BRAINFUTURES

Neurofeedback

An Efficacious Treatment for Behavioral Health

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Acknowledgements

We would like to extend our appreciation to our advisors and the individuals who provided input and critical feedback for this report, including:

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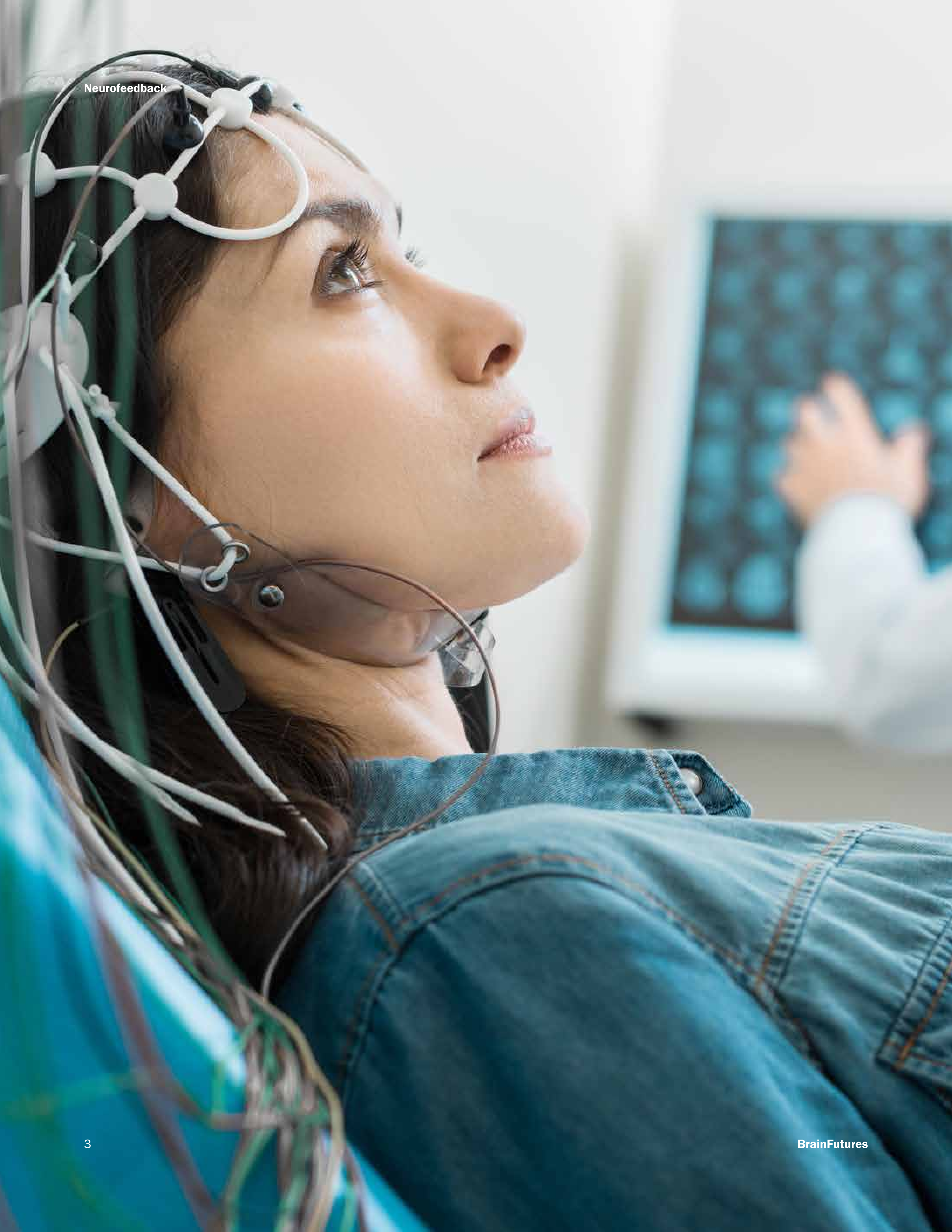


Executive Summary

A CHALLENGING TIME. BRAIN-BASED DISORDERS ON THE RISE

The incidence of attention-deficit hyperactivity disorder (ADHD) and other behavioral health issues in children, as well as overall mental health challenges in the general population are on the rise. More than 10% of youth in the U.S. are diagnosed with ADHD (Children and Adults with Attention-Deficit/Hyperactivity Disorder [CHADD], 2020), and 25% of children have some form of anxiety (Centers for Disease Control and Prevention [CDC], 2018a). Alarmingly, 64% of children diagnosed with ADHD have at least one additional behavioral, emotional, or mental health disorder (CDC, 2018b). In adults, anxiety affects 20% of Americans (National Institute of Mental Health [NIMH], 2019), with just over one-third of these individuals getting treatment (Anxiety and Depression Association of America [ADAA], n.d.).

Treatment for many behavioral conditions is primarily pharmacological, which itself carries risks and side effects. Many studies show that psychosocial therapies combined with psychotropic medications have better outcomes than medications alone. Yet large portions of the population are not adequately able to access affordable behavioral and mental health services, with recent research indicating that reimbursement for behavioral services represents only 4.4% of total medical spending (Davenport et al., 2020). Of equal note, behavioral conditions when present with a physical disorder contribute to extremely high total medical costs. In other words, there is a grave financial burden on payers when behavioral health issues go unaddressed (Davenport et al., 2020).

The onset of COVID-19 has certainly exacerbated behavioral and mental health issues, as indicated by preliminary research in China and here in the U.S. More than ever, accessible, effective treatments for ADHD and other stress- and adjustment-related mental health disorders are needed.

NEUROFEEDBACK IS AN EFFICACIOUS AND EFFECTIVE TREATMENT FOR ADHD AND OTHER CONDITIONS

With a more than 70-year history of research and real-life applications with populations ranging from school-aged children to veterans to adults, neurofeedback (NFB) is proven to be an effective standalone or adjunct treatment for ADHD and symptoms of anxiety.

Since 2009, at least four major research reviews by leading researchers in the U.S. and internationally have shown NFB to be an efficacious intervention for the treatment of ADHD. Several studies have found NFB improvement lasting up to a year post-treatment whereas improvements from ADHD medication tend to end immediately with the conclusion of treatment.

Highlights from key studies and reviews include:

- A 2020 review that investigated 2 major meta-analyses, 4 randomized controlled trials (RCTs), and 3 open-label studies found NFB treatment of ADHD to be efficacious and produce remission rates of 32-47%, with sustained post-treatment effects for 6-12 months (Arns et al., 2020).
- A 2018 meta-analysis reviewed 10 studies, finding significant effect of NFB on ADHD symptoms of inattention and hyperactivity/impulsivity, comparable to medication, and that improvements were sustained 2 to 12 months beyond the end of treatment (Van Doren et al., 2018).
- A 2014 review found that standard NFB treatment protocols have been well-investigated and are specific and effective at treating ADHD (Arns et al., 2014).
- A 2014 study found that NFB resulted in greater improvements in ADHD symptoms compared to cognitive training or control groups in public elementary schools (Steiner et al., 2014).

- A 2009 meta-analysis found NFB treatment for ADHD to be efficacious and specific: meaning treatment outcomes were statistically superior to fake treatments (known as sham treatments) or alternative treatments in at least two independent research settings (Arns et al., 2009).

NFB has also been found to be effective as a treatment for anxiety. Biofeedback equipment in general, and more specifically NFB equipment, is FDA-cleared for relaxation training. Research shows that relaxation is a primary treatment for anxiety and other symptoms of stress- and adjustment-related disorders. As a non-pharmacological option, NFB can be used to treat symptoms of anxiety and alleviate a host of related mental health disorders potentially including PTSD, depression and others.

Results from research on NFB as a treatment for anxiety include:

- A 2020 meta-analysis of 21 studies with 779 participants concluded that neurofeedback is efficacious in the treatment of anxiety and reactive stress disorders (Anxiety Disorders: Rethinking and Understanding Recent Discoveries, 2020).
- A 2008 meta-analysis that reviewed 27 studies found significant efficacy for relaxation training as a treatment to reduce anxiety (Manzoni et al., 2008).
- A 2011 study found that NFB reduced anxiety related symptoms (Moradi et al., 2011).
- A 2010 study found that NFB was approximately as effective as medication in treating anxiety and more effective in women with anxiety (Bhat, 2010).

NEUROFEEDBACK IS EFFICACIOUS AS A FIRST-LINE OR ADJUNCT TREATMENT FOR ADHD AND ANXIETY

Professional practitioner-directed NFB treatment, like any other behavioral health intervention—pharmacological, therapy or other—is based on established, evidence-based protocols implemented by trained professionals on certified equipment. This level of NFB is highly efficacious and effective, and should be considered as a first-line treatment for ADHD, anxiety, and anxiety-related mental health issues, or as an adjunct treatment to existing protocols such as cognitive behavioral therapy (CBT) or prescription medication.

Given the current rates of ADHD and anxiety-related symptoms and disorders, now is the time for increased adoption of NFB as a first-line or adjunct treatment. It is imperative that medical practitioners and insurers provide adequate NFB treatments and reimbursements for ADHD and other behavioral and mental health conditions. More than ever, we need easy-to-access interventions that support the mental health and well-being of our nation.

NFB already carries Current Procedural Terminology (CPT) codes, the equipment is FDA-cleared, and the research shows efficacious results. Recent reports on access disparities demonstrate that lack of in-network access can lead to billions of dollars in additional medical and health costs, and immeasurable negative impacts on American lives (Melek et al., 2019; Davenport et al., 2020). While some insurers reimburse for NFB, many others do not. Compliance with the Mental Health Parity and Addiction Equity Act (MHPAEA) is one reason for insurance companies to cover NFB, but more so to make effective treatments for our nation's youth and adults available more broadly, thereby supporting the health and well-being of all Americans.

Introduction

Despite billions of dollars poured into research and treatment efforts, the incidences of behavioral health disorders in the U.S. continue to rise. In particular, ADHD diagnoses in children, by some estimations, have reached epidemic proportions while stress- and adjustment-related symptoms including anxiety are increasing overall (American Psychological Association, 2016). As of the writing of this paper, it stands to reason that the advent of COVID-19 as well as heightened racial injustice concerns will likely have additional impact in these areas in yet unknown ways. Efficacious interventions and treatments for behavioral health, including mental health, are needed now and will be even more valuable in the days ahead.

Interventions and treatments vary depending on conditions and intended outcomes. Neurofeedback (NFB) is a proven treatment for ADHD and other mental health issues. Despite its growth in recent years, it remains significantly underused. NFB helps address patterns of dysregulation associated with irregular brainwave activity found in a range of conditions including ADHD, depression, anxiety, behavioral issues, and sleep disorders (McCormack et al., 2015). NFB uses non-invasive sensors and a digital interface to measure brainwaves, allowing individuals to observe and modulate their own brains' activity. A feedback-and-reward system helps patients achieve brain states associated with self-regulation, attention, focus, and other improvements relative to behavioral health conditions. While there exists a strong and rapidly growing evidence base for the use of NFB as a treatment for many behavioral health conditions, currently, the preponderance of evidence is in the domain of ADHD.

NFB is effective because it helps the brain improve itself via neuroplasticity.

NFB is effective because it helps the brain improve itself via neuroplasticity (Ros et al., 2010). Neuroplasticity is a concept in neuroscience indicating that the brain's neurocircuitry is highly changeable and, with the right stimulus, can undergo positive shifts even as we age. As such, through neuroplasticity, "the brain is capable of 'reprogramming' itself using a wide variety of inputs, including sensations, emotions, thoughts, beliefs, environmental and physical stimuli, relationships, experiences, and even metacognition— what the brain thinks of itself" (McCormack, O'Brien, 2019). Neuroplasticity occurs in every brain, and brain changes and outcomes depend on inputs and feedback. Negative inputs, such as drug use, over-exposure to violence, and so forth, tend to create dysregulation and consequent mental and behavioral health issues. Positive feedback, such as NFB, cognitive behavioral therapy (CBT) and similar techniques, positive learning, and pro-social peer experiences, tend to: create regulation in the brain; improve mental and emotional balance, learning, performance and well-being; and guard against behavioral health disorders.

NFB works within the function of neuroplasticity by providing positive or consequential feedback to the patient in real time in order to influence positive changes in brainwave activity. In this way, the brain "learns" to improve regulation and be guided toward normal functioning for the age of the patient.

The experience of NFB is non-invasive and usually relaxing, thereby improving compliance. In a typical NFB session, the patient is in a relaxed or resting position with brainwave-measuring sensors lightly attached to the head. During a standard 20- or 40-minute experience, the patient watches a monitor and/or listens to sounds or music that are part of the NFB feedback technology. This visual and auditory feedback cues the brain to modulate brainwaves toward desired regulated states. The patient is not efforting in any way as the brain "learns" to modulate brainwaves. Often following NFB, patients experience improvements in certain areas targeted for behavior change including mood, attention and focus, or other goals of therapy. As brain functioning improves over cumulative sessions, the correlated changes of the targeted behaviors are realized and measurable.

Over the past seven decades, thousands of studies have been conducted demonstrating the various applications for NFB. More recently, meta-analyses confirm the efficacy of NFB as a treatment for ADHD and stress-and-adjustment-disorder behavioral health conditions. Yet, despite supportive research, and certain biomarker assessments cleared by the Food and Drug Administration (FDA)—such as ADHD diagnostic tools (Wilkes, et al., 2018) that use digital analysis of electrical activity in the brain measured from sensors placed on the head—NFB is not being adequately utilized by psychiatrists and psychologists as a standard protocol for treating these behavioral health disorders.

NFB AND THE CURRENT ADHD AND BEHAVIORAL HEALTH CRISES

ADHD is on the rise in the United States. The overall rate of ADHD in children aged 2-17 has increased from 6.1% to 10.2% since 1997 (see Figure 1). Youth aged 12-17 have the highest rates of ADHD, coming in at 13.5% in 2016; and boys are diagnosed three times as frequently as girls, possibly caused by clinicians misreading symptoms in girls (CHADD, 2020). In adults, the lifetime prevalence of ADHD is 8.1% (NIMH, 2017a). Some studies have found NFB to be as effective as medication in treating ADHD, and with longer sustained results post treatment (Arns et al., 2020).

Beyond ADHD, mental health more broadly has become a dominant issue in our society. Rates of stress- and adjustment-related symptoms are climbing, and the number of mental health disorders that produce anxiety, depression, post-traumatic stress disorder (PTSD) and other stress-related symptoms are not showing any sign of letting up. Approximately 20% of adults in the U.S. have a mental illness (NIMH, 2017b).

According to the Anxiety and Depression Association of America, anxiety of all types affects approximately 20% of adults and 25% of teens 13- to 18-years-old. (ADAA, n.d.). Additionally, 7.5% of U.S. children are diagnosed with behavioral problems and 7% with anxiety (CDC, 2018a). Addressing these disorders and other behavioral health conditions puts U.S. national mental health market spending at approximately $225.1 billion, up 52% from a decade ago (Open Minds, 2020); and yet, many are still not receiving care. For example, only about 37% of total anxiety cases receive treatment (ADAA, n.d.). To complicate matters further, according to the CDC, 64% of children with ADHD have at least one other mental, emotional, or behavioral disorder (see Figure 2). NFB, as a cleared treatment for relaxation, has been shown to be effective in treating and alleviating symptoms of stress- and adjustment-related disorders such as anxiety.

Americans of all ages, and our youth in particular, are under siege from behavioral health challenges. And while we have made concerted efforts in the fields of medicine and pharmacology to address this crisis, in some cases, prescription drugs are showing mixed results while the epidemic continues. Pharmacological remedies have offered great relief to many and are an indispensable component of modern medicine. Yet, the latest developments in neuroscience remind us that relying exclusively or too heavily on drugs, especially when other proven treatments are available, is not always the best or healthiest solution, even if this is the current established norm. While the immediate benefits of pharmacology for ADHD are clear, much is still unknown about the long-term effects of the use of psychotropics on the developing brains of youth. Some researchers have noted that pharmacological medications used in childhood do not necessarily lead to lasting remission, and may contribute to secondary behavioral health issues such as substance abuse in adulthood (Mannuzza & Klein, 2000). Expanding access to proven protocols, including NFB, is not a counter-medication effort, but a strategic treatment add-on that would only help combat the behavioral health crisis, and support the health and well-being of our youth.

BROADENING THE SCOPE OF EFFICACIOUS AND COST-EFFECTIVE INTERVENTIONS

To truly understand and address the underpinnings of childhood and adult behavioral health, we would need to consider factors beyond pharmacology, including what affects neuronal and neural circuit development, how relationships with self and others affect the brain (i.e. interpersonal neurobiology), how and when normal development gets interrupted and affects life outcomes (i.e. developmental psychopathology), as well as other therapeutic disciplines that similarly consider the interdependent neurological and environmental causes, conditions, and impacts of behavioral health.

