What is Neurofeedback?

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Introduction

In the late 1960's and 1970's it was learned that it was possible to recondition and retrain brainwave patterns. Some of this work began with training to increase alpha brainwave activity to increase relaxation, while other work originating at UCLA focused on uncontrolled epilepsy. This brainwave training is called EEG biofeedback or neurofeedback. Before discussing this in more detail, let me provide you with some preliminary information about brainwaves. Brainwaves occur at various frequencies. Some are fast and some are quite slow. The classic names of these EEG bands are delta, theta, alpha, and beta. They are measured in cycles per second or hertz (Hz).

Beta brainwaves are small, faster brainwaves (above 13 Hz) associated with a state of mental, intellectual activity and outwardly focused concentration. This is basically a "bright-eyed, bushy-tailed" state of alertness. **Alpha** brainwaves (8-12 Hz.) are slower and larger. They are associated with a state of relaxation and basically represent the brain shifting into an idling gear, relaxed and a bit disengaged, waiting to respond when needed. If someone merely close their eyes and begin picturing something peaceful, in less than half a minute there begins to be an increase in alpha brainwaves. These brainwaves are especially large in the back third of the head. **Theta** (4-8 Hz) brainwaves generally represent a daydream-like, rather spacey state of mind that is associated with mental inefficiency. At very slow levels, theta brainwave activity is a very relaxed state, representing the twilight zone between waking and sleep. **Delta** brainwaves (.5-3.5 Hz) are the slowest, highest amplitude (magnitude) brainwaves, and are what we experience when we are asleep. In general, different levels of awareness are associated with dominant brainwave states.

Each of us, however, always has some degree of each of these brainwave bands present in different parts of our brain. Delta brainwaves will also occur, for instance, when areas of the brain go "off line" to take up nourishment and delta is also associated with learning disabilities. If someone is becoming drowsy, there are more delta and slow theta brainwaves creeping in, and if they are somewhat inattentive to external things and their mind is wandering, there is more theta present. If someone is exceptionally anxious and tense, an excessively high frequency of beta brainwaves is often present. Persons with Attention-Deficit/Hyperactivity Disorder (ADD, ADHD), head injuries, stroke, epilepsy, and often chronic fatigue syndrome and fibromyalgia tend to have excessive slow waves (usually theta and sometimes excess alpha) present. When an excessive amount of slow waves are present in the executive (frontal) parts of the brain, it becomes difficult to control attention, behavior, and/or emotions. Such persons generally have problems with concentration, memory, controlling their impulses and moods, or with hyperactivity. They can't focus very well and exhibit diminished intellectual efficiency.

What is Neurofeedback Training?

Neurofeedback training is brainwave biofeedback. During typical training, a couple of electrodes are placed on the scalp and one or two are usually put on the earlobes. Then, high-tech electronic equipment provides real-time, instantaneous audio and visual feedback about your brainwave activity. The electrodes measure the electrical patterns coming from the brain--much like a physician listens to your heart from the surface of your skin. No electrical current is put into your brain. Your brain's electrical activity is relayed to the computer and recorded.

Ordinarily, a person cannot reliably influencetheirr brainwave patterns because they lack awareness of them. However, when you can see your brainwaves on a computer screen a few thousandths of a second after they occur, it gives you the ability to influence and change them. The mechanism of action is operant conditioning. We are literally reconditioning and retraining the brain. At first, the changes are short-lived, but the changes gradually become more enduring. With continuing feedback, coaching, and practice, healthier brainwave patterns can usually be retrained in most people. It is a little like exercising or doing physical therapy with the brain, enhancing cognitive flexibility and control. Thus whether the problem stems from ADD/ADHD, a learning disability, a stroke, head injury, deficits following neurosurgery, uncontrolled epilepsy, cognitive dysfunction associated with aging, depression, anxiety, obsessive-compulsive disorder, or other brain-related conditions, neurofeedback training offers additional opportunities for rehabilitation through directly retraining the electrical activity patterns in the brain. The exciting thing is that even when a problem is biological in nature, there is now another treatment alternative than just medication. Neurofeedback is also being used increasingly to facilitate peak performance in "normal" individuals and athletes.

