IJHAS
International Journal of Health and Allied Sciences
Official Publication of JSS Academy of Higher Education and Research (JSS AHER), Mysuru

Manuscript 1024

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REVIEW

Biofeedback: Can It Be Used as an Assessment Tool?

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Abstract

Biofeedback forms an integral part of Complementary and Alternate Medicine (CAM). It acts as a self-regulation technique through which individuals voluntarily learn to control what they believe are involuntary body processes. It records physiological signals using sensors and converts them into meaningful visual and auditory cues that provide feedback about physiological responses through a computer screen. It has been widely used as an intervention tool since the time of its development. The utility and effectiveness of biofeedback are not only restricted to illness but also to enhancing health and well-being. The biofeedback mechanism relies on two primary principles: Psychophysiological Mechanism and Operant Conditioning Mechanism. Applying the same mechanisms, biofeedback can also be used as an assessment tool. It may be used in research studies to assess the efficacy of a particular intervention at various data points and also be used in clinical practice to assess the improvement in the patient, which in turn will be a self-reinforcement for the patient. Thus, research in biofeedback as an assessment tool besides an effective intervention measure is warranted in both clinical studies and pure theoretical research.

Keywords: Biofeedback, Assessment tool, Psychophysiological mechanism, Operant conditioning, Research

1. Introduction

The term 'biofeedback' was adopted for the first time at a conference of the Biofeedback Research Society in Santa Monica in 1969 [1]. It developed from several streams of research in the 1960s and 1970s, including scientific psychophysiology, sleep research, and the emerging field of neurosciences. Currently, it forms an integral part of Complementary and Alternate Medicine (CAM) [2]. Biofeedback, in its definitive utility, acts as a self-regulation technique through which individuals voluntarily learn to control what they believe are involuntary body processes. It has been widely used as an intervention tool since the time of its development. However, this intervention requires specialized equipment to convert physiological signals into meaningful visual and auditory cues that provide feedback about physiological responses [3]. Biofeedback treatment aims to establish the patient's mastery over the body independent of the biofeedback instrument and the feedback with the training and practice [4,5]. The most common responses trained in biofeedback are the electrical activity of the brain (EEG), skin temperature (thermal), muscle tension or surface electromyography (EMG), galvanic skin response (GSR), respiration (RESP), heart rate (HR), heart rate variability (HRV), and blood pulse volume (BPV) [2,3]. Ongoing research found relatively strong indications of efficacy for a wide range of applications of biofeedback, including asthma, headache, and urinary incontinence, and among psychiatric conditions in anxiety and ADHD [6]. Biofeedback emerged directly from laboratory research on psychophysiology and behaviour therapy and continues to advance through pure and applied empirical research. Based on its utility in various psychosomatic, pain, headache, and various psychological states like anxiety, better recognition of underlying mechanisms will be very helpful in

Received 15 May 2022; revised 9 January 2023; accepted 17 January 2023.
Available online 29 March 2023

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https://doi.org/10.55691/2278-344X.1024
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developing new biofeedback treatment approaches and novel uses of biofeedback [7].

Biofeedback, as has been already described, is a self-regulation technique through which patients learn to voluntarily control what is otherwise thought of by individuals as involuntary bodily mechanisms [8]. This intervention requires a specialized machine with sensors to convert physiological signals into meaningful visual and auditory cues and a trained biofeedback practitioner to guide the therapy. Often a computer monitor is used as a screen to present the feedback (the visual and auditory cues that represent the physiological signals being recorded) to the patients who, in getting the feedback, gradually develop control over their body mechanisms [9]. Biofeedback can be understood with this example − like how looking into a mirror allows us to see and change hairstyle, notice our facial expressions and get feedback as to how it is looking; biofeedback allows patients to see processes inside their bodies, with the help of a trained practitioner who guides them to use the feedback to regulate their physiology in a healthy direction.

