The Impact of Neurofeedback Training on ADHD: A Case Study

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Author Note

I have no conflict of interest to disclose.

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Abstract

This paper evaluates the impact of neurofeedback training on ADHD. Throughout the years, many researchers have tried to assess the impact of neurofeedback training on ADHD; however, studies have suffered from shortcomings in the methodological application and a lack of proper control groups. This study aims to address some of the aforementioned concerns. Questions addressed in this study include: (a) Is neurofeedback an effective intervention for ADHD? (b) Will participants significantly improve their symptoms with the combination of neurofeedback training and treatment as usual? I hypothesized the addition of neurofeedback training would yield more favorable results in reducing symptoms of ADHD, such as impulsivity, attention, and hyperactivity, than pharmacological treatment alone in adolescents 11–17 years old.

Chapter 1

Attention-deficit/hyperactivity disorder (ADHD) is one of the most predominant pediatric neuropsychiatric disorders (Bluschke et al., 2016; Danielson et al., 2018; Serrano-Troncoso et al., 2013). The *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) highlights the main symptoms of ADHD disorder, including impulsivity, inattention, and hyperactivity that lead to multiple functional impairments (American Psychiatric Association [APA], 2013; Danielson et al., 2018). Among these functional impairments include deficits in executive functions, working memory, deficits in information processing, auditory temporal processing, and inhibitory functions (Bluschke et al., 2016; Christiansen et al., 2014; Gevensleben et al., 2009; Mayer et al., 2012). Some of these functions consist of attentional control functions, set switching, planning, inhibition, and flexible goal-directed behaviors (Gibson et al., 2011). Auditory temporal processing is responsible for synchronizing sensory information and the ability to perceive stimuli released in rapid succession, including temporal sequencing, resolution, discrimination, and integration (Rieger et al., 2018; Romero et al., 2015). Children with ADHD have multiple temporal processing problems, such as discriminating the durations of sounds and the encoding of temporal information usually related to symptoms of inattention. Research has found children and adolescents with ADHD have cortical shifts in cerebral regions and pathways associated with the control of the cardinal symptoms (hyperactivity, impulsivity, and attention/concentration problems) and other executive functions, including the prefrontal lobe, basal ganglia, parietal lobe, and cerebellum (Romero et al., 2015).

Compared to typically developing peers, children and adolescents with ADHD experience a number of negative consequences and impairments in various settings. Children and adolescents with ADHD have been found to be at higher risk of challenges in social functioning, lower academic achievement, risk of injuries and hospitalization, higher risk of substance use and substance use disorder, engagement in lower labor jobs in adulthood, and lower socioeconomic status (Danielson et al., 2018).

According to Danielson et al. (2018), data from the National Survey of Children's Health, the Centers for Disease Control and Prevention (CDC) reported approximately 6 million children in the United States (2–17 years old) have ADHD. The 2014 CDC report indicated a continual increase in the percentage of children diagnosed with ADHD, from 6% to 11% (Danielson et al., 2018). This increase had led to higher expenditures related to ADHD in annual societal costs, including in the areas of education, reduced family productivity, and health care. According to Doshi et al. (2012), research exhibited a national annual incremental cost related to ADHD, ranging from $143 to $266 billion. The health care costs alone is approximately $23 billion (Danielson et al., 2018; Doshi et al., 2012). Despite the increasing prevalence of ADHD, there continues to be a lack of resources and proper treatment access for many individuals. Many children, particularly those from low-income families, lack access to assessment, effective interventions, parent training, and appropriate school-based resources (Danielson et al., 2018; Doshi et al., 2012).

ADHD Treatments and Clinical Guidelines

The clinical guidelines for ADHD diagnosis and treatment were updated in 2011 by the American Academy of Pediatrics (AAP). Currently, for children ages 5 and under, the first-line treatment is behavioral therapy. For this group, clinicians prescribe medication only if the symptoms become highly disruptive or if the impairments persist after a trial of behavioral therapy (AAP, 2011; Danielson et al., 2018). For elementary school-age children (6–11 years), the AAP recommended prescribing medication, behavioral therapy alone, or preferably the combination of both treatments. For adolescents (12–18 years), the AAP recommended prescribing medication in combination with behavioral therapy. The AAP emphasized the importance of psychotherapy in children and adolescents who continue having functional impairments while being treated with medication or have other cooccurring disorders (Danielson et al., 2018). Finally, the AAP recommended the use of psychotherapy before initiating medication treatment (Danielson et al., 2018). Research findings support the combination therapy model and the application of other adjunctive intervention as a more effective approach when treating a complex disorder, such as ADHD (Bluschke et al., 2016; Christiansen et al., 2014; Serrano-Troncoso et al., 2013)

As noted previously, for individuals ages 6 years and up, pharmacological therapy is considered the first-line treatment and is generally part of the comprehensive treatment plan for ADHD (Rostami & Dehghani-Arani, 2015). There are two main classes of pharmacological treatments for ADHD: stimulants and nonstimulants. These classes have distinct effects on dopamine and noradrenaline signaling pathways. Stimulant medications (i.e., methylphenidate and dextroamphetamine) are preferred over nonstimulant medications (i.e., tomoxetine and guanfacine; Efron et al. 2019; Rostami & Dehghani-Arani, 2015).

When choosing the appropriate pharmacological treatment, there are a number of important considerations: the presence of comorbidities, mood disorder, compliance needs, undesirable effects of the medication, flexibility of dosing and time, potential drug diversion (i.e., transferring of the medication to another person for illicit/nonprescribed use), and personal preference (Efron et al., 2019). Stimulant medications may be unsafe for people who struggle with various medical or psychiatric conditions. For example, individuals who suffer from Tourette's syndrome or tics (uncontrollable vocal or muscular tics) should avoid taking stimulant medication, which may increase the level of tics. Individuals with high blood pressure or with heart disease should avoid stimulants because they may exacerbate circulatory or heart symptoms, as well as individuals with glaucoma because the stimulant may worsen the symptoms related to high blood pressure (Efron et al., 2019). Individuals with psychotic symptoms (delusions or hallucinations) may experience an increase in the frequency and intensity of psychotic episodes. It is suspected some of these medications trigger liver disease as well as impact individuals who suffer from allergies to stimulant medications (Christiansen et al., 2014; Efron et al., 2019; Rostami & Dehghani-Arani, 2015; Serrano-Troncoso et al., 2013).

In addition to medical or psychiatric contraindications, stimulant medications can cause a host of unpleasant side effects (Efron et al., 2019). These side effects include a likely increase decreased blood pressure, decreased appetite, dizziness, weight loss or weight gain, sleep problems, irritability (i.e., rebound effect), moodiness, headaches, and stomach pain (Efron et al., 2019; Rostami & Dehghani-Arani, 2015).

Unfortunately, finding the most effective prescription drugs and dosage requires a trial-and-error process (Efron et al., 2019). This process may be extensive and vexing depending on the complexity of the ADHD and other psychiatric comorbidities (Efron et al., 2019). Many children and adolescents undergo multiple medication shifts before finding a drug and dosage that will work for them (Christiansen et al., 2014; Efron et al., 2019; Rostami & Dehghani-Arani, 2015; Serrano-Troncoso et al., 2013).

Some people opt not to take medication, seeking alternative treatments. Some of these interventions include psychotherapy, social skill training, nutrition, and other novel interventions that have claimed to diminish ADHD symptoms. Some of these interventions, including neurofeedback training, are not evidence-based approaches, as they are still in the experimental stage. Danielson et al. (2016) identified the need for improved ADHD treatment interventions as a developmental objective for the nation's health (U.S. Department of Health & Human Services, 2010; Zwi et al., 2011).

Researchers have suggested neurofeedback training may be an effective adjunctive intervention for ADHD (Christiansen et al., 2014; Gevensleben et al., 2009; Heinrich et al., 2007; Hudak et al., 2018; Liechti et al., 2012; Mayer et al., 2012; Sitaram et al., 2017; Studer et al., 2014). According to Hudak et al. (2018), neurofeedback training helps train the brain to self-regulate and redirect cortical activity. Nevertheless, there have been many shortcomings in the methodological application, as well as a lack of proper control groups (Albrecht et al., 2017). This study aimed to address the following questions: (a) Is neurofeedback an effective intervention for ADHD, leading to the reduction of ADHD symptoms, such as impulsivity, attention, and hyperactivity? and (b) Will neurofeedback training serve as an effective adjunctive intervention when combined with pharmacological treatment?

Four Main Theories of ADHD

Johnson et al. (2009) discussed the four main theories of ADHD, focusing on behavioral and cognitive dysfunction. The four main theories are the executive dysfunction theory, the state regulation model, the delay aversion and dual pathway theories, and the dynamic developmental theory (Johnson et al., 2009).

The Executive Dysfunction Theory of ADHD

The executive dysfunction theory of ADHD proposes ADHD symptoms arise from deficits in higher order cognitive processes, including holding attention, selecting appropriate behaviors, and inhibition of inappropriate responses, reasoning, sequencing, and planning (Johnson et al., 2009). Abnormalities in the structure cause the deficits in executive control, biochemical operation of the frontoparietal and striatal neural networks, and function. This theory is related to the process of neurofeedback linked to neurological testing. Tests focus on the anatomical, physiological, and biochemical dysfunctions related to the frontal cortex, the front striatal, and the frontoparietal circuits in ADHD. Results are evaluated through fMRI and EEG, which is closely associated with neurofeedback (Johnson et al., 2009).

The State Regulation Model

The state regulation model proposes ADHD symptoms increase and decrease depending on the ADHD's state of the individual (Johnson et al., 2009). For example, if the individual perceives a task as dull, the symptoms of inattention increase. Johnson et al. (2009) described the relationship with motivation, reward, and energetic state allocation. The researchers explained slow condition might be related to a missing increase of the parietal P3 amplitude, indicating a relationship to effort allocation (arousal and activation of brain signals; Johnson et al., 2009). In neurofeedback training, “the noise” or increases of waves that impact attention or executive-related tasks are targeted by decreasing or amplifying specific brain activity.

The Delay Aversion and Dual Pathway Theory

The delay aversion and dual pathway theory focus mainly on impulsiveness (Johnson et al., 2009). This theory proposes children with ADHD can “wait” but “do not want to.” Symptoms of hyperactivity and inattentiveness are attempts to reduce subjective experiences of delay. In other words, these symptoms may be categorized as secondary symptoms when the individual cannot avoid “delay” (Johnson et al., 2009).

The Dynamic Developmental Theory

This theory focuses on dopamine deficiency as one of the main factors of ADHD symptoms (Johnson et al., 2009). The dopaminergic process is associated with reinforcement, reward, and motivation for task execution. The symptoms of delay aversion, hyperactivity, and impulsivity occur in the mesolimbic dopamine system (Johnson et al., 2009). In this theory, symptoms may be associated with several factors, including failing to extinction to too many brain activation responses, deficits in the pruning of inappropriate responses, and delay aversion (Johnson et al., 2009).

Reflecting on all four theories, one can conclude all four have a common degree of homogeneity in explaining the ADHD construct, including physiological, reward, motivation, and will components (Johnson et al., 2009). Neurofeedback training may be a promising intervention to target ADHD symptoms following these main theories. The neurofeedback process may include decreasing or amplifying wave activity (energetic signals allocation), targeting specific responses in the brain (pruning, redirecting, and extinction), and self-regulation to help delay aversion.

Neurofeedback

Neurofeedback (NF) is a form of biofeedback that operates through a method of retrieving information. It monitored brain waves to promote control over naturally involuntary biological processes through conditioning (relaxation through operant conditioning). This intervention is considered a noninvasive, technology-based learning technique that provides real-time neural activity information, including visual, auditory, and sensory representations in the brain (i.e., EEG activity; Hudak et al., 2018). Electroencephalogram (EEG) is a tool used to detect abnormalities in the brain's electrical activity or brain waves. Electrodes are composed of thin wires, and small metal discs are pasted into the scalp of the trainee, using a conductor paste. The electrodes detect the electrical signals or changes made by the brain cells. Information is amplified in a graph form through a computerized system device and is interpreted by trainers, determining what is happening in the brain.

Theoretically, neurofeedback informs the brain about maladaptive or pathological activities of specific neural substrates, thereby enabling self-regulation (Christiansen et al., 2014; Gevensleben et al., 2009; Heinrich et al., 2007; Hudak et al., 2018; Liechti et al., 2012; Mayer et al., 2012; Mayer et al., 2016; Sitaram et al., 2017; Studer et al., 2014). The mechanism of neurofeedback stems from the idea that people can control or alter electroencephalographic signals (brainwave characteristics) in real time by challenging the brain to learn to recognize, condition, and redirect the brain's activity to optimal functioning (Christiansen et al., 2014; Gevensleben et al., 2009; Liechti et al., 2012;

Mayer et al., 2012; Mayer et al., 2016; Sitaram et al., 2017; Studer et al., 2014). The neurofeedback training process works through the retrieval and amplification of the brainwaves' information, displayed to the client or trainee in the form of a computer game, movie, or sound bites.

Neurofeedback can be traced back to the early 1930s when observation of EEG alpha-blocking response was demonstrated to have the ability to be classically conditioned (Mayer & Arns, 2016; Naas et al., 2019; Sitaram et al., 2017). In this study, the researchers observed the alpha waves, which are the brain waves that appear in a frequency of between 8-13 Hz per second when the individual is in a state of resting wakefulness (balanced or regulated). Alpha-blocking responses occurred when the brain was signaled to focus on a stimulus, whether auditory, tactile, visual, or cognitive. In this process, alpha waves disappear or decrease in amplitude, disrupting the slower cortical rhythms by desynchronization (amplifying the faster cortical activity waves related to executive functions and attention), allowing the person to focus better. In other words, the researchers observed, through classical conditioning methods, the brain seemed to learn to interrupt cortical activity rhythms by the process of alpha-blocker activity tasks, using an external stimulus (e.g., feedback or signals leading to high anxiety or depression) and recreate new patterns of self-regulation. However, it was not until the 1940s that EEG efficacy was confirmed and scientifically evaluated, demonstrating conditioning approaches can be implemented to EEG parameters, such as alpha-blocking response (Mayer & Arns, 2016).

In 1968, a study using cats as samples demonstrated the clinical effect of EEG conditioning on convulsions by targeting the sensorimotor rhythm (SMR; Egner &

Sterman, 2006; Mayer & Arns, 2016). The researchers started investigating learned suppression of a previously learned cup-press-food rewarded response in cats (Egner & Sterman, 2006). A particular low-voltage-background-activity EEG rhythm (wave) frequency of 12-20 Hz appeared during the learned suppression of the response over the sensorimotor cortex. The frequency wave was similar to the sleep spindle EEG frequency (12-14 Hz) and was referred to as sensorimotor rhythm (SMR). The researchers proceeded to investigate SMR rhythm by attempting to operantly condition cats using food as a reward contingent on the production of SMR. According to Egner and Sterman (2006), the cats learned self-regulation and the behaviors related to SMR production, including a drop of muscle tone and body immobility. Through this discovery, the researchers conducted a series of studies on seizures and convolution resistance using the cats previously trained to produce SMR waves (Egner & Sterman, 2006). The findings exhibited the cats conditioned with the SMR had developed a prolonged resistance to seizures compared to the other cats, indicating the cats have become inoculated against epileptic seizures. The replication of these studies in humans led to frequency band neurofeedback (Bluschke et al., 2016; Egner & Sterman, 2006; Mayer & Arns, 2016).

Neurofeedback training interrupts maladaptive activity in frequency bands, including the ratio of frequency or amplitude of power in a specific frequency band (Mayer & Arns, 2016; Sitaram et al., 2017). The frequency band neurofeedback is aimed to activate a particular brain network by changing the amplitude of a specific frequency band thought to the application of a particular protocol depending on the client's quantitative EEG (Heinrich et al., 2007; Hudak et al., 2018; Egner & Sterman, 2006; Mayer & Arns, 2016; Sitaram et al., 2017). Therefore, this neurofeedback band (protocol) was developed and initially employed in the treatment of epilepsy, aiming to interrupt the brain's signals that led to a convulsion. This neurofeedback band was later used to treat ADHD with the idea that both epilepsy and ADHD have similar difficulties related to the regulation of cortical excitation thresholds (dominant peaks of brain responses or responses evoked by transcranial magnetic stimulation; Heinrich et al., 2007; Hudak et al., 2018; Egner & Sterman, 2006; Mayer & Arns, 2016; Sitaram et al., 2017). Mayer and Arns (2016) remarked the application of this neurofeedback band was shown to be effective in diminishing the main ADHD symptoms: inattention, hyperactivity, and impulsivity.