Frank H. Duffy, M.D., a Professor and Pediatric Neurologist at Harvard Medical School, stated in an editorial in the January 2000 issue of the journal Clinical Electroencephalography that scholarly literature now suggests that neurofeedback "should play a major therapeutic role in many difficult areas. In my opinion, if any medication had demonstrated such a wide spectrum of efficacy it would be universally accepted and widely used" (p. v). "It is a field to be taken seriously by all" (p. vii).

Assessment Prior to Neurofeedback Training

Some people wish that somehow they could simply buy their own neurofeedback equipment and train themselves or their children. Neurofeedback is just not that simple. One needs to have specialized expertise concerning brain function and be knowledgeable about much more than simply how to operate equipment and software. For training to be successful and negative reactions avoided, it is vitally important for an assessment to be performed and that the training be individualized to the distinctive brainwave patterns and symptoms of each person. Everyone does not need the same training at the same locations and research has shown that a person's brainwave patterns cannot simply be distinguished by only observing the person's behavioral symptoms. Therefore, prior to doing neurofeedback training, legitimate clinicians will want to ask questions about the clinical history of the client or patient. In some cases they may do neuropsychological or psychological testing. Competent clinicians will also do a careful assessment and examine brainwave patterns. Some practitioners may do an assessment by placing one or two electrodes on the scalp and measuring brainwave patterns in a limited number of areas. Other clinicians perform more comprehensive testing by using a quantitative electro-encephalogram (QEEG) brain map where 19 or more electrodes are placed on the scalp.

A QEEG is an assessment tool to objectively and scientifically evaluate a person's brainwave function. The procedure usually takes about 1½ hours. It generally consists of placing a snug cap on the head which contains small electrodes to measure the electrical activity coming from the brain. This is done while the client is resting quietly with his or her eyes closed, eyes open, and sometimes during a task such as reading. Afterwards, we go through a lengthy procedure to remove any artifacts that occurred when the eyes moved or blinked, if the client moved slightly in the chair, or tightened their jaw or forehead. The brainwave data that was gathered is then compared to a sophisticated and large normative database that shows us how the brain should be functioning at the client's age. This assessment procedure allows us to then determine in a scientific, objective manner whether a client's brainwave patterns are significantly different from normal, and if so, how they differ.

During the 1970's and 1980's there began to be a great deal of experimentation with QEEG. QEEG has shown a scientifically documented ability to aid in the evaluation of conditions such as mild traumatic brain injury, ADD/ADHD, learning disabilities, depression, obsessive-compulsive disorder, anxiety, panic disorder, and a variety of other conditions (including autism, schizophrenia, stroke, epilepsy, and dementia) (Clarke, Barry, McCarthy, & Selikowitz, 2001; Hoffman, Lubar, Thatcher, Sterman, Rosenfeld, Striefel, Trudeau, & Stockdale, 1999; Hughes & John, 1999; Thatcher, Moore, John, Duffy, Hughes, & Krieger, 1999). QEEG has even been able to predict treatment outcomes from interventions with conditions such as ADD/ADHD (Suffin & Emory, 1995), alcoholism and drug abuse (Bauer, 1993, 2001; Prichep, Alper, Kowalik, & Rosenthal, 1996; Prichep, Alper, Kowalik, John, Merkin, Tom, & Rosenthal, 1996. Winterer, Kloppel, Heinz, Ziller, Dufeu, Schmidt, & Herrmann, 1998). The American Psychological Association has also endorsed QEEG as being within the scope of practice of psychologists who are appropriately trained, and ISNR has similarly endorsed its use by qualified health care professionals who are appropriately trained. Standards exist for the use of QEEG in neurofeedback (Hammond et al., 2004). Persons who are certified in this specialty may be identified either through the EEG & Clinical Neuroscience Society (www.ecnsweb.com/cd_directory%20names.html) or the Quantitative Electroencephalography Certification Board (www.qeegboard.org).

EEG and QEEG evaluations assist in understanding if there are abnormalities in brain function that EEG neurofeedback might be helpful in treating, and it allows us to individualize neurofeedback to the unique problems of each client. For example, scientific research has identified a *minimum* of three major subtypes of ADD/ADHD, none of which can be diagnosed from only observing the person's behavior, and each of which requires a different treatment protocol.

