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FEATURE ARTICLE

Biofeedback History: An Alternative View

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The tapestry of biofeedback history has been woven from many independent threads. Some contributors started with much vigor and nurtured others, and then they faded away. Yet they seeded ideas that the next generation rediscovered as their own. Others blossomed and disappeared, whereas still others have continued to actively nurture the field. Interest in biofeedback has waxed and waned in response to the historical forces of technology, social culture, beliefs, and economics.

History depends on who writes it and who survives it. It is shaped by those who promote it and those who contribute to it. The official history of American biofeedback started in 1969 at the Surf Rider Inn in Santa Monica, California. Barbara Brown, a Veterans Administration (VA) electroencephalography (EEG) researcher, organized this meeting and placed her feisty stamp on the field. Here, the separate threads of scientific research into the possibility of autoregulation and the autoregulation practices of millennia-old meditative techniques coalesced. This group needed a name, and the two candidates were biofeedback and autoregulation. Just before the final vote, someone in the audience yelled out that *autoregulation* sounded like government control of cars. This spontaneous comment created a tipping point, the consensus shifted to biofeedback, and the Biofeedback Research Society (BRS) was born. In 1976, the BRS was renamed the Biofeedback Society of America (BSA), and in 1989, it was renamed the Association for Applied Psychophysiology and Biofeedback.

Richness Through Diversity

From its birth, the BRS was an interdisciplinary group. EEG researchers, such as Joe Kamiya, Barry Sterman, Thomas Mulholland, and Barbara Brown (1974, 1977), were interested in the brain mechanisms underlying attention and consciousness. Several viewed the EEG as a tool for discovering the language of consciousness. Some hoped that through technologically controlled meditation, conscious awareness could be enhanced and satori could be achieved. Some perceived the EEG as the Yin Yang symbol from Chinese philosophy—an excellent metaphor for their competing, yet complementary, perspectives. Mechanistic researchers contended with humanistic meditators. The tension between these camps has generated our field's joy, excitement, and challenge. Biofeedback belongs to both practitioners and researchers, and it intersects multiple disciplines and perspectives such as humanistic and transpersonal psychology, neuroscience, neurology, parapsychology, internal medicine, sports coaching, nursing, somatic therapy, psychology, physical therapy, and consciousness studies. Through this diversity, we can appreciate the richness of our field when we allow ourselves to see the world through our colleagues' differently colored glasses.

Yet was this truly the beginning of our field? The origin of biofeedback is more complex and hidden than portrayed by its official history. Many isolated clinicians, researchers, and even research subjects helped create the field we now know as biofeedback. In this article, we will narrate the stories of just a few of the pioneers who created biofeedback. We regret that we will have to neglect so many other researchers and practitioners who also made significant contributions.[1]

[1] This alternative view is highly incomplete and does injustice to the seminal contributions of Edward Taub, Maurice B. Sterman, Joel and Judith Lubar, and so many others who helped to develop this creative field. For the sake of brevity, we apologize for not including them or others.

Challenging the Boundaries of Self-Regulation

From its inception, biofeedback had to overcome the entrenched paradigm that individuals could not voluntarily control autonomic functions. Researchers who applied B. F. Skinner's work to biofeedback used operant theory to determine which responses could be voluntarily controlled and which could not. For example, Kimble (1961) argued that although subjects could learn to consciously control skeletal muscle responses, autonomic processes (such as heart rate) were involuntary, could be only classically conditioned, and were forever outside of conscious control. This perspective ignored the almost 3,000-year-old yogic practice of autonomic control and research by Lisina (1958); Lapides, Sweet, and Lewis (1957); and Kimmel (1967) that demonstrated voluntary control of autonomic responses.

Scientific paradigms function like filters that determine which hypotheses should be investigated. When Neal Miller tried to encourage graduate students to train rats to achieve autonomic control through instrumental learning, all but one balked. Why investigate a phenomenon that could not possibly exist?