Types of Brain Waves

The different frequencies of brain waves are discussed in detail to understand some of the neurofeedback protocol and language. The brain produces different waves that travel through the human neocortex. Some frequencies of brain waves are excitatory, and others are inhibitory. Thus, the stimulation of individual waves bands may impact some characteristics related to hyperactivity or inattention (e.g., over-arousal, fidgeting, agitation, under-arousal, poor concentration, daydreaming, and spaciness). The abovementioned states of behavior and executive functions are associated with different brain waves. Brain waves, which are measured in hertz (Hz) cycles per second, can change across a wide range of variables. For example, when higher frequencies are dominant, the brain is alert and is able to engage in critical thinking; however, if the frequency of brain waves is too high, it can result in anxiety or hyper-alertness, hyper-vigilance, impulsive behavior, and/or nightmares. On the other hand, when slower brain frequencies abound, the brain state may be sluggish, scattered, or inattentive, as well as developing feelings of depression or insomnia. Types of brain wave frequencies are delta, alpha, beta, theta, and gamma (Ko & Park, 2018; Rinaldo et al., 2018).

Delta waves are slow brain waves between 1-4 Hz that first appear in Phase 3 of the sleep-cycle and dominate almost all EEG activity by Phase 4 of the sleep-cycle (Simon, 2012). These stages are essential for restorative properties of sleep; regeneration and healing are stimulated when they appear. Nevertheless, an excess of delta waves when an individual is awake may impair one's ability to focus and lead to ADHD and other learning disabilities.

The theta waves are also slower, between 4-8 Hz, and are present when the brain is in a meditative state, daydreaming, drowsy, or sleep (not the deepest sleep stage). Theta is commonly observed in younger children; however, it appears when adolescents and adults are falling asleep or meditating (Simon, 2012). The excess of theta waves when an individual is awake is observed when an individual in a daydreaming or their attention is scattered. Theta waves are frequently observed in the wakeful state of individuals with ADHD.

The theta waves in different regions of the brain appear to have different functions. For example, frontal midline theta is related to the opening of the sensory gate for intermediate storage of episodic information to the hippocampus, occurring in response to an event. Midline theta is associated with working memory, episodic encoding, and retrieval, and it varies from 5-7.5 Hz to 6Hz, occurring in 1–10 seconds burst. This type of theta mainly appears when an individual is performing a task, requiring focus, and the amplitude increases depending on the task load. It also appears when an individual is performing a deep meditation or during hypnosis. When the individual engages in feelings of anxiety and restlessness, the wave decreases or is eliminated. Research has demonstrated frontal midline theta originates from the anterior cingulate, indicating the anterior cingulate cortex is involved in regulating the emotional state (anxiety to attention and relaxation; Rinaldo et al., 2018). The hippocampal theta coordinates and stimulates memory, and its presentation is more diffused. This type of theta is found in the hypothalamus, amygdala, and the posterior cingulate (Rinaldo et al., 2018).

Alpha waves, which have frequencies between 8-12Hz, appear in a meditative stage, and in moments of quiet thoughts ("Controlling Attention," 2019; Rostami & Dehghani-Arani, 2015; Simon, 2012). According to Simon (2012), alpha waves appear during "the resting state" of the brain or "the present moment," aiding with calm, alertness, mental coordination, learning, and mind and body integration. There is a tendency of higher amplitudes of alpha waves in the right hemisphere. Alpha's lower levels in the right region are associated with social withdrawal and negative behaviors ("Controlling Attention," 2019). On the other hand, an increased amount of alpha in the frontal cortex is associated with depression. This indicates alpha is associated with the active and ample inhibition of relevant sensory pathways.

Alpha is associated with orientation, task sequences, binding mechanisms, and reticular activation. An increased level of alpha is exhibited in a high functioning brain after completing a task and feedback ("Controlling Attention," 2019). This activity is related to the consolidation of information in the brain called post reinforcement synchronization (PRS). Alpha waves decrease during sleep onset or a focus concentration task. Nevertheless, it is also a normal consequence of aging. Parkinson's disease or cognitive decline can be detected when alpha slows and Theta increases in frequency, indicating a pathologically slowed high-amplitude alpha ("Controlling Attention," 2019).

Beta waves oscillate between the 12-38 Hz, representing a normal waking state of consciousness (i.e., attention is engaged in cognitive tasks and the external environment; Ko & Park, 2018; Simon, 2012). Beta is a fast wave activity and dominates when a person needs to be alert and engage in problem-solving, attentiveness, decision making, and focused concentration activities (Simon, 2012). Low beta (12-15 Hz) appears during reflection or deep periods of thought. Beta measured at 15-22 Hz appears when the person is making decisions or involved in high-cognitive engagement activity. High beta measured at 22-38 Hz is observed when the brain is involved in integrating new experiences, complex thoughts, as well as excitement or high anxiety (Ko & Park, 2018). Continual high beta activity may cause maladaptive cortical activity, including difficulty, relaxing, falling asleep, tension, and is related to mania. Gamma waves have the highest frequencies. These waves oscillate between 30-100 Hz. Gamma is related to an excellent memory, happiness, compassion, and high IQ. In contrast, low levels of gamma are correlated with learning difficulties, limited memory, and impaired cognitive processing. However, gamma cannot be adequately measured using EEG and is currently of limited clinical value.

Neurofeedback Training Process

In neurofeedback training, learning is one of the primary keys to brain activity regulation. The brain activation serves as an independent variable, and the self-regulation takes place volitionally through the learning process (Sitaram et al., 2017). This process enables causal inferences between the connection of behavior and brain activity

(Christiansen et al., 2014; Gevensleben et al., 2009; Heinrich et al., 2007; Liechti et al., 2012; Mayer et al., 2012; Sitaram et al., 2017; Studer et al., 2014). Thus, neurofeedback's behavioral changes or psychological consequences demonstrated postneural activation might be considered a type of endogenous neural stimulation (internal neural stimulation through brain awareness and redirection; Rostami & Dehghani-Arani, 2015; Sitaram et al., 2017).

Neurofeedback begins with neural activity observation (Hudak et al., 2018; Sitaram et al., 2017). Sitaram (2017) explained neural activity is detected through electrophysiological methods, such as electroencephalography (EEG). The signal information is extracted from the electrical sensor channels (electrodes), and the reference for the relative spatial resolution is provided by networks of established neural tissues (a group of neurons with a specific task) using imaging technology. The sensor channels extract the signals, providing a representation of the variance in temporal resolution, in which both forms of signals, hemodynamic (the dynamics of the blood flow) and electrophysiological (the dynamic of ions flow), can be processed using similar methods (Sitaram et al., 2017). Once the signals are calculated through this process, they are delivered to the client via auditory, visual, electrical stimulation, or haptic feedback, enabling the client to modify the neural activity and complete the brain loop with neural processing feedback (Hudak et al., 2018; Sitaram et al., 2017). Neurofeedback is comparable to brain stimulation when functional neuroimaging is involved in the manipulation of neural activity in circumscribed regions; thus, it exhibits the relationship between behavior and brain activity (Hudak et al., 2018; Sitaram et al., 2017).

Theories of Explanatory Mechanisms of Neurofeedback Learning and Performance

Since the discovery of neurofeedback, researchers have been trying to explain the process of learning and change (Sitaram et al., 2017). Operant learning theory, motor learning theory, dual-process theory, awareness theory, skills acquisition theory, and global workspace theory all offer possible explanations.

Operant Learning Theory

One of the fundamental theories of neurofeedback learning is operant learning. Operant learning consists of three main elements for learning: discriminative stimuli, responses, and reinforcers. Operant conditioning is a learning method that occurs through a system of rewards and punishments for specific behaviors (Rostami & Dehghani-Arani, 2015). Learners are conditioned to learn by making associations between their actions and the associated consequences of these behaviors.

As it applies to neurofeedback, operant learning theory suggests control of brain activity is mastered when it is reinforced by contingent feedback (reward) given after the desired response is reached (Rostami & Dehghani-Arani, 2015; Sitaram et al., 2017). For example, a trainee is attached to the sensors looking at a movie on a screen. If the task protocol for the learner is to produce more alpha waves and diminish beta to help with their anxiety level, the screen will be lightened to enable the learner to watch the movie (serving as a reward) every time more alpha waves are produced and beta waves are diminished. By contrast, the screen will go dim as a form of negative reinforcement or punishment, when alpha waves diminish. Eventually, the brain will learn to produce preferred wave frequencies through conditioning (Rostami & Dehghani-Arani, 2015).

Motor Learning Theory

Motor learning theory focuses on the idea that skill is learned and established through the use of repetition and practice strategies, thereby leading to long-term behavioral changes or abilities (Rieger et al., 2018). Motor learning occurs when behavioral changes occur in the brain in response to a specific skill's practice and experience.

As it applies to neurofeedback, motor learning theory suggests reaching control of brain activity is acquired through symbolic information and sequence of movements (brain learns to self-regulate through experience and practicing a state balance via the computerized protocol and cue by the threshold reward; Rieger et al., 2018). According to Sitaram (2017), there is no specific application for this theory about the neurofeedback training process, and it continues to be a conjectural theory.

Dual-Process Theory

In dual-process theory people are thought to learn through the use of two modes or two ways of thinking, top-down (prior knowledge that individuals bring, starting from the top-head understanding of the situation) and bottom-up (information within the event related to them experiencing it). People have a natural tendency to allocate meaning, structure, and coherence to experiences by identifying patterns and observing how things relate to each other to understand and predict the world around them.

The idea of dual-process theory in neurofeedback suggests learners search for a mental strategy to help them reach the desired goal (the optima mental state of any given situation), either by experimental instruction or by search (trial form until the goal is achieved; Sitaram et al., 2017). The learner keeps trying until they find an effective strategy to control brain activity or feedback signals (Sitaram et al., 2017). However, some theorists remarked learners might never find an effective strategy, in which case they may fail to learn or may become dependent on the feedback signal (Sitaram et al., 2017).

Awareness Theory

Awareness theory is based on the state of being aware, having knowledge, and being conscious (Bogdanowicz et al., 2016; Crockett et al., 2017). For example, people begin learning from a starting point in knowledge; then they become aware of something different associated with what they know, that information adds to their knowledge, becoming a form of learning (Bogdanowicz et al., 2016).

Awareness theory in Neurofeedback training contradicts the operant learning theory. The operant learning theory posits desired outcomes are achieved by reinforcing target brain activity when it occurs. By contrast, awareness theory sees change occurring through the provision of data to a learner's brain, thereby enabling them to have more voluntary control over the response (Crockett et al., 2017; Sitaram et al., 2017). Brain activity awareness enables the brain to have voluntary control over the response (interrupting the activity; Crockett et al., 2017; Sitaram et al., 2017). However, research data in animals have concluded awareness is not sufficient to reach brain activity control (Sitaram et al., 2017).

Skill Acquisition Theory

Skill acquisition theory is based on the idea that people start learning through explicit processes (exposure) and through ample practice, then the learning proceeds to implicit processing (established knowledge; Taie, 2014). As it pertains to neurofeedback, skills learning theory suggests learning falls within the framework of cognitive skill learning, involving an initial phase of rapid change in performance, followed by a gradual improvement as a late phase (Andreu-Perez et al., 2016; Rostami & Dehghani-Arani, 2015; Sitaram et al., 2017). This theory suggests the dorsomedial striatum (learning from instrumental conditioning including action and reward) is involved in Phase 1, and the dorsolateral striatum (part of the reward system) is engaged in the late phase; thus, functional and structural changes in these areas have been exhibited after neurofeedback training (Rostami & Dehghani-Arani, 2015; Sitaram et al., 2017). In other words, through exposure and practice of the desire cortical activity threshold (set protocol of optimal functioning), the client transitioned from explicit process of learning (exposure and practice during neurofeedback session) to implicit process of learning, establishing a new behavior or change (decreasing anxiety, learning how to self-regulate, or remaining alert and calm; Taie, 2014).

Global Workspace Theory

The global workspace theory is one theory embraced by many neurofeedback trainers (Kip, 2017; Morsella et al., 2016). The global workspace theory is based on the phenomenon of the conscious and unconscious neural representation of information (an explicit connection of one data to a neuronal population or networks) in the brain (Kip, 2017; Mayer et al., 2012; Morsella et al., 2016; Sitaram et al., 2017). This theory suggests the brain can effectively learn by creating a brain-scale state of coherent neural activity networks (awareness or consciousness of functions) with the help of cerebral in global workplace neurons (a group of neurons creating a network; Kip, 2017; Morsella et al., 2016). This process is acquired through the help of these cerebral networks modules, which actively and independently work in parallel with other modules sub-serving a fixed limited function by synchronizing (connecting) neural representation information to a specific cerebral network (Morsella et al., 2016). The process can be better explained as long-distance connectivity, almost like sending an email to a group or selected email addresses, signaling synchronization to execute a function. The theory supports the top-down or top-bottom approach of mobilizing information from a conscious state (Morsella et al., 2016). The long-distance connectivity (the global ability of data through global workspace neurons) enables the brain to learn actively, memorize, encode, and execute intentional actions (conscious actions). Neurofeedback's global workspace theory suggests learning to control brain activity is enabled by the extensive global distribution of the feedback signals in the brain; thus, becoming aware (conscious) to self-regulate (Kip, 2017; Mayer et al., 2012; Morsella et al., 2016; Sitaram et al., 2017).

There are some heated debates regarding voluntary control versus involuntary control and unconscious versus conscious input processing. One of the controversial ideas about voluntary and involuntary control suggests complex tasks can happen under voluntary or involuntary control. These concepts may be visible with an already learned task (auto mode), instead of learning a new skill. Research has provided extensive data supporting conscious feedback training. These findings have exhibited vast access to most neuronal networks and the ability to target a single spinal motor neuron (Rieger et al., 2018). The controversy between conscious versus unconscious input processing is still unresolved. Studies have shown conscious processing engages various areas of the brain. These competing ideas stem from the conflict between traditional neurofeedback clinicians countering newer models. These newer models embrace the involuntary control theory, claiming voluntary control is not essential for behavioral change. The newer models alleged clients are not required to use conscious efforts for self-regulation, suggesting the brain will identify the maladaptive activity by itself and interrupt it. Nevertheless, most of the forerunners of traditional neurofeedback systems claim these contemporary systems are a form of "super placebo effect," which means the trainer or client does not know the origin of possible changes or outcomes.

In contrast to conscious processing, the unconscious processing findings have been limited. Several studies investigating subliminal feedback have failed to demonstrate retention in multiple-word subliminal priming and elicitation of multiple-word effects (a common task for conscious processing) in an unattended listening task. These findings indicate subliminal feedback (backward masking) does not help reach brain activity control; more research is needed to these representations. The theory emphasizes the importance of consciousness processing in the integration of neuronal networks, creating a widespread involvement (Micoulaud-Franchi & Fovet, 2018; Sitaram et al., 2017).

All these theories provide insight on the different aspects related to neurofeedback learning (Sitaram et al., 2017). For example, the global workspace theory and the awareness theory presuppose conscious awareness as a key to learning and change, the operant may be defined as a form of dual-process theory, and motor learning theory and skill learning theory have many commonalities concerning processing learning (Rieger et al., 2018; Sitaram et al., 2017). Therefore, taking from the various assumptions, many factors are involved in the learning process of brain activity control and behavioral effect in the human brain, such as contingent feedback and reward, verbal instruction, and mental strategies.

Types of Neurofeedback Training

Some of the standard neurofeedback protocols are SMR, which is the traditional neurofeedback protocol (also called EEG biofeedback or brainwave biofeedback). This form of neurofeedback is used to help the brain reset to a stage of homeostasis or decrease automatic arousal (Doehnert et al., 2008; González-Castro et al., 2016; Marzbani et al., 2016; Mayer et al., 2016). This protocol can be used to train conditions, including attention, mood, behavior, and cognition (González-Castro et al., 2016; Mayer et al., 2016). The alpha/theta neurofeedback is performed with eyes closed and is usually used to train conditions, such as addiction, peak performance, anxiety, sleep problems, and physical impairments or chronic pain (Naas et al., 2019). Hemoencephalography neurofeedback is used to increase cerebral blood in a specific region of the brain (Naas et al., 2019). This type of neurofeedback uses blood flow as the feedback mechanism instead of brainwave activity. The interactive metronome is a type of neurofeedback used to improve attention, sequencing, motor planning, language, cognition, and concentration (Andrews & Bressan, 2018; Doehnert et al., 2008; Naas et al., 2019; Marzbani et al., 2016; Shank & Harron, 2015). This type of neurofeedback incorporates physical movements and sight; the measure of interaction is determined by systematic evaluation (Andrews & Bressan, 2018; Doehnert et al., 2008; Marzbani et al., 2016; Shank & Harron, 2015).