FIGURE 1: INCREASE IN U.S. RATES OF CHILDREN WITH ADHD FROM 1997-2014

CHADD. (2020). General Prevalence of ADHD. https://chadd.org/about-adhd/general-prevalence/

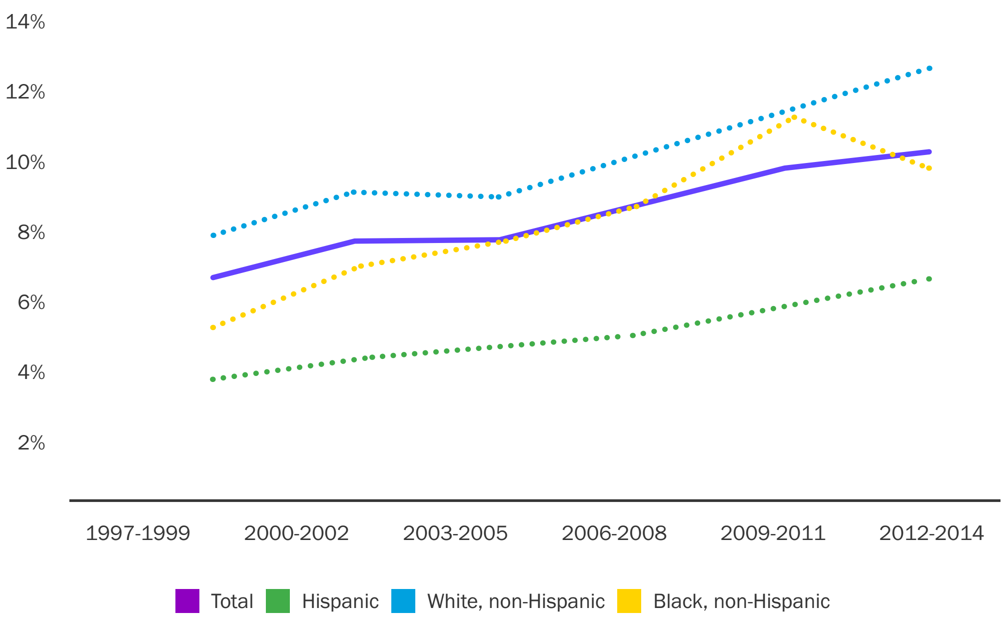
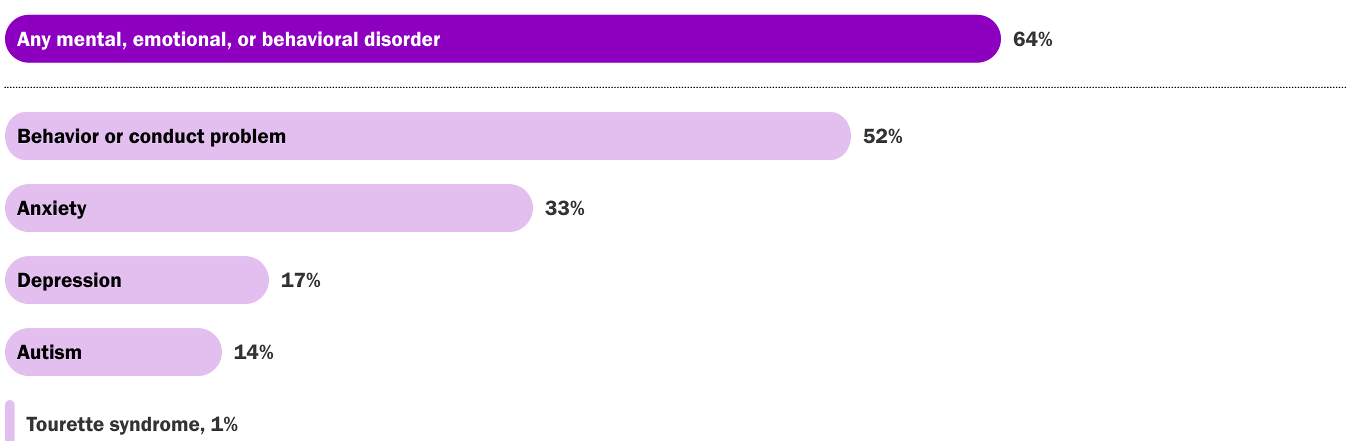


FIGURE 2: PERCENTAGE OF U.S. CHILDREN WITH ADHD AND ANOTHER DISORDER

Centers for Disease Control and Prevention. (2018, September 21). Data and Statistics About ADHD. https://www.cdc.gov/ncbddd/adhd/data.html



Given this complex interdependent nature of medicine, society, and individual genetics—how they all intersect and where they are disparate—we may never be able to align and address all the variables affecting behavioral health. This makes behavioral health treatment complicated. This also means no one treatment or practice is perfect, just as prescription medication is no panacea for ADHD, nor is, say, a mindfulness practice or talk therapy. However, to the extent that we can understand, adopt, and fully integrate non-harmful and effective interventions like NFB into the primary suite of behavioral health treatment protocols, we can support our nation's citizens, young and old, with accessible techniques and treatments for healing, recovery, and human flourishing.

Currently, while behavioral health rates are on the rise, in-network insurance coverage for behavioral health treatment is falling compared to coverage for primary care (Melek et al., 2019). This means that options for ADHD and other behavioral health treatments are fewer, less accessible, and less affordable.

In light of a recent groundbreaking report, insurance companies have more reason than ever to fast-track approval of effective evidence-based behavioral health interventions. Beyond access to coverage, not doing so could also be costing payers billions of dollars. In August 2020, Milliman Inc. provided an analysis of healthcare spending on 21 million commercially-insured individuals. Strikingly, the most expensive 10% of patients accounted for 70% of annual total health care costs; and within this high-cost group, 1.2 million individuals received a behavioral health diagnosis and/or treatment. Though this subgroup represented just 5.7% of the study participants, they accounted for 44% of annual total health care costs for the entire study population. Tragically, 50% of these individuals received less than $95 in behavioral health treatment annually, including prescription drugs (Davenport et al., 2020). Former CEO of Magellan Health and advisor to The Path Forward mental health care reform initiative, Henry Harbin, MD, stated, "Tremendous savings and improved outcomes are achievable if these individuals are identified early and provided with prompt evidence-based behavioral health treatment" (Mental Health Association of Maryland, MidAtlantic Business Group on Health, 2020).

Recent brain science encourages the medical field and insurance providers, when addressing behavioral health, to consider previously undercovered interventions like NFB. As an efficacious treatment for ADHD, for some patients NFB can achieve similar outcomes as medication, CBT and other treatments, by working with the brain's neurocircuitry to help bring about sustained behavioral change. Not only does NFB train brains to function better, heal from trauma and dysfunction, and increase capacity for learning and balanced living, but typically does so at reduced costs to insurers, health systems, individuals, and society.

This paper summarizes the more recent evidence for NFB as an efficacious and effective treatment for ADHD, and as an effective treatment for stress- and adjustment-related disorders that produce symptoms of anxiety. Included will be a cogent explanation of NFB for the interested layman to the unacquainted medical professional, including its history, an overview of various modalities and techniques, and a review of the research. The more technical aspects of NFB are covered in a series of appendices for those wishing to delve deeper.

Overall, our aim is to leave the reader with a confident, evidenced-based understanding of NFB, its main modes, functions and applications, as well as a solid rationale for the inclusion of NFB in the short list of primary treatments for ADHD and other stress- and adjustment-related disorders. Ultimately, the reader will understand the critical fundamentals of how NFB improves brain fitness and behavioral regulation, and relieves symptoms of certain behavioral health disorders, making it a valid behavioral health intervention. In consideration of coverage for behavioral health interventions, the paper also serves to support broader inclusion of NFB as a covered medical expense for the treatment of ADHD and stress- and adjustment-related mental health disorders. This is particularly relevant at a time when access to and reimbursement for effective interventions are desperately needed.

Neurofeedback: An Evidence-Based Treatment for ADHD

With historically high rates of ADHD showing no signs of abating, patients and families are looking for a full range of interventions that work. ADHD treatment, however, is largely deadlocked in a prescription medication-only scenario, with close to 70% of children diagnosed prescribed some form of psychopharmacological medication. For more than forty years, psychostimulant medications have been the most popular and powerful treatment option for ADHD. However, as new research on NFB is published, findings are indicating comparable and even superior outcomes with NFB, in some cases.

Undoubtedly, medication has a successful track record of reducing symptoms of ADHD; yet it does not work for everybody or it brings unpleasant side effects for some people due to the stimulant's mechanism of action in the brain. Additionally, potential long-term risks of taking stimulants are top-of-mind for a number of parents, and studies are limited in this regard. Furthermore, some studies suggest that outcomes from medication treatment may not last longer-term, post-treatment, or without increasing dosage. For those uncomfortable with these considerations, NFB as a non-pharmacological intervention should be a mainstream treatment option for ADHD, or at least a standard complement to medication as an adjunct therapy. Additionally, for many families the ADHD diagnosis process is stressful and inconclusive, often with differing reports from various sources. EEG, used in NFB and described below (see Neurofeedback Explained), offers a more definitive diagnostic tool, and families may prefer medical care that offers this option.

NFB has a long history and thousands of studies, many of which focus on treating behavioral health conditions, validating NFB's efficacy and effectiveness at improving behavioral health and brain fitness. In the past 11 years, for example, at least four major research reviews by leading researchers in the U.S. and internationally have shown NFB to be an efficacious intervention for ADHD.

In several studies, the effects of NFB continue after the treatment has ended, indicating progressive, positive neuroplasticity changes in the brain.

Most notably, research findings show the same rates of remission for ADHD as the leading prescription medications reviewed in the large-scale National Institute of Mental Health Multimodal Treatment Study (NIMH-MTA) for ADHD trial (The MTA Cooperative Group, 1999). Additionally, ADHD-related studies show positive treatment outcomes last longer post-NFB treatments than post-medication treatments (Arns et al., 2020). This means that in several studies, the effects of NFB continue after the treatment has ended, indicating progressive, positive neuroplasticity changes in the brain. Conversely, ADHD medication does not usually have this outcome. Rather, when medication use ends, so does the reduction in symptoms. Moreover, increasing medication dosage may be required to maintain remission.

In the U.S., among children aged 2- to 17-years-old diagnosed with ADHD, 62% take prescription medication. In total, 77% of children diagnosed with ADHD receive some form of treatment: 30% with medication alone, 15% with behavioral treatment alone, and 32% with a combination of behavioral treatment and medication (CDC, 2018b). A full 7% of children and 1.5% of adults in America take medication for ADHD, predominantly methylphenidate, most commonly known as the brand Ritalin (Brennar, 2018.). Many of these children and adults could benefit from NFB as a non-pharmacological standalone or adjunct treatment, from the perspective of both access to treatment and outcomes.

The 2014 National Survey of the Diagnosis and Treatment of ADHD surveyed 2,495 children aged 4- to 17-years-old with ADHD. A recent analysis of the survey's data found a gap in psychosocial and alternative interventions for school-aged children with ADHD (Danielson et al., 2018). According to the research, medication and school supports were the most commonly used treatments, followed by parent training, peer intervention and therapy, and then more distantly by dietary supplements and NFB. The authors stated that increasing access to treatments beyond medication and school support is "important to ensure that the millions of school-aged US children diagnosed with ADHD receive quality treatment."

Current common treatment plans for ADHD vary in approach and can be multimodal because a definitive one-size-fits all solution for ADHD does not exist. Medication and therapy each require a period of trial and adjustment to determine specific effectiveness for an individual.

Similarly, treatment for ADHD with NFB follows this same path: diagnosis, referral, evaluation, treatment plan, trial, feedback, improvement of condition, continuation of treatment, and ongoing patient evaluation and management as needed.

NFB also works very effectively as an adjunct treatment in combination with medication, where it can improve treatment outcomes and increase longer term, positive post-treatment benefits.

As a standalone treatment that is non-invasive and non-pharmacological, NFB may be preferable for some parents who would rather their child(ren) not take stimulants. Even though NFB is powerful and efficacious on its own, NFB is not exclusively a stand-alone or medication-replacement treatment. NFB also works very effectively as an adjunct treatment in combination with medication or other psychosocial interventions, where it can improve treatment outcomes and increase longer term, positive post-treatment benefits.

The fact that NFB proves itself as an efficacious and research-validated treatment modality, should only encourage insurance carriers and doctors to increase access to and application of NFB for ADHD—a formidable medical and social challenge. Having multiple effective tools to address ADHD would be a benefit to children and adults with the diagnosis, as well as to their families, doctors, and therapists.

NFB Treatment for a Broader Range of Mental Health Conditions

While the preponderance of NFB evidence is in the domain of ADHD, a strong evidence base for the use of NFB to treat other behavioral health disorders is also growing. NFB has demonstrated outcomes of effectively reducing symptoms caused by reactions to severe stress and adjustment (such as PTSD, depression, and anxiety) by improving general relaxation and brain regulation, and by reducing symptoms related to anxiety. It has, for example, been used with U.S. military veterans for more than a decade.

Relaxation training, a common treatment for anxiety, is an FDA-cleared use of NFB equipment. Biofeedback, a broader category that includes NFB, and NFB itself, have been used for decades to promote relaxation, as evidence-based, non-pharmacological methods for treating anxiety. A 2008 meta-analysis that reviewed 27 studies found significant efficacy for relaxation training as a treatment to reduce anxiety (Manzoni et al., 2008). More directly, research has shown that various specific NFB treatments have been found to do the same (Kerson et al., 2009; Moradi et al., 2011). In one study, researchers found that NFB is approximately as effective as medication in this regard (Bhat, 2010).

As previously indicated in the CDC data (CDC, 2018a), behavioral health conditions—including mental health issues that cause anxiety—are on the rise, at the same time there exists a lack of accessible and affordable treatments. According to a recent Mental Health America report, the percentage of people in 2020 seeking help with anxiety and depression has increased by 62% since the prior year, with young people ages 11–17 more likely than other age groups to indicate moderate to severe symptoms (Mental Health America, 2020). Adopting effective interventions such as NFB as part of a treatment model not only makes sense but carries lower risks than pharmacological interventions or no interventions. Later, this report will point out that NFB has few and minimal transient side effects, making it a smart choice for reducing anxiety brought on by stress- and adjustment-related disorders. In light of COVID, and with national rates of stress and anxiety in adults and children reaching new highs, now more than ever we need effective, non-pharmacological interventions like NFB to be broadly covered by insurance.

Neurofeedback Explained

What exactly is NFB? Simply put, NFB is a technology that allows patients to perceive their brainwave activity. NFB is non-invasive and non-pharmacological. An NFB device does not add electrical currents to the brain. Rather, surface sensors placed on the head, called electrodes, measure electrical output using electroencephalogram (EEG). The interpreted brainwave data is called quantitative EEG, or qEEG, as it is translated into measurement modes using various quantitative mathematical applications. These subtle qEEQ readings are converted into visible or otherwise perceivable forms such as graphs, charts, amplitude readings, colors, animated images, sounds and so forth. Using these technologies, NFB simultaneously measures, monitors and records brainwaves. The qEEG data is then used to create feedback loops that train the brain towards brainwave states that result in reduction of symptoms and/or improvement in well-being. Normative reference databases can provide trained NFB practitioners with target qEEG measures for age-matched populations as objective starting points for NFB treatment. This practice of determining treatment protocol based on historical evidence is in line with many medical procedures that use established reference databases for guidance during treatment. Further, qEEG is the only FDA-cleared, brain-based diagnostic tool for detecting ADHD, which is essentially a brain-based disorder defined by distinctive, abnormal brainwave patterns.

The brain is modulating its own brainwaves as encouraged by the NFB feedback system.

The feedback loops ultimately enable patients' brains to modulate their own brainwaves towards healthier or target frequency levels by offering rewards to the brain in the form of images, sounds, or other stimuli. NFB participants receive real-time and continuous qEEG data about their own brainwaves, and through conscious intention and reward incentives, are able to modulate brainwaves while witnessing the outcome of their efforts. More specifically, the participant is aware and engaged, but not actively modulating their own brainwaves consciously. Rather, the brain is modulating its own brainwaves as encouraged by the NFB feedback system.

During a typical NFB session, this measure-loop-modulate process continues for approximately 20 to 40 minutes. A trained NFB mental health or medical practitioner monitors the session, sets the protocol, interprets activity, and gets feedback from the patient, which is used to adjust future sessions toward more effective outcomes. Repeated NFB sessions produce lasting changes in brain function and fitness, and consequently lasting improvements indicated by remission or reduction of symptoms in mental and behavioral health disorders.

HOW NFB IS EXPERIENCED

An adult or child patient receiving NFB treatment for ADHD would likely be referred by a physician, psychiatrist or psychologist following diagnosis, but could also be referred by self or a parent. As with other forms of therapeutic treatment, initial intake and evaluation would capture key symptom information about the patient including, in the case of NFB, a qEEG baseline of the patient's brain for reference and for help in determining a treatment plan. At the point of treatment, a typical session would include the patient sitting in a chair or otherwise in a resting, relaxed pose with four or more sensors connected to their head and ears. Depending on the treatment protocol determined by the practitioner, the patient might use a visual feedback system, like watching a movie or sequence on a screen, or use audio cues such as listening to a song. When the brain is experiencing the intended brainwave, the visual or audio feedback system runs smoothly; and when an unintended brainwave occurs, there may be a visual interruption on the screen or a volume change or skip in the song. These changes give the brain feedback to help it self-correct towards target brainwaves. The treatment would continue for the prescribed amount of time. During treatment the patient is typically awake and aware, but in most cases their conscious participation is limited to a meta-witnessing of the process while the real brainwave work is being done at a faster rate by the brain itself.

The experience tends to be relaxing and non-effortful, and many patients report feeling calm, alert, and at ease, with similar feelings immediately following the session. Bookending the EEG part of the protocol, treatment would also include patient and practitioner feedback about treatment goals and progress, both from the NFB-reported changes in brainwaves as well as how improvements have translated into the patient's life between sessions. Qualitative feedback is often measured using standard tools used to assess human behavior. As with other treatments such as medication or therapy, the practitioner would use this qualitative feedback, along with any quantitative measurements, to adjust the treatment protocol towards optimal effectiveness. Repeated sessions support improvements in brain health and regulation and reduced symptoms and negative outcomes of ADHD. Overtime, improvements become more permanent, typically lasting beyond the end of treatment.

NFB can also be used in other settings, such as classrooms, on more than one student at a time, as demonstrated by a 2014 study that successfully used NFB to treat children with ADHD in grade schools (Steiner et al., 2014). In this setting, children are typically stationed at computers during a specific time period of the school day where they engage in unique, individually responsive, NFB treatment applications as determined by a licensed practitioner.

NFB provides the opportunity to affect positive change in the brain without surgery, electric shock, pharmacological medication, or other outside stimulus.

With repeated NFB sessions, the brain is trained to build more robust neuronal networks that facilitate adaptability related to positive behavioral health outcomes. As such, accessing desired brain states becomes easier and more reliable. The simple and powerful aspect of self-modulating brainwaves through feedback is what makes NFB a unique and potent brain-building treatment or intervention. NFB provides the opportunity to affect positive change in the brain without surgery, electric shock, pharmacological medication, or other outside stimulus, while providing real-time data that signals neuroplasticity changes in the brain.

The History of Neurofeedback

Modern NFB, validated by current research as an efficacious treatment for ADHD and other mental and behavioral health conditions, builds on a century-long study of EEG, and more than a half-century exploration of NFB applications.

In the 1920s, German psychiatrist Hans Berger was credited with recording the first human EEG. He later proposed that clinical disorders are detectable through EEG abnormalities (Millet, 2002).