Miller and graduate student Leo DiCara conducted the landmark study that demonstrated that curarized rats could operantly learn to control their autonomic functions. Their 1968 publication, ''Instrumental Learning of Vasomotor Responses by Rats: Learning to Respond Differentially in the Two Ears,'' in the influential journal *Science* challenged the dogma that autonomic processes cannot be voluntarily controlled (DiCara & Miller, 1968). Their evidence was compelling. Paralyzed rats couldn't ''cheat'' by altering their breathing pattern or muscle tone. Their research was a crucial thread in our tapestry because it challenged researchers to investigate which other physiological processes could be voluntarily controlled and secured prestigious National Institute of Mental Health funding, which helped to establish the scientific legitimacy of biofeedback (Miller, 1969, 1978; Miller & DiCara, 1967; Miller & Dworkin, 1974).

Despite Miller and DiCara's successful studies of paralyzed and nonparalyzed rats, few contemporary researchers actively contributed to the development of biofeedback. Most continued to investigate traditional topics in disciplines such as neuroscience and psychophysiology. Fortunately, Miller's supervision of doctoral candidates produced gifted researchers such as Bernie Brucker, who applied operant concepts to the rehabilitation of patients with spinal cord injury.

The Birth of Neurofeedback

Both the public and academic worlds recognize Joe Kamiya as the father of biofeedback. In 1966, while monitoring subjects' EEGs in his sleep lab at the University of Chicago, he performed a novel experiment by ringing a bell whenever an alpha burst occurred. He discovered that some subjects could discriminate when they produced alpha activity. His 1968 publication of ''Conscious Control of Brain Waves'' in *Psychology Today* summarized research that showed that subjects could learn to discriminate when alpha was present or absent and that they could use feedback to shift the dominant alpha frequency about 1 Hz. Almost half of his subjects experienced a pleasant alpha state, which they characterized as an ''alert calmness.'' Kamiya's article made biofeedback accessible to the public and made it exciting because it suggested that individuals can learn to control their own consciousness.

Alpha biofeedback fit an emerging zeitgeist of self-exploration. American culture in the 1960s and 1970s was shaped by a confluence of forces: exploration of consciousness through drugs such as LSD (Timothy Leary and Richard Alpert) and Eastern meditative practices such as transcendental meditation (TM). Harvard physician Herbert Benson repackaged TM as the relaxation response without an overt spiritual dimension. Kamiya's work implied that a language of consciousness was possible and resulted in neurofeedback, one of the most promising areas of biofeedback.

Thomas Mullholland's Legacy

At the same time, hidden in his Bedford, Massachusetts, VA lab, Thomas Mulholland's exploration of EEG feedback mechanisms was another crucial strand. Mulholland investigated how EEG biofeedback produced physiological change through positive and negative feedback loops and how this approach could help psychologists understand the phenomenon of attention (Peper & Mulholland, 1970; Mulholland & Peper, 1971; Mulholland, Goodman, & Goudrot, 1983). He generously nurtured visiting students who worked in his lab and gave them the freedom to explore without placing his name on their research. Unfortunately, without the resources of a university program, Mulholland's lab did not attract sufficient students to continue his vision and propagate his perspective. When VA funding shifted from research to clinical practice, his research stopped.

Erik Peper was one of Mulholland's early students who explored with Mulholland some of the mechanisms that affect the production of the alpha rhythm. He encouraged the expansion of the field through his books *Mind/Body Integration: Essential Reading in Biofeedback* (Peper, Ancoli, & Quinn, 1979) and *From the Inside Out: A Self-*

Teaching and Laboratory Manual for Biofeedback (Peper & Williams, 1981), and later was instrumental in researching and promoting the voluntary control of respiration for health and performance.

In the early days of biofeedback research, most investigators did not know about their colleagues' work due to the absence of professional meetings and journals dedicated to biofeedback. This isolation was breached when the National Institutes of Health hired science writers Gay Luce and Dolly Gotozi to write popularized descriptions of the government-funded research. They traveled from lab to lab and functioned as a human Internet that connected disparate researchers together.

