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Neurofeedback and Your Brain: A Beginner's Manual

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Introduction to Biofeedback and Neurofeedback

Biofeedback as a field has been growing since the late 1960s. This form of training and treatment uses monitoring instruments attached to the body to “feed back” to people information about the functioning of some kind of biological information about their bodies. People are able to view information about their bodies of which they are not normally aware, such as hand temperature, blood pressure, number and depth of breaths being taken, level of muscle tension in any target muscle, or the electrical activity of their brains. It has been discovered that, once people have more detailed access to information on what their bodies are doing, they are able to either consciously or subconsciously control those functions. In this way, people with tension headaches can learn to relax tense muscles, people with urinary incontinence can learn to control their bladders, people with Raynaud’s disease (circulation difficulties in the extremities) can learn to warm themselves by increasing blood flow, and people with high blood pressure can learn to control that symptom.

Of particular interest to psychologists is the electrophysiological functioning of the brain. The form of biofeedback that enables people to alter brain electrical activity is called “neurofeedback” (or EEG biofeedback). The reason that neurofeedback is of special concern to psychologists is that the brain is a central contributor to the emotions, physical symptoms, thoughts, and behaviors that define many problems for which people seek psychological consultation. The kinds of problems which have been addressed through neurofeedback include anxiety, depression, attention deficit and hyperactivity disorder, memory difficulties and various problems in cognitive functioning, learning disabilities, head injury, obsessive-compulsive disorder, chronic pain, epilepsy, immune system disturbances, panic attacks, sleep disturbances, and more. Scientists have identified specific patterns of brainwaves that contribute to many

of these disorders, and assessment includes a QEEG evaluation (quantitative electroencephalogram) in order to determine the pattern of brain wave relationships. This is described in more detail below.

The Mind-Body Connection

Biofeedback, including neurofeedback, is based on the increasingly accepted idea of the interconnectedness of mind and body. Recognition of the mind-body connection is becoming a standard in the practice of a healthy lifestyle, and many health professionals assert that the health of mind is intimately connected with the health of body. Is your brain “mind” or “body”? The answer that makes sense is, “It is both.”

During the past 30 years, there has been a powerful scientific movement to explore the mind’s capacity to affect the body and to rediscover ways in which the mind affects and is affected by the body and all of its functions. Investigation of the mind-body connection has been encouraged by the rise in chronic illnesses that appear to be related to environmental and emotional stress: heart disease, cancer, depression, arthritis, and asthma are some of these disorders. Also being examined are specific links between mental processes and the functioning of the immune and nervous systems.

Mounting evidence of the mind-body connection includes the following findings:

- Researchers in the area of obsessive-compulsive disorder have found that the changes that occur during “talk therapy” are visible in before and after PET scans. PET scans measure the metabolic activity in various parts of the brain. Thus, talk therapy has been found to alter brain functioning.
- Researchers in the area of fitness found that a group of “couch potatoes” who simply closed their eyes and visualized doing physical exercise actually increased their muscle mass by 16%.
- If a person imagines moving a particular body part, the part of the cortex associated with that body part will show some indication that the body part actually IS moving.
- Strong negative emotions, which can be triggered during abuse situations, trigger the release of toxic neurochemicals such as cortisol, which dramatically influence the developing brain in a way that makes people more vulnerable to anxiety and depression throughout the lifespan.
- One study found that medical students who experienced high levels of stress during exam week produced lesser levels of a particular messenger molecule, which resulted in compromised immune system functioning. Thus, emotional stress (mind) translated into a physical effect (body) and many of them got sick. This same messenger molecule has been shown to be related to the immune system’s ability to fight some types of cancer (interleukin-2).
- Antidepressant drugs change the availability of neurochemicals in the brain, which result in changes in thought, mood, and behavior.

These are just a few of the phenomena that make it increasingly difficult to talk about the mind and the body as separate entities. Mind changes are body changes, and body changes are mind changes. Neurofeedback is a therapy of training the mind and body to function in a more optimal way in order to ease negative emotional, cognitive, physical, and behavioral experiences. It is seen by many people as a viable alternative to medication, and instead encourages and nurtures the body’s own ability to reorganize, change, and heal itself in a natural way.