Fast-forward to the 1960s, when NFB gained notice through the research of Dr.'s Joe Kamiya and Barry Sterman. Kamiya's work at the University of Chicago was the first to show that people could control their own brainwaves with EEG feedback, and it established a scientific basis for modern biofeedback and NFB. Sterman was at University of California Los Angeles studying the ability of cats to increase their own sensorimotor rhythm (SMR)—a unique brainwave—in exchange for a food reward using EEG NFB. Then, in an unrelated NASA study that researched exposure to rocket fuel, cats from his SMR study were included as test subjects and showed fewer adverse reactions, in particular, no toxicity-related seizures. This would lead Sterman to initiate a human trial to see if increasing SMR brainwaves could be a treatment for seizure disorders. While he found some success in this area, the outcomes of positive and prophylactic brain changes opened the door to other areas of study, shifting the focus of NFB research to behavioral health treatments.

By the mid-1970s, Dr. Joel Lubar pioneered using NFB to treat ADHD while Dr. Margaret Ayers used NFB as a treatment for mental health symptoms of traumatic brain injury. In the 1980s, Dr.'s Eugene Peniston and Paul Kokosky developed the Peniston-Kulkosky NFB protocol that was used to treat alcoholism and PTSD in Vietnam War veterans. NFB research continued over the ensuing decades, exploring the possibility of treating dozens of mental and behavioral health conditions as well as physical symptoms, including addiction, anger, headache, hypertension, schizophrenia, sleep disorders, and many more.

Beginning with a 1968 article by Dr. Kamiya in *Psychology Today* about the relaxation effects of alpha wave modulation using NFB (Kamiya, 1968), the research on NFB grew to include 162 studies in the 1970s and '80s, 1,260 studies in the 1990s, 6,100 in the first decade of the millennium and more than 9,000 publications since 2011.

Taking into consideration all the research and exploration to date, the most powerful and prevalent use of EEG NFB is as a treatment for ADHD, followed by relaxation treatments for reducing the symptoms of stress- and adjustment-related disorders such as PTSD, depression and anxiety.

What the Research Shows

NFB IS EFFICACIOUS AND SPECIFIC IN TREATING ADHD

Research over the past 20 years has significantly built on the pioneering NFB studies of the 1970s, '80s, and '90s. New studies, reviews and meta-analyses have investigated the efficacy and effectiveness of NFB under a variety of standard protocols, populations and conditions. The take away from this review of evidence is that NFB should be a first-line treatment with certain conditions. Even the vast majority of sham studies—designed to test whether the outcomes of a treatment are valid or little more than placebo effect—showed that NFB does have an effect greater than placebo when properly applied. (See Sham or the Real Deal section below for more information.) Following are summary research findings that support NFB as an effective treatment for ADHD and other conditions.

NFB should be [a] first line of treatment for ADHD.

In a 2014 review, psychologist H. Edmund Pigott and neuroscientist Rex Cannon state that NFB should be the first line of treatment for ADHD. In their review, they point out that while upwards of 70% of children diagnosed with ADHD are prescribed amphetamine medication, medication as a treatment fails to result in sustained benefits for most children. They indicate challenges with comorbid symptoms such as anxiety, depression, and learning disorders, that can lead to misdiagnosis, and therefore recommend NFB be used first in the case of ADHD treatment, as it is efficacious, non-harming, and non-pharmacological (Pigott et al., 2014).

Beyond comparison to medication, NFB was found to be more than twice as effective as the other interventions, which included behavior modification, multimodal psychosocial treatment, school-based programs, working memory training, parent training, and self-monitoring, in a 2014 meta-analysis that reviewed outcomes from 14 controlled studies including 625 subjects (Hodgson et al. 2014). The review focused on NFB as a treatment for ADHD relative to the effectiveness of other evidence-based non-pharmacological treatments.

Similarly, another 2014 study—that randomly assigned 104 grade-school children from public schools diagnosed with ADHD to treatment with NFB, cognitive training (CT), or nothing (control)—found significant improvements with NFB treatment (Steiner et al., 2014). After 6 months of interventions, the NFB groups showed a strong reduction in ADHD symptoms indicated by increases in attention and executive function compared to the other two groups. In addition, of the children in the study who were already taking methylphenidate, the medication dose levels for the CT and control groups increased significantly over time based on symptoms in order to maintain outcomes, while the NFB group had no significant dosage increase. Overall, the study found significant improvements for the NFB group in children who were both on or off medication. This research supports NFB as both a stand-alone and adjunct treatment for ADHD.

The research continues to validate the effectiveness of NFB as a treatment across study designs and measures. For example, a 2014 meta-analysis of randomized control trials (RCTs) that summarized research including 263 children (146 using NFB and 117 in active control or sham control groups) found that NFB significantly improved inattentiveness, impulsivity and hyperactivity according to parent assessments. (Micoulaud-Franchi et al., 2014). Significant improvements in inattentiveness were also reported through teacher assessments.

Meanwhile, large-scale reviews have indicated across research that NFB hits high marks when it comes to efficacy of treatment for ADHD. According to a 2009 meta-analysis that included 1,194 subjects from 10 controlled studies, NFB is efficacious and specific (classified as Level 5, meaning statistically superior to sham or alternative treatment) for ADHD (Arns et al., 2009). In the research reviewed, NFB was found to be most effective at treating inattention and impulsivity aspects of ADHD.

To further support NFB as a first-line treatment, a 2012 study concluded that NFB yields similar initial outcomes to medication (Duric et al., 2012). This RCT included 91 children aged 6- to 18-years-old and investigated treating ADHD with either NFB or methylphenidate. Improvements were measured as changes in symptoms reported by parents. Both NFB and medication reported equal improvements during and following treatment: NFB three times a week for a total of 30 sessions, or 1 mg per kg of methylphenidate for the same time period. The study concluded that NFB significantly improved symptoms of ADHD with the same effectiveness as methylphenidate, supporting NFB as a valid primary treatment option for ADHD in children.

Other studies have found similar initial outcomes and further concluded more successful post-treatment outcomes for NFB. A recent meta-analysis investigated the effects of NFB as a treatment for ADHD compared to medication and found that NFB was "superior on non-active control groups [i.e. open-label] and similarly effective for inattention and hyperactivity/impulsivity compared to active treatments" (Van Doren et al., 2018). Further, this same study noted that the "findings provide evidence that there are sustained clinical benefits after neurofeedback and active treatments over an average 6–12 month follow-up period, whereas effects of non-active control groups are no longer significant at [follow-up]."

A 2019 review of meta-analyses and randomized controlled trials found similar evidence supporting NFB in lieu of medication (Enriquez-Geppert et al., 2019). The study stated: "... in response to the lack of long-term effects for both medication and behavioral therapy and the side effects of medication... we provide evidence for the efficacy and specificity of standard neurofeedback protocols." The study concluded that neurofeedback should be a viable treatment for ADHD, while encouraging continued research to further identify specific protocols.

Very recent research reinforces NFB as an equal treatment to medication as compared to the landmark ADHD medication studies. A 2020 quantitative review evaluated the effectiveness and efficacy of NFB by comparing its research outcomes to the NIMH-MTA studies for medication and behavior therapy (Arns et al, 2020). The review found NFB to be both effective and efficacious as a treatment for ADHD compared to medication and/or therapy, and failed to find any side effects from NFB as a treatment. More importantly, in RCTs, ADHD remission rates following treatment with NFB ranged from 32-47%, on par or better than rates for methylphenidate, behavior therapy, or community care as treatment (see Figure 3A). In addition, in four RCTs, NFB resulted in continued improvement in ADHD symptoms after treatment ended (see Figure 3B). This post-treatment increase in improvements was also true for behavior therapy and community care, but not for medication, which showed a decrease in effectiveness at follow-up, indicating that the benefits of medication are immediate and not lasting.

This is not to disparage medication or to position NFB as a cure-all replacement for medication. There are many behavioral health conditions where the best course of treatment is medication and, in some cases, NFB works well as an adjunct treatment to medication. However, where NFB can be used as a first-line treatment, as with ADHD, there exists the potential benefit of lasting results after treatment ends without side effects or further pharmacological intervention.

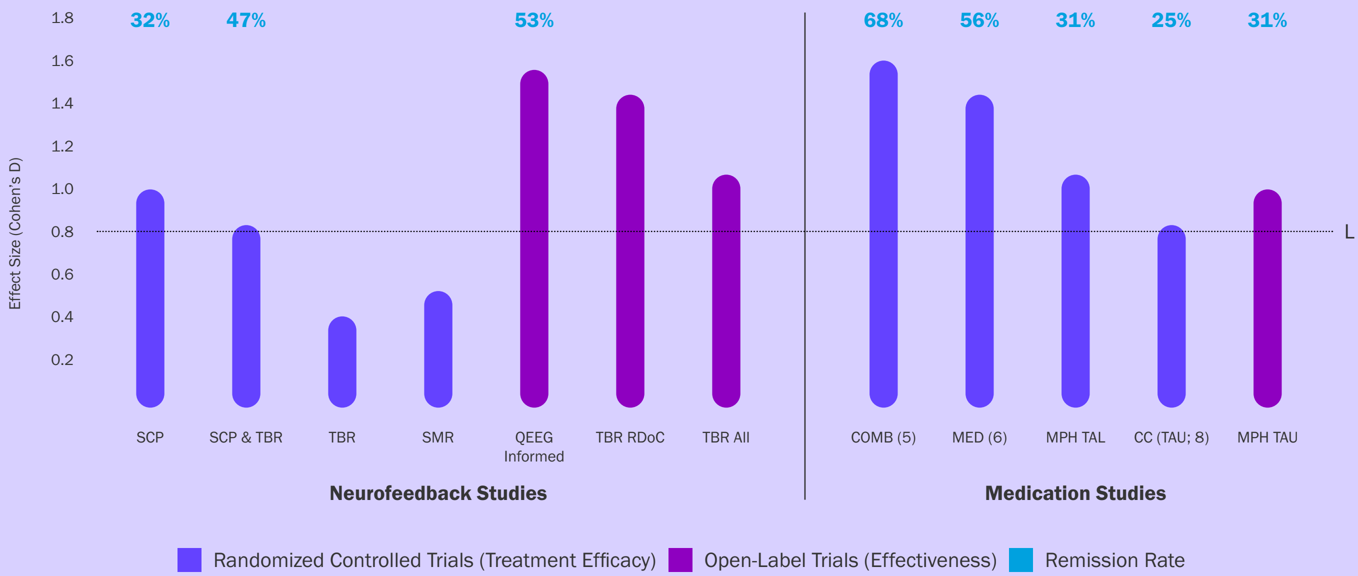
The research overviewed above supports both stand-alone NFB and a combination of NFB and medication as potential best practices for treatment of ADHD, underscoring key points that: NFB is as efficacious and effective as medication when used properly; and NFB treatment can result in long-lasting (6-12 months) improvement in symptoms even after treatment has ended, whereas medication typically does not show post-treatment improvements. These findings support NFB as a first-line or adjunct treatment for ADHD.

NFB ELIMINATES AMPHETAMINE-RELATED RISKS

The CDC reports that ADHD affects almost 10 percent of school-aged children, with approximately 3.3 million U.S. children medicated for unfocused behaviors (CDC, 2018b). As such, it is also important to consider the risks and side

FIGURE 3A: NFB COMPARED TO METHYLPHENIDATE MEDICATION

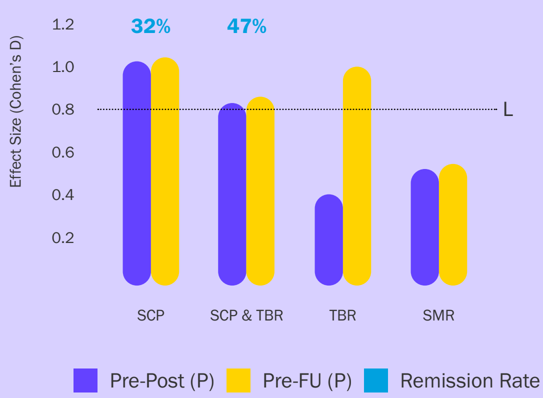
Arns, M., Clark, C. R., Trullinger, M., deBeus, R., Mack, M., & Aniftos, M. (2020). Neurofeedback and Attention-Deficit/Hyperactivity-Disorder (ADHD) in Children: Rating the Evidence and Proposed Guidelines. Applied Psychophysiology and Biofeedback, 45(2), 39–48. https://doi.org/10.1007/s10484-020-09455-2



The above figure compares effect sizes for several independent studies investigating various treatments for ADHD. L signifies a large clinical effect size (>0.8). All neurofeedback studies employed one of the following standard NFB protocols: sensori-motor Rhythm (SMR), theta/beta neurofeedback (TBR), or slow cortical potential (SCP). In the first open-label neurofeedback study a QEEG-informed procedure was used to select the right standard protocol and in the second open-label study, subjects were pre-selected on high TBR (TBR RDoC). The RCT medication outcome measures were from the NIMH Multimodal Treatment Study of Children with ADHD (MTA). The MTA study was composed of four arms: combined treatment of medication and therapy (COMB), medication only (MED), multicomponent behaviour therapy (MBEH), and community care—treatment as usual (CC:TAU). The open label medication study was a multi-centre open-label, treatment as usual (TAU) trial of methylphenidate (MPH) treatment.

FIGURE 3B: NEUROFEEDBACK EFFECT SIZE AT FOLLOW UP

Arns, M., Clark, C. R., Trullinger, M., deBeus, R., Mack, M., & Aniftos, M. (2020). Neurofeedback and Attention-Deficit/Hyperactivity-Disorder (ADHD) in Children: Rating the Evidence and Proposed Guidelines. Applied Psychophysiology and Biofeedback, 45(2), 39–48. https://doi.org/10.1007/s10484-020-09455-2



This figure compares effect sizes of neurofeedback results immediately following treatment (purple bar/Pre-Post Treatment) to follow-up 6 months post treatment (yellow bar/Pre-FU) for several randomized control trials investigating various neurofeedback protocol treatments for ADHD. L signifies a large clinical effect size (>0.8). All neurofeedback studies employed one of or more of the following standard protocols: sensori-motor rhythm (SMR), theta/beta neurofeedback (TBR), or slow cortical potential (SCP).

effects of medicating children with amphetamines, and in some cases additional antipsychotic drugs.

Beyond direct comparison between NFB and medication in terms of effectiveness or efficacy, research indicates that drugs have a higher risk of unfavorable side effects and, in other research, drugs and medication have not been shown to increase academic or life-achievement outcomes (Currie et al., 2014; Loe & Feldman, 2007). Rather, a childhood diagnosis of ADHD is usually followed into adulthood by ongoing treatment and related life challenges. Approximately 40% of treated children continue to experience ADHD as adults, and some engage in drug abuse. Adults that were medicated as children with ADHD are more likely to be antisocial, complete a lower level of education, and hold relatively lower level positions at work, while the ADHD-related attentional and impulsivity challenges from childhood tend to persevere (Mannuzza & Klein, 2000).

[NFB] offers a plausible alternative for children with ADHD whose treatment may be limited by side effects and/or poor medication response.

In a study that evaluated the effects of Ritalin compared to NFB, researchers found, using the Test of Variables of Attention (TOVA) scores, that NFB treatment resulted in sustained improvements. In the same report, they surmised that treatment with stimulants "would appear to constitute a type of prophylactic intervention, reducing or preventing the expression of symptoms without causing an enduring change in the underlying neuropathy of ADHD" (Monastra et al, 2002). These findings should be most importantly understood from the perspective that stimulant medication typically does not produce lasting positive outcomes post-treatment, whereas NFB can. And for some children, especially those with co-occurring disorders, medication may not be the best course of treatment. Researchers have stated that NFB "offers a plausible alternative for children with ADHD whose treatment may be limited by side effect and/or poor medication response" (Vernon et al., 2004).

Similarly, a 2003 study of 34 children compared NFB to methylphenidate. Twenty-two children received 3 months of NFB and 12 took methylphenidate for the same time period. The study found that both NFB and methylphenidate improved attention and reduced ADHD-related behaviors. The research concluded that NFB is a viable treatment for ADHD for parents who prefer a non-pharmacological treatment (Fuchs et al, 2003).

It stands to reason that a treatment option showing equal efficacy at reducing ADHD symptoms and promise for lasting outcomes post-treatment would be welcomed by medical and psychiatric professionals. Further, for some children, responsible and calculated treatment plans could begin with the least potentially harmful treatments—NFB and therapy—and progress towards medication as needed, depending on symptoms and outcomes. In addition, particularly in children, the experience of NFB is often in the form of watching a "movie" or listening to something, which is an enjoyable activity for children and results in higher levels of voluntary patient compliance.

Given recent comprehensive research reviews and current studies there is no reason for NFB to remain largely sidelined by the medical and psychiatric professions. Even though an ADHD diagnosis affects 11% of children aged 4-17-years in the U.S. today, only 11.4% of those diagnosed have ever received EEG NFB (Danielson et al., 2018). More patients, young and old, deserve covered access to and information about this treatment option.

NFB IMPROVES ACADEMIC PERFORMANCE AND ACHIEVEMENT

It is easy to get mired down in the comparative efficacy (and ease of use) of various treatments for ADHD from a reductionist perspective—a viewpoint that if symptoms improve, all interventions are equal relative to the scope of those reduced symptoms. Yet, as mentioned earlier, with ADHD and children, it is important to consider more inputs than just treatment modality and reduction of symptoms in addition to sustained benefits. Beyond proven efficacy as a treatment for ADHD, NFB also improves academic and social outcomes.

Families are understandably seeking solutions that maximize cognitive function, emotion regulation, and life outcomes. More pointedly, one important element, and usually one of the primary reasons why parents seek diagnosis, is to improve their child(ren)'s academic performance; another is to bolster self-reflective and/or self-regulated behavior. It also stands to reason that with improvements in academic performance, self-esteem improves, while school-related oppositional behaviors and test anxiety could be reduced. Without attempting to evaluate the totality of biological, neurological, and environmental inputs that lead to ADHD, which are numerous, for many families a preferred treatment would not only reduce symptoms by creating improvements in inattention, impulsivity and hyperactivity, but also show greater academic and social outcomes. In addition to grades, parents are seeking improvements in their children's quality of life, and in family or peer socialization that may have been obstructed or diminished as a result of ADHD. While the available research shows that NFB is equally as effective as medication alone at treating ADHD, it also shows that NFB is more effective at improving academic and life outcomes.