The utility and effectiveness of biofeedback are not only restricted to illness but also to improve the academic, sports, and corporate arena, therefore enhancing health and well-being. The biofeedback mechanism is reliant on two primary principles:

Psychophysiological mechanism

It is established that biofeedback is effective in psychosomatic conditions, and thus stress is a significant component in which biofeedback works. Employing this principle, biofeedback works in a fashion where patients know how the stress in their lives affects their physiology. This learning model uses a psychophysiological evaluation to determine the thought and behaviour patterns contributing to the patient's physiological vulnerability. During biofeedback, the emphasis is not only on therapeutic mechanisms but also on educating the patient. As the sensors of the biofeedback machine are placed on the patient's skin, for instance, on the frontalis muscle of the head, the therapist explains what each sensor will be measuring, also assuring at the same time that the sensors will not cause any pain or shock but will record signals from the body (in this case the tension of the frontalis muscle) and displaying those signals on the screen. The therapist shows and explains how each signal gets displayed on the screen in the form of a visual or auditory signal. This may be explained as simply as 'the red line or high spike shows muscle tension is high', and the blue line or low spike represents relaxed muscle'. Patients are then taught how the signals being displayed on the screen relate to their physiology and can be controlled by them. For example, the patient can be asked to tighten his/her face, and the therapist can show the muscle tension signal on the screen (red line/high spike). Similarly, the patient can be asked to relax the facial muscle and try to feel relaxed, and the changes in the muscle tension signal can be pointed to the patient (blue lines/low spike) on the screen. This repeated training helps the patient learn to relax the muscle by focusing and utilizing the screen's feedback.

Patients are also shown how their physiology is reactive to mental stimuli, particularly stressful situations. This is often done with a psychophysiological assessment through a series of activities and rest periods. First, patients are asked to relax, and then they are asked to engage in a stressful activity such as responding to Stroop colour-word Test or Signal Detection Task and then again asked to relax. The therapist can then show the feedback and explain to the patient how his or her physiological reactivity (e.g. muscle tension) is related to his/her mental task or overall mental state. The therapist may then provide the patient with suggestions on how to use grounding imagery or self-talk to reduce stress.

Operant conditioning mechanism

Operant conditioning is a learning theory that utilizes an event outcome or consequences contingent on a particular behaviour as a reward or punishment to modify the occurrence of the behaviour [10]. In biofeedback, operant conditioning works by using the signal displays as reinforcement to prompt patients to change their physiology or gain control of body mechanisms (e.g. muscle tension). When a patient sees the physiological data going in a better direction on the screen, it acts as a reinforcement and helps in feedback learning. Over multiple biofeedback training sessions, the patient observes that there is improvement in his/her muscle tension and thus feels motivated to continue the same and experiences greater control of his or her recovery and wellness.

2. Can biofeedback be used as an assessment tool?

It is known that biofeedback has its application as a therapeutic modality in multiple conditions, particularly psychosomatic disorders like tension headache, urinary incontinence, insomnia, and psychological conditions of anxiety disorders. It is

widely used as a non-pharmacological treatment and is effective for many conditions [7,11]. Can a modern tool like biofeedback that considers parameters like respiration, heart rate, muscle tension, skin temperature, blood flow, and blood pressure be tried as an assessment tool?

A study conducted in India in 2015 to assess the effectiveness of alternate nostril breathing used biofeedback as an assessment tool. The study set out to measure the effectiveness of alternate nostril breathing in reducing stress in medical students ($n = 30$) using biofeedback parameters as an assessment tool. Assessment through biofeedback instrument included pulse rate, respiratory rate, EMG, EEG, GSR, and temperature and produced an overall relaxation percentage which was recorded at baseline and post-intervention to note changes in the parameter scores [12]. The study's findings showed that before the intervention, the mean value of the overall relaxation percentage was 58.30, and the post-intervention score was 62.90 yielding a t-score of -3.800 and p-value <0.005. This suggests that the intervention (alternate nostril breathing) was effective among MBBS students as there was a significant difference in the baseline and post-intervention scores. This finding suggests that the instrument may promise to be a reliable and easy-to-use tool for assessing the effectiveness of interventions in stress-related conditions.

Similarly, GSR, EMG, or HRV can be used as an assessment tool in an intervention study. The biofeedback measures can be correlated with the scores of anxiety, stress, fear, disgust, etc. For instance, a research study assessing the efficacy of Mindfulness-based Cognitive Therapy (MBCT) for tension headaches has psychological tools like Beck Anxiety Inventory (BAI) or Hamilton Anxiety Rating Scale can also employ biofeedback measures like GSR, HRV, or EMG as an assessment tool. The researcher will not only get data on the clinical and subjective experience of anxiety that may be related to tension headaches but also get physiological ratings or value of muscle tension, skin conductance, and heart rate variability that has an established relationship with tension and anxiety. The physiological markers of anxiety, tension, and stress (GSR, HRV, EMG) contributing to the targeted condition (in this case, tension headache) can also be a helpful tool to assess the efficacy of the said intervention (in this case, MBCT) at pre, post and follow up time points.

