BIOFEEDBACK-INNOVATING TREATMENT IN MUSICIANS' MEDICINE

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Abstract. *In the recent two decades, it has become obvious that many routine treatments applied to other professions or sportsmen do not fulfil the musicians' requirements. The latter expect not only the elimination of pains and the functional recovery of the organs contributing to musical performance, but also the total recovery of the sensitiveness and movement precision, necessary for further practicing the profession. The ill musician's recovery must consider both his psychology and his physical capacity to perform a score. These requirements have brought about the creation and development of a new branch of the musicians' music: Biofeedback.*

Keywords: *musicians' medicine, biofeedback, electromechanical or electronic devices, psycho-physiological parameters, autonomic nervous system.*

1. INTRODUCTION

Feedback is a currently used procedure in setting up machines and consists in measuring the parameters of the final product (output), in guiding the results towards the parameter-control system during their machine entry and in modifying the input parameters so that the final product should fulfil the client's requirements. In the early 50s of the last century, this was the basic concept of cybernetics, a science which was coming to light at that time and which has been meanwhile incorporated in the science on the automatic control systems of the various production units or of the machines. Driving a car engine – for instance – comprises numerous feedback-based auto-adjustment systems.

In the last 40 years, the researchers in the medical system began to study the possibility of adapting this technique to treating the human body. This technique has yielded good results for many diseases affecting musicians – headache, hypertension, tinnitus, stress, over-fatigue-caused pains etc.

Biofeedback stands for a group of treatments that resort to electromechanical or electronic devices in order to measure and transmit the patient and the therapist, significant data on the neuromuscular and anatomic activity, in a readily comprehensible manner, to the purpose of developing within the patient, the capacity to perceive, understand and voluntarily influence the physiological processes of the human body. Through the process of viewing the parameters that characterize a patient's physical state – body temperature, pulse, blood pressure, frequency and other parameters of breath, sweating, brainwaves and others – through the previous training on the therapist's indications, the patient learns how to influence his psychical condition in order to normalize the values of the measured parameters and to the eliminate the hardship-producing psychic state.

All above-enumerated parameters are regulated by the autonomic nervous system (ANS, popularly known as "unconscious"), which acts independently of the human will. Until recently, the human being was not deemed capable of acting upon ANS and the currently successful experiences of several Buddhism and other Asian culture-practitioners – who can regulate their respiratory rhythm, pulse and other vital functions at will – were regarded as unexplained eccentricities. Along with miniaturizing the human body parameter-measuring devices, the possibility appeared of coupling them to electronic systems which enable their

visualization as very suggestive graphs. The treatment-undergoing person can now attempt to modify the values of these parameters in order to feel better. After a training period, he safely and securely succeeds; and later on, he will learn to regulate these parameters without their having been displayed on a screen. The patient "learns" to recognize an undesired state within his body and to influence it. He detaches from apparatuses and may correct on his own, without medical supervision, several body reactions to the environment. Healing does not occur in the medical traditional sense, but through the use of an ANS-positively affecting supplementary procedure, which "equilibrates" the human body and which leads to its functioning within "normal" parameters.

Human body is extremely complex and the functioning of the autonomic nervous system substantially differs from one patient to another. Identical methods applied to different patients lead to different results, although all other conditions (therapist, values, ambient conditions), were each time complied with. Biofeedback does not fulfil therefore the most important requirement of a scientific activity – repeatability – however it yields good results in manifold cases which cannot be otherwise solved. The hope is that, once with the development of the knowledge on the functioning of the autonomic nervous system, the biofeedback-offered results will improve. Massive efforts are being made to fathom as quickly and as deeply as possible the secrets of these procedures.

2. PATIENT'S EDUCATION

During the adjustment by an engineer of a machine's automatic control system, he "describes" in digital language what its electronic system must make when the parameters of the output somehow vary. All operations that the machine must execute have to be accurately described. The machine is not endowed with intelligence and cannot initiate a correction of its activity which has not been previously recorded within its electronic system.

In case of resorting to biofeedback, the situation is more complicated: human memory does not exactly record what the therapist intends to communicate, only what the patient understands of these words; subsequently, the memory content is altered by the intervening experience, which does not always lead to a positive result. The interaction between therapist and patient is for long term. The therapist must regularly verify and repeatedly explain what the patient must do. As every patient's ANS reacts differently, the basis of the advice cannot consist in a few rigid rules, identical for all patients, but it must change depending on every patient's personal reaction and on the result of the treatment.