For example, a 2013 RCT of boys and girls aged 7- to 14-years-old that compared 40 NFB sessions to treatment with methylphenidate also investigated the impact of treatment on academic performance (Meisel et al., 2013). While the research found that both treatments alleviated symptoms of ADHD, at 2- and 6-month follow-ups, only the NFB cohort showed significant improvements in academic performance.

In another study, researchers reviewed data to explore the possible outcomes of treating children with ADHD with medication, not only in terms of improvements in academic performance, but also changes in emotional functioning (Currie et al., 2014). The research used data from the National Longitudinal Survey of Canadian Youth, which include 8,643 participants who were born in 1985 or later. The total longitudinal survey lasted for almost 25 years. The study stated that following increases in the use of prescription medication for ADHD, researchers found "... no evidence that the performance of children with ADHD improved. In fact, the increase in medication use among children with ADHD is associated with increases in the probability of grade repetition, lower math scores, and a deterioration in relationships with parents. When we turn to an examination of long-term outcomes, we find that increases in medication use are associated with increases in the probability that a child has ever suffered from depression and decreases in the probability of post secondary education among girls."

A 2015 review in the Journal of Attention Disorders sought to evaluate the direct impact of all ADHD treatments, or combinations of treatments, on academic outcomes. The researchers looked at 176 studies that measured longer term academic outcomes (at least 2 years) for students with ADHD with and without treatment (Arnold et al., 2015). This research more specifically defined two measures of academic outcomes: 1) academic achievement as information learned, measurable by test scores; and 2) academic performance as overall success in the school environment. Treatment of any kind showed some improvement in both academic achievement and performance. However, multimodal treatment (that combined more than one treatment) had the highest improvement measures in both categories. According to this study, non-pharmacological interventions performed better at increasing academic performance than pharmacological interventions.

Again, research indicates that while pharmacological interventions may be the simplest and most direct treatment modality to immediately relieve symptoms of ADHD, they are not always the most effective for long-term improvements post-treatment or for improving other outcomes including academic performance and prosocial behaviors. Conversely, non-pharmacological treatments, namely NFB, have been found to result in longer-term post-treatment improvements and increases in academic performance and well-being.

In addition to NFB as treatment for a single child with ADHD as prescribed or directed by doctors or psychologists, as referenced earlier, there exists potential for school-based group NFB interventions for children with ADHD that could improve not only symptoms but also academic and social outcomes. A 2011 study found that computer-based NFB interventions in school successfully reduced symptoms of ADHD (Steiner et al., 2011). The study found improvements through objective measures including the Conners' Rating Scales-Revised (CRS-R), Behavior Assessment Scales for Children (BASC) and the Behavioral Rating Inventory of Executive Functioning (BRIEF).

A 2014 follow-up study by the same researchers found that "participants on medication presented at baseline with the same level of ADHD impairment as those who were not taking medications" (Steiner et al, 2014). Further, they found that because "children on stimulant medication improved to the same magnitude as those not on stimulant medication suggests that stimulant medication does not hamper the therapeutic effect of [neurofeedback] NF. This is clinically an important factor regarding NF attention training and has been debated in previous works, and it means that NF is accessible as a stand-alone therapy option or an adjunctive treatment to medication."

RESEARCH SHOWS NFB ALLEVIATES ANXIETY RELATED SYMPTOMS

As reported earlier, in addition to being an effective treatment for ADHD, research has shown NFB to be effective for other conditions and symptoms. The words anxiety, stress, and trauma represent different conditions and symptoms, depending on context. Symptoms and experiences of anxiety are common across many behavioral health issues in addition to ADHD, including PTSD, depression, general anxiety disorder (GAD), and a more inclusive general category of stress- and adjustment-related disorders. This latter category could be caused by disruptive life events such as major challenges at work, in health, relationships, or due to accident or injury, both acute and chronic, that manifest symptoms of anxiety, depression and other experiences and emotions without necessarily indicating diagnosis of those conditions per se. As previously noted, almost 20% of Americans are experiencing some form of anxiety, not to mention the high rates of depression (NIMH, 2019) and stress-related illnesses in the U.S.

When considering NFB as an effective treatment option for these conditions, it is important to remember the original outcomes of NFB, going back to the 1950s and 1960s and the work of Dr. Joe Kamiya. These outcomes were increased relaxation effects shown through voluntary, feedback-assisted modulation of specific brainwaves, namely alpha waves. In other words, NFB got its start in the behavioral health field by inducing "relaxation" as an antidote to stress, anxiety, depression, addiction, and so forth.

NFB can be successful at supporting well-being relative to depression, PTSD, trauma, and adjustment disorders.

Growth in NFB technology since the 1960s, along with discoveries in neuroscience, have resulted in greater understanding of relevant brainwaves, along with increased protocol specificity for producing relaxation outcomes. These relaxation outcomes have transferable impact, namely relieving symptoms of anxiety related to other disorders. Interestingly, NFB can be successful at supporting well-being relative to depression, PTSD, trauma, and adjustment disorders in an objective way and without necessarily having to explore the underlying contextual or traumatic experience as might occur in therapy. As such, the benefits of NFB can be used independently to support relief from symptoms of anxiety, or as an adjunct treatment in combination with talk therapy. NFB, on its own, does not heal depression, PTSD or other disorders, but its ability to relieve symptoms in a non-invasive, non-traumatic, psychophysiological way with lasting effects can contribute to remission of symptoms and improved mental well-being. Including NFB in the toolkit of therapeutic treatment for symptoms of anxiety related to various disorders could be a benefit for practitioners, therapists, and even more for people struggling with mental health symptoms like anxiety and stress.

While research in this area is not as robust as for ADHD, biofeedback equipment and its functions, including modulating alpha brainwaves, is cleared by the FDA for relaxation (CFR - Code of Federal Regulations Title 21, n.d.). Relaxation training of various forms, including biofeedback broadly, is one of the most common treatments for anxiety and reactive stress disorders (Manzoni et al., 2008). Relaxation is a broad term that acts as the basis of more specific improvement outcomes for anxiety and stress-related issues. Because the underlying causes of anxiety, stress, depression and other mental health conditions are varied and broad, NFB research covers an interesting gamut of causes and conditions. Even so, related studies show NFB to be effective at reducing symptoms of anxiety.

A 2020 meta-analysis (Anxiety Disorders: Rethinking and Understanding Recent Discoveries, 2020) of 21 studies with 779 participants concluded that neurofeedback is efficacious in the treatment of anxiety and reactive stress disorders. The relevant research highlights that regulating alpha brainwaves is an effective treatment for reducing anxiety. (See Appendix A for more about brainwaves.)

This meta-analysis states: “Although there are many variants of EEG neurofeedback, the most frequently studied of these in the anxiety disorders have focused on increasing alpha waves. Alpha is the dominant EEG rhythm in healthy adults at rest and is associated with a calm, relaxed state. Among patients with panic disorder, alpha is attenuated, though in GAD patients, alpha is increased. Increasing alpha magnitude can produce a calming effect in high-anxious individuals.”

Other, more case-specific studies support the proposition that NFB is an effective treatment for symptoms of anxiety.

A 2011 study used NFB to treat people diagnosed with anxiety disorder (Moradi et al., 2011). Following 30 NFB sessions over three months, subjects experienced significant reduction in symptoms. At one year of follow-up, subjects’ symptom checklist was in the normal range, meaning they were no longer showing clinical signs of anxiety, and self-reports indicated that they continued to experience relief from symptoms after treatment ended. Similarly, a 2015 study used NFB to treat a cancer patient with anxiety and found significant improvements after 20 NFB sessions as measured by the standard symptom checklist, SCL-90 (Benioudakis et al., 2016). Another 2012 study explored using NFB to reduce anxiety in professional athletes. Twenty professional swimmers participated in 12 NFB sessions and reported significant decreases in anxiety compared to a control group (Faridnia et al, 2012).

In more comprehensive research, D. Corydon Hammond, Ph.D., a psychologist and Professor (Clinical) Emeritus of Physical Medicine and Rehabilitation at the University of Utah School of Medicine conducted a review in 2005, exploring the then current research on NFB as a treatment for anxiety, depression and obsessive-compulsive disorder (Hammond, 2005). While he concluded that more controlled trials were needed, he stated that the research to date warranted considering NFB as an efficacious treatment for anxiety.

Still other research looked at the effects of NFB for GAD.

A 2015, quasi-experimental study evaluated NFB as a treatment for patients with GAD versus a control group (Dadashi et al, 2015). After 30 NFB sessions, the NFB group showed improvements in global functioning levels and reduced symptoms of GAD. Along the same lines, a 2010 study compared NFB to antianxiety medication as a treatment for anxiety in 100 patients with psychiatric diagnoses (Bhat, 2010). The NFB group received treatment 5 times a week for 8 weeks, with follow-ups at 4 and 8 weeks. An interesting outcome was that overall, NFB was almost as effective as pharmacotherapy for symptoms of anxiety, and in female patients, NFB was more effective than medication.

A handful of other studies have explored NFB as a treatment for symptoms of anxiety, PTSD, depression, stress and other emotional and mental conditions. Many of the studies are smaller, but all show promise for, and effectiveness in, relieving symptoms of various conditions. Given the propensity for NFB to be effective as a treatment or adjunct treatment for such symptoms, NFB is a valid option for non-invasive, non-pharmacological treatment for states of anxiety resulting from a host of mental health conditions.

Increasing NFB Access and Reducing Roadblocks

The research cited throughout this paper clearly shows that NFB is an effective treatment for ADHD and other stress- and adjustment-related symptoms. Applications include first-line, stand-alone treatment for a variety of conditions, as an adjunct intervention to a medication-based or therapy-based treatment plan, and even as a classroom intervention for school-aged children. Effectiveness of treatment is dependent on proper application protocols and standards, including practitioner training and the use of FDA-cleared equipment. In most cases, however, the research shows positive outcomes, not only in symptom reduction of behavioral health issues, but also in long-term improvements in social behaviors, increases in academic performance, and reduced symptoms of anxiety. While NFB has not yet reached ubiquity as a recommended treatment for ADHD and stress- and adjustment-related symptoms, it undoubtedly has a presence as a valid treatment in these areas.

CAN NFB BE BILLED TO INSURANCE?

NFB has had a Category I Common Procedural Technology (CPT) medical procedure code since 1978, and many reputable groups acknowledge and/or recommend NFB as a valid treatment modality. For example, the International Society for Neurofeedback and Research (ISNR) and the Association for Applied Psychophysiology and Biofeedback (AAPB) both recommend NFB as an efficacious treatment for ADHD.

Established CPT billing codes allow NFB to be billed to insurance as a standalone treatment or as a component of psychotherapy. The current standalone code is the same code for biofeedback: 90901. Practitioners may also use mental health codes for sessions that combine NFB with therapy or counseling: 90875 for a 25-minute session and 90876 for a 50-minute session. These Category I codes (Criteria for CPT® Category I and Category III Codes, 2017) must satisfy all of the following criteria:

- All devices and drugs necessary for performance of the procedure of service have received FDA clearance or approval when such is required for performance of the procedure or service.
- The procedure or service is performed by many physicians or other qualified health care professionals across the United States.
- The procedure or service is performed with frequency consistent with the intended clinical use.
- The procedure or service is consistent with current medical practice.
- The clinical efficacy of the procedure or service is documented in literature that meets the requirements set forth in the CPT code-change application.

Several insurance companies reimburse NFB CPT codes, others may be restrictive based on associated diagnostic codes, and still others may evaluate reimbursement on a case-by-case basis.

Currently, NFB is mandated to be offered at all Veterans Administration (VA) centers as part of their Whole Health Initiative—a veteran-directed wellness program. More than 26 VA hospitals and major medical centers offer NFB onsite. NFB is covered in at least 12 states by various insurance plans including Carefirst, Tricare, United Health, Aetna, Cigna, and Kaiser Positive Choice, to name a few.

Additionally, in several states NFB is reimbursable by Medicaid. These examples prove that scaled uptake is possible.

According to recent proprietary research by ISNR as part of a CPT code application, in 2019 there were an estimated 18,000 biofeedback practitioners nationwide, up to 6,000 of whom are NFB providers based on data from the U.S. Department of Labor's Bureau of Labor Statistics and on estimates from companies which provide training, equipment, and/or software to providers. This represents an increase of 20% since 2017.

In several states, insurance companies and Medicaid plans cover NFB as a treatment, while in others, coverage depends on case-by-case approval. Currently, dozens of hospitals and medical centers, including many VA hospitals, offer or cover NFB as a standard treatment.

The time has come for NFB to be a standard offering in treating ADHD and other anxiety-related conditions.

The trend is moving toward a broader inclusion of NFB in the behavioral health and brain fitness treatment toolboxes. Currently, the possibility of a unique CPT code for NFB (not just biofeedback more broadly) is being explored; and recently, the American Psychological Association recognized biofeedback, including EEG NFB, as a proficiency in professional psychology (American Psychological Association, 2019). These steps should further pave the way for the acceptance of NFB as a primary treatment option for ADHD and other conditions and symptoms. The time has come for NFB to be a standard offering in treating ADHD and other anxiety-related conditions, both as a first-line and adjunct treatment. NFB studies only underscore this point.

However, despite increases in trained practitioners and NFB adoption, and the fact that NFB is proven efficacious for behavioral health disorders and has CPT codes, NFB is not consistently reimbursed by insurance companies. Many insurance companies are out of compliance with the MHPAEA, which requires group health plans with mental health and substance use disorder benefits to offer equal coverage for these disorders as they do for medical/surgical benefits (CMS.gov, n.d.). The lack of industry adoption of this federal law is leading to increased medical costs and the exacerbation of behavioral health issues across the country. The 2019 Milliman Research Report, *Addiction and mental health vs. physical health: Widening disparities in network use and provider reimbursement* (Melek et al., 2019), found huge disparities in in-network coverage for behavioral health treatment versus surgical and medical treatment. From 2013 to 2017, out-of-network use for behavioral health increased 85% relative to medical health.

Additionally, across the U.S., reimbursement rates for primary care visits were 30-50% higher than those for behavioral health visits, and behavioral health visits for children were 10 times more likely to be out-of-network than primary care visits. The researchers also noted that these disparities are only for claims, and do not include data on consumers who did not seek or receive treatment due to inaccessibility or lack of affordability. The net effect is that while behavioral health issues, including ADHD and anxiety, are increasing, insurance companies may not be covering efficacious treatments in line with the MHPAEA. This results in reduced access to intervention options because of network availability and prohibitive costs, and therefore lower rates of treatment for said conditions. When behavioral health conditions are not adequately addressed through the medical/insurance system, they will likely continue to rise in numbers, and for some patients, the severity of the condition will worsen, translating to even greater future costs to address the crisis.

Beyond the impetus to provide equal access to and coverage of behavioral health interventions such as NFB, insurance providers may want to more seriously consider MHPAEA compliance. In July 2020, the Illinois Department of Insurance fined five major insurance companies for violating the 2008 MHPAEA. CIGNA Healthcare of IL, United Healthcare, CIGNA Health and Life, Health Care Service Corporation (Blue Cross Blue Shield of Illinois), and Celtic were fined more than $2 million for violations of the MHPAEA. In a press release announcing the disciplinary action, the Kennedy Forum also stated, "Parity enforcement is more critical than ever as Americans grapple with COVID-19 and subsequent economic and social turmoil, which are already contributing to increasing rates of anxiety and depression across the country. Additionally, new data recently released by the CDC show that drug deaths in America hit record numbers in 2019 and are steadily rising" (Kennedy Forum, 2020). More recently, in November 2020, a federal court ruled that United Behavioral Health was out of compliance with the Employee Retirement Income Security Act of 1974 (ERISA) and ordered the reprocessing of nearly 67,000 behavioral health and substance use related claims (Psych Appeal, 2020).

Including in-network reimbursement of NFB treatment for ADHD and anxiety-related symptoms would be adding a non-invasive, relatively inexpensive, efficacious and effective intervention to the set of available treatments for children and adults with behavioral health disorders. Greater coverage of NFB would also support the intent of the MHPAEA parity law—ensuring that more children and families have access to adequate care.

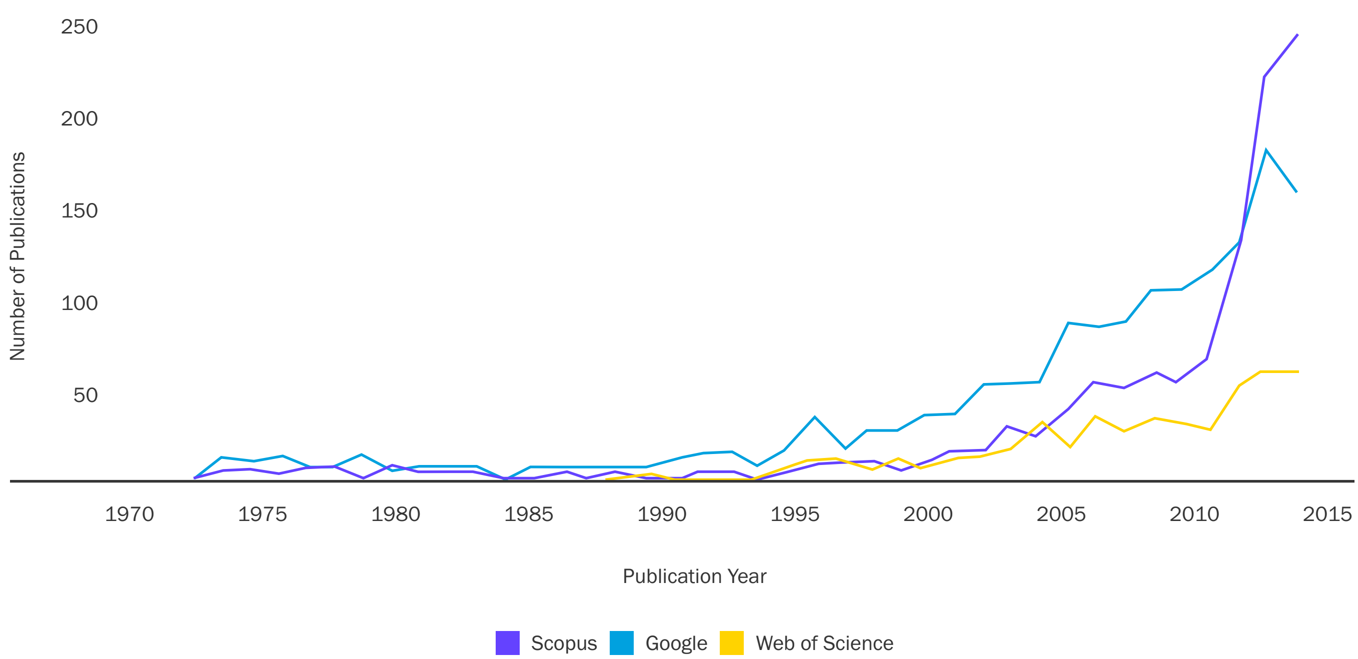
MEETING MAINSTREAM INTEREST IN NFB

Interest and research in NFB as an intervention continue to grow. According to a recent report, the search volume of scientific papers on NFB has skyrocketed. A PubMed search shows that using the search term "neurofeedback" results in 850% more journal papers published on the topic from just a decade ago (Sorger et al., 2019).

