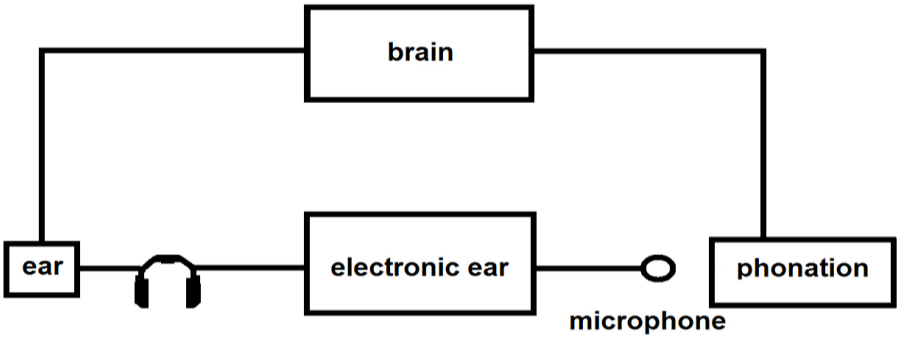


Fig. 3 The voice training scheme

Here the voice is frequentially transformed and sent back to the subject in real time. In accordance with the specific requirements of the case, the device models the sound input in order to eliminate any scotomas and give the listening curve the ascending progression – essential for a proper analysis of high frequencies – which is vital for an optimum-quality emission. This stimulates the primary functions which control the audio-vocal circuit, that is to say the voice's reaction to listening.

A singer who undergoes training with the Electronic Ear for the first time unwittingly experiences a profound transformation, which particularly affects posture. "Lending an ear" is an everyday expression, but it recalls a function which has a tangible physiological dimension, where lending an ear means lending the body. The frequential stimulation of the vestibule – the organ in the inner ear which regulates the functions of balance and muscle movement – induces the subject to seek a vertical position and places him in what is known as the **listening posture** (Fig. 4).

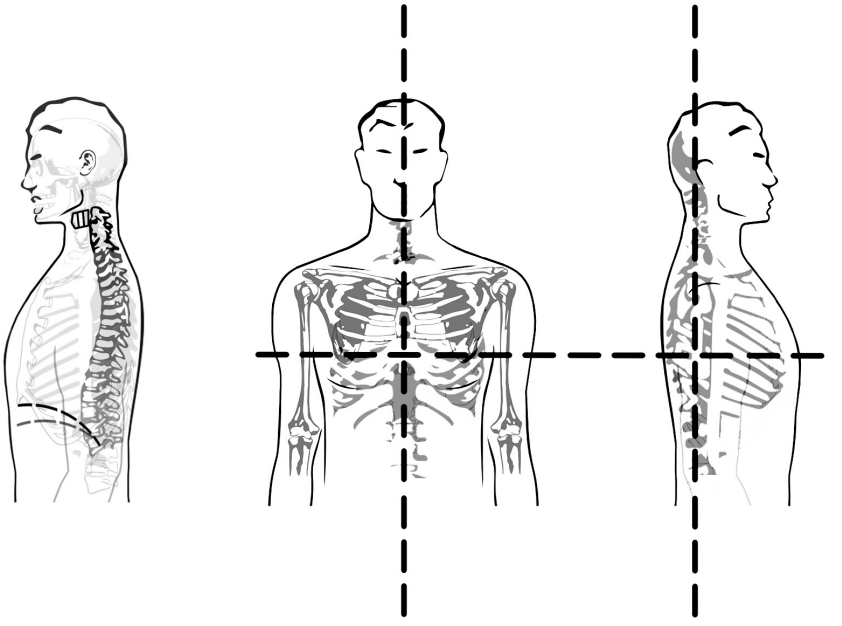


Fig. 4 The proper posture for vocal emission (listening posture)

Since the vestibular nerves affect the entire length of the spinal column, the neuronal impulses produced by sound influence the control of balance, movement and verticality. Elongation of the spinal column causes the pelvis to move forward, the collarbones to adopt a horizontal position and the shoulder blades to flatten against the ribcage. The thorax is thus considerably broadened, freeing the diaphragm to reach its maximum extension. The movement of the diaphragm is greatly facilitated in synergy with the abdominal muscles: these no longer have to be contracted, but adapt to the movements dictated by the diaphragm (Fig. 5).

