The use of sound in diagnostic and therapy of people after brain injures and strokes

The use of sound in diagnostic and therapy of people after brain injures and strokes

Halina Portalska, Marek Portalski

Institute of Management Engineering, Chair of Control and System Engineering – Technical University of Poznań

Summary: *in the paper a review of selected methods with use of sound in diagnosis and therapy has been presented. Methods proposed by the authors are mainly based on advanced methods of spectral analysis and use of disharmonic multitons, particularly those produced by special sound bowls. Usefulness of presented methods has been proved for people with various dysfunctions of central nervous system.*

1. Introduction

For a correct appraisal of the organism' condition various methods may be used. Unfortunately, many of them are of an invasive character. Proper usage of acoustic and music methods for this purpose allows for obtaining, in many cases, sufficient diagnostic information in a non-invasive way and in case of further therapy using sound, such a diagnosis is a basic feature.

One option is to use different analyses of patient's voice. Other, additional options are offered through the analysis of sounds played by the patient, for example on keyboard or percussion instruments.

Use of the sound in therapy is a separate, wide aspect. It includes both various kinds of music and specific sounds produced by acoustic instruments and by electronic equipment. The other method comprises of use of digital sound processing, using pre-recorded sounds, such as music or sounds of nature.

The use of human's voice in sound therapy cannot be omitted. Even though it requires high qualifications of the therapist as well as patient's understanding, will and need, it is still the cheapest and the most efficient method of sound therapy.

Every year the number of people suffering from brain injuries and strokes is growing. That compels us to search for new, cheap, non-invasive diagnostic and therapeutic methods. It is of special attention, as the chances for those people to be restored to their social activity depend on correct diagnosis, fast rehabilitation and regular control of its results. It has inspired us to look for new, non-invasive, cheap diagnostic and therapeutic methods using sound, which are applicable to central nervous system disorders.

2. Voice analysis

Apart from its main purpose – interpersonal communication, voice has a diagnostic and therapeutic character, what makes it an important source of information about the condition of human organism.

Voice shows how stamina, feelings, thoughts and intuition are harmonized together. It develops a style of speaking, through reacting to the stimuli, moreover it evolves with collecting new experiences. Voice influences health, feelings, appearance, self-confidence and the communicative skills.

On examining different parameters of sounds produced by a patient, you can tell a lot not only about condition of his speech organs, but also, according to an American research [2,3,4] and research carried out by the authors, about the general condition of patient's organism, his disorders and effectiveness of various types of therapy [20,23].

Voice analyses, which use DSP techniques are used in phoniatrics for a long time [42]. It is based on the assessment of a set of parameters, which were usually calculated with an expensive software MDVP and other, provided by Kay Elemetrix [13]. Analyses concern mainly the assessment of amplitude and frequency fluctuations of a larynx tone.

It allows for an assessment of the functioning of speech organs, for detecting the abnormalities, as well as for assessment of the progress of the rehabilitation of voice and hearing.

2.1. Parameterised spectral analysis

The authors, basing on their own software, originally used to analyze music pieces [33,37], found out that it was useful also for speech analysis. This software used a division of a part of acoustic band into sub-bands with regulated breadth and presentation of average energy values of those sub-bands as a method of parametrizing the results of the analysis. The average energy of whole

signal was subject to the analysis. The range of the analysis covered 7 octaves from C to e4, breadth of the bands of the analysis is tuned between 10 an 100 cents. Detailed description of this software is elaborated in [14,37].

Today we use a subsequent version of this software, which enables analysis not only in the bands conforming with twelve-tone equal-tempered scale, as it was in previous version, but also in other scales, for example unequal-tempered Zarlino scale. New software called ***anmuz7*** enables also the transposition of the middle parts of the analyzed bands.

The results of the analysis are presented in a form of a window with rectangular, with colours corresponding to the relative level of energy in a particular sub-band. An example of the analysis of speech signal with ***anmuz7*** (figure 1).