There pertain to the "patient's education":

- **Presenting the information** which are available and must be processed by the patient. A time-depending graphic is usual; however, the therapist must ascertain whether the patient can understand the submitted graphics and can deduce what he is expected to do. Comprehending the more complex graphical presentations supposes a certain degree of intellectual organization and development: this skill is not necessarily assured from the very beginning in every patient.
- **Explaining the signals**. This one includes their name (for instance: "The red line is the body temperature"), the normal variation range and the limits wherefrom the patients should intervene.
- **Explaining the relation between signal and physiology**. For instance: "A feeling of comfort installs when the body temperature is of $36,7^0$C."

  If the information presentation is time-dependant, the image displayed on the screen always moves to the left and disappears at one time. The apparatus must be equipped with the possibility of "freezing" the information (to stop the recording on the screen

but to keep the measured values in the computer memory) so as to provide the therapist with the time of offering some explanations.

- **Explaining the records in relation to symptoms**.
- **Therapist's suggestions**. From personal experience, the therapist can assess whether insignificant changes of some parameters – for instance the sitting positions, the clothing nature etc. – may contribute to improving the result of the treatment.
- **Informing the patient on the success** of his efforts ensures the collaboration between patient and therapist, which underlies the success of the treatment.

From supervising the equipment, the therapist can draw conclusions on the development of the treatment. On their basis, he can give further guidance to the patient.

Biofeedback is a state-of-art branch of the medical science, which is not related at all to various procedures offered by therapists outside the medical world. Biofeedback is not another "New Age Procedure".

3. IDENTIFYING AND MEASURING THE PSYCHO-PHYSIOLOGICAL PARAMETERS

Before the development of biofeedback, the necessity was felt to find the electrical values, which are closely correlated to those parameters of the human body on their way to be modified. The current medical practice uses – actually – the following parameters:

- **Electromyography** in order to determine the muscle contraction.

Muscle contraction is neither directly accessible to a physical measurement, nor defined so far in terms of measuring manner and benchmark. Muscular contraction itself is the contraction sum of the overall muscle fibres and each contraction occurs as a result of the electrical signals emitted by special cells (motor cells). Electrical activity may be captured with very fine wires which are inserted through the skin and reach the muscle surface or, more simply, with sensors placed on the skin. An electrical signal is thereby obtained, which does not directly measure the muscle contraction, but is closely correlated to it. The measuring unit is the microvolt (one millionth of a volt) which is not a measuring unit for the muscle contraction, but a readily-usable physical value of the measuring equipment. It may be easily viewed and stands in an invariable relation – for a certain patient and a certain muscle – with the muscle contraction.

- **Peripheral temperature** in order to determine the vasoconstriction.

Measuring the temperature on the finger or toe surface allows determining a physical value which is directly related to the blood vessel diameter. Through a greater-sized diameter vessel, more blood passes and this brings about skin heating where blood vessels are closer to the surface, i.e. fingers. From this local and indirect determination of vasoconstriction, the state of the other blood vessels in the body may be deduced.

- **Photo-transmission of light** through the fingers in order to determine the vasoconstriction.

When blood vessels are dilated and more blood circulates, the transmission of light through the fingers is hindered and they appear darker. Light differences may be determined with a photoelectric cell. This is a second method for determining vasoconstriction.

- **Electrical conductivity** of the skin varies with the gland-issued sweat quantity.

The salts within sweat are well electricity-conductive; however the skin itself only conducts electricity to a small extent. The electrical conductivity of the skin – in fact of the sweat on the skin – may be used to approximate the functioning of the sweat glands, which are in their turn influenced by the patient's emotional state. The measuring is effected through applying a very low voltage between two electrodes, which are in contact with the hand skin and which determine the intensity of the current in between the electrodes. Their ratio gives the skin