The alpha-band coherence neurofeedback training targets communication between sites or neurological regions in the brain. The coherence of the brain is referred to as the measurement of similarity in frequency between the different areas of the brain and is used to improve connectivity, improving the function of neural dynamics (Doehnert et al., 2008; Liechti et al., 2012; Marzbani et al., 2016; Mayer et al., 2016). Quantitative EEG (QEEG) is referred to as a real-time measure of the electrical activity of the brainwaves. This type of neurofeedback is used to measure and analyze the function and dysfunction of brain activity serving as a map for the neurofeedback trainer to determine a proper protocol for specific biomarkers of dysfunction (Doehnert et al., 2008; Marzbani et al., 2016; Mayer et al., 2016; Naas et al., 2019; Rummel et al., 2015; Surmeli et al., 2016).

Lastly, there is a newer system based on nonlinear dynamical neurofeedback used to restore homeostasis to the brain called NeurOptimal (Renton et al., 2017). Contrary to the other types of neurofeedback based on the active participation of clients, this training requires no conscious effort (Renton et al., 2017). This type of neurofeedback uses functional targeting to provide information to the brain about its activity; the brain then recognizes maladaptive activity and interrupts cortical activity by reorganizing itself (Renton et al., 2017).

The NeurOptimal neurofeedback system does not involve any electrical impulse or external information to the individual's brain besides the brain's own information (Neuroptimal, 2021). The actual system protocol is not public or accessible; nevertheless, many of the neurofeedback technicians assumed the system works in real-time data provided by the cortical activity. The assumption is the cortical activity information is retrieved, and the individual mean is calculated. Then the system allows the brain to monitor itself almost like holding up a mirror to self-correct or interrupt electrical activity that undermines optimal functioning, using the near real-time feedback (Neuroptimal, 2021). Real-time feedback involves the brain's own activity transferred into soundbites form through a computerized system. The mirror concept consists of the brain identifying its cortical activity and self-regulating or interrupting the activity when the brain identifies dysregulation using the calculated mean (Neuroptimal, 2021).

There are many factors of controversy between the different models and systems (Schabus et al., 2017). The traditional system claims the neurodynamic (nonlinear) neurofeedback system is not based in an operant conditioning model because the training requires no conscious effort; thus, may be eliciting a placebo effect and not targeting the specific area in need (Schabus et al., 2017). Moreover, the neurodynamic neurofeedback calculates the individual's mean of regulation using the data retrieved; if the individual is highly dysregulated, the mean point will not act as a useful baseline, and the brain training will hit a plateau effect. On the other hand, the neurodynamic (nonlinear) neurofeedback system claim the traditional system does not treat the brain as a whole, and because of the human error (the clinician applying specific protocol), the brain may be at risk of dysregulation by the selected protocol. For example, if the clinician administers the wrong protocol, the client may experience temporary side effects (hyperarousal or under-arousal; Schabus et al., 2017). The implication of the claim is directed to clinicians spending more time correcting their error than the client receiving the proper protocol. Therefore, the clinician embracing the neurodynamic approach states the brain is the best judge of regulation and awareness of its cortical activity.

The selected population of this study is children between the ages of 8 to 16 years who have been diagnosed with ADHD by a qualified clinician. The neurodynamic neurofeedback system was selected to avoid human error and effectively obtain accurate data of the brain's self-regulation abilities. During a neurofeedback session, the participants will be seated in a comfortable chair with bioelectrically sensitive electrodes affixed to the center of their scalp (targeting the NF points on the central sulcus area of the brain; Saxby & Peniston, 1995).

Signals from these sensors will be fed into the EEG biofeedback apparatus and converted into a series of clicking sounds which the client hears via a pair of earbuds. The clicks' rate is directly related to the amount of tension (high or low) in the cortical area. The client's task will be to sit back and relax. The relaxation process reduces the frequency of clicking sounds, which are the signs of maladaptive activity. Through this process, the brain is “trained” to maintain a state of balance (produce more alpha waves). Abnormal cortical patterns in the cortex accompany many neurological and medical disorders. Neurofeedback assessment will use a baseline EEG, and sometimes a multi-site quantitative EEG (QEEG), to identify abnormal patterns. This training with feedback EEG then enables the individual's brain to modify those electrical patterns, normalizing, or optimizing brain activity.

Neurofeedback Concept of Self-Regulation and Neural Substrates

Although the theories of neurofeedback generally seem complimentary with one another, there are some important incongruencies that impact how therapy may be operationalized and, in turn, may impact clinical outcomes (Heinrich et al., 2007; Sitaram et al., 2017). For example, there have been many reports of self-regulation failure, vague transfer benefits, ambiguous long-term effects, and inter-individual differences (Sitaram et al., 2017). Therefore, concise knowledge of the neural mechanisms supporting self-regulation may aid in designing effective clinical practices and protocols (Hudak et al., 2018; Sitaram et al., 2017). Thus, the goal is to understand the nervous system mechanisms to manipulate behavior-related neural processes and modulate and improve function (Hudak et al., 2018; Sitaram et al., 2017). Neurofeedback training has been used to self-regulate electroencephalography (EEG) amplitudes associated with the degree of intracortical neural synchronization, which may train to mediate, reduce, or amplify cortical and subcortical brain activity. This training aims to boost visual attention, curb mind wandering, or enable tasks requiring internal processing (music execution or metal rotation; Heinrich et al., 2007; Sitaram et al., 2017). Studies have shown neurofeedback may contribute to the downregulation of the anterior cingulate cortex, the area in the brain associated with craving cues (Heinrich et al., 2007; Sitaram et al., 2017).

Sitaram et al. (2017) cited a study where the control of negative emotions was observed through neurofeedback's application in the deeper brain region, the amygdala. The clients were trained to down-regulate the EEG correlates, amygdala blood-oxygen-level-dependent (BOLD), using visual stimuli (Sitaram et al., 2017). The finding data concluded neurofeedback training was directly associated with the downregulation of the amygdala BOLD signal, resulting in the control of negative emotions. On the other hand, neurofeedback training can also be applied multimodally, with both EEG and fMRI data applied concurrently as two independent signals, using the spatial specificity of the hemodynamic imaging and the dynamic properties of the electrophysiological signal (Sitaram et al., 2017). Compared to neurofeedback training, this method may be more useful to target biomarkers of pathological change which focuses on the dynamic interaction between areas and only involves one region of the brain (Sitaram et al., 2017).

The downregulation training of the EEG correlates associated with the amygdala is essential for the treatment of ADHD, which targets the brain activity related to emotional control and self-regulation.

The term for the correlate activation between low neural substrates is called “coherence” in electrophysiological terms and “functional connectivity” (Sitaram et al., 2017). Studies have shown functional connectivity-based feedback promotes improvement in volitional control when compared to activity-based feedback (focused on brain activity to induce specific information in a determined region of the brain; Hudak et al., 2018; Sitaram et al., 2017; Yamashita et al., 2017). Some of the changes that occurred after the application of neurofeedback included changes in negative symptoms recorded before the training and created observable positive long-term changes after a follow-up of 2 months. The long-term effects suggest neurofeedback training is not only directly involved in the alternation between two functional brain networks, but it also exerts long-term behavioral changes (Mayer et al., 2016; Sitaram et al., 2017).

In recent studies, functional connectivity has been acclaimed as one of the more effective modalities of neurofeedback training. In one study, this modality was used to increase subjective emotional valence rating by strengthening the top-down connectivity (cognitive control) and the area involving emotional control, the amygdala (Sitaram et al., 2017; Yamashita et al., 2017). ADHD can be understood as a disorder related to network dysfunction (functional disconnection; Hudak et al., 2018). Research has demonstrated networks in the brain associated with ADHD encompass most of the cortex, highlighting the underdevelopment of the prefrontal cortex, which is one of the areas related to executive functioning. The frontoparietal control network (FPCN) is the region that assumes connections between the networks, helping to regulate impulsive behaviors and improving cognitive attention tasks (Hudak et al., 2018). Strong functional connectivity is visible when the interplay between the default mode network (DMN) and the FPCN can switch between cognitively demanding tasks and rest. The switch on individuals with ADHD is less noticeable or nonexistent, leading to failure to rest during the resting time or maintain attention during task-oriented tasks (Hudak et al., 2018).

Neurofeedback-induced neuroplasticity exhibited by cortical excitability changes has been shown by transcranial magnetic stimulation (TMS). The TMS is applied to the motor cortex, measuring motor-evoked potential to examine neuroplasticity changes either after no regulation, learned self-regulation, or under other control conditions (Heinrich et al., 2007; Mayer et al., 2012; Sitaram et al., 2017; Yamashita et al., 2017). Also, neuroplasticity changes previously were measured through structural changes in the grey matter volume and white matter connectivity, which was a result of skill training. Neurofeedback training has also been demonstrated to help increase the grey matter volume and the in fractional anisotropy in the white matter pathway, improving visual and auditory attention after neurofeedback training (Heinrich et al., 2007; Rieger et al., 2018; Sitaram et al., 2017; Yamashita et al., 2017). This information is essential for clinical applications related to different clinical pathologies, such as ADHD (Heinrich et al., 2007; Mayer et al., 2012).

Neuroplasticity and Neuronal Changes

The outcomes of neurofeedback training are not always constant or predictable. Thus, there have been many controversial issues and data challenges related to measurable outcomes associated with neurofeedback training effects and change.

Additionally, the training may not always result in behavioral modification (Sitaram et al., 2017). This phenomenon may be related to the capability of the brain to change. Even though brain composition has a universal design, each brain's resilience or neuroplasticity differs. Thus, it is essential to note the outcome of the neurofeedback training may present differently in each client.

There are two measurements of plasticity, the Hebbian plasticity and the homeostatic plasticity (Fox & Stryker, 2017; Sitaram et al., 2017). The Hebbian plasticity is referred to as the mechanism used to code and retain information in the brain neurons (Fox & Stryker, 2017; Sitaram et al., 2017). The homeostatic plasticity can be referred to as the neuronal change that aims to return the neuron to baseline (initial set point; Fox & Stryker, 2017). The homeostatic plasticity counteracts or prevents saturation of the synaptic strength (excitatory or inhibitory). Both types of plasticity work in opposite directions; however, the integration of both types of activity is necessary for optimal outcomes in neurofeedback (Fox & Stryker, 2017; Sitaram et al., 2017). Homeostatic plasticity has been noted in many neuroimaging studies exhibiting rebound or reversal neural function (back to the initial set point) after neurofeedback training. Nevertheless, the long-term effect of homeostatic changes in the brain is not known, and more research is needed to evaluate the interaction of both types of plasticity concerning neurofeedback training (Sitaram et al., 2017).

Clinical Application of Neurofeedback on ADHD

According to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5), attention deficit/hyperactivity disorder is a persistent pattern of inattention and hyperactivity/impulsivity that interferes with functioning and development. The diagnostic criterion of ADHD covers the symptom of inattention in which the individual must have six or more of the included symptoms for inattention, and a persisted pattern for at least 6 months to the degree that is inconsistent with developmental level and is impacting their social, occupational, or academic activities (Christiansen et al., 2014). The following symptoms are included in the inattention criteria: lower levels of attention to details and prone to make careless mistakes in everyday tasks, difficulty sustaining attention in tasks and remaining focused, and trouble listening when spoken due to distractibility. Children with inattention also struggle with following instructions, failing to complete tasks, having difficulty organizing, avoiding dislikes or responsibilities that require sustained mental effort, losing materials or things necessary for tasks or activities, becoming distracted easily, and forgetting daily to execute or complete expectations or set tasks.

The following criteria consists of hyperactivity and impulsivity. The symptoms must persist for at least 6 months and have a substantially negative impact on the social, academic, or occupational work and activities. Some of the symptoms are fidgeting, inability to remain seated for expected times, restlessness, and engagement in activities at inappropriate times (climbing or running), failure to stay quiet when is expected. Children with ADHD often talk excessively, often blurt out an answer before the question is completed, have difficulty waiting for their turn, often interrupt or intrude on others' conversations, or take things without asking others. Moreover, the diagnosis requires the symptoms of inattentive or hyperactivity-impulsivity be present before age 12. Symptoms must be present in two or more settings (e.g., home and school), interfere with one's overall functioning, and do not occur due to other disorders or psychotic events.

The current study targeted low-frequency EEG oscillations in the resting state of children with ADHD. The study evaluated two variables: inattention and hyperactivity/impulsivity. Elevated levels of low-frequency EEG oscillations have been found in the resting state of children with ADHD and are associated with inattention, hyperactivity, and impulsivity (Sitaram et al., 2017). Neurofeedback training can be used to decrease the high amplitudes of low-frequency synchronization, which has been demonstrated to result in an improvement in ADHD symptoms (Naas et al., 2019; Sitaram et al., 2017). Some studies have gone as far as to suggest neurofeedback may be superior or comparable to computerized attention training and pharmacological treatment (Rostami & Dehghani-Arani, 2015; Sitaram et al., 2017).

The proper protocol is selected to target the specific area and function of the brain to train an individual's brain effectively (Hudak et al., 2018; Mayer et al., 2012; Mayer & Arns, 2016). These protocols are based on group-average findings and individualized data to enhance the treatment (Mayer & Arns, 2016). One unique neurofeedback approach is the slow cortical potential neurofeedback (SCP), which focuses on learned self-regulation of the cortical inhibition and activation exhibited by threshold regulation mechanisms, which are slow electrical shifts in cortical brain activity (Albrecht et al., 2017; Christiansen et al., 2014; Doehnert et al., 2008; Liechti et al., 2012; Mayer & Arns, 2016).

In disorders with impaired excitation thresholds, such as ADHD, SCP's self-regulation is essential to diminish the main symptoms of impulsivity and hyperactivity (Albrecht et al., 2017; Christiansen et al., 2014; Gevensleben et al., 2009; Heinrich et al., 2007; Liechti et al., 2012; Mayer & Arns, 2016; Studer et al., 2014). Mayer and Arns

(2016) suggested the set standard protocol for training neurofeedback should be the up-training of the sensorimotor rhythm (SMR; 12-15 Hz) or the down training of the theta/beta ratio (4-7 Hz/13-21 Hz; Heinrich et al., 2007; Liechti et al., 2012; Naas et al., 2019; Mayer & Arns, 2016; Studer et al., 2014). The SCP training was initially employed to treat epilepsy and today is used to train brains with impaired excitation thresholds, such as ADHD (Christiansen et al., 2014; Heinrich et al., 2007; Mayer & Arns, 2016).

ADHD is characterized by impairments of the cortical excitation thresholds. Research has demonstrated clinical effects with a large effect size on impulsivity and inattention, and medium effect size on hyperactivity when applying SMR training using SCP feedback (Christiansen et al., 2014; Doehnert et al., 2008; Heinrich et al., 2007; Liechti et al., 2012; Mayer & Arns, 2016; Sitaram et al., 2017). However, another study demonstrated improvements in distractibility and hyperkinetic disorder after the up training of SMR. Many of these studies used parent and teacher evaluations to follow up on the effect for 6 months, and observed similar lasting effects (Mayer & Arns, 2016; Mayer et al., 2016; Sitaram et al., 2017).

Recent studies reported positive effects of neurofeedback by parents, namely that neurofeedback is as effective or better than cognitive training. Other studies reported neurofeedback training is an effective training specifically for ADHD. Nevertheless, some studies found neurofeedback training was inferior to psychostimulants. These contradictions may be related to intervention methods, procedures, and external factors, such as environmental changes, medication, and parental report (Doehnert et al., 2008; Naas et al., 2019; Minder et al., 2018; Studer et al., 2014).

Findings are inconsistent among research studies on neurofeedback training for ADHD, raising critical issues that need to be evaluated (Gevensleben et al., 2009; Minder et al., 2018; Sitaram et al., 2017). For example, some studies have failed to confirm protocol-specific effects (Sitaram et al., 2017; Minder et al., 2018). The findings demonstrated both decreases and increases in low-frequency EEG oscillations (Naas et al., 2019; Sitaram et al., 2017). The researchers determined these conflicting outcomes may indicate neurofeedback training outcomes may depend on individuals' heterogeneity and the efficacy of the chosen neurofeedback protocol (Hudak et al., 2018; Sitaram et al., 2017). This type of neurofeedback trains the brain without selecting a specific protocol or biomarker. This system does not amplify or decrease brain waves; instead, it informs the brain of maladaptive activity through brain activity feedback in the form of sound bites. The brain identifies the activity and interrupts the patterns by resetting it or creating a new cortical activity pattern.