Neurofeedback Training

Once the assessment is complete and treatment goals have been established, two electrodes are usually placed on the scalp and one or more on the earlobes for neurotherapy training sessions. The trainee then watches a display on the computer screen and listens to audio tones, sometimes while doing a task such as reading. These training sessions are designed to teach the person to slowly change and retrain their brainwave pattern. With continuing feedback, coaching, and practice, the healthier brainwave patterns are maintained. Some persons may need to learn to increase the speed or size of brainwaves in specific areas of the brain. Other individuals need training to decrease the speed of and amplitude of their brainwaves. Neurofeedback training may only require 15-20 sessions for anxiety or insomnia, but with other conditions such as ADD/ADHD or learning disabilities it will more often involve 40-50 sessions. Each session normally lasts about 40-60 minutes. In treating very complex conditions or when multiple disorders or diagnoses are present, a clinician cannot always stipulate in advance how many treatment sessions may be required.

Other Kinds of Neurofeedback. There are also two other unique kinds of neurofeedback. One is called LENS, the Low Energy Neurofeedback System. LENS training differs from other forms of neurofeedback in that it introduces a very tiny electromagnetic signal which is only about the intensity of the output coming from a watch radio battery--far, far weaker than the input we receive from simply holding a cell phone to our ear. This very low intensity input is introduced down the electrode wires for only a few (e.g., 1-7) seconds. Its frequency varies depending on the dominant brainwave frequency from moment-to-moment and it is designed to gently help the brain become more flexible and self-regulating, reducing excess amplitude and variability of the brainwaves.

Several encouraging initial research reports have been published on this system (Cripe, in press; Donaldson et al., 1998; Larsen, Harrington, & Hicks, in press; Larsen, Larsen, Adinaro, Johnson, Hanne, Sheppard, Hammond, & Ochs, in press; Meuller et al., 2001; Shoenberger et al., 2001). Another unique form of neurofeedback is HEG (hemoencephalography and passive infared hemoencephalography). The two different HEG systems seek to modify cerebral blood flow, increasing it in areas where it appears to be deficient. Once again, preliminary research on HEG applications appears encouraging (Carmen, 2004; Friedes & Aberbach, 2003; Mize, 2004; Sherrill, 2004; Toomim, Mize, Kwong, Toomim, Marsh, Kozlowski, Kimball, & Remond, 2004).

<u>ADD/ADHD & Learning Disabilities</u>. Since the late 1970's, neurofeedback has been researched, refined, and tested with ADD/ADHD and learning disabilities. Clinical work Dr. Joel Lubar and his colleagues (e.g., Lubar et al., 1995) at the University of Tennessee as well as many others have repeatedly demonstrated that it is possible to retrain the brain. In fact, a recent study (Levesque, Beauregard, & Mensour, 2006) documented with functional MRI neuroimaging the positive changes in brain function in ADHD children after neurofeedback treatment.l This and the research cited below all provide strong support that demonstrate the effectiveness of neurofeedback in treating ADD/ADHD. Whereas the average stimulant medication treatment study follow-up is only three weeks long, with only two long-term follow-up medication studies that lasted 14 months or longer, Dr. Lubar (1995) has published 10 year follow-ups on cases and found that in about 80% of clients, neurofeedback can substantially improve the symptoms of ADD and ADHD, and that these changes are maintained. Rossiter and LaVaque (1995) found that 20 sessions of neurofeedback produced comparable improvements in attention and concentration to taking Ritalin. Fuchs et. al. (2003) and Rossiter (2005) likewise demonstrated that neurofeedback produced comparable improvements compared to Ritalin. In a one year follow-up, control group study, Monastra et al. (2002) found that neurofeedback produced superior improvements compared to Ritalin, even when the medication was discontinued.

In comparison to neurofeedback, a meta-analysis (Schachter, Pham, King, Langford, & Hoher, 2001) of randomized controlled studies of medication treatment for ADD/ADHD concluded that the studies were of poor quality, had a strong publication bias (meaning that drug company funded studies which failed to support the effectiveness of their product tended to never be submitted for publication), and often produced side effects. They concluded that long-term effects (beyond placebo effects) for longer than a 4 week follow-up period were not demonstrated. A recent comprehensive review (Drug Effectiveness Review Project, 2005) of medication treatment for ADD/ADHD concluded that there was no evidence on the long-term safety of the medications used in ADD/ADHD treatment and that good quality evidence is lacking that drug treatment improves academic performance or risky behaviors on a long term basis, or in adolescents or adults. In relation to the findings of this review, one of the latest studies (El-Zein, Abdel-Rahman, Hay, Lopez, Bondy, Morris, & Legator, 2005) concluded that "the lack of research on long-term effects of methylphenidate [Ritalin] use in humans warrants great concern" (p. 7) because they discovered that after only 3 months on Ritalin, 100% of children experienced chromosomal aberrations which could increase cancer risk, not unlike the genetic damage that has been found in adult methamphetamine users (Li, Hu, Chen, Lin, 2003).

