AN INVESTIGATIVE REPORT ON BIOFEEDBACK

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The history of psychology is filled with the mirrors with which man has tried to "see" himself and his place within the world. In fact, when a student enters the field of psychology today, he may feel as though he had entered a hall of mirrors similar to an amusement park as he tries to decide which mirror is giving the most accurate, complete picture of the psychological self. Just as in a hall of mirrors, concrete reference points are difficult to establish in psychology due to the very nature of the science. In brief, trying to put the introspection and subjectivity of early psychology into the objective operationalism of science has not been an easy task.

It has been within the last ten to fifteen years that a method for studying and evaluating internal states objectively has come to the attention of the scientific community. Commonly referred to as biofeedback, this new method gives quantitative measures of internal physiological states. The exciting part of the method is due to the fact that voluntary control of the internal physiological states has been demonstrated by subjects given biofeedback information about their internal selves. The ramifications of this discovery are many and varied and
will be explored broadly in this paper. Specifically the purpose of this paper will be to present an overview of biofeedback by looking at its origins, its significance in psychology, and some of its applications. Hopefully biofeedback is not merely another mirror in the hall of psychology, but a window for the furtherance of the science.

Reports have filtered back to western culture for years of men who could exercise voluntary control over their internal organs. These men were known as yogi masters and could willfully slow their heart rates, raise their body temperature, and perform various other feats with their bodily functions that are not normally under voluntary control. Hypnotists have also reported that some suggestions which are taken in a deep trance can also affect organ systems not thought to be voluntary such as salivation, heart rate, and blood glucose levels. The reason that these reports have been considered unusual is due to the traditional neuroanatomical conception of the nervous system.

There is a very strong traditional belief that there is a basic difference between the cerebrospinal nervous system as opposed to the autonomic nervous system. The cerebrospinal system innervates, and therefore controls, the striated voluntary muscles and their functions. The autonomic nervous system innervates the smooth musculature of the body whose activities occur without any obvious effort, training, or attention. The
heart beats, the stomach digests food, and the kidneys filter bodily wastes whether we are aware of it or not.

This anatomical dichotomy has been the main distinction between classical conditioning and instrumental or operant conditioning. Instrumental conditioning is a learned response since the reward reinforces the correct response while classical conditioning, in which the reward is initially the stimulus, was considered a somewhat inferior, automatic response of the organism. Neal E. Miller, professor of physiological psychology at Rockefeller University has for many years "been impressed with the similarity between the laws of classical conditioning and those of instrumental learning," and has postulated that there is in fact only one type of learning involved in both cases. In order to test this hypothesis, his challenge was to design an experiment in which he could show instrumental learning of the visceral responses which had previously been classically conditioned.

Aside from the more normal problems faced by experimenters in designing an experiment, Miller encountered the problem of somehow controlling for interference between the cerebrospinal and autonomic nervous systems. For instance, a confounding for increased heart rate measures would be the rate of breathing or increased muscular tension. To control for this type of interaction, Miller chose to do animal experimentation and to
paralyze all voluntary muscles of the animal. This was achieved by administering a drug of the curare group which selectively blocks out the motor end plates of the skeletal muscles which are voluntarily innervated, yet leaves the subject conscious and does not block neural control of the visceral muscles which are in turn innervated by the autonomic nervous system. This drug does affect the skeletal muscles involved in breathing and as such artificial respiration of the animals was necessary throughout the experiment. These rigorous experimental conditions made traditional reward patterns impractical, so direct stimulation of the pleasure center of the brain and escape from mildly unpleasant shock were used as rewards. Working with his associates in these initial experiments, Miller produced highly reliable, significant changes with both salivation in dogs (the classic response of classical conditioning) and heart rate control in rats. Joined in 1965 by Leo V. DiCara of the University of Michigan Medical Center, Miller and DiCara have further supported their case by showing voluntary control of many other types of "involuntary" responses including endocrine responses, urine formation, arterial hypertension, and brain waves.