Symptoms of ADHD have been noted either in theta, and alpha oscillations and in the delta theta oscillations (Gevensleben et al., 2009; Heinrich et al., 2007; Naas et al., 2019; Sitaram et al., 2017). Both protocol conditions (decreasing low-frequency oscillations or increasing negative slow cortical potential (SCP) amplitudes) have shown improvement in ADHD symptoms. Thus, the question about the more efficacious protocol to train symptoms of ADHD remains open (Albrecht et al., 2017; Christiansen et al., 2014; Gevensleben et al., 2009; Heinrich et al., 2007; Sitaram et al., 2017; Studer et al., 2014). Also, excess of task-related theta-alpha rhythms may be one of the mechanisms responsible for attention deficits in ADHD, indicating a maladaptive upregulated default mode network (DMN), involving the low-frequency oscillations

(Naas et al., 2019; Sitaram et al., 2017). Current research applying EEG-fMRI in suppressed alpha-rhythm amplitudes after neurofeedback training demonstrated the upregulation of task-positive networks, downregulation of the DMN, and reduced inattention (Liechti et al., 2012; Mayer et al., 2016; Sitaram et al., 2017). Therefore, a multimodal protocol with combined EEG-fMRI biomarkers may still provide information for proper neurofeedback protocol for future research (Christiansen et al., 2014; Gevensleben et al., 2009; Sitaram et al., 2017; Studer et al., 2014).

Findings in a recent study did not determine any significant difference between placebo-controlled training and actual neurofeedback training (Naas et al., 2019; Schabus et al., 2017; Sitaram et al., 2017). The researcher highlighted to identify a more favorable protocol for neurofeedback training for those with ADHD. It is essential to pay close attention to the clinical study design related to “the control group” to ensure an effective study design (Albrecht et al., 2017; Sitaram et al., 2017). Previously, there have been many failed attempts in the research evaluation for neurofeedback training concerning the control group (Albrecht et al., 2017; Sitaram et al., 2017). Researchers have suggested computerized training as a more suitable placebo control than the pseudo-neurofeedback training for ethical concerns (Gibson et al., 2011; Sitaram et al., 2017; Maleki et al., 2014; Torkel et al., 2005).

Gevensleben et al. (2009) conducted a study evaluating the efficacy of neurofeedback on ADHD, which aimed to reduce the claims of methodological shortcoming on a properly controlled group. Findings supported neurofeedback training as efficacious for ADHD; nevertheless, researchers have suggested addressing the specificity of the effects and optimizing the benefits of neurofeedback training. Many researchers have suggested evaluating the neurofeedback protocol for ADHD and the methodological procedure (Doehnert et al., 2008; Gevensleben et al., 2009; Sitaram et al., 2017).

Implications and Proper Adaptations of a Control Group, Criticisms, and Placebo Effect

Micoulaud-Franchi and Fovet (2018) conducted an evaluation targeting the potential elements driving the effects of EEG-neurofeedback. The researchers remarked EEG-neurofeedback suffers from a "truthful hyperbole" or over-exaggeration of the impact of neurofeedback, leading to a belief somewhat equal to a *magic pill* (Gevensleben et al., 2009; Micoulaud-Franchi & Fovet, 2018; Sitaram et al., 2017). The implication of this euphemism is the possibility of developing "pseudoscientific" thinking, and researchers encourage the exploration of these possible questions: does the technological environment produce a placebo effect? Is the neurofeedback effect unrelated to the specific marker chosen for the protocol training intervention? Is the neurofeedback effect originated from nonspecific cognitive brain training during the neurofeedback? Or are the effects related to cognitive training? These questions are related to psychosocial variables, and it is essential to assess the degree of involvement to better understand the process (Gevensleben et al., 2009; Micoulaud-Franchi & Fovet, 2018; Sitaram et al., 2017).

Researchers have proposed these effects may fall into the categories of "super placebo," where the practitioner and the client are unaware of the lack of evidence for therapeutically selected protocol (Micoulaud-Franchi & Fovet, 2018). Likewise, researchers have proposed if the effect originated from unspecified neurological compensatory brain mechanisms and oscillation regulation, which requires the use of both cognitive training and the super placebo, it is an indication of the ultimate placebo effect as a means for illness prevention and not as specific training for the chosen biomarkers. With that note, there is also the claim that empirical evidence about the neurofeedback effect, targeting selected biomarkers is weak (Gevensleben et al., 2009; Micoulaud-Franchi & Fovet, 2018). The researchers encouraged the assessment of all of these concerns. They proposed to evaluate and refine the conceptualization of control groups and to understand the role of the possible origin of the effects, as well as evaluating the integrations of proper neurofeedback protocols (Albrecht et al., 2017; Gevensleben et al., 2009; Liechti et al., 2012; Micoulaud-Franchi & Fovet, 2018).

In a study conducted by Bradley et al. (2011), findings suggested adaptive training of working memory (WM) using the Cogmed-RM adaptive training demonstrated WM training might serve as a proper control group for neurofeedback training. Minder et al. (2018) conducted a study evaluating the efficacy of neurofeedback and computerized cognitive training (CogT) as a treatment for ADHD. The researchers controlled the informant-specific effect by manipulating the involvement of the informants by adding a blinded outcome measure and monitoring for the waiting time effect (Minder et al., 2018). Participants consisted of 77 children between the ages of 8-16 diagnosed with ADHD with or without hyperactivity (Minder et al., 2018). Both the neurofeedback and the WM intervention had a positive result in reducing the symptoms of ADHD. Results of this research raised two main questions. First, is neurofeedback an effective intervention for ADHD? Second, is working memory a comparable intervention and a valid control group? However, within the results, the three different informants (parent, teacher, and pre- and post-testing) had contradictory data. This contraction may be attributed to human error with self-report and understanding the symptomatic elements being assessed. Future consideration for symptom measurement and evaluation is suggested instead of self-report instruments (Gevensleben et al., 2009; Minder et al., 2018).

Advances of neurofeedback as a scientific intervention are rapidly evolving (Gevensleben et al., 2009; Minder et al., 2018). Current neurofeedback research has led to a growing understanding of neural function through the use of behavior and thought as dependent variables, and brain activation as an independent variable (Minder et al., 2018). Researchers have noted learning the control of brain activity with neurofeedback training is comparable to skill acquisition, involving the corticosteroid loop with the glutamatergic and the dopaminergic synaptic organization (Gevensleben et al., 2009; Minder et al., 2018). Multivariate methods and real-time connectivity facilitate modulation of patterns of neural activation (Gevensleben et al., 2009; Mayer et al., 2016; Minder et al., 2018). Evidence has demonstrated modulation of neural oscillations and deep brain structures can be executed by using neurofeedback based on subcortical regions and electrophysiological tasks (Gevensleben et al., 2009; Minder et al., 2018).

Studies have led to more understanding about neurofeedback regulation and learned modulation, resulting in behavioral changes (Gevensleben et al., 2009; Liechti et al., 2012; Minder et al., 2018). The researchers used the Conners-3 rating scale and the Behavior Rating Inventory of Executive Functions (BRIEF) to measure changes in ADHD symptoms (Minder et al., 2018). A baseline was set 3 months before the intervention (Minder et al., 2018). The parent and teacher report's treatment effects indicated a substantial change for both the neurofeedback and Cog.T groups (Gevensleben et al., 2009; Minder et al., 2018). There was no differential treatment effect in favor of neurofeedback training, and the setting effect had no significant bearing on treatment response. (Minder et al., 2018). However, the researchers remarked this phenomenon might be attributed to the interventions targeting regulatory control instead of ADHD symptoms, as well as unrealistic hopes and expectations of the treatment by the informants (Minder et al., 2018). These findings increased researchers' responsibility to evaluate further neurofeedback training at the efficacy of treatment for ADHD (Gevensleben et al., 2009; Liechti et al., 2012; Minder et al., 2018).

The current study tried to implement a case study design, using the same participant as control of before and after the intervention (e.g., are the participants doing better with treatment as usual or with the combination of neurofeedback and treatment as usual?). The aim was not to compare neurofeedback with other interventions; instead, the objective was to find the impact of neurofeedback on ADHD symptoms and help individuals to be more productive on their daily day task. The participant needed to be taking a stimulant type of medication and stabilized to be included in the study. The participant not taking medication will be excluded from the study. Stimulants are well-established as a favorable treatment for ADHD.

Rationale/Purpose of the Study

Currently, the standard treatment for ADHD is pharmacological therapy (Rostami & Dehghani-Arani, 2015; Serrano-Troncoso et al., 2013). Pharmacological therapy is a well-established treatment and is considered as treatment as usual for children and adults diagnosed with ADHD (Rostami & Dehghani-Arani, 2015). However, concerns about this treatment continue to raise concerns due to the various side effects and life-long effect complexity between clients (Bluschke et al., 2016; Christiansen et al., 2014). Thus, nonpharmacological treatments that may ameliorate issues encountered with pharmacological treatments are often considered (Christiansen et al., 2014; Rostami & Dehghani-Arani, 2015; Serrano-Troncoso et al., 2013). Neurofeedback, in conjunction with pharmacological treatment, has been demonstrated as an effective adjunctive intervention; this study aimed to evaluate those claims and provided further information concerning multi-method procedures (Christiansen et al., 2014; Rostami & Dehghani-Arani, 2015). Neurofeedback has been shown as beneficial in the treatment of ADHD; however, many complaints associated with critical components such as measurement procedures, instruments, and control groups have been raised (Micoulaud-Franchi & Fovet, 2018; Rostami & Dehghani-Arani, 2015; Vollebregt et al., 2014).

Many researchers imply the technological environment may produce a placebo effect (Micoulaud-Franchi & Fovet, 2018; Schabus et al., 2017). This current study aimed to address these concerns by adding a sound control group and using a record system to assess variability regarding external factors, such as medication, environmental factors, sleep, and home environment. Most research concerns relate to finding control groups similar to the neurofeedback training concerning time, procedure, and environmental factors to dismiss the null of the placebo effect (Vollebregt et al., 2014). Previously mentioned, this study aimed to investigate the Impact of neurofeedback as an additional tool to improve the ADHD symptoms and optimize functionality in individuals diagnosed with ADHD. Even though this research study used a case study design, it may serve as a pilot, providing critical information vital to future research in a randomized control study with a larger sample size.

This study aimed to address some of the concerns mentioned above. Questions addressed in this study are, is neurofeedback an effective intervention for ADHD? Will the participant significantly improve their symptoms with the combination of neurofeedback training and treatment as usual? H1: the researcher hypothesizes the addition of neurofeedback training will yield more favorable outcomes in reducing symptoms of ADHD (i.e., impulsivity, attention, and hyperactivity) than pharmacological treatment alone in an adolescent 11 to 17 years old. H2: the baseline score will improve after the 12 sessions are completed and remain the same at the 4 week follow-up baseline assessment. The null hypothesis (H0) is as follows: the addition of neurofeedback training will show no difference in the improvement of symptoms.

As an advocate for best practices, I would like to contribute to the existing body of research on the impact of neurofeedback as an intervention for ADHD. If found to be efficacious, neurofeedback could potentially offer a reasonable alternative to other adjunct therapies and be made available to a larger population through expanded insurance coverage. This research also aspired to be a starting point to advocate for more research concerning nonpharmacological interventions that may improve the outcomes of many people who have ADHD and do not have access to medication. In addition, it aimed to consider people who struggle with the contraindication of prescription drugs and those who are experiencing high side effects due to the medication.

Chapter 2

This chapter begins with a disclosure of current events and an overview of the quantitative data analysis procedures before and after adjustments related to the COVID-19 pandemic impacted the criterion requirements for this study. Prior to COVID-19, this study aimed to evaluate neurofeedback training on a nonmedicated participant diagnosed with ADHD. All other disorders, except ODD, anxiety, and depression were going to be excluded. The pandemic made it challenging to recruit participants due to contact restrictions and organizations' plans to protect clients and students during restriction requirements and first choice of treatment. During this time, people were advised to have minimal to no contact per social distant national code; thus, recruiting via social media for in person neurofeedback training was impossible. Thus, due to the lack of participant access and the persistent cases of COVID-19 reinforcing the social distant specific restrictions, this study took a different approach to include the relationship that happens in the real world when one thing makes life experience more vulnerable and vice-versa when life experiences affect the vulnerability of an individual. Individuals who are diagnosed with ADHD are more prone to trauma and other comorbidities that develop through an individual's life in the real world. Therefore, the study assessed the relative improvement of symptoms of ADHD amid environmental distress, as well as other comorbid diagnoses.

This study aimed to evaluate the impact of neurofeedback training on ADHD. Neurofeedback has become a controversial subject amongst practitioners, embracing a skeptical view on its *true* effect that leads to improvement and mechanism of change on specific diagnosis and symptomatology. Most insurances have rejected neurofeedback experimental validity due to errors in the statistical measures and methodological procedures; thus, neurofeedback remains an experimental intervention instead of an evidence-based practice. This study attempted to add to the existing body of research investigating the impact of neurofeedback training on ADHD as a promising adjunctive treatment, lending the need for further research with proper procedure to address the above-mentioned concerns. Through observations in clinical settings, the evidence of improvement and change has been inconsistent across clients, where sometimes neurofeedback has worked for some clients, but not on others. These elements bring the question of neurofeedback being an actual intervention or just a placebo effect and its impact as an intervention on clients diagnosed with ADHD.

The study proposed two hypotheses: (H1a) neurofeedback training will help reduce ADHD symptoms of impulsivity, and its integration as an adjunctive tool will have a more significant effect size than treatment as usual alone, (H1b) neurofeedback training will help reduce ADHD symptoms of inattention, and its integration as an adjunctive tool will have a more significant effect size than treatment as usual alone, (H1c) neurofeedback training will help reduce ADHD symptoms of hyperactivity, and its integration as an adjunctive tool will have a more significant effect size than treatment as usual alone; (H2a) the baseline on the ADHD rating scale-5 scores will improve after the 12 sessions and remain the same at the 4-week follow-up assessment.

Participant Recruitment

The participant was recruited via social media, training organizations, adolescent clinics, and school settings. Impact of neurofeedback was measured by the scores on the ADHD Rating Scale-5. This study was designed as a case study, using an ABA design.

An initial contact letter briefly describing the study was provided to school and other organization officials who then shared with parents of adolescents in the district whose children may be eligible. This letter also circulated in the social media recruitment venue. The privacy of the social media inquiry was protected by request to forward all questions and inquiries via private email. The people who were interested personally contacted the research to protect their confidentiality. Informed consent was given to the parent of the participant with full details about the procedure and the objectives of the study.

The participant, caregiver, and teacher were informed they could quit their participation in the study at any time. The participant was compensated with a $25 Amazon card at the follow-up point of assessment. ADHD is also known as a dopamine deficient disorder which impacts motivation and task completion related to the impairments in the reward system; thus, an external motivational reward system was needed for the participant to remain seated for the length of time during the session and well as the motivation to return to every session (Johnson et al., 2009).

The initial screening consisted of a 2-hour session composed of the preliminary assessment and the first neurofeedback training. The informed consent was provided and consent to treat was reviewed with client and parent. The parent provided information about the participant's prior treatments, the type of medication, and the dosage. The information was documented through a questionnaire format. A multimethod diagnosis of ADHD was required for the inclusion of this study, including multiple sources of assessment, a clinical interview, and evidence of other disorders ruled out. The parent participated in the initial parent report of symptoms using a structured interview, the ADHD Rating Scale-5 for children and adolescents, and adaptive scale to assess other potential comorbid psychiatric conditions, such as depression, anxiety, and (not ruling out oppositional defiant disorder). The participant's teacher also completed the initial teacher report, as well as the end of the week and final report. Other learning disabilities, neurodevelopmental disorders (e.g., autism), adjustment disorder, and mood disorders were also part of the exclusion criteria.

The sample consisted of one participant aged 11 to 17 with a clinical diagnosis of ADHD. The participant selected for this study is a born female, who identifies as gender fluid and uses the pronouns he, him, and his. The participant was medicated and not planning to go off or change medication before completing the study. The participant and parent(s) were asked to maintain the child without any changes during the study that could affect the data. Other types of neurodevelopmental disorders, adjustment disorder, and mood disorder were excluded, except depression, anxiety, and PTSD.