In light of these findings, neurofeedback provides an important, non-invasive, and relatively side effect free treatment alternative for ADD/ADHD. In the long run it is also very cost effective. Some individuals express concern about the cost of neurofeedback being greater than the expense involved in drug treatment. Research has shown, however, that the costs associated with medication treatment are actually quite sizable. For instance, a study (Marchetti, Magar, Lau, Murphy, Jensen, Conners, Findling, Wineburg, Carotenuto, Einarson, & Iskedjian, 2001) of 6 different medications for ADD/ADHD treatment found that the average cost per school-aged patient was

$1,678 each year. Another study (Swensen, Birnbaum, Secnik, Marynchenko, Greenberg, & Claxton, 2003) examined the health care costs in more than 100,000 families where ADHD was either present or not present. They found that in families where a member had ADHD, the direct costs of health care expenditures plus indirect costs (such as work loss) averaged $1,288 per year higher for the other family members (who did not have ADD/ADHD) in comparison with members of families where ADHD was not present. This would mean that the cost of medication cited above, combined with indirect costs each year for a family with two children, one of whom had ADHD, would be $5,542.

With regard to learning disabilities, Fernandez et al. (2003) demonstrated in a placebo-controlled study that neurofeedback was an effective treatment. Other papers have also been published on the value of neurofeedback with learning disabilities (Orlando & Rivera, 2004; Tansey, 1991; Thornton & Carmody, 2005).

Neurofeedback training for ADD/ADHD is commonly found to be associated with decreased impulsiveness/hyperactivity, increased mood stability, improved sleep patterns, increased attention span and concentration, improved academic performance, and increased retention and memory. Fascinatingly, every ADD/ADHD or learning disability study that has evaluated IQ pre- and post-treatment has found that IQ increases following neurofeedback training. These improvements ranged from an average of 9 IQ points improvement in one study (Linden et al., 1996), to an average 12 IQ point improvement in a study by Thompson and Thompson, (1998), a mean of 19 IQ points in another study (Tansey, 1990), and even up to an average increase of 23 IQ points in a study by Othmer, Othmer and Kaiser, (1999).

<u>Epilepsy, Brain Injuries & Stroke</u>. Uncontrolled epileptic seizures have also been effectively treated using neurofeedback. Research in this area began in the early 1970's, and is extensive and rigorous, including blinded, placebo-controlled, cross-over studies (reviewed in Sterman, 2000). Neurofeedback has been found to be helpful with all kinds of epilepsy, including grand mal, complex partial, and petit mal (absence) seizures. Although the larger proportion of seizure patients are adequately controlled by medication, most of the individuals who have been treated with neurofeedback in research studies were among the most severe epilepsy patients, where anticonvulsant drug therapy was unable to control their seizures. However, even in this most severe group of patients research found that neurofeedback training on average produces a 70% reduction in seizures. In these harsh cases of medically intractable epilepsy, neurofeedback has been able to facilitate greater control of seizures in 82% of patients, often reducing the level of medication required, which can be very positive given the long-term negative effects of some medications. Many patients, however, may still need to remain on some level of medication following neurofeedback. Walker and Kozlowski (2005) reported on 10 consecutive cases and 90% were seizure free after neurofeedback, although only 20% were able to cease taking medication.

Neurofeedback treatment outcome studies of closed and open head injuries are also now beginning to be seen (Ayers, 1987, 1991, 1999; Bounias et al., 2001, 2002; Byers, 1995; Hoffman et al., 1995, 1996a b; Keller, 2001; Laibow et al., 2001; Shoenberger et al., 2001; Thornton, 2000; Tinius & Tinius, 2001), as well as with stroke (Ayers, 1981, 1995a,b, 1999; Bearden et al., 2003; Putnam, 2001; Rozelle & Budzynski, 1995; Wing, 2001), but continued research needs to be done in these areas. It is believeed that neurofeedback offers a valuable additional therapy to assist in rehabilitation.