In the remainder of this short manual, you will learn about:

- The Birth of Neurofeedback as a Discipline
- Quantitative Electroencephalography (QEEG)
- The Variables of Brain Functioning
- The Experience of Neurofeedback
- Whether Neurofeedback May Be Right for You.

The Birth of Neurofeedback as a Discipline

In the early 1960s at the University of Chicago, psychologist Joe Kamiya made the discovery that some of his research subjects could learn how to alter the power and speed of their brainwaves if they were provided with information on the activity of their brains.

Barry Sterman also did research involving neurofeedback in the 1960s. He found that cats could learn to alter their brainwaves if they were given rewards for producing the “goal” brainwave. With repeated exposure to neurofeedback training, the cats became adept at doing so. Sterman’s subsequent research project studied the effects of rocket fuel toxicity. Sterman injected cats with the rocket fuel, and found a close relationship between the cats’ seizure activity and the amount of exposure to rocket fuel. The more rocket fuel, the more seizures. It is always scientifically validating to find a straightforward relationship, and Sterman began to make some conclusions from his results. However, he began to get results that did not fit the relationship he had been establishing. Some of these cats seemed to remain seizure free, even at dosages that had made other cats erupt into seizures. Upon further examination, Sterman found that it was his neurofeedback cats (that had been trained to increase certain brain waves) that were throwing off his results. The cats who had received neurofeedback had a higher seizure threshold than did other cats. There was a clear clinical application that had not been apparent before. Research on neurofeedback for epilepsy began.

While these were astounding discoveries, this technique soon fell into disrepute for a number of reasons: some parties made claims for neurofeedback that were not yet supported by science; other involved parties formed a close link with “flakier” movements that compromised the scientific integrity of the discipline; and still others thought that this technique was too close to “mind control.” The result was that neurofeedback was kept only barely alive by a few diehard pioneers until its revival in the 1980s.

The field of neurofeedback has grown rapidly in the last 20 years, and especially in the last 10 years. The number of practitioners worldwide is approaching 2000, with the bulk of those practitioners residing in the U.S.A. There is a small scattering of practitioners across Canada. The field is beginning to recover from the low esteem in which it was formerly held – now, the science is catching up with the claims that have been made for its efficacy. Even while new information is being collected and published, many health professionals such as psychologists, psychiatrists, and family physicians are unaware of current developments in the field.

Quantitative Electroencephalography (QEEG)

The electroencephalograph (EEG) has been studied and applied since the 1930s as a way of looking at the electrical functioning of the brain. Billions of neurons in the cortex, which are also influenced by structures beneath the cortex, produce electrical activity that is readable by attaching sensors to the scalp. Because of the skull thickness, the impulses are very faint at the level of the scalp. The electroencephalograph amplifies those faint impulses so they may be viewed by the human eye.

As digital computer technology developed in the 1960s and 1970s, scientists were able to more precisely examine a person's electrical brain functioning in ways not possible through simple visual inspection of raw brain wave tracings. The computer can calculate and make visible many features of the EEG that the human eye can not. This form of computer analyzed brainwaves is called quantitative EEG, or QEEG.

Recording of the QEEG involves placing an elastic cap on the head, with 19 sensors held in place on the scalp by the cap. In addition, a clip on each earlobe provides a reference point for the brain activity. Because there is very little electrical activity in the earlobes, they are much more electrically "dead" than the scalp sites. Once the cap has been placed on the head, each of the 19 sensors is checked to ensure that it has a good connection with the scalp. The electrical activity at each of the 19 scalp sites is then recorded and calculated by comparing it to the more electrically neutral earlobe. Data on the electrical functioning of the brain is recorded simultaneously at each of the 19 sites. One set of data is recorded with eyes open, and a second set is recorded with eyes closed. During recording of the brainwave data, it is very important to remain as still as possible so as not to contaminate it with a lot of electrical "noise."

Prior to the quantitative analysis of the brainwave recordings, the data is "artifacted." An artifact is defined as any activity that can be seen in the EEG recording that is not actually brain activity. For example, muscles also operate electrically. This means that any muscle tension on the scalp, the forehead, or anywhere near the sensors will be picked up by the sensor. This "artifact" is electrical noise that must be cleaned out of the brainwave recording in order to ensure that the results reflect brain activity and not irrelevant information.