It becomes apparent then that the neat division between voluntary and involuntary responses must be reevaluated. It seems to be the absence of continuous feedback information
about visceral responses which makes them so different from the actions of the voluntary striated muscle. Learning occurs normally only after we are able to perceive the results of some behavior, or, borrowing from the jargon of information theory, after we receive some feedback. A baseball player doesn't learn to hit the ball blindfolded because he needs information or feedback to know where the bat and ball must meet. Feedback for voluntary responses comes from our senses, but for the many visceral regulatory mechanisms no conscious senses are inherent to give feedback. However, with the aid of the electronics revolution, artificial senses can be arranged to give a person constant conscious knowledge of his viscera the same way that the five senses keep us informed of our voluntary selves. This is the principle on which biofeedback operates. The principles of biofeedback training are no different from other commonly studied forms of training. The only difference is that the goal or performance of biofeedback is a change of internal physiological states, whereas operant conditioning required a performance on the external environment in which a change occurred as a result of the subject "operating" on that environment.

The training technique has, in general, three essential requirements:

1) The physiological function to be changed must
be monitored with immediate feedback of moment to moment changes.

2) This feedback must be given to the subject immediately. In animal experiments, this may be accomplished by small amounts of food or water given after appropriate deprivation, stimulation of the pleasure center of the brain, or by avoidance of mild electric shocks. These would be given to the subject automatically whenever the physiological change reaches a certain pre-determined level. In human subjects, feedback is usually given either visually or auditorily as a light on a screen or a tone of varying intensities.

3) The subject must possess enough motivation to be conducive to the learning experience. Motivation is supplied for animals by deprivation states of food and water, the presentation of an extremely pleasant stimulus, or the chance to avoid a noxious stimulus. Humans are often sufficiently motivated by simple curiosity. With some verbal encouragement such as "Try to keep the tone as loud as possible," or "Keep the light right on the line," there is the added motivation for mastery of a task. It has also been found effective to give the subject a quantitative
score which is given every few minutes and informs the person of his performance.

The first serious research evidence that humans could gain control of their visceral organs came from the Russian psychologist, M. I. Lisina. As early as 1958 she reported that when subjects were allowed to watch recording device monitoring vasoconstriction and vasodilation of the blood vessels, they were able to change these vascular responses to avoid mild electric shocks. In the early 1960's, Peter J. Lang, initially at the University of Pittsburg and later at the University of Wisconsin, built a machine to allow a subject to "drive" his own heart rate. Similar to the driving skill booths in a pinball arcade, a subject was told to keep his heart rate within a certain range as indicated by a vertical line in the center of a screen directly in front of him. The subject watched a small spot of light on the screen and when the interval between two heart beats was within the desired range, the light was observed to be on the line. If the interval became longer or shorter, the light moved either left or right of the line accordingly. The game was its own reward and subjects were able to gain control of their heart beat intervals to within a range of ninety milliseconds!

The physiological mechanism for this phenomenon is not understood. The subjective reports of the subjects who par-
ticipated in this type of experiment are diverse and inarticulate; however, two very general types of explanations of methods for control can be delineated: 1) idiosyncratic mental routines such as counting backwards or thinking about emotionally exciting events, and 2) superstitious behavior which they believed could give them visceral control. In humans, the effects of voluntary interference can not be controlled for completely due to the rigors such control would entail. It is possible that even controlling skeletal muscles does not inhibit a higher order mediational relationship between the voluntary and involuntary systems. There is much more research desperately needed in this area. Although we can use the purely descriptive aspect of biofeedback in many ways, the full scope and potential of biofeedback must await a more detailed mechanism of how and why it works.

As just stated there are many ways in which biofeedback can be used even in this frontier stage of development. Within the therapeutic setting of psychology, biofeedback has been used to aid in systematic desensitization situations with good success. A subject is able to monitor his own physiological states while the therapist describes scenes which are normally anxiety inducing to the patient. As the patient achieves greater control of his anxiety reactions, the therapist increases the reality of the description until eventually the total phobia can be con-
trolled. It is important to realize that in order for biofeedback to be a useful tool in this type of situation that the psychologist must have a physiological understanding of what visceral responses define the phobia in the patient. Without this vital understanding, no real progress can be made. Conversely it is the hope for the future in biofeedback that other reactions can be physiologically defined and treated in this same simple way.