As discussed above, the biofeedback system acts based on the psychophysiological and operant conditioning mechanisms. Applying the same mechanisms, biofeedback, when used as an assessment tool, can help assess how much the individual taking biofeedback has been able to utilize the reinforcement or how much has he/she been affected by the feedback learning process. When the individual is trained to utilize the feedback and control the physiological mechanism, which earlier seemed to be an involuntary and uncontrolled process, it becomes reinforcing and may contribute to feedback learning. For instance, for a child experiencing bedwetting and the therapist plans intensive behavioural therapy, the child may be taught kegel exercise, with other techniques like enuresis alarm, limiting fluid intake, and the like supported by a reinforcement schedule. In the therapy session, the child may be taught to find the muscles he/she uses to stop urinating, that is, the pelvic floor muscles. EMG sensors may be then placed around the lower abdomen and perineum. The electrodes then capture the tension of pelvic floor muscles, record them, and send information about their contraction to the apparatus connected to them. The child who is otherwise unable to understand the extent of contraction and relaxation may be able to monitor muscle contraction changes he/she exercises on the monitor on an ongoing basis. Then the child may be taught to squeeze these muscles for 3 s. Then relax for 3 s and gradually add 1 s each week until he/she can squeeze for 10 s each time. The child is asked to repeat this exercise 10 to 15 times per session. This biofeedback procedure acts as an adjunct to behaviour therapy; however, its recording findings may also be used as an assessment tool. Over the sessions, the EMG recording of the pelvic floor muscle can show how the child is improving and that not only will act as a self-reinforcement for the child but also show us how effective the behaviour therapy is working on the child. Therefore, biofeedback can be used as an adjunct therapeutic tool and also as an assessment tool to test the efficacy of any intervention carried out on a patient.

3. Future directions

Biofeedback is non-invasive and has been found not only efficacious in stress, and various clinical and non-clinical conditions but also is believed to have a long-term effect on the cognition and behaviour of the individual and allows the patient to rely on his/her ability to bring changes and see the results. Also, the biomedical instruments used in biofeedback may elicit a conditioned mind-body therapeutic placebo effect and work on the suggestibility and trait hypnotic ability of individuals [13]. There is empirical evidence that suggests

biomedical instruments can have placebo effects. A study conducted in 1988 found that ultrasound was effective in reducing both pains and swelling whether the ultrasound instrument was turned on or off, as long as the patient believed the instrument was emitting sound [14]. Placebo effects of medical and surgical tools and instruments are well established based on previous learning of healing exercises [13]. Often, it has also been noticed in some clinical practice, the mere use of biofeedback helped in alleviating symptoms as the recipient perceived a significant procedure being done based on the elaborate instrument and monitor. Based on this therapeutic placebo effect it can also be used as a reliable tool for assessing various physiological responses as the method is free from manipulation or social desirability. We are all aware of the strong connection between mind and body and if the bodily changes can be assessed using biofeedback measures and correlated with psychological correlates, the intervention and treatment outcomes can be improved to a large extent.

Despite its efficacy, non-invasive nature, and its utility, it has some limitations. One of the drawbacks of biofeedback is that the mechanism and machines may be expensive. Most of the time it may also require the assistance and guidance of a trained practitioner who has to be trained with the system and software and knows the interpretation of the signal cues displayed on the screen.

However, if we focus on the pros of biofeedback, studies can be undertaken with adherence to the instrument's research guidelines and technical specifications to use biofeedback as an assessment tool in the future. It can be a good indicator of many psychological reactions and states and also help identify the efficacy of particular interventions by assessing biofeedback measures at various data points and analyzing the changes in physiological signals. The use of biofeedback as an assessment tool is not restricted to adults but is also applicable to the child population. Additionally, as already established, biofeedback finds its utility among the clinical and non-clinical populations for general well-being and healthy living; therefore, it can be used as an assessment tool in both clinical and non-clinical research studies. Thus, research in biofeedback as an assessment tool besides an effective intervention measure is warranted in both clinical studies and pure theoretical research.

Acknowledgement

Dr Susmita Halder, Associate Professor & Head of the Department, Department of Psychology, St. Xaviers College, Kolkata

Conflict of interest

There are no conflicts of interest.

Financial support and sponsorship

Nil.

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