Once the brainwave recording is cleaned up, it is put through a number of analyses by the computer, and the result is a collection of measurements. The variables of brain functioning are calculated and compared to a database comprised of the same collection of measurements taken from people who are free of difficulties, injury, and disease. Scientists have created such databases to enable the comparison of one individual's brain functioning to a group of others of the same age and gender. In this way, an individual's brain may be evaluated in terms of how much its functioning departs from "normal" or "optimal." These variables of functioning and the degree to which they are higher or lower than optimal are of interest in assessing the strengths and weaknesses of an individual's brain functioning. An outline of some key variables follows.

The Variables of Brain Functioning

Quantitative analysis of brainwaves produces measurements of frequency, amplitude, symmetry, coherence, and others (these measures are described below). The report of the analysis provides a value for each of these variables for each of the 19 sites at which the brainwaves have been measured. Each value represents how much the activity at a given site differs from usual. Values that are positive (i.e. +2.4) represent activity that is higher than usual, and values that are negative (i.e. -2.4) represent activity

that is lower than usual. Because each value represents how different a site is from usual, the number “0” represents a close match with the brains to which an individual’s brain has been compared.

Frequency

Frequency refers to the rate at which a brainwave repeats its cycle within one second. The number of cycles per second is called “hertz” (Hz). The more times a brainwave repeats its cycle per second, the FASTER it is said to be. The most common way practitioners divide the frequency of brainwaves into categories is:

- 0-4 Hz Delta
- 4-8 Hz Theta
- 8-12 Hz Alpha
- 12 Hz and above Beta

Delta waves occur primarily during sleep, however, they are also present to various degrees throughout normal brains when awake.

Theta waves are also slow waves, and are often associated with twilight states such as that between sleep and wakefulness. Theta is much more complicated than this simple explanation, as it has also been shown to be important in memory consolidation. In many people with Attention Deficit Disorder, there is more Theta in various parts of the brain (particularly frontal areas) than in normal people.

Alpha is thought of as an idling rhythm, sometimes associated with relaxation or meditation. Alpha is also associated with multi-tasking. For example, a person is multi-tasking when he is focused on many things at once such as ironing a shirt, listening to the weather report, and wondering what is for breakfast. Alpha is produced by large groups of neurons that are not engaged in any particular task, but rather, are standing ready to serve a function should they be called upon. Alpha may be likened to “the ready position” in volleyball, or a car sitting in neutral.

Beta is the fastest and most active form of brainwave and is associated with focus and concentration. When excessively present, Beta can contribute to anxiety. Consider how much focus and concentration one may have while driving down a busy freeway in a snowstorm: This is focus that is heightened to the point of possible anxiety.

Frequency is one of the parameters of brain functioning that has to do with the speed of the brainwaves or how many times it repeats itself per second. All sites of the brain show all frequencies of activity. However, the amount of a particular frequency that is desirable depends on where it is located in the brain. In general, concentrations of alpha are found at the back of the head, and faster waves are more prominent at the front of the head. Thus, no brain wave is good or bad. It is simply more or less adaptive, depending upon where it is concentrated in the brain.

Amplitude

The amplitude of the EEG is defined as the voltage in microvolts. Another way to think of amplitude is in terms of “power” or how much energy is being manifested in a particular brainwave. Put simply, the amplitude can be thought of as the “volume” of the brainwave. A high amplitude theta signal at a particular site means that there is a lot of energy or power of theta at that site.

Symmetry

Symmetry is the degree to which the activity at a particular site on one side of the brain is similar to the corresponding site on the other side. In this way, a person can serve as his or her own reference. For the most part, the activity at one site should look similar to the activity at the corresponding site on the opposite side of the head. Recording data simultaneously from each of the 19 sites enables the symmetry between left and right to be calculated.

Coherence

Coherence is a measure of how closely each site communicates with each other site. There is an ideal amount of communication that should take place among sites. With too much communication, the brain is devoting too much energy to doing the same thing – and this is not a good use of resources. With too little communication between sites, the brain also is not using its resources most optimally. Communication in the brain may be thought of in the context of the crew on a sailing vessel. If the captain issues an order for some of the crew to solve a problem on one side of the ship, it would not be wise for the entire crew to rush over and leave the rest of the ship unattended. Similarly, if none of the crew communicated with each other, the running of the ship would quickly become disorganized. Recording data simultaneously from each of the 19 sites enables calculation of the coherence, or level of communication between each pair of sites.