<u>Alcoholism & Drug Abuse</u>. EEG investigations of alcoholics (and the children of alcoholics) have documented that even after prolonged periods of abstinence, they have lower levels of alpha and theta waves and an excess of fast beta brainwaves. This suggests that alcoholics and their children tend to be hard-wired differently from other people, which makes it difficult for them to relax. Following the intake of alcohol, however, the levels of alpha and theta brainwaves increase. Thus individuals with a biological predisposition to develop alcoholism (and their children) are

particularly vulnerable to the effects of alcohol because, without realizing it, alcoholics seem to be trying to self-medicate in an effort to treat their own brain pathology. The relaxing mental state that occurs following alcohol use is highly reinforcing to them because of their underlying brain activity pattern. Several research studies now show that the best predictor of relapse is the amount of excessive beta brainwave activity that is present in both alcoholics and cocaine addicts (Bauer, 1993, 2001; Prichep et al., 1996a,b; Winterer, 1998).

Recently, neurofeedback training to teach alcoholics how to achieve stress reduction and profoundly relaxed states through increasing alpha and theta brainwaves and reducing fast beta brainwaves has demonstrated promising potential as an adjunct to alcoholism, treatment. Peniston and Kulkosky (1989) used such training in a study with chronic alcoholics compared to a nonalcoholic control group and a control group of alcoholics receiving traditional treatment. Alcoholics receiving 30 sessions of brainwave training demonstrated significant increases in the percentages of their EEG that was in the alpha and theta frequencies, and increased alpha rhythm amplitudes. The EEG biofeedback treatment group also demonstrated sharp reductions in depression when compared to controls. Alcoholics in standard (traditional) treatment showed a significant elevation in serum beta-endorphin levels (an index of stress and a stimulant of caloric [e.g., ethanol] intake), while those with brainwave training added to their treatment did not demonstrate this increase in beta-endorphin levels. On four-year follow-up checks (Peniston & Kulkosky, 1990), only 20% of the traditionally treated group of alcoholics remained sober, compared with 80% of the experimental group who had received neurofeedback training. Furthermore, the experimental group showed improvement in psychological adjustment on 13 scales of the Millon Clinical Multiaxial Inventory compared to the traditionally treated alcoholics who improved on only two scales and became worse on one scale. On the 16-PF personality inventory, the neurofeedback training group demonstrated improvement on 7 scales, compared to only one scale among the traditional treatment group. Thus neurofeedback training appears to hold encouraging promise as an adjunctive module in the treatment of alcoholism, and it may have real potential in both treating and in remediating damage done through drug abuse (Burkett, Cummins, Dickson, & Skolnick, 2005).

<u>Posttraumatic Stress Disorder (PTSD)</u>. Peniston and Kulkosky (1991) added thirty, 30-minute sessions of alpha/theta neurofeedback training to the traditional VA hospital treatment provided to a group of PTSD Vietnam combat veterans, and then compared them at 30 months post-treatment with a contrast group who received only traditional treatment. On follow-up, all 14 traditional treatment patients had relapsed and been rehospitalized, while only 3 of 15 neurofeedback training patients had relapsed. While all 14 patients who were on medication and were treated with neurofeedback had decreased their medication requirements by follow-up, among the patients receiving traditional treatment only one patient decreased medication needs, two reported no change, and 10 required an increase in psychiatric medications. On the Minnesota Multiphasic Personality Inventory, neurofeedback training patients improved significantly on all 10 clinical scales--dramatically on many of them--while there were no significant improvements on any scales in the traditional treatment group.