conductivity, measured in micro-ohms. Conductivity – which, from physical standpoint, is the reverse of electrical resistance – may be interpreted as a measure of the patient's emotional state.
An important problem in resorting to such fine electrical appliances is that the human body itself – as a whole – acts as an amplifier of the either naturally occurring or manmade electric currents. These currents freely and uncontrollably circulate throughout the human body and obviously modify the physiological values to be measured. These currents – which cause some "background noise" - are eliminated from the measurement with a differential amplifier – a supplementary electrical device – that is incorporated in the measuring apparatus, which further contains various filters that remove the currents produced by the apparatus or by the human body.
Human brain produces multifarious electrical signals, depending on the conducted activity and they may be recorded through an **electroencephalogram**. **Alpha waves** - with sinusoidal form, with the frequency of 8 – 13 Hz and with the amplitude around 50 mV (greatly varying from one person to another) may be especially determined in the back of the head and they appear when one's body is at rest. The occurrence of visual stimuli leads to alpha wave blurring; however, during hypnosis or meditation, their amplitude reaches maximum value. **Beta waves** (13 -30 Hz) may be measured in the front of the skull and they appear during alertness or active dream. **Gamma waves** have higher frequency (30 – 100 Hz), may be determined in various head regions and they are produced by cognitive and behavioural activities. **Theta waves** have low frequency (4 – 8 Hz) and they appear in the posterior cortex, especially beneath three years old. After this age, they change into alpha waves, although they may be determined up to thirty years old for certain persons. **Delta waves** have frequencies ranging between 0,5 and 4 Hz and they appear in the healthy persons' case during deep sleep. Measuring electromagnetic waves offers information on the brain functioning, on the analyzed problem type, on the patient's emotions and health state. All these information are useful in ascertaining sickness and in choosing treatment.
On every point on the scalp, another brainwave composition may be determined. In order to ensure the measurement compatibility, the electrodes are applied on well defined areas of the scalp, in compliance with an international scheme.

4. BASIC CONCEPTS IN PSYCHO-PHYSIOLOGY

Psycho-physiology is underlain by a few concepts which ensure its scientific character. **Autonomous equilibrium** refers to the manner in which ANS responds to some stimuli through the modification of the pulse, blood pressure and salivation. Numeric scales were created for different diseases, such as hypertension, headache, antisocial syndrome, schizophrenia, attention deficit, hyperactivity, wherein high values show normal functioning and low values denote a certain degree of mental illness. **Stereotype of individual answer and specific answer** comprises complex evaluation schemes that include several psycho-physiological measurements, systematized so as to allow the identification of certain psycho-physiological disorders. **Law of the initial values** demonstrates that the values of some stimuli applied before the so-called measurement (pre-stimuli) determine the value measured after the application of the final stimuli. The greater the value of the pre-stimulus, the lower the rise of the final value at the passage from pre-stimulus to stimulus. **Homeostasis** shows the tendency of any human body to reach an equilibrium or rest stage. **Answer of orientation** refers to the manner in which the body responds to new and unique stimuli. **Effect of transfer** is a basic working methodology which considers that previous experiments may influence the result of the current experiment. **Temporary stableness** lays the stress on the necessity for the response to a set of stimuli to repeat during the application of the same stimuli after a time

interval. This is the guarantee for the safety of the investigations, and subsequently of the treatment.
Information upon the manner in which these methods are used to the purpose of achieving the psycho-feedback are reserved for the specialized doctors. The procedures which are, on the one hand, complex, on the other hand, incorrectly used, may bring disadvantages to patients.

5. PSYCHO-PHYSIOLOGY FOR MUSICIANS

A high level of control upon the emotional processes is of great importance for the level of performance that musicians are expected to reach. The level of performance must be attained without exceeding an admissible degree of tension, however maintaining the flexibility, the mental relaxation and the necessary safety, in order to express the individual creativity and to maintain the communication with the audience. EEG-biofeedback offers the musician, the possibility to learn how to control the electrical activity of the brain through these emotional processes it undergoes.
Studies conducted on Music Academy students have proved that, following the training with biofeedback processes, they reach high performance in terms of artistic aspects of the performance, such as: musicality, stylistic accuracy, emotional persuasion and performing imagination. Neural-feedback has been further noticed to optimize the cognitive and neural-physiological dimensions of attention.
These results have led to raising the importance paid to biofeedback procedures and to using them for fields outside the medical treatment. The treatment occurs in three stages:

a) Recognizing the existence of a deficient situation (for instance muscle strain above the regular or necessary one)
b) Discovering and learning – resorting to biofeedback – the connection between certain changes in the metal condition or body state and the removal of the deficient situation through self-adjustment.
c) Applying the acquired dexterities in daily life.

Over the last 30 years, a significant number of health problems could be solved with feedback, as follows:
- biofeedback of blood pressure and skin conductivity was used for treating hypertension;
- biofeedback of finger temperature was used in treating Raynaud disease and headache;
- biofeedback of electromyography was used in treating the headaches caused by high blood pressure, the asthma, also during the muscle recovery after a stroke and – in the musicians' specific case – in treating tendon injury.
All the above can be used for the complementary treatment of the various musician-characteristic fear states, for providing relaxation and for eliminating or reducing the stress. Biofeedback leads to the modification of an excitation state in ANS into a more relaxed condition, with the rise in the treated person's sensitivity towards the manifestations of his own body, as well in his awareness of the capacity to keep body manifestations under control.
Among the biofeedback-treated cases, mention should be made of:
- reducing the extensor muscle tension in the violin players' left arm;
- reducing the clarinet players' general tension in the body and the pains it brings along. Subsequently conducted studies because of the fear lest this relaxation should lead to a diminution in the level of performance have shown that performance stays unaffected[1];
- eliminating the blowers' face muscle and neck tics, caused by having exaggeratedly strained the respective muscles;
- eliminating the tension of the violin players' left hand through the feedback of the adductor muscle's electrical activity.