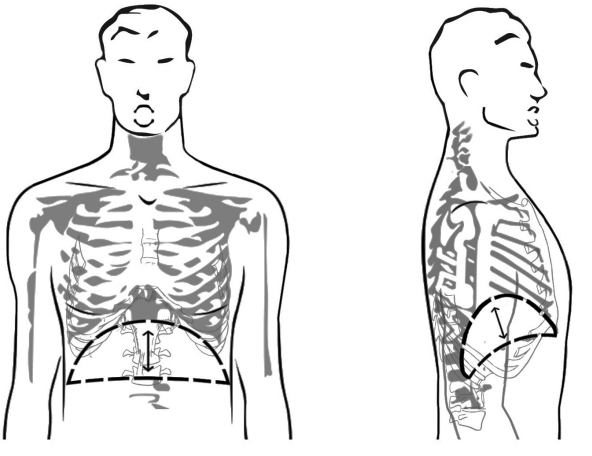


Fig. 5 The diaphragmatic excursion

This is the extraordinary innovative technical conclusion which Tomatis reached: the complex structure of vocal emission depends on, and is regulated by, the circuit of reactions whose origin and quality control are to be found in listening. Though the various levels of this structure (laryngeal, pharyngeal, articulation, resonance, breathing) work in close synergy, each responds to a specific reaction circuit whose activation is completely automatic. The principle task of the singer is therefore to become aware of these automatic mechanisms and make them his own, trying to interfere as little as possible with the natural vocal performance, in a continuous quest for what Tomatis calls the "bone sound".

Because of the attempt to attain maximum verticality, listening posture enables the head to adopt a position with respect to the trunk such that the back of the larynx rests on the front edge of the spinal column. The laryngeal sound thus sets up a resonance with the bone structure which then starts to sing, lending the voice the quality that makes it sound warmer, more vibrant and harmonious. The vocal chords benefit from their proper tension, while the larynx spontaneously adopts the positions required to produce the proper range of sounds.

To quote Tomatis:

> "When the bone voice is established, with all the advantages that it bestows on the nervous systems, not only does it induce the larynx to adopt its various positions according to the pitch register, but it helps to make the mechanisms of the pharyngeal walls perceptible. The impression is that the pharynx is trying to dilate to its maximum extent, thus counteracting the natural tendency to constriction, which leads to narrowing. What is more, in continuous emission this sound re-sets respiration to a non-forced mode. The act of breathing effectively depends on laryngeal behaviour, because there is a definite connection between the movements of the larynx and the respiratory flow" (Tomatis 1987, 233f).

Unlike many specialists, then as now, Tomatis did not consider breathing as the basic element governing all the mechanisms of the singing voice. Though he assigned it an indispensable role, he saw it as part of the complex structure of the audio-vocal circuit, a function belonging to the sphere of induced and acquired behaviours. A singer may thus overcome his natural tendency to act voluntarily through his muscles and abandon himself to the de-conditioning produced by the progressive discovery of the spontaneous physiological mechanisms of diaphragmatic sound support, thanks to which the vocal act produces the maximum acoustic and sonorous yield with the minimum of muscle effort.

The quest for mastery of emission, especially in a professional context, entails a complex course of training, which has to take account of physiological reality and the functional interactions that underpin and regulate the basic mechanisms of the vocal act. Since the teaching method inevitably hinges on the communication of sensations, it is not difficult to foresee how the didactic

process may be hampered by misunderstandings and distortions on the part of the new pupil, especially if he is not properly supported by solid theoretical basis. I quote Tomatis again:

> "These sensations are destined to become perceptions, which means that they have to enter the consciousness. They thus become suitable for recognition and reproduction. Then they can be summoned at will and call upon the muscle movements associated with them. This establishes a neuro-perceptual-muscular structure whose result is an integrated act. It is therefore clear that the act must be precise and appropriate" (Tomatis 1987, 193).

It is an "act" whose application is fraught with objective problems, precisely because of the peculiarity of the instrument in question, that is to say the human body. If we consider complicated the movement of a bow on the strings of a violin or the movement of the fingers on the piano keyboard, we can imagine the difficulty in "feeling" and distinguishing the various somatic areas involved in vocal emission.

The activation and coordination of the various elements that go to make up the "body-as-instrument" take us inevitably into a new and unfamiliar perceptual dimension.

Tomatis considered singing to be in the category of "natural acts", even though it requires a complex organisation of the various psycho-corporeal activities that synergetically contribute to the emission.