Risks of EEG Neurofeedback

EGG neurofeedback is a noninvasive, safe procedure that has been used for many years (Arnold et al., 2013; Bink et al., 2015). The method causes no discomfort or any kind of sensation. The electrodes solely record brain activity, and there is no risk of any electric shock (Arnold et al., 2013; Bink et al.,2015). Studies have reported no negative adverse effect between interventions within a 6-month period following training (Arnold et al., 2013; Bink et al.,2015).

Materials or Measures

This study used the NeurOptimal System. Neurofeedback training is a noninvasive and safe intervention (Naas et al., 2019). Neurofeedback is not a medical procedure or treatment, nor is it used to diagnose medical disorders; instead, it is designed to train brain optimization. Neurofeedback allows the brain to monitor itself, almost like holding up a mirror to self-correct or interrupt electrical activity that undermines optimal functioning (Naas et al., 2019; Neuroptimal, 2021). There is no external electrical impulse or extra information introduced to the brain besides its feedback. The neurofeedback training equipment was used as designed, and the person administering the neurofeedback intervention was trained to deliver the training. According to previous research, no harmful effect has been documented.

Symptoms of ADHD

This study used the ADHD Rating Scale-5 to measure symptoms of ADHD. The ADHD Rating Scale-5 is an informant rating scale for children 11–17 years of age that assesses the core symptoms of ADHD and Oppositional Defiant Disorder, and indicators of conduct problems and emotional and academic difficulty. The baseline ADHD Rating Scale-5 adolescent scores were recorded before the neurofeedback intervention, after the completion of the 12 sessions, and at the 3–week follow-up assessment. The ADHD Rating Scale was chosen due to its length of research work, reliability, and validity. The instrument focuses specifically on the study's targeted symptoms: inattention, impulsivity, and hyperactivity. The ADHD Rating Scale also has a specific form evaluating this study's demographic sample (adolescents ages 11-17), supporting this study's face validity.

The reliability of the scale exhibited an internal consistency of symptom rating for the inattention and hyperactivity-impulsivity are high, the alpha coefficient for the scale ranged from .89 to .96, and the test-retest reliability of the home version range from .80 to .87 and the school version range from .62 to .90 with a high-test sensitivity. Both forms were used in this study (see Appendices A and B).

Demographic

There are two versions of the ADHD Rating Scale-5: a parent-completed form and a teacher-completed form. The instrument measures two categories of symptoms (inattentiveness and hyperactivity/impulsivity), as well as associated functional impairments. Scores are normed based on gender and age and cutoff scores are established for screening and diagnosis

Neurofeedback Training Session Procedure

The participant was administered a total of twelve 33-minute sessions of neurofeedback training for 3 weeks and one last follow-up appointment after 3 weeks post neurofeedback to assess treatment outcomes. The ADHD Rating Scale-5 was administered during the last session, establishing a new baseline (second phase A). The parent or guardian of the participant was present at every session.

During the neurofeedback session, the participant was asked to sit comfortably in a chair; two electrodes were attached to their scalp and two receivers, and one grounder electrode was attached to his ears. These electrodes were attached to the scalp with a conductive paste. The participant was instructed not to wear any hair products or jewelry, which may interfere with the reading or the pasting of the electrodes. The trainer asked the participant to relax during the neurofeedback intervention. The participant chose between reading a book and drawing as he heard the music stimulation from the earbuds and occasionally watched the visual stimulation of the Neuroptimal program or selected a movie from the system library. Once the intervention phase was completed, the electrodes were removed and washed. The participant's scalp was cleaned with a sanitizer wipe to remove any remaining residual paste.

Analysis

This study implemented a case study design (ABA design). Phase A is the baseline established before the Neurofeedback intervention, which is the response level of behavior before the intervention and serves as a form of control. Phase B is the introduction of the intervention and post assessment. During this phase, the brain needs a period of adjustment to the neurofeedback intervention to reach a steady state. By removing the “noise” and allowing the intervention to achieve a stable state, the researcher helps the researcher identify the effects of the independent variable. The second phase, A, is the follow-up phase which is the level of response behavior after the intervention. The neurofeedback intervention served as the dependent variable and the changes in inattention, hyperactivity, and impulsivity will serve as the independent variables. Two tables were created to evaluate the prediction of neurofeedback training in children and adolescents with ADHD and its overall effects in reducing the main selected symptoms of inattention, hyperactivity, and impulsivity across settings (home and school). The parent/teacher scores of the ADHD rating scale were summed and the average will be measured at the end.

Case Study Design

The development of the single study design, as a contemporary practice, can be traced to the work of Skinner (Kazdin, 2). Single-subject design provides valuable and practical information for the continuous growth of the school of psychology (Kazdin, 2011). Although this study was a case study that cannot generalize to a population or demographic group, it provided helpful information for the development of evidence-based practice for randomized control trials (RCTs) by assessing the Impact of neurofeedback on ADHD. Case studies offer flexibility and may serve as a model tool for establishing the validity of treatments (in this case, training sessions design) in a real-life setting before applying them at the scale needed for RCTs (Byiers, 2012). Furthermore, this study contributed to the specific field of neurofeedback by evaluating the new Zengar neurodynamic system on a case study.

The sessions took place at a private room at the Schweitzer Brentwood Branch library in Springfield, MO, using portable neurofeedback equipment, including a portable laptop, digital screen, alcohol, paste conductor, all the cleaning supplies and token rewards. The neurofeedback training was administered using the proper clinical protocol and safety procedures for participants. Adequate safety procedures were taken to record and protect the confidentiality of participant records, such as a locked briefcase, fila number assignment in place of participant names, and secure file records.

Even though this study was a pilot, the researcher aimed to apply the proper experimental procedures. Limitations and future considerations will be discussed in Chapter 4. Studies have tried to demonstrate the Impact of neurofeedback training on

ADHD and other disorders. More research is needed to confirm a reliable, evidence-based approach.

Summary

This study used a single-subject design to evaluate the extent to which the NeurOptimal System of neurofeedback improved attention/concentration and hyperactivity/impulsivity symptoms in a child over control. Treatment outcomes were measured through a parent- and teacher-completed objective instrument, the ADHD Rating Scale-5. External events such as the COVID 19 pandemic, online schooling, and social distancing mandates were significant markers during this study and possibly impacting the outcomes. Future studies integrating the common comorbidities associated with ADHD and the real-world internal and external experiences that impact vulnerability are needed to evaluate these implications. This study used a single-subject design to evaluate the extent to which the NeurOptimal System of neurofeedback improved attention/concentration and hyperactivity/impulsivity symptoms in a child over control. Treatment outcomes were measured through a parent- and teacher-completed objective instrument, the ADHD Rating Scale-5.

Chapter 3

Analytic Strategy

This study used a case study design to evaluate the extent to which the NeurOptimal System of neurofeedback improved attention/concentration and hyperactivity/impulsivity symptoms in a child over control. This study was originally designed as an ABA designed and a *t* test was going to be used to measure the variables of change. Nevertheless, due to the nature of the case study design (descriptive information), this study prohibited inferential statistics and the scores were plotted across the three time points. The intervention outcomes were measured through a parent- and teacher-completed objective instrument, the ADHD Rating Scale-5. The results were based on the observation between parent and teacher scores across the three phase points. Unfortunately, priori assumptions about the magnitude of expected change in ADHD symptoms were not made. Twelve neurofeedback training sessions with an average time of 33.3 minutes per session were administered to a single participant with a diagnosis of ADHD. The home/school version ADHD Rating Scale, Fifth Edition (ADHD-RS-5) was completed by the parent and the teacher at three different times: pre, post (after the last neurofeedback session), and follow-up (3 weeks after the last neurofeedback session). Two tables were created to evaluate the prediction of neurofeedback training in children and adolescents with ADHD and its overall effects in reducing the main selected symptoms of inattention, hyperactivity, and impulsivity across settings (home and school). The questions addressed in this study are: What is the impact of neurofeedback training on ADHD when comorbidities are present and the real-world experiences impact individuals' vulnerability? Will neurofeedback training serve as an adjunctive intervention alongside pharmacological treatment?

Two main hypotheses were formulated: (H1a) neurofeedback training impact on ADHD symptoms of attention/concentration and (H1b) neurofeedback training impact on ADHD symptoms of hyperactivity/impulsivity.

Hypothesis 2 was looking at the overall impact after completion of the research methodology: (H2) the baseline on the ADHD rating scale-5 scores will improve after the 12 sessions and remain the same at the 3-week follow-up assessment.

Results

The participant was an 11-year-old biologically female who identifies as male, using the pronouns he, his, and him. The participant had a diagnosis of attention deficit/hyperactive disorder, combined presentation; posttraumatic stress disorder, chronic; diagnoses; generalized anxiety disorder, and oppositional defiant disorder (provisional). The medication treatment prior and during this study was Guanfacine (Intuniv) ER 3 MG tablet. The participant was not receiving mental health services prior or during this study. The parents' primary concerns were inattention, initiation, and completion of tasks at school and at home, inability to deal with change or transitions, academic struggle, siblings and peer relationships, emotional regulation, and low self-esteem. The teacher's primary concern was inattention, homework submission, and self-deprecating behaviors. The participant was administered the ADHD Rating Scale-5, which is an informant rating scale for children 11–17 years of age that assesses the core symptoms of ADHD and oppositional defiant disorder, and indicators of conduct problems and emotional and academic difficulty. The participant's parent completed the

ADHD Rating Scale-5 Parent throughout the three phase point. The participant's current teacher completed the ADHD Rating Scale-5 Teacher school version. Due to the timing of the study, the participant's ratings were based on the last 2 months of the scholastic year. The school interaction was done 100% online.

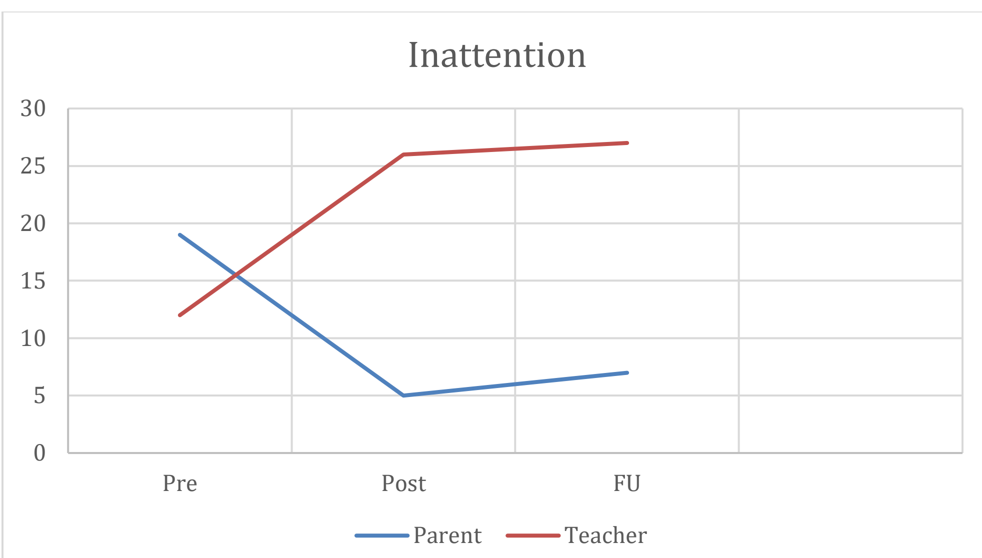
Informants' Demographics and Background

The participant's mother served as the home version informant. She was middle aged, White female, who identifies as heterosexual, and is married with three children. Both parents work full time in the household. The participant is the youngest child.

The participant general room teacher was the school version informant. No specific demographic background information was acquired for the teacher, except that she was an online school the entire scholastic year. The scores of inattention and hyperactivity/impulsivity were plotted across the three time points. The results are depicted in Figures 1 and 2.

Figure 1

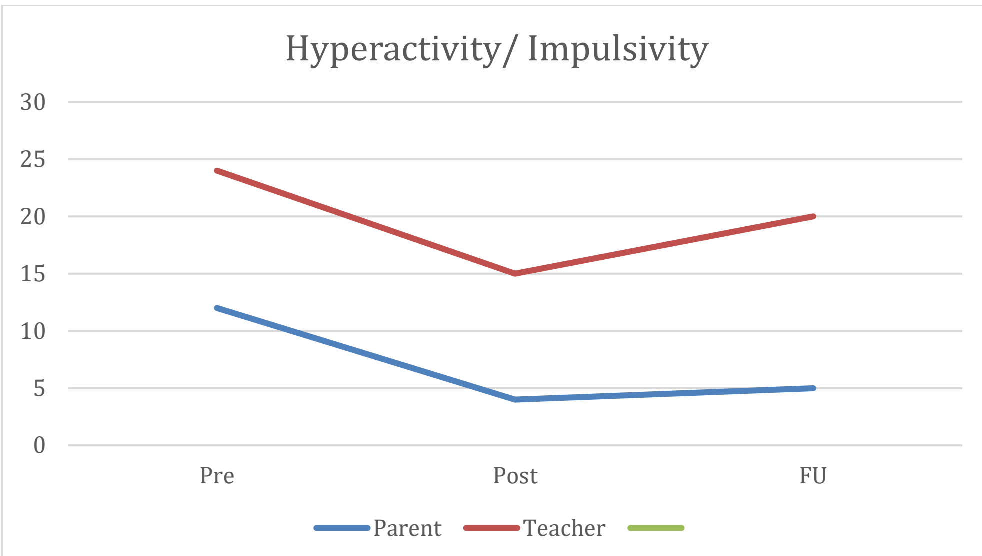
ADHD Inattention Scores Home and School



The scores of inattention/concentration were plotted across the three time points. The data exhibit that even at T1 the scores were rated differently. The interaction between them implies a meaningful difference in that they improved according to the parent, and they got worse according to the teacher.

Figure 2

ADHD Hyperactivity/Impulsivity Scores Home and School



The scores of hyperactivity/impulsivity were plotted across the three time points. There was meaningful difference at T1 between both raters and a difference between T2 and T3 in which both raters saw the same reduction but rated differently.

The parent reported a significant reduction on both the symptoms and impairments domains. The parent reported a decrease of ADHD symptoms at Phases 2 and 3. The family relationship, homework, and self-esteem impairment scores remained the same throughout the three phase points. Peer relationship scores decreased post neurofeedback intervention; however, the score increased back to the pre-neurofeedback baseline assessment scores at Phase 3. Overall, impairment scores decreased from Phase 1 to Phase 2.

The teacher report demonstrated an increase in inattentive symptoms at Phase 2, and the hyperactivity/impulsive symptoms exhibited a decrease at Phase 2 but increased at Phase 3. Peer and teacher relationships, as well as academic performance, increased in elevation at Phase 2. Homework and self-esteem remained the same. Behavior rating scores decreased at Phase 2. The teacher endorsed elevated scores in homework and self-esteem impairments for the participant across the three phase points.

Chapter 4

Due to the COVID-19 pandemic, this research study was designed as a case study to mediate contact and accessibility restrictions. The original design required a nonmedicated participant between the ages of 11 to 17 with a formal mental health diagnosis of ADHD, and with no other diagnoses except anxiety or depression, which are commonly associated with an ADHD diagnosis. Due to the lack of participant access and the persistent cases of COVID-19 as well as the specific restrictions, this study included the relationship that happens in the real world when one thing makes life experience more vulnerable and vice versa, when life experiences affect the vulnerability of an individual. ADHD is a complex diagnosis, and it does not happen in a vacuum environmental design. People who are diagnosed with ADHD are more prone to trauma and other comorbidities that develop through an individual's life in the real world. Therefore, the study assessed the relative improvement of symptoms of ADHD amid environmental distress, as well as other comorbid diagnoses. The participant's age remained the same, and mood, personality, and psychotic disorders were still excluded. However, medication was removed from the exclusionary criteria and the participant was told to maintain the same dosage and type of medication for the duration of the research study. In addition, a trauma diagnosis, such as PTSD or adjustment disorder was not excluded in this research study. The chosen participant has a diagnosis of ADHD, as well as GAD, OCD, and PTSD. The participant is currently taking Guanfacine (intuniv) ER 3 MG daily.