Gay Luce popularized research in sleep and biological rhythms through her influential books *Sleep* (Luce & Segel, 1966) and *Body Time* (Luce, 1971). Still, neither the public nor the academic world would have known about the revolutionary developments in biofeedback at that time without Gay Luce and Erik Peper's *New York Times Magazine* article, ''Mind Over Body, Mind Over Mind,'' which was published in 1971 and received the prestigious American Psychological Association award for scientific reporting.

Naval veteran Durant Kiefer also helped to connect isolated EEG researchers in the late 1960s. Kiefer sought to experience Zen satori through EEG biofeedback. As he wandered from lab to lab, he shared his information about researchers he had previously met. This is how Erik Peper and Thomas Mulholland learned about Johann Stoyva's work. When Kiefer showed up at Mulholland's Bedford, Massachusetts, VA lab, Mulholland supported Peper's recording of Kiefer's EEG in a soundproof, lightproof room while he practiced alpha biofeedback for 2 weeks, 24 hours a day (what some people will do for research!).

Jacobson's Progressive Relaxation

Physician Edmund Jacobson (1938) started using progressive relaxation in diverse clinical cases about 1918, published the seminal books *Progressive Relaxation* and *You Must Relax*, and devoted seven decades to studying the clinical efficacy of this procedure (McGuigan & Lehrer, 2007). Jacobson was one of the first to monitor electromyography (EMG) of patients to document whether their muscles were relaxed. Progressive relaxation was not widely used until Wolpe incorporated an abbreviated version of this procedure in systematic desensitization. Jacobson's standard procedure, which covered 50 muscle groups over 3 to 6 months of training, has given rise to many abbreviated versions. For example, Wolpe's version trains about 15 muscle groups in 20 minutes (Lichstein, 1988).

Despite case study and clinical evidence of its effectiveness in treating disorders such as chronic pain and hypertension, progressive relaxation has failed to become an integral part of general practice medicine. Most likely this is because learning progressive relaxation is not like simply taking a pill but requires time to teach and time for clients to acquire and generalize these skills. Mastery of progressive relaxation is similar to learning a sport or playing a musical instrument.

Elmer and Alyce Green Foster Innovation

Elmer and Alyce Green made unequaled contributions to the developing field of biofeedback. They nurtured research and scholarship in the areas of consciousness, humanistic psychology, and transpersonal psychology. They co-founded the Biofeedback Research Society in 1969. They, more than any other researchers, popularized biofeedback through the publication of their book *Beyond Biofeedback* in 1977 and through their indefatigable teaching of hundreds of workshops around the nation, in which they experientially taught the concepts of biofeedback through temperature control within a humanistic and transpersonal perspective.

Despite their success, Elmer and Alyce faced the same academic myopia that Miller and DiCara encountered. As late as the 1970s, some BSA researchers continued to argue that voluntary hand warming was impossible. Likewise, when Elmer discussed the anatomical evidence supporting psychoneuroimmunology with immunologists, many participants rejected the idea that psychological processes could affect immunocompetence or vice-versa. Green's psychophysiological principle had to be wrong because ''everyone knew'' that the brain and immune system were completely isolated.

Their Voluntary Controls Program at the Menninger Foundation in Topeka, Kansas, developed many clinical applications that are widely used to treat addiction, hypertension, and migraine and to enhance creativity. Their alpha-theta training protocol provided the basis for Peniston and Kulkosky's multimodal treatment for alcoholism (Peniston & Kulkosky, 1989, 1991; Peniston, Marrinan, Deming, & Kulkosky, 1993). They investigated the voluntary control of internal states by individuals such as Swami Rama and American Indian medicine man Rolling Thunder. Most important, they organized the annual Council Grove Conference for the study of Voluntary Control of States of Consciousness: Body, Mind, and Spirit beginning in 1969, where notable clinicians, educators, and researchers came together to explore consciousness and spiritual transpersonal concepts in a climate of openness that encouraged free inquiry.