He distinguished various stages of activation: in the first place there is a desire to emit a sound, and before the body-as-instrument is used, a specific intentional attitude is assumed. This sets off a process of preparation of corporeal activity such that it may effect all the transformations required for the desire to become an act. Before the performance of the phonatory act, there occurs what Tomatis describes thus:

> "a second-degree objectification, I would go so far as to say, is established starting from the instrument now placed in position and ready to play thanks to the first-degree objectification. This is how the subject decides to trigger his aspiration to sing, to turn into an instrument and begin to make it sound" (Tomatis 1987, 195).

This is a matter of using organs in a way which differs from their primary function and whose actions must therefore be experienced in a different dimension. The tongue, for instance, which has the function of swallowing and belongs to the digestive system, plays a highly important role in the articulation phase and in the concentration of resonances. And breathing is no longer just the absorption of oxygen and the expulsion of carbon dioxide; by means of the lungs and the muscles which make them work, it produces and regulates the airflow which is

essential for phonation. It is therefore important that the subject be able to make a conscious distinction between the various perceptual levels that pertain to the act of singing, separating the self-as-instrument from the self-as-performer, effecting an integration whose speed and effectiveness will be as great as the detachment between the two levels.

> "The more the artist considers himself an artist, possessing an instrument with which he observes himself playing, the more he is master of the body of operations induced by the act of singing and the more he can give the impression of the fusion of these different levels. This means he has achieved a high degree of mastery" (Tomatis 1987, 196).

The singing subject, the body-as-instrument and the sound produced by its resonances are the dimensional features, autonomous but interconnected, that the teacher must know fully if he is to make sure they are communicated to the pupil. In turn, the pupil must develop a psychological sensitivity and a bodily deportment, which will translate into a mental attitude and a search for the posture required for the execution of a high-quality act of singing.

Briefly described below is a simple experiment, carried out with the aid of the Electronic Ear, which clearly illustrates the practical application of the Tomatis Effect.

Experiment

A series of 50 sounds on the D3 note are recorded, sung by two professional tenors (**M** and **R**) of the same technical level. This is carried out in two phases.

Condition 1

The two singers **M** and **R** are given headphones through which each of them hears his voice in real time, picked up by a microphone and passed through the Electronic Ear, which in this case acts simply as an amplifier. Its special functions are not activated, so it does not affect what the singers hear.

Singer **M** acts only in this condition, executing the sequence of 50 sounds without the regulating intervention of the Electronic Ear.

Condition 2

Singer **R** performs 10 executions in Condition 1, following which for the other 40 the Electronic Ear settings are changed, adjusting the device to the frequency, filtering, delay and precession parameters, which Tomatis thought would produce the listening experience needed for proper vocal emission, with enhanced perception of the fundamental formants and those between 2,000 and 4,000 Hz.

Results and conclusions

Singer M (ever without Electronic Ear regulations)

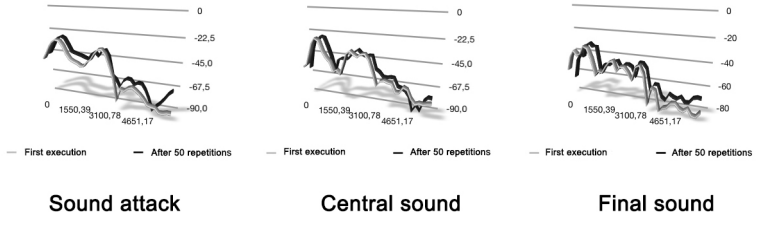


Fig. 6

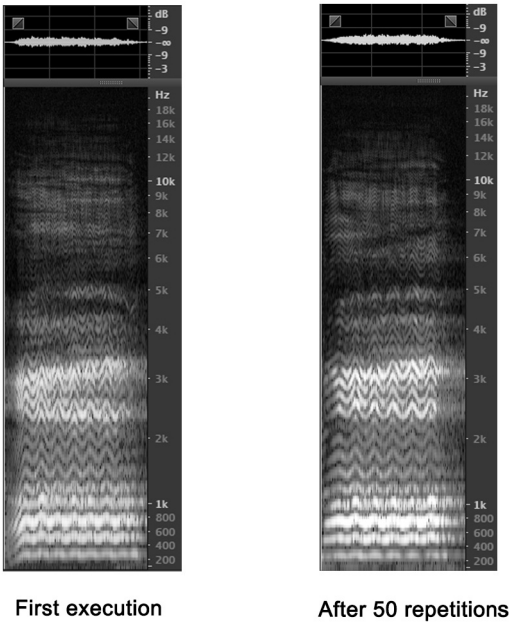
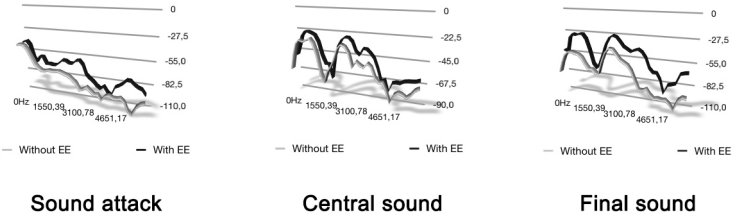