Additionally, personal development and human performance markets are driving increased interest and improvements in consumer NFB technology. As seen from search data, the number of publications available on the web when searching for "neurofeedback" or "EEG biofeedback" has been increasing exponentially (see Figure 4).

FIGURE 4: NUMBER OF PUBLICATIONS FOR SEARCH TERMS "NEUROFEEDBACK" OR "EEG BIOFEEDBACK"

Ali, Y., Mahmud, N. A., & Samaneh, R. (2015). Current advances in neurofeedback techniques for the treatment of ADHD. *Biomed. Pharma.* J, 8, 65-177



As research and interest continue to grow, greater familiarity will likely instill increased curiosity in both patients and consumers. While the focus of this paper is strictly on evidence-based treatments by certified professionals for behavioral health conditions, significant increase in NFB use for various cognitive and physical increases in personal performance cannot be denied. It is reasonable to conclude that the increased interest in the consumer market will only support increased demand in the medical field. The greatest opportunity for rapid adoption of NFB as an effective treatment depends on practitioner awareness and confidence. As doctors and therapists understand the intervention's efficacy and evidence-base, NFB can take its rightful place as a best-in-class practice for ADHD and other mental and behavioral health disorders.

One of the obstacles in explaining NFB is its complexity. A multitude of brainwaves, electrodes, feedback loops and protocols present a challenge in trying to briefly and succinctly describe its mechanism of action and outcomes. NFB is more complicated than, say, taking a pill. It is more akin to psychotherapy, which employs various protocols to treat different causes and conditions, and relies on skilled and experienced therapists as well as positive patient-practitioner relationships to be most effective. In this way, explaining NFB is similar to answering the question: what exactly is psychotherapy and how does it work? The answer is nuanced, yet once familiar with the essential inner workings of NFB (or with therapy), the practice makes more sense; and NFB undoubtedly holds the potential to become as mainstream as talk therapy.

The remainder of this paper offers the reader an opportunity to cultivate a more comprehensive understanding of NFB's inner workings. Even more specific details about NFB are available in Appendices A-E, which include: What Are Brainwaves?; EEG Electrodes; Brain Regions and Functions; Quantitative and Statistical NFB Measures; and, NFB Treatment Protocols for ADHD and other Conditions. What follows now is a look at how and why NFB works, neuroplasticity and operant conditioning, risks and sham claims, and considerations for how to safely and effectively choose a practitioner.

Details on How NFB Works

As outlined earlier in this report, NFB is the technology of measuring brainwaves, creating feedback loops with the data, and incentivizing modulation towards healthier brain states and brain regulation. To understand the hows and whys of NFB, a closer and more detailed look is required.

On the conceptual level, the reason why NFB works is neuroplasticity—the ability of the brain to change itself, and in the case of NFB, with specific, targeted feedback. To understand the basics of how this happens, we need to consider two key functions: reward mechanisms and operant conditioning. Moving into the application level, understanding how NFB "reads" or measures brainwaves requires an overview of brainwaves (see Appendix A) and of electrode sensors, including where they are mounted on the head, and what they are measuring and why (see Appendix B). A level deeper takes us into the different lobes of the brain and their correlated behaviors and emotions (see Appendix C). To understand how brainwave data is evaluated and used for feedback, a cursory overview of various analysis techniques is needed (see Appendix D). Fundamentally, brainwave data is analyzed quantitatively as measurements of the aspects of the brainwave signal, such as amplitude, the strength of the brainwave, or as derivative of quantitative data that allows other brain modeling and comparisons to normative databases. Some investigation and learning is required to fully understand how NFB measures brainwaves and uses the data.

Once familiarity with the operation of NFB has been established, a broad summary of which treatment protocols are used for different conditions can be considered (see Appendix E). This is part of the complexity of NFB as it is not a one-size-fits all treatment. Much in the same way therapy uses different modalities or medication uses different doses or combinations of medication depending on symptoms and treatment goals, NFB also has different treatment protocols. For example, anxiety-related treatments tend to modulate alpha waves, while ADHD treatments often seek to adjust the relationship between theta and beta waves. Proper protocols for treating ADHD and stress- and adjustment-related symptoms have been derived from research studies that show efficacy.

Equipment is another consideration. Bona fide professional-level equipment must meet certain standards and capabilities and be FDA-cleared; and it requires the practitioner to have a minimum level of training.

In addition to practitioners needing professional-level application skills—including using electrodes and NFB equipment, and interpreting brainwave data—they should also have skilled capacity to solicit and interpret patient feedback and interact with patients in a therapeutic way as part of the treatment. All together, the combination of technical and therapeutic skills provides key feedback that enables the practitioner to adjust protocols with proficiency and towards greater effectiveness, as with other behavioral health treatments.

NFB is similar to therapy, with varying evidence-based modalities, a number of influences in determining treatment, and the requirement of a skilled and trained practitioner.

Each of these variables is important, and a basic overview is essential to understand more specifically how and why NFB works. While at first glance this may seem complex, it is important to remember how, in many ways, NFB is similar to therapy, with varying evidence-based modalities, a number of influences in determining treatment, and the requirement of a skilled and trained practitioner to be effective. Taking a look at these key pieces, one at a time, will support a fuller picture of the intervention.

NFB FOUNDATIONS: NEUROPLASTICITY AND OPERANT CONDITIONING

Self-neuromodulation is the brain's ability to train itself, in this case through NFB, to reach a desired brain state. Through NFB, a shift in brainwaves and brain regulation occurs, in part as a result of 1) the patient's awareness of the desired brain/brainwave state, and 2) the real-time changes that are happening in the patient's brainwave activity, all through feedback derived from the EEG NFB technology.

NFB is a powerful intervention because it brings to bear self-awareness components that have been found to increase positive outcomes. The patient's awareness of brain states, awareness of optimal goals or at least directional goals, and awareness of what is happening during the process are the foundation of NFB effects on positive neuromodulation. In addition, NFB as a system works through a behavioral change paradigm commonly known as operant conditioning.

Operant conditioning occurs when specific events that create positive or negative rewards are connected to ongoing behaviors such that the frequency of certain targeted behaviors/brainwaves are modified. In the case of NFB, a rewarding event is typically a visual and/or auditory experience, such as a movie, music and/or video game, that serve to help reinforce the occurrence of specific aspects of brainwave activity. As EEG readings from specific brain regions indicate shifts towards target values, the rewarding events are enhanced to encourage the presence of desirable brain function characteristics. In other words, as brainwaves shift towards target frequencies, the brain is rewarded with pleasurable stimuli. Repeated reward stimulus leads to healthier brainwave states that, over time, replace dysregulated brainwave states. The process of providing a stimulus, measuring the effect in terms of targeted brainwave activity, and modifying the reinforcing stimulus to optimize these brainwaves is an example of operant conditioning. The use of operant conditioning has a long and well-documented history of effectiveness in many aspects of influencing and shifting animal and human behavior; and a growing body of literature supports the effective utilization of operant conditioning principles to train neural responses.

As a very simplistic example, imagine trying to housetrain a puppy. When the puppy has undesirable behavior, it gets undesirable consequences—lack of praise and being quickly ushered outside. Conversely, when it sits by the door and waits to go outside, it gets desirable feedback in the form of attention and usually food. Over time, the positive feedback wins out, and the new behavior becomes the norm. Similarly, NFB uses feedback methods for incentivizing brain modulation such as watching a movie. In this example, as brainwaves approach a desired state, the movie gets brighter and set to the right volume; as the brainwaves drift away from the desired state, the movie gets dimmer and quieter. The changes either positively or negatively reward the brain for shifting states/brainwaves, which creates a learning experience for the brain that over time trends toward healthier brainwave states. The patient is not consciously redirecting brainwaves; this is an automatic action in the brain, much in the same way desiring to pick up a cup causes the arm to reach out and clasp it.

Repeated modulation towards the goal produces lasting changes in brain fitness and function, which, in turn, lead to lasting improvements in mental and behavioral states.

EEG is an instant measure of brain activity; there is no time delay for confirmation indicators. Therefore, when participants' brains are successful at modulating brainwaves towards a goal, they promptly get a reward in the form of a visual or auditory stimulus. This "cookie for the brain" gives a hit of dopamine (Sulzer et al., 2013), a win not unlike "winning" a video game or hitting the bull's-eye with a dart. The brain likes this form of reward, and the whole system—the participants, their intentions, the neurological and neurochemical brain activity—is incentivized and trained to repeat the effort in anticipation of another reward. Over time, and with practitioner adjustments based not only on quantitative brainwave data but also qualitative participant self-reports, the brain is conditioned into a new state. Repeated modulation towards the goal produces lasting changes in brain fitness and function, which, in turn, lead to lasting improvements in mental and behavioral states.

These shifts in brainwaves and improvements in brain regulation are occurring within the context of neuroplasticity—the fact that a human brain can reprogram itself, modify its own neural hardware, modulate brainwaves, and create sustained neural changes. In this case, neuroplasticity is being harnessed by NFB to guide the brain and person towards regulation and improvements in behavior and well-being. The mechanism of action and target outcomes can be described by operant conditioning. Consequently, repeated treatments result in lasting brain states, and improvements in behavioral and mental health.

PRACTICE AND PRACTITIONER ARE EQUALLY IMPORTANT

While the technology of NFB effectively modulates brainwaves towards regulation to positively influence behavioral and mental health, the application of NFB also has human components, including:

1. The patient, who voluntarily engages in the intervention and remains conscious as the brain learns to modulate brainwaves, self-reporting any changes in symptoms or condition (in the case of young children, parents or teachers may observe and report instead of the child); and
2. The practitioner, who is proficient in the use of EEG technology, an expert in protocol selection, adept at understanding brainwaves and their implications in mental and behavioral health, and has the skills needed to interact with the patient.

For these reasons, NFB cannot be viewed as an external application, like a medication that works independently without a patient's (or practitioner's) engaged participation. At least not for the effective treatment of ADHD and symptoms of anxiety.

To this point, while the efficacy and effectiveness of NFB can be compared to medication, the mechanism of action is different. NFB is not the same as taking a pill to stimulate a chemical change in the brain without the conscious participation of the patient. NFB is not an external treatment that operates independent of patient and practitioner. As alluded to earlier, NFB is more akin to CBT, where the first step is a professional intake and assessment of state or condition, followed by diagnosis, a treatment plan with target state or goal(s) identified, best practices and protocols selected, applied, monitored and modified, and all with patient awareness and interaction.

To be effective, researched and efficacious protocols must be applied by trained practitioners on certified equipment.

Where NFB is similar to medication (and further analogous to CBT), is in that the practitioner and patient work together, cooperatively, according to the treatment plan, toward the goal. In this process, the practitioner observes quantitative and qualitative indicators, using feedback to manage and/or adjust the treatment plan toward optimal effectiveness. The NFB techniques and protocols used depend on the underlying condition or symptoms, and are determined by the experience and recommendations of the practitioner. It could take up to five sessions, for example, for the patient, their brain, the computer system/equipment, and clinician to reach an optimized treatment application. Progress would be continuously monitored to ensure that treatment is effectively enabling the patient to improve through operant conditioning, neuroplasticity and neuromodulation. Improvements would be tracked through assessment and self-report, and treatment modified as needed towards optimal settings that bring positive results for the patient. To be effective, researched and efficacious protocols must be applied by trained practitioners on certified equipment.

This interdependent system of EEG, patient, and practitioner works to shift brainwave activity toward a healthier or more regulated state. Over a course of sessions, the patient indicates, through evaluation or self-report, whether they are seeing progress toward goals as indicated by abilities, symptoms or other markers. In time, operant conditioning and neuroplasticity affect significant improvements in condition, and in neural structures, which is why the intervention has the potential to be long-lasting even after treatment ends.

In a professional setting, the practitioner will likely conduct a brain map or some other qEEG evaluation as a baseline to guide treatment and progress, and to identify areas of greater or lesser activity in the brain compared to a normative database or a research-validated theoretical model. Normative data or theoretical models are used as a starting point for treatment and identifying target brainwave activity, not as a determinant of specific brainwave outcomes. The practitioner begins the treatment based on evidence and best-practices, engages with the patient to get feedback in various behavioral and emotional measures, and adjusts the treatment accordingly to achieve optimal changes in behavioral health beyond specific brainwave ratios. Again, this is not unlike the use of pharmacological medications that are prescribed based on normative and typical symptoms, tested for a period with patient feedback, and adjusted or changed until optimal dosage and ongoing outcomes are achieved.

WHAT IS BONA FIDE NFB?

Similar to CBT or Eye Movement Desensitization and Reprocessing (EMDR) therapy, NFB training is currently not standard coursework for a psychologist or psychiatrist's academic degree, so some post-degree level of training is recommended to ensure professional use. The American Psychological Association's recent recognition of biofeedback and psychophysiology as proficiencies in professional psychology (American Psychological Association, 2019) validate a move towards a potential standard.

Further, organizations such as the Biofeedback Certification International Alliance (BCIA) offer robust certification programs (Biofeedback Certification International Alliance, 2020); and other organizations, such as ISNR, publish a code of ethics that outlines qualification recommendations for professional NFB practitioners including, "members who treat medical or psychological conditions must demonstrate professional competence and relevant licensure as defined by applicable local, state, and national licensing/credentialing laws" (International Society for Neuroregulation and Research [ISNR], 2020a). ISNR also hosts a member directory of licensed, certified practitioners (ISNR, 2020b). The AAPB publishes a Code of Ethics and Standards for Performing Biofeedback (Association of Applied Psychophysiology and Biofeedback, 2020), as well as a menu of references and resources for certification, equipment, insurance, practitioners, and so forth.

The FDA considers any professional EEG NFB or biofeedback equipment to be a medical device, and therefore may only be sold to authorized dealers or licensed/certified practitioners. Those seeking NFB treatment for ADHD or other stress- and adjustment-related symptoms should use the above listed association resources as a starting point for finding a qualified practitioner. As a safety threshold, a bona fide NFB practitioner would be a licensed clinician or therapist and have NFB certification from BCIA.

NFB TREATMENT HAS MINIMAL SIDE EFFECTS AND RISKS

NFB's side effects are minimal when administered by a certified professional. There are no known long-term risks or side effects associated with proper, certified NFB treatment. However, below are limited considerations related to transient side effects.

Typical possible transient side effects that any BCIA-certified practitioner would be aware of are headache and tiredness. Any side effects are best dealt with by adjusting protocol, or in the rare case, discontinuing treatment if a better solution is not available. Similarly, side effects or unintended effects occurring from, say, a Selective Serotonin Reuptake Inhibitor known as SSRI medication (a common type of antidepressants) prescribed by a psychiatrist, or hypertension medicine prescribed by a cardiologist would prompt a change in dosage or protocol in an effort to achieve similar or better positive results without negative outcomes. Adjusting treatment in response to side effects is not unique to NFB, and should be practiced with any treatment by any medical practitioner as a basic clinical skill.

A fair amount of research has been done to evaluate potential side effects from NFB, both applied correctly and potentially incorrectly. For example, to evaluate the potential risks of NFB treatment protocols that modulate SMR brainwaves (typical for ADHD) and upper alpha brainwaves (typical for relaxation), a 2015 study was conducted outside standard NFB protocols on subjects by increasing the amplitude of said waves beyond the norm (Rogel et al., 2015). In other words, this test procedure increased the "dose" to be significantly greater than the prescribed protocol. After 10 sessions, twice a week for 5 weeks, the most commonly reported adverse effects were headaches, followed by tiredness, mood swings, as well as feeling high. A few subjects had nightmares, eye aches or nausea. All of these effects were transient, dissipating quickly following the end of the exaggerated treatment.

As with any medical or therapeutic modality, improper NFB application or provider negligence can lead to ill effects or even harm. Similarly, medical mistakes such as wrongly prescribing medication or botching a surgery can also cause harm. However, unlike ingesting the wrong medication or undergoing an incorrect surgery, with NFB, the risks of potential mistakes are typically mild, such as headaches and tiredness, and transient, passing quickly. These ill effects are also quickly detectable and protocols can be easily modified to address them.

In summary, the side effects or risks involved with NFB treatment administered by a trained and competent provider can be considered to be extremely low, especially compared to the risks associated with other medical interventions and procedures.

NFB: SHAM OR THE REAL DEAL?

Over NFB's seven decades of research, just like all standard treatments, there have been some studies that have indicated a lack of efficacy. Several of the studies that initially reported no difference between NFB and sham treatments have since been shown to have design flaws or to lack evidence of an absence of effect. In some other studies, researchers who once concluded NFB's inefficacy have in more recent years published new findings underscoring its value as a treatment intervention. Based on the full review of evidence, this report concludes that there is sufficient evidence that reinforces NFB's efficacy. Below is a closer look at the top reservations some researchers have had about NFB and why a deeper dive into these concerns still show NFB to be a viable treatment.

Despite empirical evidence to the contrary, some critics of NFB are concerned that research findings are problematic. This concern has grown largely out of the fact that NFB research does not include any large-scale studies. There are, however, hundreds of smaller studies that show efficacy. Additionally, since 2018, two distinct meta-analyses—regarded as a higher level of evidence than single studies or large trials by clinical associations such as the American Medical Association—found NFB to be an effective treatment for ADHD, and further to have sustained effects after treatment has ended (Van Doren et al., 2018; Arns et al, 2020).