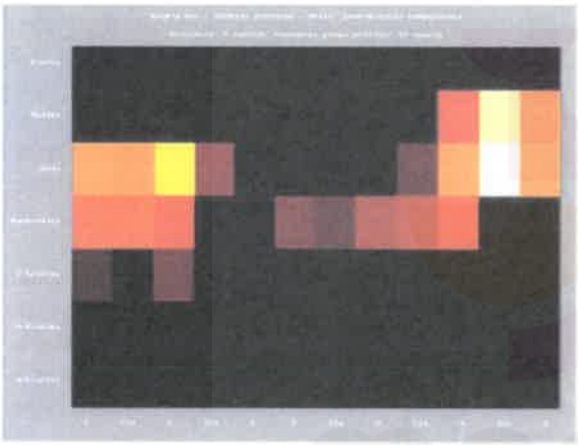

Fig. 1. An example of voice analysis

Using the analysis of how maxima of energy and main energetical intervals change their location, it is possible to deduce the psychological condition of the patients [11,32]. For example, basing on those results, direction of changes in the patient's organism after a therapeutical treatment may be assessed.

At the moment there are research conducted on subsequent version of this software, that would enable temporal and frequency analysis, i.e. parameterized specterogram in various musical scales.

Simultaneously the authors are working on selection of most suitable words or test phrases and proper scales for the analysis. At this stage Zarlino scale seem to be betterand so do the texts of proper affirmations from twelve-tone equal-tempered scale and random statements.

2.2. Examination of the equalization of produced sounds

Another diagnostic method is an analysis of the unequalization of the time of speaking or playing the same tunes. Human organism is a rhythmised structure. This rhythmicality manifests in words spoken, sounds produced or moves. During the disturbances in functioning of the central nervous system the distortions of the synchronization of the rhythmicality of the moves or sounds produced are observed. Such changes can be a sign of developing illness or proceedeing rehabilitation and recovery, after a stroke or brain injury.

Rhythm, metrum or pace are associated with physiological movement, feeling of life, creation, being. Particularly the pace and its dynamics are reflected in respiratory and blood circulation system. For example cardio-vascular changes are correlated with speed of the speech and voice volume [5]. Those parameters along with breath and pauses in produced sounds reflect the expression of emotions, particularly the anxiety. Changes of the pace in time are of diagnostic importance, for instance increasing pace may be an indication of an attempt to keep control, to lead.

In order to examine the speed of produced sounds special programmes, which analyse changes of the momentary speed of a sequence of identical sounds have been created, with participation of the authors [15,16,34]. They allow for measuring both average speed and its trend using the straight-lined regression and standard deviation from straight regression. Deviation is a measure of accidental fluctuations of the speed of produced sounds.

Figure 2 presents a demonstration screen of results by ***wavspeed*** programme for a number **"8"** pronounced by a healthy person.

Fig. 2. Demonstration screen of results by ***wavspeed*** programme number „8"

Similarly to sounds produced with voice, sounds produced by a percussion instrument can be analysed, for example sounds tapped on a silenced drum with a felt drumstick or, in worst case, on the table. Such kind of analysis allows for an assessment of the work of hand muscles and of a part of nervous system that is responsible for its control.

Preliminary research conducted by the authors shown an significant differences in the value of standard deviation from a straight regression in healthy persons and patients with diseases of central nervous system [34]. It also shown changes of the parameter in a group of healthy people under the influence of visual-relaxation sessions with a music background [16].

Further research is planned in this subject, particularly on further development of the software and optimization of testing sounds or phrases. Preliminary research work proved this method to be useful for a support of psychological diagnostic provided that appropriate set of testing phrases has been selected.

3. Seven-tone test

Assumptions of the original seven-tone test and its variation – twelve-tone test as well as the technique of conducting the tests have been presented in previous publications by the author [26,27,29,39]. During the test a patient plays any three sounds from octave **c1** (**A** = 440 Hz) on the keyboard. The time of selecting the sound and playing it should not exceed 6 seconds, while the whole test should not last longer than 30 seconds. The exceptions are allowed for disabled patients with limited manual dexterity (up to 1 minute).