<u>Other Clinical Applications of Neurofeedback Training</u>. Neurofeedback has shown good research support for its effectiveness in treating anxiety (Hammond, 2005a; Moore, 2000). It is also being used to work with other clinical problems such as depression (Baehr, Rosenfeld & Baehr, 2001; Hammond, 2001, 2005c), chronic fatigue syndrome (Hammond, 2001), fibromyalgia (Donaldson et al., 1998; Meuller et al., 2001), sleep disorders, Tourette's, obsessive-compulsive disorder (Hammond, 2003, 2004), autism (Jarusiuwicz, 2002; Scolnick, , 2002; Sichel, Fehmi, & Goldstein, 1995), Parkinson's tremors (Thompson & Thompson, 2002), tinnitus (Gosepath et al., 2001; Schenk et al., 2005; Weiler et al., 2001), physical balance, swallowing, gagging and incontinence (Hammond, 2005b), cerebral palsy (Ayers, 2004), and essential tremor. Neurofeedback is also being utilized in

peak performance training, for instance in enhancing musical performance (Egner & Gruzelier, 2003), dance performance (Raymond et al., 2005), and with athletes, business executives, and for cognitive and memory enhancement in normal individuals (Hanslmayer et al., 2005; Rasey, Lubar, McIntyre, Zoffuto & Abbott, 1996; Vernon et al., 2003), which has been referred to as "brain brightening" when used to counter the effects of normal aging (Budzynski, 1996). However, these areas of application do not yet have strong research validation.

Although there are many health care practitioners who are convinced of the effectiveness and value of this cutting-edge technology (and several thousand clinicians are using neurofeedback), you should be aware that some insurance company personnel and even some professionals, many of whom may not be aware of the latest published research, may regard all neurofeedback as experimental. Even in the case of well validated neurofeedback treatments, some insurance companies insist on defining all biofeedback as experimental and, thus, may not reimburse for these services.

Adverse Effects, Home Training, & Selecting a Practitioner

Mild side effects can sometimes occur during neurofeedback training. For example, occasionally someone may feel tired, spacey, anxious, experience a headache, have difficulty falling asleep, or feel agitated or irritable. Many of these feelings pass within a short time after a training session. If you make your therapist aware of such feelings, they can alter training protocols and usually quickly eliminate such mild adverse effects.

It is possible, however, for more significant negative effects to occur (Hammond et al., 2001) if training is not being supervised by a knowledgeable, certified (www.bcia.org) professional who will individualize the training. A "one-size-fits-all" approach that is not tailored to the individual will undoubtedly pose a greater risk of either producing an adverse reaction or of simply being ineffective. Due to the heterogeneity in the brainwave activity within broad diagnostic categories (e.g., ADD/ADHD, head injuries, depression, autism, or obsessive-compulsive disorder) the treatment requires individualization. Thus it is emphasized once again that everyone does not need the same treatment and that if training is not tailored to the person, the risk is greater of it being ineffective or very infrequently even detrimental. For instance, Lubar et al. (1981) published a reversal double blind controlled study with epilepsy which documented that problems with seizure disorder could be improved with neurofeedback, but they could also be made worse if the wrong kind of training was done. Similarly, Lubar and Shouse (1976, 1977) documented that ADD/ADHD symptoms could both improve, but also be worsened if inappropriate training was done. Therefore, seeking out a qualified and certified professional who will do a comprehensive assessment of brain function (e.g., with a QEEG or careful assessment of the raw EEG activity) is deemed to be vitally important.

If you are seeking help for a psychological, psychiatric, or medical problem like those discussed above, it is recommended that you determine that the practitioner you select is not only certified, but is also licensed or certified for independent practice in your state as a mental health or health care professional. An increasing number of unqualified and unlicensed persons are managing to obtain neurofeedback equipment and seeking to basically practice psychology and medicine without a license. It is unfortunately becoming a "buyer beware" marketplace. In this regard, some individuals are now renting and leasing home training equipment. It is our strong recommendation that training with equipment at home should *only* be done under the *regular* consultation and supervision of a legitimately trained and certified professional, and preferably home training should only occur following closely supervised training that has occurred in the office for a period of time. It is important to caution the public that if this is not done, some negative effects (and a much higher probability of ineffective results) could occur from such unsupervised self-training. It is important to remember that the impressive success documented in research on neurofeedback is based on work by qualified professionals, following individualized assessment, and with training sessions that are supervised by a knowledgeable therapist rather than with unsupervised sessions taking place in an office or at home.

Referral Sources

You may identify certified practitioners who are doing neurofeedback training by consulting the website for the Biofeedback Certification Institute of America (www.bcia.org) and by examining the membership directory for ISNR (www.isnr.org). In addition to the references included in this paper, the ISNR website also includes a comprehensive bibliography of scientific outcome literature on neurofeedback which is periodically updated.

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