Some of the researchers in the field who, 10 to 15 years ago, were skeptical or even critical of NFB as a first-line treatment (Loo & Makeig, 2012), have now co-authored a paper in support of NFB as a treatment for ADHD. The recent publication supports NFB as a valid treatment offering long-term improvements as it states, "Compared to non-active control treatments, [NFB] appears to have more durable treatment effects, for at least 6 months following treatment" (Van Doren et al., 2018).

Further, attempts to discredit NFB as an effective treatment for ADHD or other disorders have typically tried to apply one protocol for all conditions and patients. This is an invalid approach, as a key requirement for effective NFB treatment is adjusting protocols to the individual, much in the same way that medication dosage would be adjusted to the individual.

Some skepticism is related to the subjective nature of evaluating treatment outcomes for ADHD. Symptoms and outcomes of children's ADHD-related behavior are most frequently evaluated by parents and teachers, and therefore not evaluated using blinded study measures. In other words, during some of the studies, the parents or teachers reporting on improvements may know that their child is receiving NFB, which has the potential to bias their impression of any improvement in outcomes. As such, an argument against NFB's positive research outcomes would state that because the parents knew the children were receiving NFB treatment, they could have falsely perceived improvements. This could be grounds to consider whether or not parent-reported outcomes were real or a form of placebo effect.

In subjective reports about improvements, these biases are possible. However, many NFB studies have sought to eliminate the possibilities of "false readings" by implementing objective measurement tools and behavioral rating scales such as TOVA, IVA, and other computerized performance measures normed on age. TOVA is a continuous performance test that measures how a subject tracks visual stimuli—both target and non-target stimuli—

and produces a quantitative, objective report on levels of inattention, impulsivity and hyperactivity. A 2015 study found, using TOVA scores, that a combination of NFB and medication was more effective than either one alone, and that NFB alone improved executive control more than medication (González-Castro et al., 2015).

The efficacy of NFB as validated by objective measures goes back to the work of NFB pioneer Dr. Joel Lubar, who used TOVA scores in his research on NFB for the treatment of ADHD (Lubar et al., 1995). Similarly, another early study found no significant difference between NFB and Ritalin in treating ADHD as measured by TOVA scores (Rossiter & La Vaque, 1995). More importantly, the same, potentially biased, subjective, parent and teacher reports on improvements in children's ADHD symptoms are also used to measure outcomes for treatment with medication, therapy and other interventions. In fact, due to the social nature of childhood ADHD, parent and teacher observations are critical for monitoring progress, regardless of treatment modality.

Critics would also like to see a single oversight body as well as universal certification required for all NFB practitioners. Board certification is available from BCIA, but practitioners are not required to carry this credential. As such, a universal "stamp of validation" is yet to be defined for the field, and this frustrates some. Such a development for the field may in fact be a good step, but the current absence of it does not diminish the strength of NFB research outcomes. Rather, trained NFB practitioners are similar to generally trained mental health therapists with post-degree specialized training for a specific treatment modality, one that may or may not have a central certifying body or national licensure.

Critics have also taken issue with the lack of a single protocol per condition in NFB. As with other treatments, recommendations for protocols come from clinical studies and can be varied and demonstrate efficacy. Similarly in CBT, a therapist may select from multiple effective protocols when administering or adjusting a treatment plan based on how an individual is presenting and/or responding to an intervention. This report finds multiple, evidence-based protocols a positive aspect of NFB treatment, as practitioners and patients have access to a range of proven treatment protocols that can be used to optimize individual treatment plans.

NFB has been subject to specific types of research studies designed to attempt to disprove the efficacy of a treatment for various conditions, known as sham studies. While some of these studies have sought to discredit NFB as placebo or sham, a more thorough review of the sham research revealed design flaws and failure to prove evidence of an absence of effect. More specifically, some of the sham studies left out key parts of standard treatment protocols or proved that NFB is indeed more effective than placebo.

For example, a 2018 review analyzed six sham-controlled NFB trials that reported no evidence of effect from NFB (Pigott et al., 2018). Upon review, it was determined that in each of the six trials, the methods used prevented participants from getting accurate reward feedback that would allow them to self-neuromodulate through operant conditioning. As described earlier, operant conditioning is the process of learning through feedback or consequence. For NFB, accurate reward feedback for an intended brain state is a necessary and required component for effective "learning" and treatment. In other words, the sham studies conducted a form of NFB outside of the protocols that have been shown to work. This would be analogous to administering medication outside of dose and prescription guidelines.

In the six studies reviewed, rather than accurate, real-time reward feedback as part of the treatment protocol, the NFB system was adjusted every 15 to 30 seconds to give positive reward feedback up to 80% of the time to participants, regardless of performance. Because clear and accurate feedback loops and reward systems are key components of any NFB protocol, a treatment that automatically adjusts rewards upwards would not be considered an accurate application of NFB. In fact, one of the forefathers of NFB for ADHD, Dr. Joel Lubar, was a proponent of lower reward levels for effective NFB treatment as a way to more powerfully rely on operant conditioning to incentivize reward-based neuromodulation.

A more recent study concluding no specific effect of theta-beta ratio (TBR) protocol on ADHD (Arnold et al., 2020) was shown to include a Type III error, or "false no-effect" error (Trullinger et al., 2019). This type of error occurs when a flaw in the study's control group design renders the results inconclusive. In this particular study, the authors found that NFB treatment did not differ substantially from the control group treatment. However, the control group in this study actually showed a substantial improvement in ADHD symptoms comparable to improvements seen by combined medication and behavioral treatment in previous studies. In other words, the control group was a fully active treatment, comparable to medication and behavioral therapy, not an inactive or inert treatment. In this study, then, NFB was found to be not substantially different in its effects as compared to a fully active treatment for ADHD. This means that the authors found a "false no-effect," as the design of the control group did not allow them to truly determine that NFB was ineffective.

By comparison, the volume of published research that shows efficacy for NFB as a treatment, particularly for ADHD, eclipses the few sham studies that exist (Perl & Perl, 2019). The discrepancies inevitably come down to study design. In cases where proper protocols and application are followed, a significant degree of effectiveness results.

NFB has at times been over-championed by proponents who let their enthusiasm trump research and who have made exaggerated treatment claims, triggering some of the sham studies previously mentioned and seeding doubt about the treatment modality. However, time and time again, valid research studies show that NFB applied by certified medical or mental health practitioners within defined protocols and standards, over a period of time, is highly efficacious at treating ADHD and effective at treating other stress- and adjustment-related disorders.

Recommendations

Even with a strong evidence-base, NFB is still not fully adopted as a first-line or adjunct treatment for ADHD and anxiety. Meanwhile, the behavioral health arena remains desperate for effective treatment options as rates of disorders continue to rise. In part, the diversity of NFB techniques and applications, along with the complexity of the intersection of brain science and novel technology, have presented obstacles for easily understanding NFB. However, the medical and mental health fields are obligated to overcome these challenges, as patients deserve and need access to the full range of efficacious treatments available today. To help ensure NFB is broadly accessible this report makes the following recommendations:

1

CONSUMERS AND PATIENTS MAKE THEIR INTEREST IN NFB CLEAR TO PROVIDERS

With growing awareness of neuroplasticity and brain health and fitness, consumers and patients can advocate for medical and psychological practitioners to make NFB part of a broader standard toolkit to address mental health, brain fitness, and well-being. By directing providers to this brief and other NFB resources, including the websites of state, regional, and (inter)national professional associations for NFB and biofeedback, the public can greatly influence the attention providers pay to this intervention.

2

PROVIDERS AND PAYERS RECOGNIZE NFB THROUGH TREATMENT OPTIONS AND COVERAGE

The fastest path to clinical and responsible access is for insurance companies and medical providers to acknowledge NFB as a first-line or adjunct treatment for patients with ADHD or stress- and adjustment-related symptoms. This means taking action toward greater access and affordability through more practitioners offering/referring NFB and by more insurance companies covering the treatment. Increasing coverage of NFB would also help in the battle to reduce rates of behavioral health conditions across the population and give insurance companies an opportunity to come into greater compliance with the MHPAEA parity law.

With advances in technology and technique in the field of NFB, and more rigorous certification available to ensure treatment standards (Biofeedback Certification International Alliance, 2020) there has never been a better time to increase adoption of NFB into the mental and behavioral health treatment paradigms for ADHD and anxiety, and as a treatment for improving brain health and well-being.

Appendices

Appendix A: What Are Brainwaves?

In NFB, brainwaves are the markers of overall brain activity that indicate regulated or deregulated states of brain fitness or behavioral health. Brainwaves are patterns of neural activity generated by the central nervous system also referred to as neural oscillations. These oscillations are electrical pulses that occur as a result of spontaneous nerve cell firings reflecting the communication between different areas of the brain. The electrical pulses can be detected by EEG technology, and together with specialized computer analytic software, form brainwave activity readings such as frequency and amplitude.

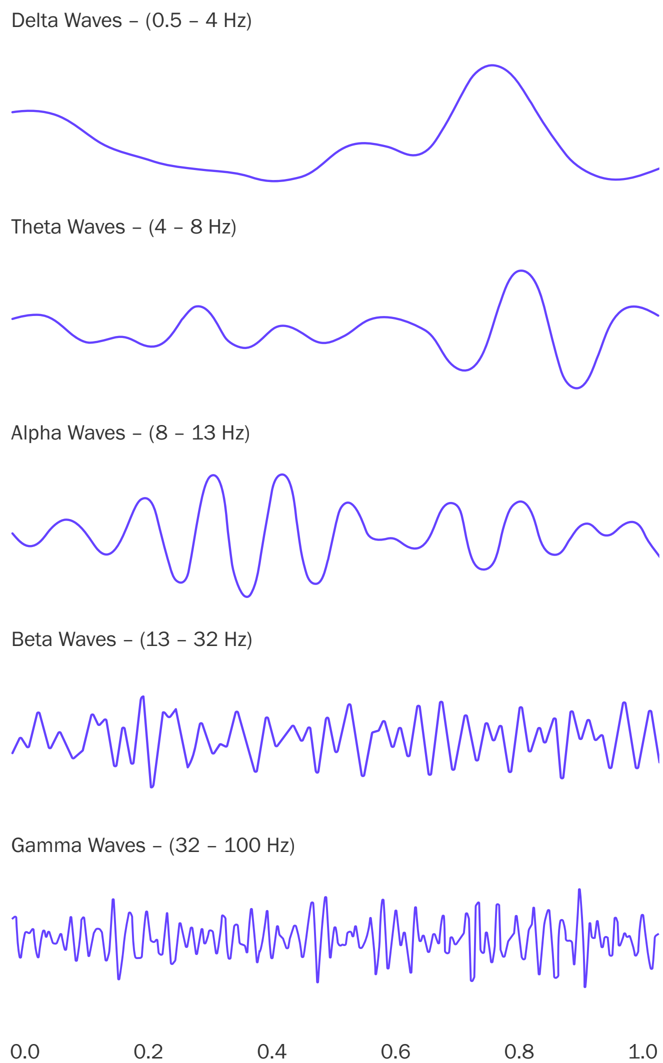
Frequency is a count of how often a brainwave repeats—how many times a wave completes its pattern in a given period. Frequency is measured in units of Hertz (Hz), which are equal to the number of cycles per second. One cycle per second equals 1 Hz. If a wave has a frequency of 5 Hz, it completes its wave cycle five times every second.

Amplitude is the height of the wave, and can grow taller or shorter, depending on brain activity, without changing frequency. Amplitude can be thought of as volume or intensity. Higher amplitude tends to be "louder," or more easily detected. Changes in amplitude are the primary unit of measurement in quantitative EEG data—how much the intensity of size of a wave has increased or decreased.

Brainwaves are divided up into different categories as defined by their frequency ranges and where they occur in particular regions of the brain. How brain regions and brainwaves communicate to other specific regions can be correlated to specific types of human perceptions, motor, or thought activity. The five primary commonly referred brainwave types (see Figure 5) are: delta, theta, alpha, beta, and gamma. Beyond the five primary waves, additional, more specific brainwaves like Sensorimotor Rhythm (SMR), are also used in NFB and neuroscience. A more complete list of brainwaves that may be applicable to specific NFB treatments can be found in Figure 6.

FIGURE 5: BRAINWAVES

Different Types of Brainwaves: Delta, Theta, Alpha, Beta, Gamma : Itsu Sync, Brainwave Entrainment and Binaural Beats. (n.d.). Itsusync.com. https://itsusync.com/different-types-of-brain-waves-delta-theta-alpha-beta-gamma-ezp-9



NFB protocols for ADHD or other conditions are precise, and work with specific brainwaves or sets of brainwaves. For example, theta waves are more present in a dreamy, sleepy, distracted state while beta waves are more present in a focused, alert state. Several effective protocols for treating ADHD involve training the theta/beta ratio (TBR) into states that alleviate dysregulation and reduce ADHD symptoms. These TBR protocols typically involve decreasing levels of theta waves in relation to levels of beta waves, or increasing beta in relation to theta. Successful treatment using this type of protocol would decrease inattention and distractibility (lower theta), and increase alertness and focus (higher beta). Achieving this repeatedly over time can result in lasting mental, behavioral, academic, and brain fitness changes. In a different approach, treatments for anxiety would employ protocols that target and enhance alpha waves, which are related to relaxation and peacefulness.

To fully understand brainwaves, how they work in the brain, their interdependent relationships and how they correlate to different emotions and behaviors is a deep dive into neuroscience, and beyond the scope of this paper. This cursory overview should suffice to offer a basic understanding of why NFB works with brainwaves. Brainwaves are detected and recorded by EEG, which senses the unique electrical signals of different brainwaves and feeds data into an interface that measures, tracks and informs feedback loops. The location of EEG sensors on the head, as referenced in Appendix B, is also an important consideration, because similar to how brainwaves correlate to experiential states, the different areas of the brain correlate to generalized behaviors and experiences. Taking EEG readings of the correct waves at the correct locations on the head is an important component of efficacious protocols for treatment of ADHD and other conditions.

FIGURE 6: COMMON BRAINWAVES

Marzbani, H., Marateb, H., & Mansourian, M. (2016). Methodological Note: Neurofeedback: A Comprehensive Review on System Design, Methodology and Clinical Applications. *Basic and Clinical Neuroscience Journal*, 7(2). https://doi.org/10.15412/j.bcn.03070208

Common brainwave frequency	Frequency range (Hz)	General characteristics
Delta	1-4	Sleep, repair, complex problem solving, unawareness, deep-unconsciousness
Theta	4-8	Creativity, insight, deep states, unconsciousness, optimal meditative state, depression, anxiety, distractibility
Alpha	8-13	Alertness and peacefulness, readiness, meditation, deeply-relaxed
Lower alpha	8-10	Recalling
Upper alpha	10-13	Optimize cognitive performance
SMR (sensorimotor rhythm)	13-15	Mental alertness, physical relaxation
Beta	15-20	Thinking, focusing, sustained attention, tension, alertness, excitement Intensity, hyperalertness, anxiety
High beta	20-32	Intensity, hyperalertness, anxiety
Gamma	32-100 or 40	Learning, cognitive processing, problem solving tasks, mental sharpness, brain activity, organize the brain

Appendix B: EEG Electrode Placement

As mentioned in the main report, electrodes are sensors placed on the head of a patient to measure brainwaves and help facilitate feedback from NFB devices to the brain regarding targeted brain states. Specific areas of the skull and face are defined and correspond to specific brain regions and brainwaves. To label these for EEG-NFB treatment, electrode placement points are depicted with letters and numbers that identify areas of the brain (See Figures 7 and 8).

The letters F, P, T, O, and C correspond to the frontal, parietal, temporal, occipital, and central areas of the brain. Numbers identify the hemisphere of the brain—odd numbers for the left hemisphere and even numbers for the right. In addition, the subtext z instead of a number indicates a point that is along the central channel between the hemispheres. The letter A indicates the ear region, used for ground and/or reference electrodes.

As an example, F4 would be a point on the right side of the head over the frontal lobe, P3 would be a point on the left side of the head over the parietal lobe. A1 and A2 are the left and right reference areas near or on the ear, and Fz and Pz would be points along the centerline of the skull over the frontal and parietal lobes, respectively.

A treatment protocol would not only indicate which brainwaves to target at what frequencies and amplitude, but also where EEG readings should be taken on the scalp—in other words, the specific points for mounting electrodes. Depending on the equipment and treatment protocol, NFB practitioners typically connect 2 to 19 electrodes for EEG-NFB. More detailed brain reading EEG applications may use more electrodes.

FIGURE 7: LOCATION OF EEG POINTS ON THE HEAD

Sharbrough, F. (1991, January). American Electroencephalographic Society guidelines for standard electrode position nomenclature. *Journal of Clinical Neurophysiology*, 8, 200-202.