Interpretation

According to the parent (home version rating scores), this study failed to confirm my hypotheses (H1a) neurofeedback training will reduce ADHD symptoms, and its integration as an adjunctive tool will have a more significant effect size than treatment as usual exhibited by the parent report of a decrease and a maintained neurofeedback effect at the follow-up phase in the overall symptoms of ADHD in through the ADHD Rating Scale-5 home version. Nevertheless, the teacher reported an elevation in most ADHD symptoms, except behavior impairment. My hypothesis (H1b) that neurofeedback training will impact ADHD symptoms of attention/ concentration associated with ADHD was partially supported. Results from the parent-report measures showed improvement in the participant’s ability to listen to instructions and not having to repeat commands and expectations as often as usual. For example, reminders of tasks or chores being completed. In contrast, results from the teacher-report measures exhibited an increase in inattention, hyperactivity, and impulsivity, as well as impairments (relational, behavioral, academic, and self-esteem). My hypothesis (H1c) that neurofeedback training will reduce symptoms of hyperactivity/impulsivity associated with ADHD was partially supported. Results from the parents-report measures showed improvements in behavior and sleep. According to the participant’s parent, the participant's behavior improved and seemed more regulated than prior with improved sleep. The participant’s parent reported improvements in sleep as an explanation of reduction of symptoms of hyperactivity at nighttime—for example, going to bed at a “normal” time between 9 p.m. to 10 p.m. and waking up in the morning between 6 a.m. and 7 a.m. The parent explained, prior to neurofeedback training, the participant could stay up the entire night or would go to bed past midnight.

Regarding my second hypothesis (H2) that the baseline on the ADHD rating scale-5 scores will improve after the 12 sessions and effects will remain after the 3-week follow-up assessment was partially supported. Results from the parent-report measures exhibited improvement and maintenance of neurofeedback effects at the follow-up assessment. However, results from the teacher-report measures (school version) differed from the parents score exhibiting elevation in most domains. This elevation may be derived by several factors, such as online setting instead of face-to-face school and isolation and social distance restrictions due to the COVID-19 pandemic, blocked memories or imprints in the brain that are being resurfaced by the neurofeedback training, or participant's lack of adaptive resources. One strong potential issue that may have differentially impacted the parent and teacher scores was that the parent was more directly involved in the neurofeedback training and was a higher stakeholder than the teacher. Thus, the parent was much more subjected to the placebo effect than the teacher, who may be aware the treatment is happening, but it was much more peripheral to her. Therefore, the teacher is likely to be less vulnerable to the placebo effect than the parent. Another possibility is that the reaction response may be related to teacher-student dynamics. More exploration is needed to assess this discrepancy between parent and teacher rating scores. This study was impacted by numerous external factors that may have impacted the overall results, such as the all implications of COVID-19, participant cooccurring diagnosis, informant method, relational dynamics, and timing of the data collection. A list of limitations and implications are explored in depth next.

Exploration of the Study Limitations and Current Events Implications

Researcher Bias Error

This study was designed as a case study design case study. A priori assumption about the magnitude of expected change that would constitute an intervention impact in

ADHD symptoms was not defined; thus, changes were not defined as clinically significant. Results were based solely on the observations of variance and changes between parent and teacher report. This factor made this study sensitive to research bias and the possibility of skewing the entire investigation process towards a desired outcome by introducing a systematic error into the sample information. Future research with larger samples is needed to confirm a clinically significant outcome.

ABA Design and No Control

For this study, an ABA design was originally selected. However, this study failed to perform an ABA design. To use an ABA design, the ADHD Rating Scale-5 needed to be administered at four points in time to establish a baseline. Thus, any potential changes during Phase A that could occur due to chance would be measured before the first session. To do that, the instrument needed to be administered at T1, then wait a defined period, and then administer the instrument at T2 before starting the neurofeedback. After neurofeedback, the instrument would have had to be administered again at T3, then wait for the 3-week period and, finally, administer the instrument at T4. In this study, the ADHD Rating Scale-5 was administered before the start of neurofeedback (T1) and then after treatment (T2) and follow-up (T3). Thus, an ABA design was not used, and a control was not established.

Cooccurring Diagnosis

One of the limitations of this study was the participant's cooccurring diagnosis of PTSD. Neurofeedback may help decrease symptoms of ADHD; however, it may be difficult to determine the exact Impact due to the presence of PTSD symptoms. On the other hand, neurofeedback may exhibit a significant difference in both clusters of symptoms of ADHD and PTSD. PTSD and ADHD symptoms often overlap and can be commonly confused (Schilpzand et al., 2018). Often individuals who endorse symptoms of anxiety or a mood disorder present similar profiles to those with ADHD. At the same time, these complex disorders can coexist together, making the diagnostic clarification process critically important. Studies have suggested PTSD is one of the most complex cooccurring disorders to decipher differential diagnoses or overlapping symptoms, as well as to apply an effective treatment. Brown et al. (2017) found a significant relationship between ADHD (moderate to severe) and ACE scores. Children diagnosed with ADHD exhibited an elevated ACE exposure compared to children without the diagnosis of ADHD (Brown et al., 2017).

ADHD is a neurological and developmental disorder in which active areas of the brain are impacted, such as emotional regulation, impulsivity, and self-awareness. ADHD is commonly present at birth; however, symptoms become more apparent during early childhood. In contrast, PTSD symptoms arise because of a traumatic event or stressor, targeting the same brain areas as ADHD. Although they differ in etiology, both disorders can appear similar and can have the same presentation of symptoms. Individuals with ADHD are more prone to impairment, making them less resilient and more vulnerable to stressors than typically developing individuals. Studies recognized treating both complex co-occurring disorders have better outcomes when a multimodal approach is applied (Schilpzand et al., 2018). Individuals with cooccurring diagnosis of PTSD and ADHD have better outcomes when the ADHD symptoms are treated, reducing vulnerability by increasing resilience, emotional regulation, and adding organizational, social, and life skills to be more active in their trauma healing experience. Treatment of ADHD also includes sleep, which may reduce sleep problems associated with PTSD symptoms. Applying a multimodal approach that uses adjunctive interventions combined with the first choice of treatment may lead to positive results.

Gender Normative Rating Scales

Another limitation present in the study was the gender norms on the rating scales. The ADHD Rating Scale-5 scores are only normed for boys and girls. These norms do not consider individuals who do not fit into those two limited categories. The participant for this study is female by birth but self-identifies as gender fluid and indicated pronouns of he/him. The clinical cut-off scores were quite different depending on gender and it was confusing whether to score based on assigned gender or the patient's gender identity. Similarly, this element highlighted established gender biases about behavior and functioning (e.g., hyperactivity is more normalized among boys than girls). It was uncertain how the biases of the reporters (mom and teacher) pertaining to this participant may have influenced outcomes.

For this specific study, the sex at birth was chosen. Future research will benefit from using assessment measures that have a more inclusive approach to sexual and gender identity in their normative measures (Yu et al., 2021).

Self-Report and Informant Discrepancies

This study encountered an observable discrepancy between parent and teacher scores. According to De Los Reyes and Kazdin (2005), discrepancies have always existed among different informants and have an impact on empirical outcomes. He highlighted attribution bias as one of the main factors, explaining the importance of an established theoretical framework to help the researcher retrieve the desired information. Attribution bias refers to assumptions or judgments people make to explain their own behavior, as well as their own, leading to systematic errors. De Los Reyes and Kazdin (2005) explained, to avoid this phenomenon, the data source of the informants needs to be retrieved from multiple sources, including, both parents, other caregivers (grandmother or babysitters), multiple teachers, and other instructors or coaches. He mentioned the need for future experimental approaches to decrease informant discrepancies in empirical settings (De Los Reyes & Kazdin, 2005). Therefore, this case study lacked multiple informants from both settings. Another limitation related to the informants was the lack of the raters' demographic information. This information is important to possibly understand the relationship between the informants and the scores. In addition, a self-report measure was not given to the participant to assess his perception of change.

The COVID-19 Pandemic

This study was completed during the COVID-19 pandemic. This resulted in difficulty finding a participant with the criteria specification of the first design. Contact restrictions made it difficult to have an ample selection, as well as opportunities to recruit participants from community centers and schools. Children had online classes for most of the academic year. This factor not only made it difficult to recruit, but it also increased symptoms of anxiety, depression, and emotional dysregulation of children (Xu Chen et al., 2021; Lu et al., 2020), which may have influenced the study results. During this time, children reported feeling isolated and endorsed elevated symptoms of depression and anxiety, as well as family conflict due to the stay-at-home mandate. It is important to note these results should be interpreted with caution and there should be future research assessing the influence of real life internal and external experiences influencing symptoms of cooccurring disorders, such as ADHD and PTSD.

One can infer these events have impacted the teacher and parent evaluations. The teacher is likely more overwhelmed and has no direct contact with the participant. Which is different from typical interaction in school. Virtual interactions are much more limited in their ability to evaluate specific behavioral changes within one individual. In contrast, the parent has direct interaction with the participant and sees the nuanced changes in their child's behavior more comprehensively. Another implication may be the possibility that the parent has become more lenient or has a desire for change and is measuring participant's behaviors differently

History Effect in Relationship to COVID-19 Affecting Validity

Prior research has demonstrated how events or circumstances outside the research setting impact validity and outcome variables. This experiment was done during the COVID-19 pandemic and outcomes may have been influenced by this event. The participant, as well as the informant in both settings had significant changes in environment and social interaction. Thus, more research around these areas in relation to the increase of symptoms of ADHD is recommended.

Research Timing and Academic Effort

This study was performed during the last month and a half of the academic year. The teacher reported an increased elevation of inattention, lack of motivation, academic, and self-esteem impairments. The elevations differ from the parent score ratings. The end of the school year factor may have influenced these elevations. More research is encouraged to assess the limitation in relationship to school season and academic effort.

Integration

Outcomes of neurofeedback training are not always constant or predictable (Sitaram et al., 2017). The outcome of this study supported this statement through the discrepancy between parent and teacher rating scores. This phenomenon has raised controversial issues and data challenges related to measurable outcomes associated with neurofeedback training effects and change. Neurofeedback training does not always result in behavioral modification or change (Sitaram et al., 2017). This phenomenon may be related to the capability (neuroplasticity) of the brain to change. Even though brain composition has a universal design, each brain's capacity (resilience or neuroplasticity) differs. Thus, it is essential to note that the outcome of the neurofeedback training may present differently on each client.

Chapter 1 provides an extensive explanation of the two measurements of plasticity, the Hebbian plasticity and the homeostatic plasticity (Fox & Stryker, 2017; Sitaram et al., 2017). The Hebbian plasticity is referred to as the mechanism used to code and retain information in the brain neurons (Fox & Stryker, 2017; Sitaram et al., 2017). The homeostatic plasticity can be explained as the neuronal change that aims to return the neuron to baseline (initial setpoint; Fox & Stryker, 2017). The homeostatic plasticity counteracts or prevents saturation of the synaptic strength (excitatory or inhibitory). Both types of plasticity work in opposite directions; however, the integration of both types of activity is necessary for optimal outcomes (Fox & Stryker, 2017; Sitaram et al., 2017). However, these theories are only looking at neuroplasticity (resilience) from a neurological perspective. Using a biopsychosocial perspective, biology is equally as important as the psychological and social factors. Humans are social beings, and they need social interactions to learn, adapt, and bring change. According to the attachment theory, Ainsworth (1963) explained behavioral responses and adaptation are learned through relational attachments, primarily by the main caregiver, and it is limited to the provision of the individuals' main needs during their developmental years. Recent studies are looking at the intergenerational transmission of attachment patterns. These patterns influence individuals' abilities to receive their development needs across generations, impacting adaptation and resilience resources. According to Bowlby (1980) the stability of internal working models (responses and adaptation) is influenced by defensive distortions, leading to social interaction and dyadic patterns of relating becoming less accessible to awareness, adapting an automatic or habitual response, and developing a resistance to change. The person brain model (i.e., neurotransactional model) emphasize the importance of receiving the four elements of flourishing in relationship and the impact on resilience and ability to change and adapt (Baker & White-Mcmahon, 2019).

Many studies have highlighted the phenomenological differences of neurofeedback outcome-effects. Many researchers have proposed the idea of neurodiversity, explaining brains are different, and neurofeedback may or may not work for certain individuals. Most of the time the explanation is vague and leaves many clinical interventionists with the questions of "why." The following questions were raised throughout the experimental time: Are the positive or negative results related to brain structure and composition; What are the key differences of individuals who have positive neurofeedback outcomes from the ones who experience minimal to no outcome? Can these differences be observed and measured; Are cognitive distortion influences maintaining unhealthy patterns regardless of emotional regulation or reset time; Are neurofeedback training outcomes limited to brain resilience; And how can resilience of individuals be measure in relationship to neurofeedback training outcomes and neurotransactional experiences?

Baker and White-Mcmahon (2019) suggested an individual has four elements of flourishing learned through neurotransactional experiences: safe, related to, respected, and significant. They proposed transformation results from addressing and filling the needs of individuals by integrating power of social relationships and connecting possibilities of an ever-changing brain with hope. Adaptability is primarily based on individuals' neurotransactional experiences (social interactions). If the person is lacking files of neurotransactional interaction, the response will be distorted and dysregulated, affecting the neuroplasticity (resilience) of the brain (Baker & White-Mcmahon, 2019). Through neurotransactional experiences, individuals can receive a reimbursement for their specific need and decrease vulnerability (Baker & White-Mcmahon, 2019). Research has highlighted the phenomenological experience of individuals having different outcomes with neurofeedback training. Many of the individuals have endorsed thought disorders, trauma experiences, and other factors that may be related to neurotransactional needs. One can suggest if the brain does not have resilience files due to lack of neurotransactional experiences in specific areas, the brain self-regulation will reach a skewed mean.

With this information, one can propose the brain needs neurotransactional files to increase resilience (neuroplasticity) to learn and experience transformation; without resilience, the brain is limited, and it will reach its own "plateau" (Baker & White-Mcmahon, 2019). Neurofeedback training does not provide neurotransactional experiences. Even though the brain will benefit from neurofeedback training, the regulation and learning experience will be limited to the individual's stored files. Baker and White-Mcmahon (2019) remarked the brain is designed to relate to others. Trauma, stressors, and negative neurotransactional experiences switch the brain from relational to survival mode. The brain is unable to learn when in a survival state; therefore, neurofeedback is beneficial to help the brain reset to safety and reach a regulated state to learn new information. The neurotransactional experiences are needed for increasing neuroplasticity and resilience, increasing the individual's self-regulation. Relationship and ecological factors generate traits and states in individuals, helping them to better adapt to adverse situations (Baker & White-Mcmahon, 2019). Baker and White-Mcmahon (2019) highlighted the idea of neurotransactional experiences being the key to transformation and resilience. Individuals who are vulnerable or less resilient will benefit from an integrative approach blending a brain-based and social science treatment (Baker & White-Mcmahon, 2019).

Future research around the area of brain resilience measurements related to positive neurofeedback training outcomes is needed to assess best practices and treatment. Creating a treatment that includes neurotransactional experiences to assess needs simultaneously with neurofeedback training may be another area of future study. Neurofeedback training is a costly procedure, and it is important to assess an individual's treatment fit to provide best care.

Conclusion

The outcome of the study provided limited information to generalize significant conclusions. Due to methodological design and current events, this study failed to confirm the two main hypotheses. Contradicting changes were observed from both settings (home and school) which made it difficult to determine the relationship of change to neurofeedback training. Future studies should focus on conducting large, randomized control trials looking at neurofeedback training effects on complex and cooccurring disorders, integrating real-life events that influence individuals' life and global settings. In addition, this study raised the question about neuroplasticity and resilience resources correlated to ability to learn, modified brain activity, and change behavior. Future research should strive to measure a global concept of resilience, assessing individual established resources and identifying the omitted needs. These variables may be assessed by integrating a neurotransactional model, evaluating the samples through a biopsychosocial lens for conceptualization and methodological selection. Furthermore, future studies should also focus on evaluating the implications of the COVID-19 pandemic on symptoms of ADHD, such as online school, isolation (social distance), academic impairments, measuring resilience by the ability to adapt to unexpected changes. The gender normative rating scales were raised as a concern and limitation in this study. The normative scoring scales were norm on by and girl and limited individuals who do not identify by either gender or are identify by other than sex at birth. Future research will benefit from using assessment measures that have a more inclusive approach to sexual and gender identity in their normative measures. Thus, it is crucial to encourage the development of forthcoming interventions with an all-encompassing diversified design, including gender diversity, race, cultural and ethnic differences, and biological abilities.

Among researchers, medical practitioners, and psychological clinicians, neurofeedback has sparked an ongoing controversy that has been ensued by numerous concerns. One question is whether the origin of the concerns is not derived by the neurofeedback training itself, but by the capability of the individuals' brains to learn and change. Resilience is a pivotal element for change and transformation and should be of utmost concern in future research studies looking at the Impact of neurofeedback across diagnosis and comorbidities.