Fig. 7

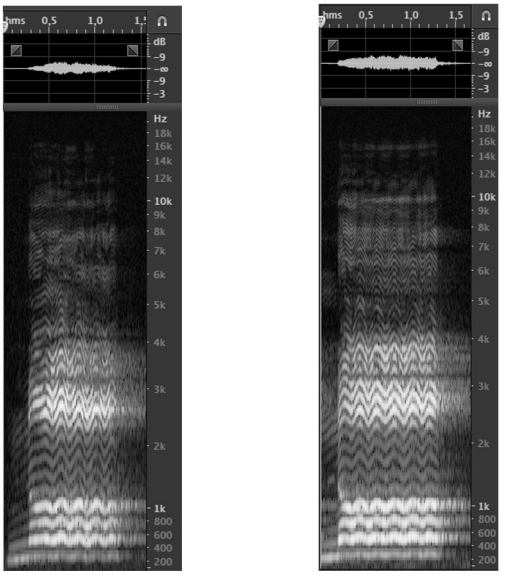
In the 50 executions performed by singer **M** minor variations were recorded, mostly the result of an improvement of the capacity to focus brought about by repetition.

Singer R



Sound attack Central sound Final sound

Fig. 8



Without Electronic Ear With Electronic Ear

Fig. 9

A comparison of the first and the fiftieth execution performed by singer **R** showed a substantial increase in the formants between 2,000 and 4,000 Hz, which is the range crucial to the control and quality of the singing voice.

Many performers benefited from the Tomatis therapy. Actors like Gérard Depardieu, Romy Schneider and Catherine Deneuve, singers like Maria Callas and Placido Domingo attended the Paris Center, in order to undergo training under the guidance of the scientist.

The son of a famous singer, Tomatis always lived in close contact with the world of the theatre, developing a strong interest in everything to do with voice

production, attracted above all by the enthusiasm and fascination that great voices excited in the public. A lively intelligence and a spirit unbound by dogmas and preconceptions enabled him to strike out on a path never followed before: to show that the emotion produced in a listener by the sound of a voice is governed by specific and universal principles of acoustic physiology.
Tomatis wrote:

> "A fine voice is one that enables *the listener's body* to perceive pleasurable resonances. Hearing someone sing means entering into vibration with him. Why? Simply because producing a sound means making the air outside vibrate. A listener situated in this air finds himself somehow 'sculpted' by the vibrations. For the 'magic' of music you need look no further! For the 'magic of the word' you need look no further! Listening to someone playing, singing or speaking means somehow letting yourself be set into vibration by him. We inevitably supplement the way in which he who addresses us uses his body... If the great singer is he who makes you pleasurably resonate, this implies – because the sound has first sculpted his body before having sculpted yours – that he himself has resonated in that way. In other words, the quality of the result is highly dependent on parameters such as the distribution, strength and elasticity of the musculature, the density of the bony walls etc. In this respect every man is like a musical instrument endowed with his own peculiar characteristics" (Tomatis 1990, 80f, italics in original).

The impressive body of research, discovery and dissemination developed by Tomatis on the workings of the voice leads to a clear and unequivocal conclusion: everything concerning vocal emission and its training belongs squarely in the field of natural physiological structure. Everything occurring within it stems from listening and from the complex system of neuromuscular functions connected to it. Learning to sing means gradually building your own instrument, learning to recognise and knowingly exercise these functions, whose physiological control mechanisms must be understood and supplemented with rigorous discipline.
Discovering your true physical nature and entrusting yourself unconditionally to the physical and emotional processes involved in it and imposed by it, you embark on a journey of transformation and self-knowledge, a quest for your deepest and most profound essence, acquiring the ability to communicate the truth of emotions through sound. Thanks to their remarkable psycho-physical structure, human beings are able to co-penetrate the universal dimension and the mysterious semantics of one of the most complete and captivating forms of expression known to us: singing.