Early Contributors to EMG Biofeedback

A health care model that sees no role for self-regulation in healing has frequently impeded acceptance of innovative biofeedback concepts and applications. Physicians Alberto Marinacci and George Whatmore practiced clinical biofeedback before the term existed. In the 1950s and 1960s, Marinacci used EMG biofeedback to treat diverse neuromuscular disorders ranging from stroke to spasticity. In his 1955 book *Clinical Electromyography*, he reported numerous successful EMG applications. Unfortunately, other clinicians did not adopt his work because the culture could not conceive that patients could learn to voluntarily control their motor system and because his training protocol often required a year. Then, as now, teaching patients to self-regulate is time intensive and sacrifices the profits generated by prescription drugs and surgical procedures.

Marinacci's work, just like Edmund Jacobson's progressive relaxation, remained in the backwaters as medicine ignored voluntary control and favored instant external cures. As long as physicians perceived the human body as a machine that can only break down, they were unable to conceive of self-regulation. For example, although Marinacci used EMG to treat neuromuscular disorders, his colleagues used the EMG only for diagnosis. They were unable to recognize its potential as a teaching tool even when the evidence stared them in the face! Many electromyographers who performed nerve conduction studies used visual and auditory feedback to reduce interference when a patient recruited too many motor units. Even though they used EMG biofeedback to guide the patient to relax so that clean diagnostic EMG tests could be recorded, they were unable to envision EMG biofeedback treatment of motor disorders. Because Marinacci's work was not continued by others and challenged prevailing cultural beliefs, his contributions to neuromuscular reeducation languished until they were rediscovered.

Herschel Toomin and Susanne Owen, who were familiar with Marinacci's work, presented a case study that described how EMG feedback can help patients recover from a stroke. Two years after seeing their informal presentation at a biofeedback meeting, John Basmajian, a founder of the field of EMG, and others started to report about EMG biofeedback's promise in rehabilitation. Several of these professionals may have forgotten where they first learned about this concept.

The clinical applications of EMG biofeedback, especially those for tension headaches and psychotherapy, owe their origins to the creative work of Thomas Budzynski and Johann Stoyva, who published the first study using EMG feedback for the treatment of tension headaches (Budzynski, Stoyva, & Adler, 1970). Their successful clinical study incorporated relaxation practice as homework. They clearly foresaw that successful biofeedback training involves more than just teaching a skill in the office. In most cases, success depends on transferring and integrating the learned skill into the patients' daily lives.

Whatmore and Kohli's Dysponesis

Physicians George Whatmore and Daniel Kohli (1974) provide another example of innovative clinical ideas that were largely ignored because they contradicted the dominant medical paradigm. They applied EMG biofeedback to treat diverse medical disorders. In their Seattle clinic, they often simultaneously monitored eight channels of EMG and searched for inappropriate muscle activity.

They coined the term dysponesis, which means ''misplaced effort.'' For example, when you tighten your shoulders while typing on a keyboard, this is wasted activity that might produce musculoskeletal pain. They summarized their work in the 1974 text *The Physiopathology and Treatment of Functional Disease*. Their clinical findings suggested that patients can learn to reverse many disorders and inspired recent interventions to reduce autonomic arousal to inhibit trigger point activity. Their work, although rarely taught, provided some of the most useful biofeedback concepts and strategies for reducing illness.

Why weren't Whatmore and Kohli's findings more widely accepted? The prevailing disease model in the 1970s did not encompass functional disease, the idea that dysfunctional behavior patterns could produce medical symptoms, or its corollary, that learning healthy behavior patterns could reverse these symptoms. The underlying concept that use modifies structure and structure limits use was not part of the worldview. By changing its use, a structure may change. The split between mind and body is still seen in the treatment of many disorders and depression, where cognitive therapy and exercise can be a more effective treatment than medication, even though medication continues to be prescribed.

Does Autogenic Training Produce Hand Warming?