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Appendix A

ADHD Rating Scale-5: Home Version and School: Adolescent

Attention and Behavior Rating Form, Home Version: Adolescent (English)

Child's name: ______________________ Sex: M F Age: _______ Grade: ________________

Completed by: Mother ____ Father ____ Guardian ____ Grandparent ____

Please select the answer that *best describes your teenager's behavior over the past 6 months.*

How often does your child display this behavior?	Never or Rarely	Sometimes	Often	Very Often
Fails to give close attention to details or makes careless mistakes in schoolwork, at work, or during other activities	0	1	2	3
Has difficulty sustaining attention in tasks or play activities (e.g., has difficulty remaining focused during conversations or lengthy reading)	0	1	2	3
Does not seem to listen when spoken to directly	0	1	2	3
Does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace	0	1	2	3
Has difficulty organizing tasks and activities	0	1	2	3
Avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (e.g., schoolwork or homework; preparing reports)	0	1	2	3
Loses things necessary for tasks or activities (e.g., school materials, pencils, books, tools, wallets, keys, paperwork, eyeglasses, mobile telephones)	0	1	2	3
Easily distracted	0	1	2	3
Forgetful in daily activities (e.g., doing chores, running errands, returning calls, keeping appointments)	0	1	2	3

How much do the nine behaviors in the previous question cause problems for your teenager:	No Problem	Minor Problem	Moderate Problem	Severe Problem
Getting along with family members	0	1	2	3
Getting along with other teenagers	0	1	2	3
Completing or returning homework	0	1	2	3
Performing academically in school	0	1	2	3
Controlling behavior in school	0	1	2	3
Feeling good about himself/herself	0	1	2	3

(continued)

Attention and Behavior Rating Form, Home Version: Adolescent (English) *(page 2 of 2)*

How often does your teenager display this behavior?	Never or Rarely	Sometimes	Often	Very Often
Fidgets with or taps hands or feet or squirms in seat	0	1	2	3
Leaves seat in situations when remaining seated is expected	0	1	2	3
Runs about or climbs in situations where it is inappropriate or feels restless	0	1	2	3
Unable to play or engage in leisure activities quietly (e.g., is unable to be or is uncomfortable being still for an extended period of time)	0	1	2	3
"On the go," acts as if "driven by a motor"	0	1	2	3
Talks excessively	0	1	2	3
Blurts out an answer before a question has been completed	0	1	2	3
Has difficulty waiting his or her turn (e.g., while waiting in line).	0	1	2	3
Interrupts or intrudes on others (e.g., butts into conversations, games, or activities; may intrude into or take over what others are doing)	0	1	2	3

How much do the nine behaviors in the previous question cause problems for your teenager:	No Problem	Minor Problem	Moderate Problem	Severe Problem
Getting along with family members	0	1	2	3
Getting along with other teenagers	0	1	2	3
Completing or returning homework	0	1	2	3
Performing academically in school	0	1	2	3
Controlling behavior in school	0	1	2	3
Feeling good about himself/herself	0	1	2	3

Attention and Behavior Rating Form, School Version: Adolescent

Student's name: ______________ Sex: M F Age: ______ Grade: ______________

Completed by: ______________________________

Please select the answer that *best describes this student's behavior over the past 6 months (or since the beginning of the school year).*

How often does this student display this behavior?	Never or Rarely	Sometimes	Often	Very Often
Fails to give close attention to details or makes careless mistakes in schoolwork or during other activities	0	1	2	3
Has difficulty sustaining attention in tasks or play activities (e.g., has difficulty remaining focused during lectures, conversations or lengthy reading)	0	1	2	3
Does not seem to listen when spoken to directly	0	1	2	3
Does not follow through on instructions and fails to finish schoolwork	0	1	2	3
Has difficulty organizing tasks and activities	0	1	2	3
Avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (e.g., schoolwork or homework; preparing reports)	0	1	2	3
Loses things necessary for tasks or activities (e.g., school materials, pencils, books)	0	1	2	3
Easily distracted by extraneous stimuli or unrelated thoughts	0	1	2	3
Forgetful in daily activities	0	1	2	3

How much do the nine behaviors in the previous question cause problems for this student?	No Problem	Minor Problem	Moderate Problem	Severe Problem
Getting along with school professionals	0	1	2	3
Getting along with other students	0	1	2	3
Completing or returning homework	0	1	2	3
Performing academically in school	0	1	2	3
Controlling behavior in school	0	1	2	3
Feeling good about himself/herself	0	1	2	3

(continued)

Attention and Behavior Rating Form, School Version: Adolescent *(page 2 of 2)*

How often does this student display this behavior?	Never or Rarely	Sometimes	Often	Very Often
Fidgets with or taps hands or feet or squirms in seat	0	1	2	3
Leaves seat in situations when remaining seated is expected	0	1	2	3
Runs about or climbs in situations where it is inappropriate or feels restless	0	1	2	3
Unable to play or engage in leisure activities quietly	0	1	2	3
"On the go," acts as if "driven by a motor" (e.g., unable to be or uncomfortable being still for an extended time)	0	1	2	3
Talks excessively	0	1	2	3
Blurts out an answer before a question has been completed	0	1	2	3
Has difficulty waiting his or her turn (e.g., while waiting in line).	0	1	2	3
Interrupts or intrudes on others (e.g., butts into conversations, games, or activities; may intrude into or take over what others are doing)	0	1	2	3

How much do the nine behaviors in the previous question cause problems for this student?	No Problem	Minor Problem	Moderate Problem	Severe Problem
Getting along with school professionals	0	1	2	3
Getting along with other students	0	1	2	3
Completing or returning homework	0	1	2	3
Performing academically in school	0	1	2	3
Controlling behavior in school	0	1	2	3
Feeling good about himself/herself	0	1	2	3

Appendix B

ADHD Rating Scale-5 Home Version: Impairments Scoring and Symptoms Boys

ADHD Rating Scale–5, Home Version: Impairment Scoring Sheet for Boys

Child's name: ____________________ Date: __________ Age: __________

	Family Relations				Peer Relations				Homework				Academics				Behavior				Self-Esteem				
%ile	5–7	8–10	11–13	14–17	5–7	8–10	11–13	14–17	5–7	8–10	11–13	14–17	5–7	8–10	11–13	14–17	5–7	8–10	11–13	14–17	5–7	8–10	11–13	14–17	%ile
99.5+	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2-3	3	99.5+
99			2				2	2		2										2		2		2	99
98	2	2		2	2	2					2			2				2	2		2				98
95				1				1	2			2	2		2	2	2			1	1			1	95
93		1	1		1	1	1							1								1	1		93
90	1								1	1			1					1	1						90
85											1	1			1	1	1								85
80								0																	80
75							0												0	0	0	0		0	75
70		0		0	0	0			0				0	0				0					0		70
65	0		0														0								65
60										0					0	0									60
55											0	0													55
50																									50

From *ADHD Rating Scale–5 for Children and Adolescents: Checklists, Norms, and Clinical Interpretation* by George J. DuPaul, Thomas J. Power, Arthur D. Anastopoulos, and Robert Reid.

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ADHD Rating Scale–5, Home Version: Symptom Scoring Sheet for Boys

Child's name: ______________________ Date: __________ Age: __________

%ile	HI 5–7	HI 8–10	HI 11–13	HI 14–17	IA 5–7	IA 8–10	IA 11–13	IA 14–17	Total 5–7	Total 8–10	Total 11–13	Total 14–17	%ile
99+	27	27	26	21	27	27	27	27	50	53	52	47	99+
99	24	26	22	16	25	27	27	26	45	49	47	39	99
98	19	20	19	15	23	25	27	25	41	44	43	37	98
97	18	20	18	13	22	21	25	21	38	38	38	34	97
96	17	19	17	12	21	20	22	20	38	36	36	30	96
95	17	18	15	10	18	17	21	19	35	35	34	27	95
94	17	17	14	9	17	16	21	18	32	33	31	26	94
93	17	16	13	9	17	16	19	18	31	31	30	25	93
92	16	16	12	9	16	16	18	17	29	30	28	25	92
91	15	15	11	8	15	15	18	16	27	29	26	22	91
90	15	14	10	8	14	14	17	16	27	28	25	21	90
89	13	13	10	7	14	12	16	15	26	25	24	20	89
88	13	11	9	7	12	12	15	14	25	24	23	19	88
87	12	10	9	6	11	12	15	13	24	22	22	18	87
86	12	10	9	5	11	11	15	12	22	21	22	18	86
85	10	9	9	5	10	11	14	11	20	19	21	17	85
84	10	9	9	5	10	11	13	11	20	19	21	16	84
80	9	8	7	4	9	9	12	10	18	17	19	14	80
75	8	7	6	3	9	9	10	9	16	14	17	11	75
50	5	3	2	1	5	4	6	4	10	8	8	5	50
25	2	1	0	0	2	2	1	1	4	3	2	2	25
10	0	0	0	0	0	0	0	0	0	1	0	0	10
1	0	0	0	0	0	0	0	0	0	0	0	0	1

Note. HI, Hyperactivity–Impulsivity; IA, Inattention.

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ADHD Rating Scale-5 Home Version: Impairments Scoring

ADHD Rating Scale–5, School Version: Impairment Scoring Sheet for Girls

Student's name: ____________________ Date: __________ Age: __________

	Teacher Relations				Peer Relations				Homework				
%ile	5–7	8–10	11–13	14–17	5–7	8–10	11–13	14–17	5–7	8–10	11–13	14–17	%ile
99.5+	2–3	3	3	3	3	3	3	3	3	3	3	3	99.5+
99		2		2		2		2					99
98			2		2		2	1	2			2	98
95										2			95
93	1	1	1	1									93
90						1	1				2	1	90
85					1								85
80				0				0	1	1	1		80
75	0	0	0				0						75
70													70
65												0	65
60					0	0				0			60
55									0				55
50											0		50
45													45
40													40

	Academics				Behavior				Self-Esteem				
%ile	5–7	8–10	11–13	14–17	5–7	8–10	11–13	14–17	5–7	8–10	11–13	14–17	%ile
99.5+	3	3	3	3	3	3	3	3	3	3	3	3	99.5+
99											2	2	99
98				2			2	2		2			98
95					2	2			2				95
93		2						1			1	1	93
90	2		2				1			1			90
85				1		1		0	1				85
80	1												80
75		1	1		1							0	75
70							0		0		0		70
65				0		0				0			65
60													60
55	0	0	0		0								55
50													50
45													45
40													40

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ADHD Rating Scale–5, Home Version: Symptom Scoring Sheet for Girls

Child's name: ______________________ Date: __________ Age: __________

%ile	HI 5–7	HI 8–10	HI 11–13	HI 14–17	IA 5–7	IA 8–10	IA 11–13	IA 14–17	Total 5–7	Total 8–10	Total 11–13	Total 14–17	%ile
99+	27	26	22	20	26	27	27	25	50	53	38	42	99+
99	25	23	16	19	23	26	25	23	45	47	35	36	99
98	20	21	15	12	21	22	21	19	43	37	32	32	98
97	17	15	14	11	18	18	20	18	35	36	29	28	97
96	16	13	13	9	17	17	19	18	32	30	29	25	96
95	15	11	12	9	16	16	17	18	29	28	27	24	95
94	14	10	12	8	15	15	15	17	27	25	24	23	94
93	13	9	11	8	14	14	15	17	25	21	23	21	93
92	12	9	9	7	13	13	13	15	24	21	22	20	92
91	12	9	9	6	13	13	13	14	22	20	21	20	91
90	11	9	8	6	12	12	12	14	21	20	20	19	90
89	10	8	8	6	12	12	12	13	21	18	19	18	89
88	9	8	7	5	12	11	11	13	20	18	18	18	88
87	9	8	7	5	12	11	11	12	18	17	18	17	87
86	8	7	7	5	11	11	10	12	18	17	18	16	86
85	8	7	6	4	10	10	10	11	18	16	17	15	85
84	8	7	6	4	10	10	10	11	17	16	16	15	84
80	7	6	5	3	9	9	9	9	15	14	13	12	80
75	6	5	4	3	8	8	8	7	13	12	11	10	75
50	3	2	1	1	3	3	3	3	7	6	5	4	50
25	1	0	0	0	1	1	1	0	3	2	1	1	25
10	0	0	0	0	0	0	0	0	0	0	0	0	10
1	0	0	0	0	0	0	0	0	0	0	0	0	1

Note. HI, Hyperactivity–Impulsivity; IA, Inattention.

Appendix C

Informed Consent Form for Parents and Participant

You are invited to participate in a research study conducted by Genevieve Bendeck, psychology student in the PsyD program at Northwest University. The study is being conducted as a dissertation study. The purpose of this study is further the investigation on the impact of neurofeedback training in ADHD.

If you agree to participate in the study, you will be participating in a total of 13 sessions. You will be administered 12 free-33-minute neurofeedback sessions three times a week for a total period of 4 weeks. The initial session will consist in a 2-hour session divided between the initial assessment and the first neurofeedback session. The following sessions will last between 45-60 minutes. At the completion of the 12 sessions, the parent or the caregiver, as well as the teacher (home and school version) will fill-out the post assessment forms and at a 4-week follow-up assessment session at 4 weeks to record the levels of symptoms and behaviors related to ADHD. To participate, the parent will need to be present in every session and provide a formal clinical diagnosis of ADHD. The participant needs to be nonmedicated and not thinking in going on medication during the period of the study, including the 4-week follow-up assessment.

There are minimal risks associated with participation. The participant may be uncomfortable answering personal questions. You may choose not to participate in this research study at any time. The benefit of taking part in this study is the opportunity to participate in the research process as a research subject. Another advantage is the 12 neurofeedback sessions offered at no cost to you. In addition, at the completion of the 12 week, you will receive a $25 Amazon gift card. If any questions or content of this questionnaire bring up personal questions, confusion, or anxiety, please contact the Crisis Call Center at 1 (800) 273-8255 or http://crisiscallcenter.org/. You may also seek further help by contacting the Crisis Text Line at www.crisistextline.org, or by texting “HOME” to 741741.

For this study, no high physical risk is associated with participation, although the participant may (or may not) experience some mild sensations in their body or head, like tingling or warmth (Brown, 1995). For the neurofeedback, Kingsley Outpatient Clinic neurofeedback system will be used. Neurofeedback training is a noninvasive form of neurofeedback training that does not introduce anything into the brain apart from the information obtained by the same brain (feedback). Neurofeedback is not a medical procedure or treatment; it is a training for the brain. This system works allowing the brain to see what is doing almost like holding up a mirror to self-correct or interrupt electrical activity that undermines the optimal functioning of the brain.

The neurofeedback process is usually seamless; however, not all change are seamless, and the participant may experience mild feelings discomfort, such as feeling more open, vulnerable, raw, reactive or tearful. Sometimes it is not that they feel more of these emotions, but that they become more aware of their feelings. These elements are similar to how clients may respond to psychotherapy or other healing modality.

Participant may experience bodily shifts as it becomes more finely tuned as the bad habits or patterns become harder to ignore, such as not getting enough sleep. Participant’s tolerance for medication may reduce, this may present in a form of increase of medication side-effects. Please follow up with your physician if you encounter some shift or have any questions. For this study, it is important to remain in the same dosage and medication type until completion, as well as to take the necessary precautions by consulting with your physician throughout the intervention process. Participation in this study is voluntary. You may choose not to participate in this study at any time and for any reason. There will not be any negative consequences for you if you refuse to participate. You may refuse to answer any questions asked. All responses are confidential; therefore, it is imperative that you DO NOT put your name on your response sheets. You may keep this consent form for your records.

The results from this study will be presented in at a dissertation defense at Northwest University in January 2021**.** Also, results may be published in a psychological journal. Add that no identifying information about you will be reported, however. All raw data forms will be destroyed 12/31/2028

If you have any questions about this study, contact Genevieve Bendeck at xxxxx@northwestu.edu, or (XXX) XXX-XXXX. If you have further questions, please contact my dissertation chair Dr. Nikki Johnson at nikki.johnson@northwestu.edu, or at 425-889-5367**.** You may also contact the Chair of the Northwest University IRB, Dr. Cherri Seese, at cherri.seese@northwestu.edu or 425-889-5327.

Thank you for your consideration of this request.