We dare say therefore that biofeedback may be much successfully used for treating the symptoms which are related to practicing the profession of musician. Experience shows that psycho-physiology may offer, for the musicians' suffering, solutions provided by no other medical branch.

6. TREATMENT OF THE MUSICIANS' MUSCULAR-OSSEOUS SYSTEM

Problems – especially pains – of the muscular-osseous system are the musicians' most frequently encountered symptoms. Psycho-physiologists are aware of the subtle relation between tension and relaxation states, which alternate almost every second in various places of this system. They have developed a manner of interrogating the musicians' suffering history, which includes both the use of the musical instrument and the psycho-social aspects, as well as the history of the previous treatments. The last information are the more important, as the musicians – often without adequate health insurance – address themselves for treatment to any available persons, including their colleagues, medically inexperienced musicians except for their own suffering. Their goal is to obtain healing as soon as possible, as disease leads to the impossibility to perform, hence the impossibility to earn one's living.

A musician-specific problem consists in erroneous diagnosis, mostly caused by the scarcity of the physicians specialized in the musicians' particularly delicate problems. For many doctors, the musicians' minor intensity suffering is to be neglected, although for the musicians, their suffering means at least the impossibility to attain the required level of performance. Musicians often give up the physician-recommended treatment and resort to alternative treatments.

Over their study, musicians are not trained in interpreting the data of the human behaviour. Therefore, they cannot make the connection between cause and effect, between the different manifestations of their problems and their evolution in time. Moreover, confronted to a psychotherapist, they have already accumulated some negative experience which renders them very sceptical in relation to all unusual aspects of a psycho-physiological treatment.

EMG is the pre-eminent information source in treating the muscular osseous system, as most musicians' diseases are caused by excessive muscle strain, and their activity may be easily measured. To excessive strain, brief-duration involuntary contractions add, increasing the pain felt by the musician. Hence the phenomenon of over-fatigue, very painful in itself.

Studies upon the phenomenon have suggested that permanent tension is not the one which brings about the greatest pains, but the specific of the tension-relaxation cycle, which occurs during the very performance. Ever since 1921, works have been published which prove that experimented pianists succeed, after a maximum effort required by the score, to detent for a few second fractions, a fact which diminishes the level of suffering and allows a high-level activity for much longer time. In a procedure, developed in 1998 [2], pianists are instructed how to alternate maximum strain and utter detent. Hence the conclusion that the non-economical use of hand tension is a decisive factor in musicians' injuries. Their treatment with EMG-feedback leads to removing the non-adequate habits and to eliminating pains.

Biofeedback may be successfully used for treating performance anxiety and its related somatic symptoms. Hand temperature sensibly varies depending on the musician's anxiety state. Gleen Gould's case is famous, whose hands would become so cold during concert, that he had to wear cut-off tip gloves. Vasoconstriction and vasodilatation likewise offer sufficiently precise data for determining and treating the musician's stress state. Other stress manifestations are heart palpitations, the "lack of air" because of an insufficiently deep breath, vomiting, numbness, diarrhoea, low salivation, as well as skin aspect changes. Biofeedback can treat all these symptoms.

7. CONCLUSIONS

Specialized knowledge have been ever-evolving and developing, a fact which is reflected by a high number of seminaries, symposia and other continuous medical-education measures, which are annually offered worldwide. The increasingly extensive bibliography of the recent years has been dedicated to the instrumentalists' problems [3]. A number of authors have reported on variegated problems, such as the biomechanics of playing different instruments, physical therapy, occupational therapy, psychological problems and emotional aspects or on other parameters such as neurological problems, orthopaedic problems, dental problems, hearing evaluation, vocal dysfunctions.
Much progress is still to be attained in basic and clinical research, in multifarious collateral subjects. For instance, too few standards exist with reference to the physical qualities necessary for playing a musical instrument.
The musician's recovery – considered as intrinsic part of the treatment – remains an essential problem in a medical team's care [4]. Preventing injuries or eliminating the professional-disease causes also remain in every performer's care, who has to play an active role in his own therapy and in his behavioural adjustment, which should prevent injury relapse.

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