From the outset, we want to express our admiration for the superb work of Robert Freedman and colleagues in identifying the mechanisms of local finger vasodilation and in developing treatment protocols for Raynaud's disease and menopausal hot flashes. Unfortunately, their 1983 Raynaud's study (Freedman, Ianni, & Wenig, 1983)

provides an example of how researchers might learn from successful clinicians such as Elmer and Alyce Green, who routinely trained diverse clients using autogenic biofeedback to achieve hand temperature increases of 5°F (2.8°C) or more to reach criteria such as 95°F (35°C).

In 1983, Freedman and colleagues compared finger temperature biofeedback, finger temperature biofeedback with cold stress, frontalis SEMG biofeedback, and autogenic training in the treatment of idiopathic Raynaud's disease. The temperature biofeedback subjects increased an average of 1.08°F (.6°C), whereas subjects in the other groups declined. Nevertheless, in the discussion, the authors concluded, ''Likewise, the results obtained for autogenic training in the present study are similar to those reported previously'' (p. 547). In other words, don't expect autogenic training to help increase your patients' hand temperature.

Did Freedman and colleagues really test autogenic training? Their autogenic training consisted of 10 biweekly sessions in which they listened to 3 minutes of tape-recorded instructions followed by repeating the phrase, ''My hands are warm and heavy,'' for 13 minutes. These instructions had failed to produce hand warming in a previous study by Surwit, Pilon, and Fenton (1978).

A critic might argue that Freedman and colleagues used a crippled version of autogenic training and missed an opportunity to fairly test the efficacy of autogenic training as a treatment for Raynaud's. Schultz and Luthe's (1969) autogenic training was not 3 minutes of instruction and the repetition of a single phrase. In traditional autogenic training, training is individually guided and includes intensive practice in mastering passive attention and may take as long as 6 months. A patient practices six standard exercises, each with its own relaxation theme (Lichstein, 1988).

At least 80 studies have demonstrated a consistent increase in surface skin temperature and peripheral blood flow during autogenic training (Lichstein, 1988). Freedman and colleagues inadvertently contributed to misinformation about this procedure's potential value in teaching hand warming.

Conclusion

The beauty of the tapestry of biofeedback history has come from the unique perspectives of its contributors; the courage of researchers such as Joe Kamiya, Neil Miller, and Leo DiCara to challenge prevailing dogma; the generosity of mentors such as Thomas Mulholland; and the imagination of visionaries such as Elmer and Alyce Green. Continued progress in biofeedback depends on vigorous collaboration between clinicians and academic researchers. Clinicians can teach investigators how to successfully train their subjects, whereas researchers can help clinicians evaluate the efficacy of their interventions.

References

Brown, B. B. (1974). *New mind, new body*. New York: Harper & Row.

Brown, B. B. (1977). *Stress and the art of biofeedback*. New York: Harper & Row.

Budzynski, T., Stoyva, J., & Adler, C. (1970). Feedback induced relaxation: Application to tension headache. *Journal of Behavior Therapy and Experimental Psychiatry, 1*, 205.

DiCara, L., & Miller, N. (1968). Instrumental learning of vasomotor responses by rats: Learning to respond differentially in the two ears. *Science, 159*, 1485–1486.

Freedman, R. R., Ianni, P., & Wenig, P. (1983). Behavioral treatment of Raynaud's disease. *Journal of Consulting and Clinical Psychology, 51*, 539–549.

Green, E., & Green, A. (1977). *Beyond biofeedback*. New York: Delacorte Press/Seymour.

Jacobson, E. (1938). *Progressive relaxation*. Chicago: University of Chicago Press.

Kamiya, J. (1968). Conscious control of brain waves. *Psychology Today, 1*, 56–60.

Kimble, G. A. (1961). *Hilgard and Marquis' conditioning and learning* (2nd ed.). New York: Appleton-Century-Crofts.

Kimmel, H. D. (1967). Instrumental conditioning of autonomically mediated behavior. *Psychological Bulletin, 67*, 337–345.

Lapides, J., Sweet, R. B., & Lewis, L. W. (1957). Role of striated muscle in urination. *Journal of Urology, 77*, 247–253.

Lichstein, K. L. (1988). *Clinical relaxation strategies*. New York: John Wiley & Sons.