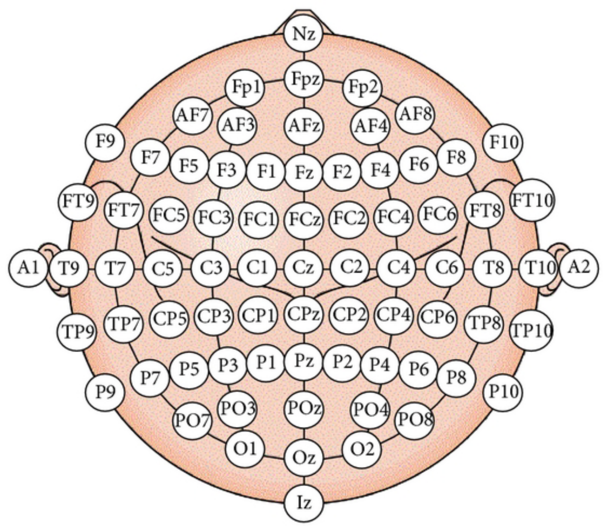
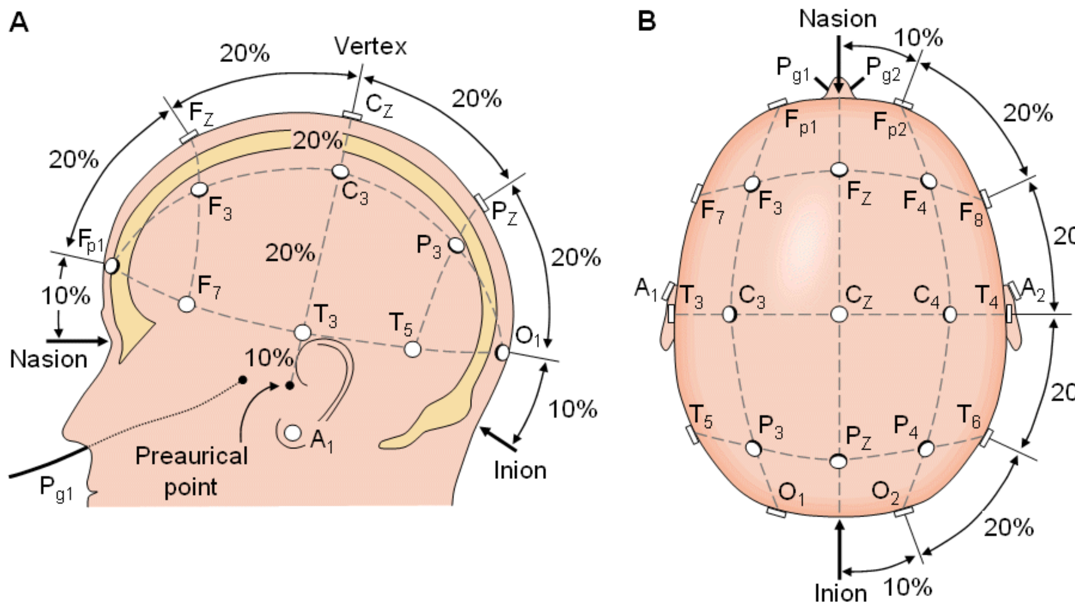


FIGURE 8: LOCATION OF EEG POINTS, SIDE VIEW

Malmivuo, J. & Plonsey, R. (1995). *Bioelectromagnetism –Principles and Applications of Bioelectric and Biomagnetic Fields*. Oxford University Press. http://www.bem.fi/book/13/13.htm



Appendix C: Brain Regions and Functions

In addition to unique brainwaves correlating to emotional and behavioral characteristics, areas of the brain (or lobes) correspond to different human functions and experiences (See Figure 9 and 10). The following are simplified ways to describe the lobes of the brain and the primary functions they often serve:

- Frontal lobes relate to sustained attention, time management, working memory, executive function, social skills, emotion and empathy.
- Parietal lobes process problem-solving, naming objects, complex language and speech, as well as mathematical processing.
- Temporal lobes are more uniquely divided. The left temporal lobe works with reading, learning and memory, and positive mood. The right temporal lobe processes facial recognition, anxiety, sense of direction and music.
- Occipital lobes hold visual memories and other recall, as well as traumatic experiences and flashbacks, seeing colors, identifying objects, writing, spelling and recognizing familiar environments.
- The central area of the brain holds the sensorimotor cortex which controls motion and body movements used in playing an instrument, typing, writing, operating machinery, speaking and being aware of one's own physical body.

This is by no means a comprehensive description of the brain areas and their functions, but an outline of the essential roles of different brain areas. NFB uses neuroscience—the brain function by area, and the behavioral or symptomatic experiences correlated to brainwaves—to develop relevant treatment protocols. Treatment protocols use evidence-based standards to work very specifically with these brain elements towards efficacious and proven outcomes. Professional NFB treatments are in no way random or imprecise; they are specific and based on research findings.

FIGURE 9: PRIMARY BRAIN REGIONS

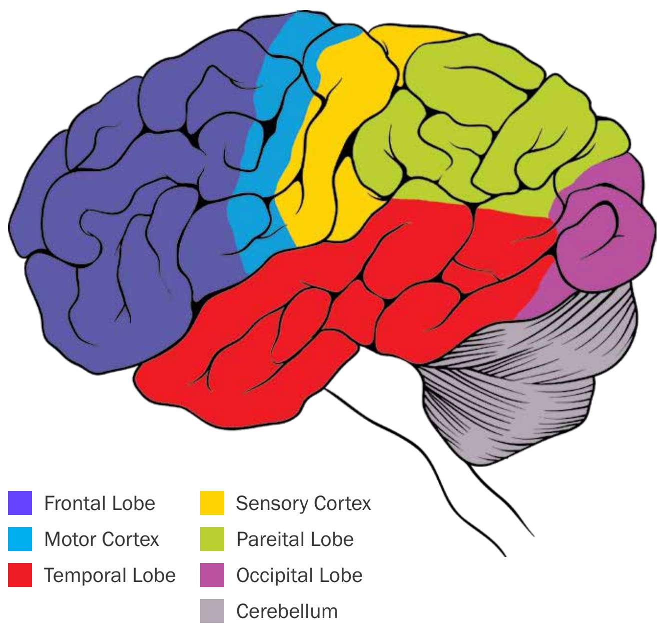


FIGURE 10: BRAIN LOBES, EEG SITES AND RELATED FUNCTIONS

Demos, J. N. (2005). *Getting started with neurofeedback*. WW Norton & Company.

	Sites	Functions	Considerations
Parietal lobes	P_Z P_3 P_4	LH: Problem solving, math, complex grammar, attention, association RH: Spatial awareness, Geometry	Dyscalculia sense of direction learning disorders
Frontal lobes	F_{P1} F_{P2} F_{PZ} F_z F_3 F_4 F_7 F_8	LH: Working memory, concentration, Executive planning, positive emotions RH: Episodic memory, social awareness Fontal poles: attention judgment	LH: Depression RH: Anxiety, fear, executive planning, poor executive functioning
Temporal lobes	T_3 T_4 T_5 T_6	LH: Word recognition, reading, language, memory RH: Object recognition, music, social cues Facial recognition	Anger, rage, dyslexia, long-term memory, closed head injury
Occipital lobes	O_Z O_1 O_2	Visual learning, reading, parietal-temporal-occipital functions	Learning disorders
Sensorimotor cortex	C_z C_3 C_4	LH: Attention, mental processing, RH: Calmness, emotion, Empathy Combined: Fine motor skills, manual dexterity, sensory and motor integration and processing	Paralysis (stroke), seizure disorder, poor handwriting, ADHD symptoms
Cingulate gyrus	F_{PZ} F_Z C_Z P_Z O_Z	Mental flexibility, cooperation, attention, motivation, morals	Obsessions, compulsions, tics, perfectionism, worry, ADHD symptoms, OCD & OCD spectrum
Broca's area	F_7 T_3	Verbal expression	Dyslexia, poor spelling, poor reading
Left hemisphere	All odd numbered sites	Logical sequencing, detail oriented, language abilities, word retrieval, fluency, reading, math, science, problem solving, verbal memory	Depression (underactivation)
Right hemisphere	All even numbered sites	Episodic memory encoding, social awareness, eye contact, music, humor, empathy, spatial awareness, art, insight, intuition, non-verbal memory, seeing the whole picture	Anxiety(overactivation)

Appendix D: Quantitative and Statistical NFB Measures

Due to the complexity of the brain, its different regions, different brainwaves and what they indicate, several unique protocols could be used for the treatment of the same condition, depending on diagnosis, symptoms, and intended outcomes. As with the treatment of any condition under any modality, the first steps are evaluation and diagnosis, and then treatment plan and goals, at which point the practitioner, depending on training and approach, would determine the best course of NFB treatment. Initial treatments would be evaluated for effectiveness and adjusted as needed to help the patient approach a healthier status/state or reduction of symptoms.

How brainwave data is analyzed and a treatment is validated depends on the technique for measuring and evaluating EEG output. A variety of methods exist but all fundamentally fall into one of two categories: quantitative or derivative, roughly speaking.

QUANTITATIVE MEASUREMENTS

Quantitative EEG is the most commonly used measurement and evaluation technique. This technique reads amplitude and other measures as a direct measure and indicator of a brainwave's character relative to another reference or location, such as the earlobe, that does not produce electrical activity or relative to other active areas of the brain. As treatment progresses, the quantitative measures—meaning increases or decreases in brainwaves as indicated by these measurements—show progress towards or away from the protocol-defined target values being achieved. Following are some examples of quantitative NFB measures often derived and monitored in treatment:

- **Sensorimotor Rhythm (SMR)** – This is the idle rhythm for the motor strip in the brain. Typically, as this rhythm increases, a person becomes more relaxed. SMR is a primary measurement/wave in many NFB treatments for ADHD.
- **Theta/Beta Ratio (TBR)** – This measurement was created by Dr. Joel Lubar of the University of Tennessee in the 1970s. It measures the relationship between theta waves and beta waves across the frontal and central areas of the brain. A higher ratio is indicative of ADHD, meaning theta waves—associated with dreaming and distraction—are greater relative to beta waves—associated with focus and attention. As beta increases relative to theta, the ratio value goes down. A lower ratio corresponds to reduced symptoms and/or remission of ADHD symptoms, and often improvements in behavioral and academic outcomes. In 2013, the FDA approved TBR as a marker for the diagnosis of ADHD as part of the Neuropsychiatric EEG-Based Assessment Aid for ADHD (NEBA) system. This is the only brain-based diagnostic tool for assessing ADHD.
- **Slow Cortical Potentials (SCP)** – This is a measurement of low frequency brain activity, usually less than 1 Hz, that is generated primarily by glial cells, a group of non-neuronal cells that maintain balance in brain health and brain activity. SCPs can be used to evaluate and influence the overall health and functioning of the brain.
- **Alpha/Theta Protocol (A/T)** – This protocol was developed by Peniston and Kulkosky and first used for the treatment of alcoholism in Vietnam veterans. A/T is also used to reduce symptoms of anxiety and PTSD. The protocol could involve increasing both waves or only alpha waves, depending on the treatment application. This protocol can be used for treatment of stress- and adjustment-related symptoms.

DERIVATIVE AND STATISTICAL MEASUREMENTS

Other methods of data analysis fall into the category of derivative and statistical measurements. These techniques measure multiple variable quantitative outputs and use complex calculations to find statistical output readings that can be compared to normative databases or translated into 3D imaging, among other uses. Following are examples of some of the derivative methods:

- **Z-Score Training** – This is a complex calculation of multiple variable measurements from at least four electrodes that looks at how a brain is functioning compared to a normative database of "healthy" brain behavior. The treatment can be used to reward the brain toward a healthier state for various conditions.
- **LORETA** – Refers to low-resolution electromagnetic tomography. This technique uses EEG frequency measurements to create a 3-dimensional, color-coded image of the brain. Typically, at least 19 electrodes are used to generate enough data to estimate current density in various brain areas. This is a brain-mapping technique for visual reference to brain states and changes in brain activity.
- **Infra-low Frequency (ILF) and Infra-slow Fluctuation (ISF)** – These terms refer to very low brain frequencies, below 0.1 Hz only recently detectable and trainable through advances in brainwave amplification technology. The idea is that the lowest base frequencies in the brain influence all the frequencies above it. Since the higher frequencies are harmonics of the lower frequencies, by training the low frequencies, the whole brain benefits.
- **Multichannel Coherence** – This newer method of measuring and using qEEG data can be thought of as neurofeedback 2.0. Whereas in a typical NFB setup, a single stream of data is processed and used for feedback and rewards, with Mulitchannel (or Multivariate) NFB, two or more data streams are being used to create different feedback systems simultaneously. In this way, the research suggests that, during a single session, the brain can be trained in more than one way at the same time (Coben et al., 2018).

Appendix E: NFB Treatment Protocols for ADHD and Other Conditions

The majority of research that shows successful treatment of ADHD with NFB uses TBR, SMR, or a combination of both. The tables in Figure 11 show some of the significant studies and include the treatment site on the head, number of sessions, age of children, and outcomes.

FIGURE 11: NFB TRAINING PROTOCOLS

Marzbani, H., Marateb, H., & Mansourian, M. (2016). Methodological Note: Neurofeedback: A Comprehensive Review on System Design, Methodology and Clinical Applications. *Basic and Clinical Neuroscience Journal*, 7(2). https://doi.org/10.15412/j.bcn.03070208

ADHD NFB Training Protocols for Children

Study	Site of Treatment	NFB Protocol	# of Sessions	Age Range in Years	Outcome
Linden, Habib, & Radojevic, 1996	CZ	Enhance beta Inhibit theta	20	5-15	Improvement in mental functions and accuracy
Palsson et al., 2001	CZ	Theta/beta, SMR	40	9-13	Improvement in effects of ADHD
Orlandi, 2004	CZ	Theta/beta, SMR	40	9-11	Improvement in attention, focus and memory
Lévesque, Beauregard, & Mensour, 2006	CZ	Theta/beta, SMR	40	8-12	Improving performance of anterior cingulate cortex
Leins et al., 2007	CZ	Theta/beta	30	8-13	Improvement in attention, hyperactivity and distraction
Gevensleben et al., 2009	CZ	Theta/beta	18	9-12	Improvement in combined treatment of neurofeedback protocols
Perreau-Linck, Lessard, Lévesque, & Beauregard, 2010	CZ	Theta/SMR	40	8-13	Improvement in the effects of ADHD

Beta Training Protocols for Various Cognitive Performance Improvements

Study	Site of Treatment	NFB Protocol	# of Sessions	Outcomes
(Rasey, Lubar, McIntyre, Zoffuto, & Abbott, 1995)	Central-posterior region (CPZ , PCZ)	Enhance beta (16-22 Hz) and inhibit high theta and low alpha	20	Improvement in attentional performance
(Egner & Gruzelier, 2001)	(12-15 Hz) at right central region (C4) and (15-18 Hz) at the left central region (C3)	Enhance low beta (12-15 and 15- 18 Hz), inhibiting theta (4-7 Hz) and high beta (22-30 Hz)	10	Successful enhancement of attentional performance
(Vernon et al., 2003)	CZ	Enhance low beta (12-15 Hz), inhibiting theta (4-8 Hz) and high beta (18-23 Hz)	15	Enhance cognitive performance
(Egner & Gruzelier, 2001)	CZ	Enhance SMR (12-15 Hz) and inhibit theta (4-7 Hz) and high beta (22-30 Hz)	10	Improve perceptual sensitivity
(Egner & Gruzelier, 2001)	CZ	Enhance low beta (15-18 Hz), inhibiting theta (4-7 Hz) and high beta (22-30 Hz)	10	Increase cortical arousal
(Vernon et al., 2003)	CZ	Enhance SMR (12-15 Hz) and inhibit theta (4-7 Hz) and high beta (18-22 Hz)	8	Increased recall in semantic working memory
(Lubar, Swartwood, Swart-wood, & O'Donnell, 1995)	FCZ , CPZ	Enhance beta (16-20 Hz) and inhibit theta	40	Reduction of inattention, hyperactivity and impulsivity
(Fuchs, Birbaumer, Lutzen-berger, Gruzelier, & Kaiser, 2003)	C3 , C4	Enhance beta (15-18 Hz) and SMR (12-15), inhibit theta	36	Improvement in attention and intelligence
(Heinrich, Gevensleben, & Strehl, 2007)	C4, CZ	Enhance SMR and inhibit theta		Treatment epilepsy disorder and ADHD
(Heinrich, Gevensleben, & Strehl, 2007)	CZ , C3	Enhance beta (13-20 Hz) and inhibit theta		Treatment ADHD

References

American Medical Association. (2017). Criteria for CPT® Category I and Category III codes. https://www.ama-assn.org/practice-management/cpt/criteria-cpt-category-i-and-category-iii-codes

American Psychological Association. (2019). Biofeedback and Applied Psychophysiology. https://www.apa.org/ed/graduate/specialize/biofeedback

American Psychological Association. (2016). Stress in America: The impact of discrimination. Stress in America™ Survey, 2016.

Anxiety and Depression Association of America [ADAA]. (n.d.) Facts & Statistics. https://adaa.org/about-adaa/press-room/facts-statistics

Anxiety Disorders: Rethinking and Understanding Recent Discoveries. (2020). In Y.-K. Kim (Ed.), www.springer.com. Springer Singapore. https://www.springer.com/gp/book/9789813297043

Arnold, L. E., Hodgkins, P., Kahle, J., Madhoo, M., & Kewley, G. (2015). Long-Term Outcomes of ADHD. Journal of Attention Disorders, 20(4), 293–305. https://doi.org/10.1177/1087054714566076

Arnold, L. E., Arns, M., Barterian, J., Bergman, R., Black, S., Conners, C. K., Connor, S., Dasgupta, S., deBeus, R., Higgins, T., Hirshberg, L., Hollway, J., Kerson, C., Lightstone, H., Lofthouse, N., Lubar, J., McBurnett, K., Monastra, V., Buchan-Page, K., ... Williams, C. E. (2020, August 24). Double-Blind Placebo-Controlled Randomized Clinical Trial of Neurofeedback for Attention-Deficit/Hyperactivity Disorder With 13 Month Follow-up. Journal of the American Academy of Child & Adolescent Psychiatry. https://doi.org/10.1016/j.jaac.2020.07.906

Arns, M., Clark, C. R., Trullinger, M., deBeus, R., Mack, M., & Aniftos, M. (2020). Neurofeedback and Attention-Deficit/Hyperactivity-Disorder (ADHD) in Children: Rating the Evidence and Proposed Guidelines. Applied Psychophysiology and Biofeedback, 45(2), 39–48. https://doi.org/10.1007/s10484-020-09455-2

Arns, M., Heinrich, H., & Strehl, U. (2014). Evaluation of neurofeedback in ADHD: The long and winding road. Biological Psychology, 95, 108–115. https://doi.org/10.1016/j.biopsycho.2013.11.013

Arns, M., de Ridder, S., Strehl, U., Breteler, M., & Coenen, A. (2009). Efficacy of Neurofeedback Treatment in ADHD: The Effects on Inattention, Impulsivity and Hyperactivity: A Meta-Analysis. Clinical EEG and Neuroscience, 40(3), 180–189. https://doi.org/10.1177/155005940904000311

Association of Applied Psychophysiology and Biofeedback. (2020). Standards for Performing Biofeedback - AAPB. www.aapb.org. https://www.aapb.org/i4a/pages/index.cfm?pageid=3678

Bialik, M. (2015). Meta-Learning: The Importance of Thinking about Thinking. https://www.learningandthebrain.com/blog/meta-learning