Francis M. Forster and associates have used a very similar desensitization paradigm in the treatment of epileptics. For example, one patient who was found to have seizures when exposed to specific rates of flickering light was treated by a computer controlled feedback system. The subject was exposed to frequencies progressively closer to the critical frequency while the computer analyzed changes in the electrical activity of the brain. As the brain waves began to build up to the paroxysmal spike which characteristically precedes a seizure, the computer shut off the light and gave auditory stimuli to completely break the seizure pattern before it began. The patient was able to bring his seizures under his own voluntary control with only periodic check-ups and no medication. Some doctors have begun to use biofeedback methodology to treat patients with high blood pressure and cardiac arrhythmias (disorders of heart beat rhythm.) By providing some external stimuli feedback of their internal...
states, a good deal of success has been wrought with these dan-
gerous symptoms. David Shapiro, Bernard Tursky, and Gary Schwartz
produced significant results in lowering blood pressure with a
single training session of only thirty minutes. The common
tension headache has long been known to be caused by the sus-
tained contraction of scalp and neck muscles. A group of doc-
tors at the University of California, Irvine, have found that
by giving their patients biofeedback as to their electromyoo-
graphic activity of those muscles that not only did the patients
gain quick relief, but future headache activity also decreased.

Although some research like that cited above holds out a
ray of promise for the future, it is not yet clear that visceral
learning through biofeedback will become an important therapeutic
method. No one has yet achieved consistent large changes in
cardiovascular or intestinal activity and most learned changes in
human heart rate experiments have been modest at best. Many
argue that it is doubtful that any learning can overcome auto-
nomic abnormalities of organic origin that result from physical
damage to the organ tissue. It is also possible that only people
who are unable to control their visceral responses are the ones
who develop systemic diseases in the first place.

There are others, however, with whom I more strongly identify
as of this writing, who foresee a more optimistic future for bio-
feedback. I have for some time believed that the direction in
which psychology as a science should move is towards physiological definitions of behavioral problems and their correlating therapeutic cures. Unfortunately thus far, man has not been able to solve the mysterious code that the brain uses in the processes of thinking, learning, acting—in a word, behaving. This is a stumbling block for biofeedback, also. Until we understand the significance of each visceral response and its interrelationship with the brain's activities in the perception of the psychological self, the uses are limited to what we do now know, which is very little. But at least in the understanding of many contemporary psychologists, biofeedback is a step in the right direction.

There is no question that biofeedback research has already taught us much that we previously did not know. The question of our ability to develop practical therapies for psychological or pathological disease is, I believe, one of the most exciting questions in psychology today, and one that demands an answer.


4. Ibid., pp. 79-80.


6. Ibid., p. 85

7. Ibid., p. 394-399
BIBLIOGRAPHY


Lang, Peter J. "Autonomic Control or Learning to Play the Internal Organs," Psychology Today, October 1970.


Companies that Commercially Build Biofeedback Devices

Some equipment may be purchased through commercial manufacturing companies such as preamplifier filters and recording equipment. Below is a list of companies that specialize in the production of biofeedback equipment.

Aquarius Electronics
Box 96
Albion, CA 95410

Huma-Tech Industries
1725 Rogers Avenue
San Jose, CA 95112

Autogenic Systems, Inc.
809 Allston Way
Berkley, CA 94710

Narco Bio-Systems, Inc.
P.O. Box 12511, 7651 Airport Rd.
Houston, TX 77017

Bio-Behavioral Instruments
P.O. Box 631
Claremont, CA 91767

Ortec, Inc.
100 Midland Rd.
Oak Ridge, TN 37830

Biofeedback Research Inst.
6233 Wilshire Blvd.
Los Angeles, CA 90048

Scott Behavioral Electronics, Inc.
500 Locust St.
Lawrence, KA 66044

Biofeedback Technology, Inc.
10592 Trask Ave.
Garden Grove, CA 92643

Self Control Systems
Box 6462
San Diego, CA 92106

BioScan Corporation
P.O. Box 14168
Houston, TX 77021

Electro Labs
P.O. Box 2386
Pomona, CA 91766

Cyborg Corporation
342 Western Ave.
Boston, MA 02135

J & J Enterprises
Route 8, Box 8102
Bainbridge Island, WA 98110

Coulbourn Instrument, Inc.
Box 2551
Lehigh Valley, PA 19001

Bio-Dyne Corporation
161 East Erie
Chicago, IL 60611