The Experience of Neurofeedback

Once the specifics of an individual's brain functioning have been assessed, psychologists look for connections between troubling symptoms and the strengths and weaknesses that have been identified by the QEEG. While the QEEG often reveals generalized problems in brain functioning that will influence many aspects of the individual's experience, people most often seek assistance from psychologists for a particular difficulty – the QEEG variable that most closely matches the complaint of the individual will be addressed first.

It is on the basis of this “strengths and weaknesses” QEEG profile that the psychologist will write a computer program to assist the individual in the learning process that will lead to the enhancement of strengths, or, more often, the amelioration of weaknesses. For example, if QEEG assessment shows that an individual has too much slow activity (theta and delta) and not enough fast activity (beta) at the front of the brain, and that person's complaint is of attentional difficulties (which matches the complaint of frontal slowing), training might consist of inhibiting the slow (theta) activity and enhancing faster activity (beta).

What exactly happens in the neurofeedback session? The individual receiving neurofeedback training wears a clip on each ear, or one of these sensors on another place on the head, and one sensor on the site that has been targeted for training (i.e. the sites that the QEEG indicated was different from normal). The sensor that is designated as the “target” site is referred to as the “active sensor.” The brainwave activity recorded by the active sensor is displayed on the computer monitor, perhaps as a colored bar or a moving line. In the example above, where the goal is to enhance faster activity (beta), the colored line represents beta and fluctuates up and down in accord with the individual's own beta waves. Also visible on the screen is a threshold bar, set at an appropriate level such that the beta activity is able to “stay above it” (exceed the threshold) at least 60% of the time. Each time the beta “jumps” over the bar (i.e. each time

the beta recording reaches or exceeds the goal threshold set for it), the computer emits a tone. With repeated exposure to this form of feedback that is both visual and auditory, the brain begins to recognize a relationship between its own activity and what it is observing on the computer monitor. In other words, the brain begins to recognize its own mental states. This is when learning begins to take place.

Once the brain “catches on” to what it needs to do in order to make the line or bar successfully stay above the line a certain percentage of time, and to hear the pleasant tone, it begins to do so more consistently. Although this sounds hard to believe, it has been established that this process helps most people learn how to control their own brain waves, and therefore their own internal states. Fortunately, the changes are quantifiable and observable through measurements taken during neurofeedback sessions, as well as through follow up QEEG assessments.

Learning may be looked at in three ways: subconscious learning, the forming of a conscious association between feelings and brain states, and the development of flexibility in neural pathways.

Subconscious learning occurs in a process whereby the brain, at a level below awareness, begins to recognize itself on the computer monitor and to make the changes required to keep the bar above the high jump. As this is occurring, the individual may feel quite disconnected from the process. People feel as though they are simply watching the display and listening to the tones, without experiencing it as a personal process being driven by their own neural activity. This learning is on a subconscious level. Remember, cats and other animals can learn to alter their brain functioning when appropriate rewards are utilized— and they are not consciously considering what they need to do in order to receive the reward. This learning process occurs over time and outside the level of conscious awareness.

The second way that learning occurs is through the conscious association between indications that the target is being met (i.e., the visual and auditory cues) and how the individual feels. Often, a description of how it feels to meet the target defies words. For example, many people are unable to express in words what “more alpha” feels like although they can tell when it is occurring. This process of learning is conscious, and involves the development of an awareness of sensations in one’s body that were not present before. In this way, individuals are able to do voluntarily what is necessary in order to produce that sensation at will. There is the sense that “this is what it is supposed to feel like when I produce more alpha.”

Finally, change through neurofeedback occurs as a result of exercising underdeveloped neural pathways. The more the brain practices moving into a more optimal state, the more flexible it will be in responding to demands.

Neurofeedback is seldom used in isolation from other techniques. It is usual for a session with your psychologist to include neurofeedback as well as other techniques such as EMDR and/or cognitive-behavioral exercises to support the changes you would like to make in your life.

Is Neurofeedback Right for You?

