Review

APPLIED NEUROSCIENCE: WHY AND HOW BIO-FEEDBACK METHODOLOGY WORK?

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Abstract

Science cannot achieve its purpose without some practical applications. The aim of this article is to inform our colleagues about some practical uses of the methodology named biofeedback in the general population. It is important for the staff, especially for those employed in the public health service, because this method is not useful only for treating some disorders, but also for obtaining some health attitudes, performances and mental relaxation in the general population.

Преглед на литература

ПРИМЕНЕТА НЕУРОНАУКА: ЗОШТО И КАКО ФУНКЦИОНИРА БИОФИДБЕК МЕТОДОЛОГИЈАТА?

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Извадок

Науката без да има практична апликација не ја постигнува својата намена. Овој напис има за цел да ги информира колегите за некои практични примени на методологијата наречена биофидбек во општата популација. Ова е особено важно за кадарот во јавното здравство, затоа што методологијата е полезна не само за третман на некои растројства, туку и за стекнување здрави навики, успешност во работата и ментална релаксација кај општата популација.

Introduction

EAs defined, public health is the branch of the medical science devoted to protecting and improving the health of people and their communities. This work is achieved by promoting healthy lifestyles, researching disease and injury prevention, and detecting, preventing and responding to infectious diseases especially. In other words, the concern of the public health is to protect the health of the general population in some region. In this context, we will present some more important application of the biofeedback methodology, as well as our own experience with an accent to children and adolescents.

Biofeedback is a modern computer-related operant conditioning technique used for assessment and therapy of many psychophysiological disorders, especially the stress-related ones. Its objective is to increase the voluntary control over the physiological processes that are otherwise outside awareness, using the information about them in the form of an external signal. This methodology generally can be peripheral or central. The peripheral biofeedback uses electrodes placed on skin, on muscles, over blood vessels, heart etc. The aim is to measure the activity of the mentioned organs and following the obtained results to provide self-regulation of autonomic nervous system. In neurofeedback (i.e. central biofeedback), self-regulation of specific aspects of electrical brain activity is acquired by means of immediate feedback and positive reinforcement. How biofeedback works is presented in Fig. 1.
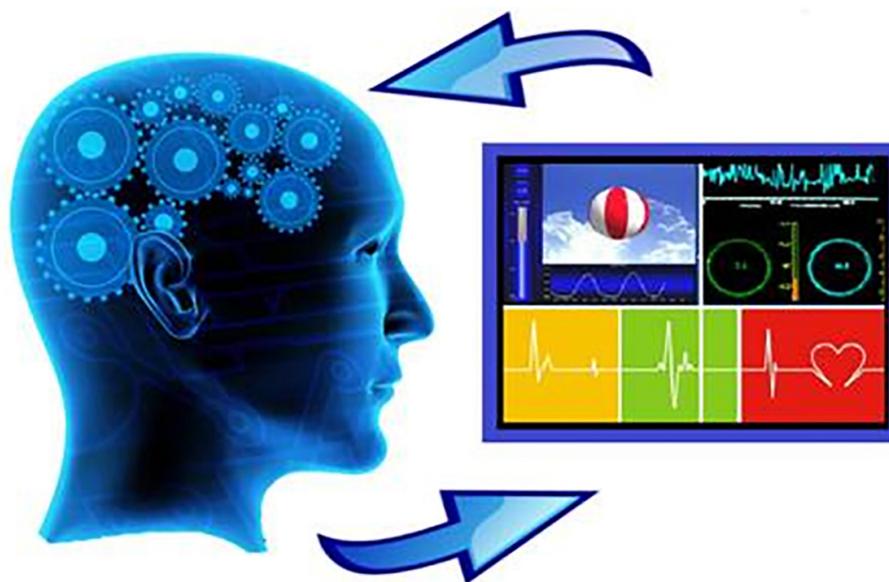
Picture 1. Biofeedback methodology

It is very important to point out that biofeedback therapy is a non-drug treatment in which patients learn to control bodily processes that are normally involuntary. Neurofeedback is more scientifically developed tool of biofeedback aimed to change the electroencephalogram record by changing the power of different wave bands (Alpha, Betha, Theta or Delta)[1].

The neurofeedback paradigm comprises watching and listening to real-time multimedia representations of its own electrical activity, by which the brain can improve its functionality and even its structure.

All biofeedback modalities are non-invasive and do not involve drugs, there is a low risk of undesirable side effects.

As mentioned before, biofeedback could be used not only for therapy but also for assessment of different bodily functions, especially stress-related ones. The assessment comprises information about skin activity, heart rate parameters, muscle tension, breathing parameters, peripheral vascular activity together with temperature, as well as spectra of waves power recorded on the scalp. However, the three most used types of biofeedback therapy are:

• Electrodermal activity which measures skin conductance/resistance.

• Electromyography measures muscle tension.

• Neurofeedback, or EEG biofeedback focuses on electrical brain activity.

During a biofeedback session, the therapist attaches electrodes to the patient's skin, and these send information to a computer. The therapist views the measurements on the monitor, and, through the processes of trial and error, identifies a range of mental activities and relaxation techniques that can help regulate the patient's bodily processes. Sessions typically last about 50 minutes. For some conditions, patients experience relief in 8 to 10 sessions. For other conditions, such as high blood pressure, improvements may take 20 sessions. Alongside these sessions, there are mental and relaxation activities that the individual will complete at home for 5 to 10 minutes a day. For treatment of ADHD and similar psychiatric disorder about 40 sessions are needed.