Benioudakis, E. S., Kountzaki, S., Batzou, K., Markogiannaki, K., Seliniotaki, T., Darakis, E., Saridaki, M., Vergoti, A., & Nestoros, J. N. (2016). Can Neurofeedback Decrease Anxiety and Fear in Cancer Patients? A Case Study. Postępy Psychiatrii i Neurologii, 25(1), 59–65. https://doi.org/10.1016/j.pin.2015.12.001

Bhat, P. (2010). Efficacy of Alfa EEG wave biofeedback in the management of anxiety. Industrial Psychiatry Journal, 19(2), 111. https://doi.org/10.4103/0972-6748.90341

Biofeedback Certification International Alliance. (2020). Biofeedback Certification. https://www.bcia.org/i4a/pages/index.cfm?pageid=3373

Brennar, G.H. (2018, October 2). Global Use of ADHD Medication Is Rising. Psychology Today. https://www.psychologytoday.com/us/blog/psychiatry-the-people/201810/global-use-adhd-medication-is-risin

Centers for Disease Control and Prevention [CDC]. (2018a, December 20). Data and Statistics on Children's Mental Health. https://www.cdc.gov/childrensmentalhealth/data.html

CDC. (2018b, September 21). Data and Statistics About ADHD. https://www.cdc.gov/ncbddd/adhd/data.html

CFR - Code of Federal Regulations Title 21. (n.d.). www.accessdata.fda.gov. https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm?fr=882.5050

Children and Adults with Attention-Deficit/Hyperactivity Disorder (CHADD). (2020). General Prevalence of ADHD. https://chadd.org/about-adhd/general-prevalence/

CMS.gov. (n.d.). The Center for Consumer Information & Insurance Oversight, Mental Health Parity and Addiction Equity Act (MHPAEA). https://www.cms.gov/CCIIO/Programs-and-Initiatives/Other-Insurance-Protections/MHPAEA

Coben, R., Middlebrooks, M., Lightstone, H., & Corbell, M. (2018, October 11). Four Channel Multivariate Coherence Training: Development and Evidence in Support of a New Form of Neurofeedback. Frontiers in Neuroscience, 12. https://doi.org/10.3389/fnins.2018.00729

Currie, J., Stabile, M., & Jones, L. (2014, September). Do stimulant medications improve educational and behavioral outcomes for children with ADHD? Journal of Health Economics, 37, 58–69. https://doi.org/10.1016/j.jhealeco.2014.05.002

Dadashi, M., Birashk, B., Taremian, F., Asgarnejad, A. A., & Momtazi, S. (2015, January). Effects of increase in amplitude of occipital alpha & theta brainwaves on global functioning level of patients with GAD. Basic and Clinical Neuroscience, 6(1), 14–20. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4741268/

Danielson, M. L., Visser, S. N., Chronis-Tuscano, A., & DuPaul, G. J. (2018, January). A national description of treatment among United States children and adolescents with attention-deficit/hyperactivity disorder. The Journal of Pediatrics, 192, 240–246. https://pubmed.ncbi.nlm.nih.gov/29132817/

Davenport, S., Gray, T.J., and Melek, S.P. (2020, August 13). How do individuals with behavioral health conditions contribute to physical and total healthcare spending? Milliman, Inc. https://www.milliman.com/en/insight/How-do-individuals-with-behavioral-health-conditions-contribute-to-physical

Duric, N. S., Assmus, J., Gundersen, D., & Elgen, I. B. (2012, August 10). Neurofeedback for the treatment of children and adolescents with ADHD: a randomized and controlled clinical trial using parental reports. BMC Psychiatry, 12(1). https://doi.org/10.1186/1471-244x-12-107

Enriquez-Geppert, S., Smit, D., Pimenta, M. G., & Arns, M. (2019, May 28). Neurofeedback as a Treatment Intervention in ADHD: Current Evidence and Practice. Current Psychiatry Reports, 21(46). https://doi.org/10.1007/s11920-019-1021-4

Faridnia, M., Shojaei, M., & Rahimi, A. (2012). The effect of neurofeedback training on the anxiety of elite female swimmers. Annals of Biological Research, 3(2), 1020–1028. https://www.scholarsresearchlibrary.com/articles/the-effect-of-neurofeedback-training-on-the-anxiety-of-elite-female-swimmers.pdf

Fuchs, T., Birbaumer, N., Lutzenberger, W., Gruzelier, JH., & Kaiser, J. (2003, March). Neurofeedback Treatment for Attention-Deficit/Hyperactivity Disorder in Children: A Comparison with Methylphenidate. Applied Psychophysiology and Biofeedback, 28(1), 1–12. https://link.springer.com/article/10.1023%2FA%3A1022353731579

González-Castro, P., Cueli, M., Rodríguez, C., García, T., & Álvarez, L. (2015, August 20). Efficacy of Neurofeedback Versus Pharmacological Support in Subjects with ADHD. Applied Psychophysiology and Biofeedback, 41(1), 17–25(2016). https://doi.org/10.1007/s10484-015-9299-4

Hammond, D. C. (2005, August). Neurofeedback Treatment of Depression and Anxiety. Journal of Adult Development, 12(2–3), 131–137. https://doi.org/10.1007/s10804-005-7029-5

Hodgson, K., Hutchinson, A. D., & Denson, L. (2014, May). Nonpharmacological treatments for ADHD: a meta-analytic review. Journal of Attention Disorders, 18(4), 275–282. https://doi.org/10.1177/1087054712444732

International Society for Neuroregulation & Research [ISNR]. (2020, August 9). ISNR Code of Ethics | Neurofeedback Training Guidance. ISNR. https://isnr.org/interested-professionals/isnr-code-of-ethics

ISNR. (2020, August 9). ISNR Provider Search | Find a Neurofeedback Practitioner. https://isnr.org/find-a-member

Kamiya, J. (1968). Conscious control of brainwaves. Psychology Today, 1, 57–60.

Kennedy Forum. (2020, July 17). Fines hold Illinois insurers accountable for equal coverage of mental health and addiction care. https://www.thekennedyforum.org/blog/fines-hold-illinois-insurers-accountable-for-equal-coverage-of-mental-health-and-addiction-care/

Kerson, C., Sherman, R. A., & Kozlowski, G. P. (2009, September 2). Alpha suppression and symmetry training for generalized anxiety symptoms. Journal of Neurotherapy, 13(3), 146–155. https://www.neurofeedbackclinic.ca/journals/anxiety/anxiety02.pdf

Loe, I. M., & Feldman, H. M. (2007, January). Academic and Educational Outcomes of Children With ADHD. Ambulatory Pediatrics, 7(1), 82–90. https://doi.org/10.1016/j.ambp.2006.05.005

Loo, S. K., & Makeig, S. (2012, July 20). Clinical Utility of EEG in Attention-Deficit/Hyperactivity Disorder: A Research Update. Neurotherapeutics, 9(3), 569–587. https://doi.org/10.1007/s13311-012-0131-z

Lubar, J. F., Swartwood, M. O., Swartwood, J. N., & O'Donnell, P. H. (1995, March). Evaluation of the effectiveness of EEG neurofeedback training for ADHD in a clinical setting as measured by changes in T.O.V.A. scores, behavioral ratings, and WISC-R performance. Biofeedback and Self-Regulation, 20(1), 83–99. https://doi.org/10.1007/bf01712768

Mannuzza, S., & Klein, R. G. (2000, July). Long-term Prognosis in Attention-Deficit/Hyperactivity Disorder. Child and Adolescent Psychiatric Clinics of North America, 9(3), 711–726. https://doi.org/10.1016/s1056-4993(18)30114-7

Manzoni, G. M., Pagnini, F., Castelnuovo, G., & Molinari, E. (2008, June 2). Relaxation training for anxiety: a ten-years systematic review with meta-analysis. BMC Psychiatry, 8(1). https://doi.org/10.1186/1471-244x-8-41

McCormack, H., O'Brien, C., Kennedy, P., Harbin, H., Carneal, J., & Alfred, L. (2015) Promoting Brain Health and Brain Fitness: A National Call for Action. Kennedy Forum. www.thekennedyforum.org/app/uploads/2017/06/issue-brief-Brain_Fitness_160725.pdf

McCormack, H., O'Brien, C. (2019) Brain Fitness and Executive Function: Evidence-Based Interventions That Improve Student Outcomes. BrainFutures. www.brainfutures.org/wp-content/uploads/2020/02/Youth-Issue-Brief-November-2019.pdf

Meisel, V., Servera, M., Garcia-Banda, G., Cardo, E., & Moreno, I. (2013, September). Neurofeedback and standard pharmacological intervention in ADHD: A randomized controlled trial with six-month follow-up. Biological Psychology, 94(1), 12–21. https://doi.org/10.1016/j.biopsycho.2013.04.015

Melek, S., Fsa, Maaa, S., Davenport, M., & Gray. (2019). Addiction and mental health vs. physical health: Widening disparities in network use and provider reimbursement. A deeper analytical dive and updated results through 2017 for 37 million employees and dependents. Milliman Research Report. http://assets.milliman.com/ektron/Addiction_and_mental_health_vs_physical_health_Widening_disparities_in_network_use_and_provider_reimbursement.pdf

Mental Health America. (2020). 2021 | COVID-19 and Mental Health: A Growing Crisis. https://mhanational.org/sites/default/files/Spotlight%202021%20-%20COVID-19%20and%20Mental%20Health.pdf

Mental Health Association of Maryland, MidAtlantic Business Group on Health. (2020, August 13). Groundbreaking New Study Reveals People Diagnosed with Both Behavioral and Physical Health Conditions are Among the Highest-Cost Patients, Yet Less than 5% of Health Care Spending is Directed Toward Behavioral Health Treatment [Press release]. https://www.mhamd.org/news/2020-milliman-press-release/

Micoulaud-Franchi, J.-A., Geoffroy, P. A., Fond, G., Lopez, R., Bioulac, S., & Philip, P. (2014, November 13). EEG neurofeedback treatments in children with ADHD: an updated meta-analysis of randomized controlled trials. Frontiers in Human Neuroscience, 8. https://doi.org/10.3389/fnhum.2014.00906

Millet, D. (2002, June 3). The origins of EEG. Session VI–Anatomical and Physiological Models and Techniques, Seventh Annual Meeting of the International Society for the History of the Neurosciences (ISHN). http://www.bri.ucla.edu/nha/ishn/ab24-2002.htm

Monastra, V. J., Monastra, D. M., & George, S. (2002, December). The effects of stimulant therapy, EEG biofeedback, and parenting style on the primary symptoms of attention-deficit/hyperactivity disorder. Applied Psychophysiology and Biofeedback, 27(4), 231–249. https://doi.org/10.1023/A:1021018700609

Moradi, A., Pouladi, F., Pishva, N., Rezaei, B., Torshabi, M., & Mehrjerdi, Z. A. (2011). Treatment of Anxiety Disorder with Neurofeedback: Case Study. Procedia - Social and Behavioral Sciences, 30, 103–107. https://doi.org/10.1016/j.sbspro.2011.10.021

The MTA Cooperative Group. (1999, December). A 14-month Randomized Clinical Trial of Treatment Strategies for Attention-deficit/hyperactivity Disorder. Multimodal Treatment Study of Children with ADHD. Archives of General Psychiatry, 56(12), 1073–1086. https://jamanetwork.com/journals/jamapsychiatry/fullarticle/205525

National Institute of Mental Health [NIMH]. (2019, February). Major Depression. https://www.nimh.nih.gov/health/statistics/major-depression.shtml

NIMH. (2017a, November). Attention-Deficit/Hyperactivity Disorder (ADHD). https://www.nimh.nih.gov/health/statistics/attention-deficit-hyperactivity-disorder-adhd.shtml

NIMH. (2017b, November 1). Mental Illness. https://www.nimh.nih.gov/health/statistics/mental-illness.shtml

Open Minds. (2020, May 6). The U.S. Mental Health Market: $225.1 Billion In Spending In 2019: An OPEN MINDS Market Intelligence Report. https://www.prnewswire.com/news-releases/2019-us-mental-health-spending-topped-225-billion-with-per-capita-spending-ranging-from-37-in-florida-to-375-in-maine--open-minds-releases-new-analysis-301058381.html

Patrick J Kennedy. (n.d.). Priorities. https://www.patrickjkennedy.net/agenda/

Perl, M., & Perl, D. (2019). EEG amplitude neurofeedback: a review of the research. Asia Pacific Journal of Neurotherapy, 1(1), 44–55. https://apjnt.org/wp-content/uploads/2019/05/David-_Perl_APJNT_Journal_Vol1_No1_2019.pdf

Psych Appeal. (2020, November 4). U.S. Federal Court Orders Special Master and 10-Year Injunctions for UnitedHealthcare Affiliate That Breached Fiduciary Duties. https://www.globenewswire.com/news-release/2020/11/04/2120403/0/en/U-S-Federal-Court-Orders-Special-Master-and-10-Year-Injunctions-for-UnitedHealthcare-Affiliate-That-Breached-Fiduciary-Duties.html

Pigott, H. E., & Cannon, R. (2014). Neurofeedback is the Best Available First-Line Treatment for ADHD: What is the Evidence for this Claim? NeuroRegulation, 1(1), 4–23. https://doi.org/10.15540/nr.11.4

Pigott, H. E., Cannon, R., & Trullinger, M. (2018, August 6). The Fallacy of Sham-Controlled Neurofeedback Trials: A Reply to Thibault and Colleagues (2018). Journal of Attention Disorders, https://doi.org/10.1177/1087054718790802

Rogel, A., Guez, J., Getter, N., Keha, E., Cohen, T., Amor, T., & Todder, D. (2015, September). Transient adverse side effects during neurofeedback training: a randomized, sham-controlled, double blind study. Applied Psychophysiology and Biofeedback, 40(3), 209–218. https://doi.org/10.1007/s10484-015-9289-6

Ros, T., Munneke, M. A., Ruge, D., Gruzelier, J. H., & Rothwell, J. C. (2010, February 15). Endogenous control of waking brain rhythms induces neuroplasticity in humans. European Journal of Neuroscience, 31(4), 770–778. https://doi.org/10.1111/j.1460-9568.2010.07100.x

Rossiter, D. T. R., & La Vaque, T. J. (1995). A Comparison of EEG Biofeedback and Psychostimulants in Treating Attention Deficit/Hyperactivity Disorders. Journal of Neurotherapy, 1(1), 48–59. https://doi.org/10.1300/j184v01n01_07

Sorger, B., Scharnowski, F., Linden, D. E. J., Hampson, M., & Young, K. D. (2019, February). Control freaks: Towards optimal selection of control conditions for fMRI neurofeedback studies. NeuroImage, 186(1), 256–265. https://doi.org/10.1016/j.neuroimage.2018.11.004

Steiner, N. J., Frenette, E. C., Rene, K. M., Brennan, R. T., & Perrin, E. C. (2014, January). Neurofeedback and Cognitive Attention Training for Children with Attention-Deficit Hyperactivity Disorder in Schools. Journal of Developmental & Behavioral Pediatrics, 35(1), 18–27. https://doi.org/10.1097/dbp.0000000000000009

Steiner, N. J., Sheldrick, R. C., Gotthelf, D., & Perrin, E. C. (2011, July). Computer-Based Attention Training in the Schools for Children With Attention Deficit/Hyperactivity Disorder: A Preliminary Trial. Clinical Pediatrics, 50(7), 615–622. https://doi.org/10.1177/0009922810397887

Sulzer, J., Sitaram, R., Blefari, M. L., Kollias, S., Birbaumer, N., Stephan, K. E., Luft, A., & Gassert, R. (2013). Neurofeedback-mediated self-regulation of the dopaminergic midbrain. NeuroImage, 83, 817–825. https://doi.org/10.1016/j.neuroimage.2013.05.115

Trullinger, M., Novian, A., Russell-Chapin, L., & Pradhan, D. (2019, March 25). Perspectives on Type III Statistical Errors: Exaggerating the Effects of Placebo in Neurofeedback. NeuroRegulation, 6(1), 38–41. https://doi.org/10.15540/nr.6.1.38

Van Doren, J., Arns, M., Heinrich, H., Vollebregt, M. A., Strehl, U., & K. Loo, S. (2018, February 14). Sustained effects of neurofeedback in ADHD: a systematic review and meta-analysis. European Child & Adolescent Psychiatry, 28(3), 293–305. https://doi.org/10.1007/s00787-018-1121-4

Vernon, D., Frick, A., & Gruzelier, J. (2004, May). Neurofeedback as a Treatment for ADHD: A Methodological Review with Implications for Future Research. Journal of Neurotherapy, 8(2), 53–82. https://doi.org/10.1300/j184v08n02_04

Wilkes, M.A., Cobb, S.M., Spratt, E.G. (2018, November 20). What Is the Neuropsychiatric EEG-Based Assessment Aid (NEBA) System and How Is It Used in the Diagnosis of Pediatric Attention Deficit Hyperactivity Disorder (ADHD)? In C. Pataki (Ed.), Medscape. https://www.medscape.com/answers/912633-3774/what-is-the-neuropsychiatric-eeg-based-assessment-aid-neba-system-and-how-is-it-used-in-the-diagnosis-of-pediatric-attention-deficit-hyperactivity-disorder-adhd

BRAINFUTURES

BrainFutures was launched in 2015 by the nation's second oldest mental health advocacy organization, the Mental Health Association of Maryland (MHAMD). For more than 100 years, MHAMD has addressed the mental health needs of Marylanders of all ages through programs that educate the public, advance public policy, and monitor the quality of mental healthcare services. Building on this success, and bolstered by a cross-disciplinary advisory board of leading experts, BrainFutures brings together diverse stakeholders, policymakers, funders, and influencers to accelerate and scaffold national adoption of effective practices targeting four main areas: youth, workforce, mental health treatment, and older adults. Breakthroughs in our understanding of the brain have the potential to improve learning outcomes for children, optimize functioning at work, enhance treatment for mental health or substance use problems, and maintain sharp thinking as we age.

BrainFutures writes evidence-based issue briefs and releases recommendations that fill knowledge gaps related to brain-focused applications targeting the above segments of society. These educational resources highlight the latest advances in brain plasticity and how their application is transforming quality of life for people of all ages. Through this process, we not only gain insight from experts and innovators, we also foster support for change, building coalitions and cross-disciplinary collaborations to advance both adoption and access to new breakthrough applications. Ultimately, by informing the public, cultivating influential relationships, and connecting communities of diverse advocates we help propel the change that is needed to make meaningful progress.

BRAINFUTURES