Applications and the future of biofeedback

David A. Horner

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IPFW University

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Abstract

Biofeedback is a technique for achieving mind-body integration in order to promote well-being and health. Biofeedback devices record information about the patient's body and feedback or display the information in a comprehensible format to allow the individual to gain insight and control of their physiological and/or pyschophysiological functions. In the past research studies have had mixed results claiming placebo accounts for much of the results. However there have also been many research articles showing a significant amount of feedback therapy actually allows the individual more control of their autonomic functions. This paper addresses the history, theory of operation, applications, and future of biofeedback as a clinical treatment for illness.

Applications and future of biofeedback

Today people are using crude forms of biofeedback devices all the time and most don't even know it. If a person has ever used a thermometer or a weight scale and modified their behavior according to what the device told them, they have used a biofeedback device. Biofeedback devices are devices that record signals or measurements from the body and display or "feedback" the information gathered in a manner that allows the user to modify their behavior to receive a desired result. For example, if one doesn't like the weight registered when stepping on the scale, then that person would diet and exercise accordingly to decrease the weight registered on the scale. Traditionally physicians rely on machines that monitor internal activities of the autonomic system, such as heart rate, respiration, blood pressure, skin conductance, muscular tension, and brain activity in an attempt to increase knowledge about the underlying functions of the body. Biofeedback is a technique that was devised to help the individual gain willful control of their health or to help individuals learn to do things with their bodies that they normally couldn't do. A typical biofeedback session includes some sort of measuring device such as an electroencephalography otherwise know as an EEG machine that records small differences in potential on the scalp of an individual. While the EEG is recording signals the patient is asked to perform some sort of task that would cause the signals of the EEG to deviate from baseline or resting potentials recorded from the scalp. The patient may be asked to play some sort of video game or mediate to obtain activity of a desired potential or frequency.

Biofeedback evolved out of early laboratory research in the 1940's. In the 1950's and 1960's researchers from different areas of expertise studied applications of feedback to modify psycho physiological functions in animals and humans. Early researchers thought that the instrumentation itself exerted direct pyscho physiological effects and that the feedback information functioned as a kind of behavioral reward which led to symptom reduction. Today the view held by most physicians is that it is more about the training and acquisition of skills which lead to symptom reduction and less about the feedback of information. Today biofeedback is getting a lot of interest from physicians as it is starting to be used as supplement or in place of traditional drug therapies.

Biofeedback has been researched extensively as a treatment for migraine in both adults and children, and a recent review of empirically supported treatments in pediatric headache concluded that "some argument can be made that thermal biofeedback should be included as a 'well established treatment' for migraine headache" (Scharff 2002) At first thermal biofeedback was regarded as more placebo than anything else. Many studies had shown that a sense of self control over ones body as well as expectations of positive change may be the strongest component of the treatment. These expectations alone may be the cause of the results because some studies have shown that even when patients received false positives for thermal increase they reported similar reduction in headache when compared to those who actually learn to increase their temperatures. The study that I reviewed was about pediatric migraine in an effort to decrease the cognitive placebo effects. Thirty four children (mean age:12.8 years), as well as mothers and fathers of these children enrolled in the study and were

assigned to three different groups. The children were to keep diaries of their headache pain on a scale of zero to four and received a biofeedback device to take home for use in the study. Two groups of biofeedback were devised, one in which the hands were cooled and another in which the hands were warmed. Control groups were made through use of a wait list technique in which participants recorded 8 weeks of baseline information before the initiation of treatment. Both treatment groups were provided with the rationale that blood vessel constriction followed by dilation were associated with migraine pain. The hand warming group was instructed that they should learn to dilate blood vessels during constriction phase, and the hand cooling group was instructed to constrict during the dilation phase. In both groups the children rated the biofeedback as equally creditable for decreasing the pain associated with headaches. Data showed that the children in both groups learned to decrease and increase hand temperatures according to feedback groups assigned. However, those children assigned to the hand warming group were more likely to show signs of clinical improvement than those assigned to the hand cooling group (Scharff, 2002).

Biofeedback is going to become more interesting as researchers begin to acquire more sophisticated equipment that allows for more precise measurements of the body. One such technology now being researched is the use of functional magnetic resonance imaging or fMRI machines. fMRI allows researchers to determine the parts of the brain that are activated by different types of physical sensation or activity by measuring increases in blood flow to activated areas of the brain. During a typical biofeedback session a baseline image is taken of the subject without stimulus. This allows the researcher to compare subsequent images with stimulation to look for

activation changes. The fMRI technique is a very good because it allows researchers to see the exact regions of activation inside the brain whereas traditional techniques that record signals on the exterior of the body allow only generalized activation information. Five right handed and healthy subjects two females and three males took part in a study in which fMRI feedback was used to teach participants to maximize hand motor task activation. Participants were shown sample images from the MRI scanner and taught how to interpret activation within different regions in the brain. Participants were then placed inside the scanner with a mirror that displayed activation information about their brain and immobilized to decrease false activation. Patients were then asked to tap their right index finger to a 1 Hz audio tone to create a reference functional map that was necessary for patients to be able to compare and evaluate during trials. Then participants were told to engage in their own finger movement strategy to increase activation. The feedback then continued with rest/task blocks, each 30s long and 10s dummy readings at the beginning. After a task block fMRI data was computed and displayed to the participant so that they could compare and evaluate their method of activation. All subjects achieved activation to some degree when compared to the reference scan. The fMRI feedback successfully guided the subjects to adjust their task and increase brain activation (Yoo, 2002).