An assumption has been made, that patient's subconsciousness chooses the sounds and their order in such a way to provide the organism with what it needs to keep its homeostasis. Chosen sounds reflect the set of deviations in the energetic-information field of the organism, however without showing any clear determination of the directions of those deviations. This additional information is given by other premises, e.g. by the analysis of the order of given sounds, the way of selecting the sounds (dynamic, intervals etc.) and selected elements of body language.

Recorded sounds are treated as symbols for a specific frequency band, focused upon particular sounds e.g. C,D, etc, equal tempered tune. Mostly, it is enough to use only white keys during the test – seven-tone version.

To extend the circle of patients (especially the disabled) it is admissible to use the variations of the test, e.g. sing three sounds, give the names of three sounds, write and mark on the picture of the keyboard three sounds etc.

This test allows for assessment of the general psycho-physiological condition of the organism and its energetic-information condition. The test indicates the areas of the body and groups of organs that diverge from the standard, it allows for appraisal of the current emotional condition, predispositions or family relations.

Information delivered by the test are particularly important in setting the general trends of the therapy or the rehabilitation, e.g. programming the therapeutical actions, priorities in the trends of therapy, particularly in monitoring the effectiveness of various therapeutical sessions. The test turns out to be useful especially in techniques of cultural therapy, particularly the sound therapy.

Participation in the test may be a beginning of the autotherapy, an incitation to learn one's inner life, to go outside, to meet one's own organism. The participation itself lowers the level of fear. It triggers the will of cognition. It may even become an element of releasing the stress in the form of play or even catharsis [27].

4. The sound in therapy of people suffering from central nervous system illnesses

Both music and specific sounds have been used in the therapy of various illnesses from ancient times. Nowadays a growing interest in such methods is being observed, as well as a comeback to well known old ethnic instruments, which are today successfully used in the therapy. Specific properties of the sound, as a stimulus of positive energy and multi-level information, proved to be particularly useful in various forms of therapy of people suffering from central nervous system illnesses. Regarding the extensiveness and complexity of this topic, the authors decided to present only the selected issues and examples, that are particularly useful for this group of patients.

4.1. The use of sound bowls

Sound bowls are the percussion instruments, from the group of idiophones, known from ancient times. Even today they are produced accordingly to the old regulations. The original production technology of the therapy bowls is based mainly on the manual forging of the pane made of multicomponent alloy, which determines the final and unique sound of the instrument [7]. Such a sound is a complexed disharmonic multitone, where spectrum fringes are focused in several characteristic groups. The authors have spent many years on examining the properties of this sound [18,19,24,25,36]. The spectrum of the sound produced by a model bowl, so called solar plexus bowl, is presented on figure 3.

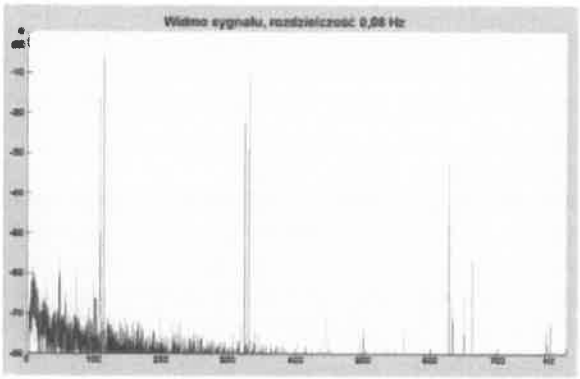

Fig. 3. Spectrum of a model solar plexus bowl

There are insignificant differences of the frequency of the fringes in the group. They cause rumbling with sub-acoustic frequency, which lie in the bands of most magnetic resonances of the human body and in the bands of bioelectric brain activity – especially in alpha and theta rhythm.