The team at the Paediatric University Clinic introduced this methodology in 1996 as the first team in the East-European region. The following technologies were used:

Relax plus-Ultramind, London; Inner Tunner Professional-Ultramind, London; Biograph ProComp.Thought Technology, LTD., Canada. The last one contains several biofeedback modalities related to changes in the skin, muscle activities, peripheral temperature, breathing as well as brain waves changes. The electrophysiological assessment of brain activity in our research was performed with the system Mitsar 19-channel QEEG 201 (Mitsar Ltd). Additionally, for obtaining better achievement in healthy subjects, we used Peak Achievement Trainer, NeuroTek, LLC 2003, USA.

Stress, as a kind of emotion, is inevitable in everyday life. In psychosomatic medicine stress represents a powerful link in the pathophysiological chain of disorder. Having evidence about the power of stress on the body, the interest in medicine was how to measure it in appropriate, fast way and with minimal cost. Electrodermal activity seems to be available for this purpose. Peripheral biofeedback was used for stress reduction, relaxation training in different chronic disorders in children, post-traumatic stress disorder (PTSD), general anxiety, or as an introduction to neurofeedback therapy. EEG biofeedback may help patients with attention deficit hyperactivity disorder (ADHD), addiction, anxiety, seizures, depression, and other types of brain condition. In the following text we will present shortly some of the most important applications of biofeedback in practice.

Use of biofeedback in practice

Beginning with functional enhancement and prevention of pathology, developmental implications of biofeedback methodology are especially relevant. Related to ageing processes, Frantzidis *et al.*, 2014[2,3] published articles where healthy and pathological ageing like Alzheimer's disease were treated from the perspective of an altered cooperative capacity between neuronal populations. This also opens the door for neuroplasticity-based training aimed at facilitating coherent interaction between distant brain regions and concomitantly improving cognition. This was the first demonstration of enhanced function in the elderly with a synchronisation outcome measure.

It was approved that in normal elderly subjects the best electroencephalogram (EEG)-based predictor of cognitive impairment was theta EEG activity abnormally high for their age. In this context training with neurofeedback could prevent cognitive declaims in these people, help people with insomnia and help people in rehabilitation after stroke[4-10].

The results of the Québec Longitudinal Study of Child Development are very interesting for the public health issue (Pagani, 2013)[11]. In this study it was shown that children of mother's smokers during pregnancy manifested a high impulsivity and were less engaged in classrooms. In this context Stankovic *et al.*, 2013[12] investigated neuroendocrine and neuropsychological functions in boys with conduct disorder where it was demonstrated that psychosocial stress provoked endocrine and autonomic responses, which produced trait impulsivity and disclosed electrodermal responsiveness. Additionally, characterisation of ten-year-old children with learning deficits was also facilitated by event-realted potential (ERP) recording in a report by Liu *et al.*, 2014[13].

A better achievement in school, sport, music and dance performance was approved after neurofeedback training. As part of a programme of optimal performance studies in the performing arts (Gruzelier *et al.*) 14-17, applications for music and dance performance were extended with one important design change in the music report when compared to the other performing arts studies.

Together with Olga Bazanova, from Novosibirsk Institute, our team applied neurofeedback in a group of musicians and obtained very satisfied results. In addition, HRV training (training of heart rate variability) reduced anxiety and the reduction in anxiety correlated with the improved technique and artistry in performance[18].

Peeters *et al.* utilised a single-session neurofeedback training for mood regulation, a convenient experimental approach which enables a quick investigation of the viability of a protocol and can allow an increased statistical power[19].

Our colleague Tenev *et al.* demonstrated the application of „support vector machine" modelling as an effective EEG power spectral method for discriminating between adults with ADHD and controls. With measures taken during rest and cognitive performance, providing four data sets in all, the method was especially successful in discriminating between DSM-IV ADHD inattentive and hyperactive-impulsive subtypes [20].

For faster evaluation of the mental arousal Pop-Jordanova N. and Pop-Jordanov J. (2005) introduced the so called "brain-rate" parameter which allows calculation of arousal in only one point on the scalp. Authors sug-

gested the application of this measurement in the general medical practice, together with the measurement of body temperature and arterial tension[21,22, 23].

The biofeedback was used in schools' settings in Israel by Daniel Hamiel in the project named "The value of a resilience program in the school setting and in the primary care as a preventing tool" (2005). The same author in 2008 allied biofeedback in the project "A prevention resilience protocol for possible traumatic events in the future in elementary schools and kindergartens. A study done before and after the war in the southern part of Israel". We have a piece of information that the application of biofeedback tools in Israel is actual until now.

Our team used biofeedback modalities in training better sport achievement, especially in ski and tennis athletes[24]. Additionally, we used biofeedback for better school achievement in a group of high school students[25], for treating nonepileptic seizures[26], for somatoform disorders and especially for ADHD[27]. In the risk assessment, we evaluated cognitive abilities in children exposed to lead emission in Veles[28]. Our experience with specific use of biofeedback in children and adolescent has been published in several papers[29-32].

Conclusions

Biofeedback is a modern com¬puter-related operant conditioning technique used for assessment and therapy of many psychophys¬iological disorders, especially the stress-related ones. Its objective is to increase the voluntary control over the physiological processes that are otherwise outside awareness, using the informa¬tion about them in the form of an external signal. The peripheral biofeedback, based on electroder-mal activity, is a very helpful tool for stress-related disorders in children.

It is hypothesized that operant conditioning methodology, such as neurofeedback, produces its behavioural and electrophysiological effects by gaining access to and control over regulatory mechanisms that increase or decrease synchronous or dyssynchronous activity in brain networks. Our results have confirmed the validity, effectiveness and cost-benefit of this methodology in large population.

In public health this methodology has many areas for application such as: addiction, eating disorder, better achievement at work, sport and arts, prevention of cognitive decline in elderly people etc. It is non-invasive, cost-effective and relatively easy for use.

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