A Trendelenburg gait is seen in patients with poorly functioning hip abductors. The patients tend to fall to the opposite side when in the stance phase on the affected side. The patient then tends to shift their center of gravity to keep from falling causing a lateral lurch toward the affected side. If left untreated the patient can cause more physiological damage to the hip, knee, and jolts. Electromyogram or EMG is a device

that measures muscle activity is used many times in therapy to help patients evaluate their gait and correct the abnormal tendencies before it causes other problems. A study of 10 male subjects suffering from Trendelenburg gait were involved in muscle strengthening and gait training for 2 hours a day, 5 days a week. Biofeedback with EMG was also used for 30 minutes a day on all subjects. However, five of the subjects were given portable feedback devices that they could wear at home. These devices sampled EMG from the two legs of the subject and compared the good leg activity to the abnormal leg activity. Switches were planted in the patients shoes so that the microprocessor in the device could determine the stride and stance of the subject will in use. If there is any irregular activities with the muscles involved with gait, a tone would be played allowed the subject to learn to correct such abnormalities. The results of this study were fantastic in that the subjects receiving only clinical feedback show a 50% reduction in gait whereas the group using the biofeedback device full time showed almost normal gait after a period of two months (Petrofsky, 2001).

Voluntary control of our autonomic bodily functions is sometimes hard to achieve. Researchers studied 33 participants all female ages 17 to 25. These participants were then separated in two groups. One group was told verbally to decrease heart rate while running on a treadmill and being monitored on an electrocardiogram or ECG that measures the heart activity of the individual. The other group was told to decrease heart verbally but this group was able to view their heart rate a form of feedback. The work load of the participants was varied in order to test the effectiveness of the procedure. Participants trained with ECG biofeedback information showed a great

degree of control of their heart rate than those who were trained with verbal control instructions (Moleiro, 2001).

Vesicoureteral reflux is an abnormal flow of urine that doesn't flow in the normal direction of from the kidneys to the bladder. Reflux is something that is usually diagnosed in infancy and childhood after urinary tract infections. About 1/3 of the children diagnosed have problems expelling all urine when they urinate. A study of children 25 children ages 6 to 10 years old with reflux were brought in for a study on applying biofeedback to this illness. Traditionally teaching a child to understand the dynamics of voiding and muscle group activity is challenging. Patients were hooked up to an EMG in which they measured the activity of the muscles involved during urination and a flow rate meter that recorded the flow of urine. The patients were then taught to associate the feeling of expelling urine with the readings on the EMG machine and flow meter. At first a baseline recording of the patient is recorded to monitor progress and the child then begins weekly/biweekly one-on-one session in which they practiced contraction of related muscle groups and flow activity recognition. Performance was rated before, during, and after biofeedback therapy. Overall 56% of the 25 children with vesicoureteral reflux were cured after one year. Symptoms of urgency, daytime wetting, and hoarding of urine improved or were eliminated in all children with resolved reflux (Palmer, 2002).

The future of biofeedback is definitely going to be interesting as data acquisition methods becoming increasing more cost effective and user friendly. Developments such as miniaturized wireless electrodes make the task of acquiring data from the individual less intrusive and labor intensive. Tiny single chip computers either worn by

the individual or implanted into the body for short term data storage and analysis can receive data from the wireless electrodes/probes distributed throughout the organism. With increasing technological advances we are able to store and process a wealth of information previously unavailable to scientific inquiry. It is possible that one day it will be commonplace for physicians to review patient data gathered from BF devices days or even months prior to critical medical breakdowns. The application of nanotechnology, a technology in which we built microscopic machines that actually reside inside the human body and perform specialized tasks is also a very interesting candidate for research and development in biofeedback. Nanotechnology could theoretically place millions of tiny sensors inside the body to report information such as activation of dopamine containing neurons or even a single synapse.

Biofeedback is a viable medical treatment for a wide range of illnesses and regenerative therapies. The results have shown that those individuals who receive biofeedback during a course of treatment generally gain a higher sense of symptom reduction when compared to those individuals who do not receive such feedback during treatment. The future for such biofeedback technologies will really depend on the strength, precision, and usability of our measurement devices and the user interaction that takes place during training sessions with those devices. Today researchers are thinking of new ways in which to apply feedback techniques in a way that will help people live healthier lives.

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