The intervals between groups are also of a specific stimulating character. Accordingly to the authors' survey [18,24,36] and Maman's works [11], dependent on the type and copy of the bowl, the functioning of the intervals between first and second group of the fringes has a waking, opening, expanding character. For selected heart bowls it may even make it easier to transit from inner to outer world, to release the artistic potential. The intervals between second and third group of fringes for medium sized bowls are the enhancement, an aspiration to look for solution. As well as the stimulation of healthy cells and destruction the pathologic or cancerous ones [11].

These properties of sounds produced by bowls in the therapy allows the brain for a fast transition from beta to alpha condition and then towards theta, which provides quick state of deep relaxation (what has been often observed also by the authors) [7,9,25]. Proper usage of the bowls allows for achieving the interhemispheric synchronization, which is used in Hemisync method [9]. Simultaneously blood circulation and processes of toxins removal from the organism improve. Delicate vibroacoustic stimulation along with the proper usage of the bowl improves the blood supply and regeneration processes in various parts of the body [7,19]. Specific features of the bowl sound trigger positive changes in psyche and predispose them to nonverbal communication, which is very important in aphasia, a disorder that often accompanies strokes or brain injuries [30].

4.2. The usage of tuning forks

Tuning forks generate sinusoidal tones of varied frequency. They correspond to the varied frequency of organism, especially certain organs or tissues [40]. Using two slightly distuned from each other tuning forks, we can generate subacoustic rumbling which synchronize the work of the brain, or even achieve the FFR effect, used in Hemisync method [17], and interhemispheric synchronization. Tuning forks are also successfully used for stimulating the acupuncture points [12,40]. The usage of tuning forks in sound therapy include mainly stimulation of particular areas of the body and particular acupuncture points. The specificity of tuning forks sound requires highly qualified therapist.

Observation of the therapy with use of the tuning forks for patients in the association CEREBRUM in Poznan, proved this method to have a positive effect.

As each tuning fork generate only one tone, the therapist has to be equipped with an expensive and wide set of it. For this reason the authors are examining the possibility of creating a technical inductor of the vibrations, which would replace the set of tuning forks and provide with additional therapeutic opportunities.

4.3. Electronically processed sounds and music

Such acoustic stimuli are mainly used in therapy of autistic children. Most of the methods is based on various modulations of an envelope of a spectrum of an acoustic signal, mainly the stochastic one. The examples include AIT method, Samonas, Digital Auditory Aerobics or the most recent KAMS method synthetically shown in [31]. For a modulation different types of music are used – from classical music to pop and sounds of nature.

Other method includes proper processing of the recorded bowl sound. Thanks to appropriate placement of the particular sound in time in the stereo data base, accordingly to slow changeable rhythm of blood saturation with oxygen in the brain [8], it is possible to multiply their functioning in relation to the sound of the bowl itself. A CD with such a record prepared by the authors [28] has been implemented into therapy in Day Childcare and Educational Centre for Children and Youth with Autism in Szczecin and got a positive therapeutical effect [10,31].

4.4. Visualization sessions with a music background

Visualization sessions are part of various types of therapies. Creating particular, controlled by a therapist images in the patient's imagination may affect both

psychological condition and physiological processes in the organism [6,21,33,41]. Visualization may be also very useful in therapy for patients with disturbances of c.n.s.

Correctly matched music background is very helpful. Such a background, unlike random music (even so called relaxation music), enables to multiply the effectiveness of the therapy. Optimization of both text of the session and music background is of great importance and should be oriented to a particular patient or similar group of patients [21,35]. It concerns both the sessions carried out live by a qualified therapist and the appropriate selection of the recorded sessions. Therefore before selecting any kind of training, patient, and especially his voice, music preferences and reactions to particular situations and sounds, should be carefully diagnosed. For such a diagnosis voice analysis in music bands and seven-tone test may be successfully used.