Lisina, M. I. (1958). The role of orientation in the transformation of involuntary into voluntary reactions. In L. G. Voronin, A. N. Leontiev, A. R. Luria, E. N. Sokolv, & O. S. Vinogradova (Eds.), *Orienting reflex and exploratory behavior* (pp. 339–344). Moscow, Russia: Akad. Pedag. Nauk RSFSR.

Luce, G. G. (1971). *Body time: Physiological rhythms and social stress*. New York: Pantheon Books.

Luce, G. G., & Peper, E. (1971, September 12). Mind over body, mind over mind. *New York Times Magazine*, p. 34.

Luce, G. G., & Segal, J. (1966). *Sleep*. New York: Coward-McCann.

Marinacci, A. O. (1955). *Clinical electromyography: A brief review of the electrophysiology of the motor unit and its application to the diagnosis of lower motor neuron diseases, peripheral neuropathy and the myopathies*. Los Angeles: San Lucas Press.

McGuigan, F. J., & Lehrer, P. M. (2007). Progressive relaxation: Origins, principles, and clinical applications. In P. M. Lehrer, R. L. Woolfolk, & W. E. Sime (Eds.), *Principles and practice of stress management* (3rd ed., pp. 57–87). New York: Guilford Press.

Miller, N. E. (1969). Learning of visceral and glandular responses. *Science, 163*, 434–445.

Miller, N. E. (1978). Biofeedback and visceral learning. *Annual Review of Psychology, 29*, 373–404.

Miller, N. E., & DiCara, L. (1967). Instrumental learning of heart rate changes in curarized rats: Shaping and specificity to discriminative stimulus. *Journal of Comparative and Physiological Psychology*, *63*, 12–19.

Miller, N. E., & Dworkin, B. (1974). Visceral learning: Recent difficulties with curarized rats and significant problems for human research. In P. A. Obrist, A. H. Black, J. Brener, & L. V. DiCara (Eds.), *Cardiovascular psychophysiology* (pp. 312–331). New York: Aldine.

Peniston, E. G., & Kulkosky, P. J. (1989). Alpha-theta brainwave training and beta-endorphin levels in alcoholics. *Alcohol: Clinical & Experimental Research*, *13*, 271–279.

Peniston, E. G., & Kulkosky, P. J. (1991). Alcoholic personality and alpha-theta brainwave training. *Medical Psychotherapy*, *2*, 37–55.

Peniston, E. G., Marrinan, D. A., Deming, W. A., & Kulkosky, P. J. (1993). EEG alpha-theta brainwave synchronization in Vietnam theater veterans with combat-related posttraumatic stress disorder and alcohol abuse. *Advances in Medical Psychotherapy*, *6*, 37–50.

Peper, E., & Mulholland, T. (1970). Methodological and theoretical problems in the voluntary control of electroencephalographic occipital alpha by the subject. *Kybernetik*, *7*(1), 10–13.

Mulholland, T., Goodman, D., & Boudrot, R. (1983). Attention and regulation of EEG alpha attenuation responses. *Biofeedback & Self-Regulation*, *8*, 585–600.

Mulholland, T. B., & Peper, E. (1971). Occipital alpha and accommodative vergence, pursuit tracking and fast eye movements. *Psychophysiology*, *8*, 556–575.

Peper, E., Ancoli, S., & Quinn, M. (Eds.). (1979). *Mind/body integration: Essential readings in biofeedback*. New York: Plenum.

Peper, E., & Williams, E. A. (1981). *From the inside out: A self-teaching and laboratory manual for biofeedback*. New York: Plenum.

Schultz, J. H., & Luthe, W. (1969). *Autogenic methods* (Vol. 1). New York: Grune & Stratton.

Surwit, R., Pilon, R., & Fenton, C. (1978), Behavioral treatment of Raynaud's disease. *Journal of Behavioral Medicine*, *1*, 323–335.

Whatmore, G., & Kohli, D. (1974). *The pathophysiology and treatment of functional disorders*. New York: Grune & Stratton.

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