Summary
The Tomatis Effect states that "a person cannot reproduce by voice the frequencies he is not able to hear", and that "any variation of the auditory pattern produces an effect on the vocal emission". In order to put into practice his own theoretical insights, Alfred

Tomatis (1920-2001) designed an electronic equipment based on sound filtering, able to re-balance hearing ability. He called this device the "Electronic Ear". The aim of our pilot study was to empirically test the efficacy of the Electronic Ear in improving vocal emission under the most simple and basic conditions. Two singers, both professional tenors of the same technical level, vocally performed a predetermined sequence on the same note in two different listening conditions (one singer for each condition): Electronic Ear Condition 1, having vocal emission set to ideal parameters, and Electronic Ear Condition 2, having vocal emission set to neutral parameters. Measures were carried out through the comparative analysis of the obtained sonograms; this analysis highlighted the difference between the amplitudes of the sinusoidal wavelength, and, in the frequency spectrum, highlighted the increase of the high-quality singing emission parameters according to the neurophysiological patterns proposed by Tomatis. Our pilot study shows a clear improvement in the richness of harmonics and in the density of the vocal timbre for the singer in the Electronic Ear Condition 1, compared to the singer in the Electronic Ear Condition 2.
Keywords: Alfred Tomatis, Audio-Psycho-Phonology, Electronic Ear, singing.

Zusammenfassung

Der Tomatis-Effekt stellt fest, dass „eine Person Frequenzen, die sie nicht hören kann, auch nicht stimmlich reproduzieren kann", und dass „jede Variation des Hörmusters einen Effekt auf den Stimmaustritt hat". Um seine theoretischen Erkenntnisse in die Praxis umzusetzen entwickelte Alfred Tomatis (1920-2001) eine auf Klangfilterung basierende elektronische Vorrichtung, die die Hörfähigkeit wieder ausbalancieren kann. Er nannte dieses Gerät „Elektronisches Ohr". Ziel unserer Pilot-Studie war die empirische Überprüfung der Wirksamkeit des elektronischen Ohrs bei der Verbesserung des Stimmaustritts unter einfachsten Rahmenbedingungen. Zwei Sänger, professionelle Tenöre mit vergleichbarem technischen Niveau, sangen eine vorgegebene Sequenz derselben Note unter zwei verschiedenen Hör-Bedingungen (ein Sänger für jede Bedingung): Elektronisches Ohr – Bedingung 1: Stimmaustritt gekoppelt mit optimalen Parametern, und Elektronisches Ohr – Bedingung 2: Stimmaustritt gekoppelt mit neutralen Parametern. Die Messungen wurden während der vergleichenden Analyse der erhaltenen Sonogramme durchgeführt: diese Analyse hebt den Unterschied zwischen den Amplituden der sinusoidalen Wellenlänge ebenso heraus wie, im Frequenzspektrum,
den Qualitätsanstieg der Gesangs-Austritts-Parameter entsprechend den von Tomatis vorgeschlagenen neurophysiologischen Mustern. Unsere Pilot-Studie zeigt eine eindeutige Verbesserung in der Reichhaltigkeit der Obertöne und der Dichte des vokalen Timbres des Sängers unter der Bedingung 1 im Vergleich zum Sänger unter der Bedingung 2.
Schlüsselwörter: Alfred Tomatis, Audio-Psycho-Phonologie, elektronisches Ohr, Gesang.

References

Tomatis, A. (1987): *L'oreille et la voix*. Paris: Laffont.
Tomatis, A. (1990): *L'oreille et la vie. Itinéraire d'une recherche sur l'audition, la langue et la communication*, 2e éd. Paris: Laffont.

Walter Coppola, b. 1956, graduated both in Philosophy and Psychology. As an opera singer, he pursued an international career, performing in prestigious opera houses and concert institutions, participating in many recordings. He also took a training course in Audio-Psycho-Phonology (APP) under the guidance of immediate pupils and collaborators of Alfred Tomatis. He is currently Ph.D. student in Neuroscience and Cognitive Sciences at the University of Trieste: his main research interests are in vocal rehabilitation and experimentation in acoustic perception.
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