Engaging in neurofeedback requires a strong commitment, as people may not experience the beneficial effects until 15 or more sessions. Some people will require forty or more sessions. It is usually not helpful for people to engage in a highly limited number of sessions, as change does not often occur quickly. It requires a time commitment and a financial commitment, and you should be prepared for both. Preliminary indications have shown that the changes tend to be permanent, with booster sessions sometimes necessary if some type of life experience or substance use compromises gains that have been made.

Neurofeedback is very helpful for many people, depending upon the particular problem that they want to address. Those who are interested should be aware that it is a form of training that is considered experimental by many people. Please read the attached consent form carefully for more information.

Neurofeedback is a healthy alternative to other forms of treatment that are more invasive, such as the use of medications that may have troubling side effects. Neurofeedback, used by qualified practitioners, is largely free of side effects. Possible side effects that may occur are managed as they come up, by making slight changes in the way the treatment is delivered. For example, a protocol to increase faster activity, if delivered late in the day, may make for some difficulty in sleeping that night. With slight modifications, side effects are easily managed. Another possibly uncomfortable effect of neurofeedback is emotional. When changing the activity of the brain, it is possible that a person may notice a change such as the surfacing of difficult emotions that may have been experienced in the past. While this is sometimes initially troubling, it also forms an integral part of the treatment, as people learn to better manage their emotions and process past experiences when it previously may have been difficult to do so.

As you think about whether or not to engage in this process, you should:

- Consider the time involved: Minimum 2 sessions per week for 10 consecutive weeks
- Consider the cost involved: \$130/ session, \$65/session on some Saturdays
- Consider your commitment to this process
- Ask questions of your psychologist
- Do your own research to make an educated decision about whether or not this is right for you
- Review the attached consent form with your psychologist
- Consider whether neurofeedback might be a useful addition to other forms of treatment such as psychotherapy, physical therapy, medication, etc. or whether one of these other forms of treatment might be appropriate for you.

This document was intended to provide preliminary information regarding the process of neurofeedback. More information is available to you upon request. I can provide you with copies of scientific papers that describe how neurofeedback is used to treat your problem. Also, you may begin to do your own research on the Internet. The following websites contain information that may be of interest.

Web Sites. The following web sites may be useful, and give information beyond what is provided here.

thebrainclinic.com (my own)	eegspectrum.com	greatbrain.com
brainplace.com	snr-jnt.org	qeeg.com
mindprofile.com	eegbiofeedbackneurofeedback.com	

References

The following references range from those written for the lay person to high level texts and articles for the well informed professional. Those wanting controlled, scientific studies that prove, beyond doubt, that neurofeedback is an effective treatment, will have to wait a few years. Some clinical studies exist, and a good one is by the Thompsons, noted below; other experimental studies are in press (which I have read). This emerging work shows that neurofeedback is a positive, viable treatment option.

Robbins, Jim. *A Symphony in the Brain*. NY: Atlantic Monthly Press, 2000. This popular book, written by a journalist, tells the story of neurofeedback, with a history of its development, including some of the professional in-fighting (which I fail to understand why the public would find interesting). While Robbins claims that neurofeedback cures all kinds of ills with great effectiveness, for most people the improvements are likely to be more modest. Nonetheless, this book provides a lot of answers for the inquisitive person who has a serious interest in neurofeedback and its development. By reading this book, a great deal of time can be saved helping the patient understand the process. Having studied with almost everyone prominently mentioned in this book, I can attest to the integrity and sincerity of all these major players.

Evans, James and Andrew Abarbanel. *Quantitative EEG and Neurofeedback*. San Diego, CA: Academic Press, 1999. This book is intended for the professional who can read chapters on the technical aspects of neurofeedback and electrophysiology written by the most active people in the field of neurofeedback. It is likely to be dense for most lay people, but may be comprehensible for some people with the right background. There are hundreds of academic references cited throughout this book.

Thompson, Lynda and Michael. Neurofeedback combined with training in metacognitive strategies: effectiveness in students with ADD. *Applied Psychophysiology and Biofeedback*, Vol 23, No. 4, 1999, pp. 243-263. This article describes a study in which the authors compare two groups of children and adults, gave neurofeedback and other psychological interventions, and compared with those who did not get neurofeedback; the neurofeedback children increased their intelligence scores along with other improvements.