Research conducted by the authors conformed those rules and allowed for determining significant features of a good music background [35]. Key role in the research plays the analysis of a sound spectrum in bands of music scales [14,37] and analysis of this sound's envelope [1,38]. A good background should have properly matched melodic line, arrangement of the accord, pace. In precisely selected intervals there should appear non-music sounds (e.g. sounds of nature) and especially words from the session text. It is easier for the brain to achieve the desired state of consciousness when envelopes of particular components in appropriate parts of the background dominate in the spectrum. Band 6÷7 Hz is of a great importance [35].

A tape „In the land of imagination 1", which is based on number of authors' experiences and analyses [22], proved to be useful in various types of therapy for example for people with c.n.s. disturbances, such as multiply sclerosis [20,21], or Parkinson disease. To illustrate the acoustic features of sound record from the tape, figures 4 and 5 shows respectively a spectrum of sound in bands of equal tempered twelve-tone scale and a spectrum of envelope of the second part of the tape.

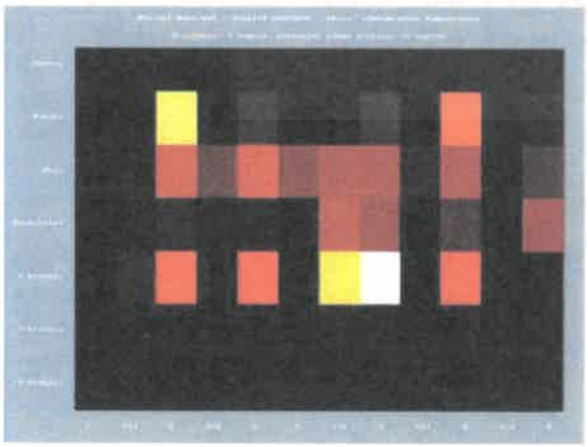

Fig. 4. The layout of the energy in subbands for the second part of „In the land of imagination 1"

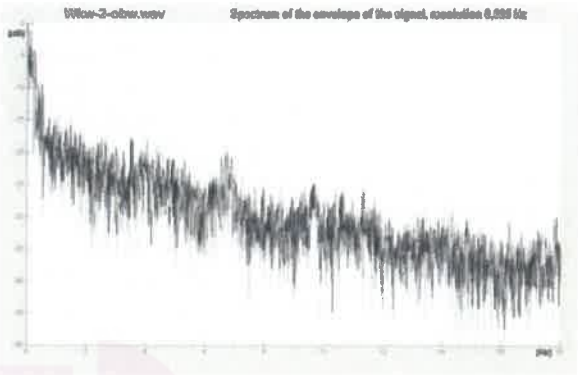

Fig. 5 Spectrum of the envelope for the second part of „In the land of imagination 1"

5. Summary

Human's nervous system is a tender tune fork, which reacts to various outer sound stimuli and produces strong resonance inside itself. In the case of strokes and brain injuries a contact with appropriate sounds provides a wide range of non-invasive diagnostic and therapeutic opportunities. It can reveal the cause, incite the recovery process, bring calm and comfort or even eliminate the pain. Moreover it may be an excellent source of releasing the stress, improvement of the general disposition and a way of fun.

■

6. Literature

1. Dąbrowski A., Meyer A., Portalski M.: *Analiza obwiedni sygnałów akustycznych w podpasmach.* IX Sympozjum Reżyserii i Inżynierii Dźwięku ISSET 2001. Warszawa 2001.
2. Edwards S.: *Decloaking Pathogenes with Sound.* \ w: Nexus Vol.7, No 6 / 2000
3. Edwards S.: *Definitive Theory of Human BioAcoustic Vocal Profiling & Sound Presentation.* Journal of BioAcoustic Biology, Vol. 5, Issue 11, USA 2005
4. Edwards S.: *The Significance of Mathematical Vocal Codes.* Journal of BioAcoustic Biology, Vol. 5, Issue 11, USA 2005

Strokes and craniocerebral injures - what next?

A MONOGRAPH

Poznań 2008