Various authors. *Clinical Electroencephalography*, Special Issue, January, 2000. This issue of this well regarded academic journal reviews the professional literature on the effectiveness of neurofeedback with a variety of disorders, including Attention Deficit Disorder, Depression, Addictive Disorders, Head Trauma, and Schizophrenia. Dr. Frank Duffy, a Professor at Harvard Medical School, writes that if we were to go by standards using other medical procedures, neurofeedback would qualify as a legitimate treatment. This issue can be obtained from Clinical EEG, 805 Liberty Dr., Wheaton, IL 60187 (e: Clnicaleeg@aol.com) for \$22, which includes US shipping. A copy of this issue might be good to give to your physician or other health professionals skeptical about neurofeedback. And highlight Dr. Duffy's remarks.

James Lawrence Thomas, PhD, is a clinical psychologist and neuropsychologist, on the Faculty of NYU Medical Center for the last 22 years, author, with 7 books to his credit, one of which is *Do you have Attention Deficit Disorder?* (Dell, 1996). He has specialized in diagnosing and treating adult ADD, LD and mild head injury for over two decades, with post-doctoral certificates in group therapy, cognitive therapy, relationship therapy, and neuropsychology. He has degrees from Yale, UC Berkeley, and CUNY (Clinical Psychology, 1980), is Past President of the Independent Practice Division of the *New York State Psychological Association* (NYSPA) and the Neuropsychology Division of NYSPA. He is on the Board of Directors of the *International Dyslexia Association* and the *New York Academy of Traumatic Brain Injury*; he is a full member of the *International Neuropsychology Society*, the *National Academy of Neuropsychology*, the *American Psychological Association*, and is a Lifetime Professional Member of the *National Brain Injury Foundation*. He was awarded the *Distinguished Service Award* by the New York State Psychological Association in June of 2000. In October of 2001, Dr. Thomas was elected as *Distinguished Practitioner of Psychology* in the National Academies of Practice.

Consent for Doing Neurofeedback

Please note the following points prior to commencing neurofeedback training.

- The goals for neurofeedback training are to:
 - Learn skills for increasing self-awareness
 - Increase the brain's ability to organize itself
 - Allow the brain to interrupt maladaptive patterns, and to increase quality of life and level of functioning to a more optimal level.
- Many published clinical studies have demonstrated the effectiveness of neurofeedback for treating various problems. Neurofeedback as an intervention for some problems has extensive published support, while little published support exists for other problems. As such, you should be aware that some insurance company personnel and professionals like physicians and psychologists are not aware of the latest published research or may consider neurofeedback an "experimental" intervention for your problem. There are also many health care practitioners who are convinced that this intervention is not experimental. They believe that the efficacy of neurofeedback for dealing with your problem has been adequately demonstrated. Copies of the relevant literature on neurofeedback for your problem will be provided upon request.
- Your course of neurofeedback should begin with a *quantitative electroencephalograph* (QEEG) evaluation. This procedure allows Dr. Thomas to design a treatment program that will address the specifics of your brain's strengths and weaknesses. *EEG testing is not intended to be a medical diagnosis of brain abnormality. A neurologist will not be reviewing the test for seizures, tumors, or other neurological problems.* The cost of the QEEG is \$700.00, and is done on Saturdays.
- It is not common to experience any noticeable effects from neurofeedback prior to completion of about 20 sessions, but they occasionally occur. It is not possible to predict precisely how many sessions you will require to assist your brain to function more optimally. A range of 10 to 40 sessions is usual, and it is best to have steady attendance. The cost of each training session is \$130.00 for 45 minutes; missed sessions or cancellation with less than 48 hours notice are expected to be paid for.
- Dr. Thomas must be provided with information about any medical diagnosis you have, as well as your use of medication. Please inform Dr. Thomas about any history of dissociative symptoms, post-traumatic stress, bipolar disorder, schizophrenia, and/or seizures. This is so that I may, if necessary, consult with your physician regarding your care. By signing this form, you are authorizing Dr. Thomas to consult with your physician and to share and receive information about your treatment, physical status, and psychological status.
- By signing this form, you are approving of the use of your data for scientific, research, training, and/or publication purposes. Should this occur, your confidentiality will be preserved at all times.
- Any amendments to this signed consent form need to be dated and initialed by both you and Dr. Thomas.

 Signature

 Witness

 Date