Genevieve Bendeck
Doctoral Student in Counseling Psychology
College of Social and Behavioral Sciences

425-221-0672
xxxxx@northwestu.edu

Nikki Johnson PsyD
Associate Professor
College of Social and Behavioral Sciences
(425) 889-5367
nikki.johnson@northwestu.edu

______________________________ ________________
Participant Date

______________________________ ________________
Principal Investigator Date

______________________ ________________
Witness Date

Informed Consent Form for Teacher

You are invited to participate in a research study conducted by Genevieve Bendeck, psychology student in the PsyD program at Northwest University. The study is being conducted as a dissertation Study. The purpose of this study is further the investigation on the impact of neurofeedback training on ADHD.

If you agree to participate in the study, you will be participating in a total of three session tasks. You will fill out a structured questionnaire about observational symptoms about the chosen participant in the school setting. The questionnaire will be fill out before and after the intervention sessions, and at the 4-week follow-up assessment, making a total of 8 weeks.

Participation in this study is voluntary. There are minimal risks associated with participation. The participant may be uncomfortable answering questions. You may choose not to participate in this study at any time and for any reason. There will not be any negative consequences for you if you refuse to participate. You may refuse to answer any questions asked. All responses are confidential; therefore, it is imperative that you DO NOT put your name on your response sheets. You may keep this consent form for your records.

The benefit of taking part in this study is the opportunity to participate in the research process as a research subject.

If any questions or content of this questionnaire bring up personal questions, confusion, or anxiety, please contact the Crisis Call Center at 1 (800) 273-8255 or http://crisiscallcenter.org/. You may also seek further help by contacting the Crisis Text Line at www.crisistextline.org, or by texting "HOME" to 741741.

The results from this study will be presented in at a dissertation defense at Northwest University in January 2021**.** Also, results may be published in a psychological journal. Add that no identifying information about you will be reported, however. All raw data forms will be destroyed 12/31/2028

If you have any questions about this study, contact Genevieve Bendeck at xxxxx@northwestu.edu, or 206-502-9989. If you have further questions, please contact my dissertation chair Dr. Nikki Johnson at nikki.johnson@northwestu.edu, or at 425-889-5367**.** You may also contact the Chair of the Northwest University IRB, Dr. Cherri Seese, at molly.quick@northwestu.edu or 425-889-5327.

Thank you for your consideration of this request.

Genevieve Bendeck
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Nikki Johnson PsyD
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________________________________ _________________

Participant Date

_____________________________________ _____________________

Principal Investigator Date

_________________________________ ____________________

Witness Date

Appendix D

Basic Certification in Neuroptimal

NEUROPTIMAL®
ADVANCED BRAIN TRAINING SYSTEMS

Genevieve Bendeck

who has successfully completed the course requirements

of

BASIC CERTIFICATION IN NEUROPTIMAL®

Valdeane W. Brown, Ph.D.

NEUROPTIMAL® CERTIFIED BASIC TRAINER
ZENGAR INSTITUTE
2017

Susan Cheshire Brown, Ph.D.

Appendix E

Neurofeedback Brain Training

Neurofeedback is a training technology for the brain.
Based upon unique principles, it "simply" provides information to your brain which it can use to identify the underlying dysregulation in the brain that may cause clinical symptoms, encouraging self-regulation. The awareness of the dysregulation encourage neurophysiological resilience with the introduction of relaxation, brain flexibility, and a more balanced central nervous system. When the brains learns to self-regulate, individuals usually feel better and have an easier access to more optimal functioning physically and emotionally. Neurofeedback provides information to the brain about its own activity, which your brain will use to adjust itself. Neurofeedback is a noninvasive and safe intervention with minimal to no side-effects. However, the process of integrating the information and growing and changing can be a powerful one, one that many of individuals are not familiar with and which can feel disorienting for some. We have prepared this document to explain this process as fully as we can, so that when you sign consent for training you are doing so knowledgeably. Please ask for clarification on any issue that is not clear.

Neurofeedback is not a medical treatment, device or methodology. It is not used to diagnose medical disorders, nor is it used as a medical treatment for disorders. It has not been approved for any medical purpose whatsoever by the FDA, Health Canada or any other governing agency. While many neurofeedback trainers may or may not be licensed health care practitioners, their use of neurofeedback is as a tool for brain training and optimization, not as a means of diagnosis or as a medical intervention.

Sessions. Most people find the sessions enjoyable—you can just relax and enjoy them. There is absolutely nothing you have to do. You will sit down and watch a movie on a monitor screen, and have your eyes open. The movie will be paying simultaneously as the neurofeedback training informs your brain about its own activity. Some individuals may feel sensations in their body or head, like tingling or warmth, or they may feel nothing. It's not important whether you are aware of sensations or not. It's not related to its efficacy. **We cannot predict your personal response to neurofeedback training, nor its outcome.** Each person's journey and their results will vary. Some people experience dramatic shift (changes) and growth while others are slower in how they change. It's possible you will perceive little or no effect.

Progress can be variable—it often doesn't follow a straight path forward. This is normal. It can go up and down, but we do like to see a general trend in the desired direction. Neurofeedback training program can demonstrate some analyses that can contribute to your understanding of your progress, but in the end it is always how you are doing in your life that demonstrate the most important progress and change.

Once your central nervous system (CNS) starts to shift (change towards regulation) in response to training you may feel the effects of this physically, emotionally or in your daily life. While these effects are often what we want, there can sometimes be some unwanted effects also. These can fall into one or more of several groups depending on when they are experienced during a session, after a session, effects before the changes have "settled in" (between sessions), and the more ongoing effects of change.

Effects felt between sessions and before the full change has "settled in". Very often the change people experience with neurofeedback training is remarkably effortless and seamless. You are in "this universe" now, and "this new universe" in the next moment. The challenge with this is to notice the changes that are happening—when you are in your "new universe" you don't remember accurately what it was like in the old one. This process of seamless change is why it is important to decide ahead of time how you will know if you are getting the results you want. But not all change is seamless, and some people may have feelings that are less comfortable, such as feeling more open, vulnerable, raw, reactive or tearful. Sometimes it is not that they feel more of these emotions, but instead are becoming more aware of their feelings. Another effect is that some of the people in your environment can be challenged by the changes in you, as you become clearer around your needs. These challenges are all similar to how people can feel in response to good psychotherapy or other healing modality. There can be bodily shifts too (physiological awareness). As your brain becomes more finely tuned the negative effects of some of our bad habits become harder to ignore, such as not getting enough sleep. If you are on medication for a disorder, there may come a time when you need less medication. During this study, it will be required to remain in the same dosage and medication type until completion. For this particular study, the participant need to be nonmedicated prior intervention, during the intervention, and 4 weeks after the intervention. It is important that the child did NOT stop medication or limit medication because of this current study. The participant will be selected with the specification of never been under an ADHD medication, had contraindication, or stopped due to negative side effect prior the current study. All medication decisions will be handled by your physician. Please let your physician know about your or your child participation in neurofeedback training and any medication affects you are having. Please make sure you follow your physician's advice and treatment on-goingly for your medical issues. Neurofeedback in no way replaces medical care, and indeed, Neurofeedback trainers will often require that you are under such care before they work with you.

On-going change. Your tastes can change—things that have been appealing to you in the past may not seem so any more. While this is usually in line with your well-being, if you earn your living by one of your senses, please be aware these senses may change, and it may take you time to adapt to the new sensations. So, foods may not taste the same, for example. If your system exhibits some dehydration and it was "unaware," as you shift (change) you may feel a bit "out of water" for a while as you reach for the familiar and find it is not there in the same way as it was before. It could also be that if you had a particular talent that was based on "being blocked" (or stuck) in a particular state. You may find this "talent" dropping away initially as the CNS releases its points of being blocked. You will have access to these states, but you will need to develop the skill to "go there" and "come back."

How long do the effects last? As your changes become more stable, they will become your new norm and will remain with you through your lifetime. It's like learning how to read or swim. Once you know, you can't not know, although you may get rusty. Your brain is living tissue and can get thrown off by stress, chemicals, hormonal changes, an anesthetic, head injury or other challenge. If this happens to you, a few booster sessions will help your brain return to its good place.

Appendix F

Attention and Behavior Rating Form, Home Version: Adolescent (English)

Child's name: ______________________ Sex: M F Age: _______ Grade: ______________

Completed by: Mother ____ Father ____ Guardian ____ Grandparent ____

Please select the answer that *best describes your teenager's behavior over the past 6 months.*

How often does your child display this behavior?	Never or Rarely	Sometimes	Often	Very Often
Fails to give close attention to details or makes careless mistakes in schoolwork, at work, or during other activities	0	1	2	3
Has difficulty sustaining attention in tasks or play activities (e.g., has difficulty remaining focused during conversations or lengthy reading)	0	1	2	3
Does not seem to listen when spoken to directly	0	1	2	3
Does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace	0	1	2	3
Has difficulty organizing tasks and activities	0	1	2	3
Avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (e.g., schoolwork or homework; preparing reports)	0	1	2	3
Loses things necessary for tasks or activities (e.g., school materials, pencils, books, tools, wallets, keys, paperwork, eyeglasses, mobile telephones)	0	1	2	3
Easily distracted	0	1	2	3
Forgetful in daily activities (e.g., doing chores, running errands, returning calls, keeping appointments)	0	1	2	3

How much do the nine behaviors in the previous question cause problems for your teenager:	No Problem	Minor Problem	Moderate Problem	Severe Problem
Getting along with family members	0	1	2	3
Getting along with other teenagers	0	1	2	3
Completing or returning homework	0	1	2	3
Performing academically in school	0	1	2	3
Controlling behavior in school	0	1	2	3
Feeling good about himself/herself	0	1	2	3

(continued)

Attention and Behavior Rating Form, Home Version: Adolescent (English) *(page 2 of 2)*

How often does your teenager display this behavior?	Never or Rarely	Sometimes	Often	Very Often
Fidgets with or taps hands or feet or squirms in seat	0	1	2	3
Leaves seat in situations when remaining seated is expected	0	1	2	3
Runs about or climbs in situations where it is inappropriate or feels restless	0	1	2	3
Unable to play or engage in leisure activities quietly (e.g., is unable to be or is uncomfortable being still for an extended period of time)	0	1	2	3
"On the go," acts as if "driven by a motor"	0	1	2	3
Talks excessively	0	1	2	3
Blurts out an answer before a question has been completed	0	1	2	3
Has difficulty waiting his or her turn (e.g., while waiting in line).	0	1	2	3
Interrupts or intrudes on others (e.g., butts into conversations, games, or activities; may intrude into or take over what others are doing)	0	1	2	3

How much do the nine behaviors in the previous question cause problems for your teenager:	No Problem	Minor Problem	Moderate Problem	Severe Problem
Getting along with family members	0	1	2	3
Getting along with other teenagers	0	1	2	3
Completing or returning homework	0	1	2	3
Performing academically in school	0	1	2	3
Controlling behavior in school	0	1	2	3
Feeling good about himself/herself	0	1	2	3

Appendix G

Attention and Behavior Rating Form, School Version: Adolescent

Student's name: ____________________ Sex: M F Age: ________ Grade: ________________

Completed by: ____

Please select the answer that *best describes this student's behavior over the past 6 months (or since the beginning of the school year).*

How often does this student display this behavior?	Never or Rarely	Sometimes	Often	Very Often
Fails to give close attention to details or makes careless mistakes in schoolwork or during other activities	0	1	2	3
Has difficulty sustaining attention in tasks or play activities (e.g., has difficulty remaining focused during lectures, conversations or lengthy reading)	0	1	2	3
Does not seem to listen when spoken to directly	0	1	2	3
Does not follow through on instructions and fails to finish schoolwork	0	1	2	3
Has difficulty organizing tasks and activities	0	1	2	3
Avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (e.g., schoolwork or homework; preparing reports)	0	1	2	3
Loses things necessary for tasks or activities (e.g., school materials, pencils, books)	0	1	2	3
Easily distracted by extraneous stimuli or unrelated thoughts	0	1	2	3
Forgetful in daily activities	0	1	2	3

How much do the nine behaviors in the previous question cause problems for this student?	No Problem	Minor Problem	Moderate Problem	Severe Problem
Getting along with school professionals	0	1	2	3
Getting along with other students	0	1	2	3
Completing or returning homework	0	1	2	3
Performing academically in school	0	1	2	3
Controlling behavior in school	0	1	2	3
Feeling good about himself/herself	0	1	2	3

(continued)

Attention and Behavior Rating Form, School Version: Adolescent *(page 2 of 2)*

How often does this student display this behavior?	Never or Rarely	Sometimes	Often	Very Often
Fidgets with or taps hands or feet or squirms in seat	0	1	2	3
Leaves seat in situations when remaining seated is expected	0	1	2	3
Runs about or climbs in situations where it is inappropriate or feels restless	0	1	2	3
Unable to play or engage in leisure activities quietly	0	1	2	3
"On the go," acts as if "driven by a motor" (e.g., unable to be or uncomfortable being still for an extended time)	0	1	2	3
Talks excessively	0	1	2	3
Blurts out an answer before a question has been completed	0	1	2	3
Has difficulty waiting his or her turn (e.g., while waiting in line).	0	1	2	3
Interrupts or intrudes on others (e.g., butts into conversations, games, or activities; may intrude into or take over what others are doing)	0	1	2	3

How much do the nine behaviors in the previous question cause problems for this student?	No Problem	Minor Problem	Moderate Problem	Severe Problem
Getting along with school professionals	0	1	2	3
Getting along with other students	0	1	2	3
Completing or returning homework	0	1	2	3
Performing academically in school	0	1	2	3
Controlling behavior in school	0	1	2	3
Feeling good about himself/herself	0	1	2	3

Appendix H

inLife clinic
RESTORING HOPE, HEALTH & RELATIONSHIPS
www.inlifeclinic.com

Re: Permission to Conduct Research Using inLife Clinic Facilities

To whom it may concern:

This letter is being produced in response to Genevieve Bendeck request, a student at Northwest University who wishes to conduct a research study using the machinery and facilities of inLife Clinic in order to support her research. Genevieve Bendeck is a certified brain training technician at inLife. She is competent and knowledgeable in how to properly use the Neurofeedback program and machine. Genevieve Bendeck has indicated that Northwest University IRB requires a letter for inLife Clinic granting them permission to do her research. Please accept this letter as evidence of such permission, stating that Genevieve Bendeck is permitted to conduct her research study at inLife Clinic facilities provided that she abides by our Term of Use.

If you have any questions about this letter, please contact us at info@inlifeclinic.com

Sincerely

4/2/18

Phyllis Rogers
Inlife Clinic Director
425.822.3252

Date

T 425.822.3252 | F 425.576.5149 | 3055 112th Avenue NE, Suite 125 | Bellevue, WA 98004

Appendix I

ACKNOWLEDGMENT OF RISK AND HOLD HARMLESS AGREEMENT

I hereby acknowledge that I have voluntarily chosen to participate in Neurofeedback provided by Genevieve Bendeck, a Northwest University Student Washington Limited Liability Company and an Intern at Burrell Behavioral Health, including, but not limited to having electrodes connected to my head for an EEG amplifier to provide my brain waves to a computer and that computer will then provide feedback to my brain for my brain to generate optimum brain wave patterns and frequencies. (hereinafter called “Neuro-training”).

I understand the risks involved in the program. I recognize that the programs and its activities involves risk of injury and I agree to accept any and all risks associated with it, including but not limited to minor bodily injury, severe bodily injury, and death. I am voluntarily participating in the program with the knowledge of the risks involved and hereby agree to accept any and all inherent risks of bodily injury.

In consideration of my participation in the Neuro-training and to the fullest extent permitted by law, I agree to indemnify, defend and hold harmless Genevieve Bendeck, Northwest University, its managers, members, employees, agents, volunteers and assigns from and against all claims arising out of or resulting from my participation in the Neuro-training. “Claim” as used in this agreement means any financial loss, claim, suit, action, damage, or expense, including but not limited to attorney’s fees, attributable to bodily injury, sickness, disease or death. In addition, I hereby voluntarily hold harmless Genevieve Bendeck, Northwest University, and Burrell Behavioral Health, including its managers, members, employees, agents, volunteers and assigns from any and all claims, both present and future, that may be made by me, my family, estate, heirs or assigns.

I hereby expressly agree to indemnify, defend and hold harmless Genevieve Bendeck, Northwest University, and Burrell Behavioral Health, inclding its managers, members, employees, agents, volunteers and assigns for any claim arising out of or incident to my participation in the Neuro-training, unless claim is caused by the willful misconduct.

I further understand that this acknowledgment of risk and hold harmless is intended to be as broad and inclusive as permitted by the laws of the State and that if any portion hereof is held invalid, I agree that the balance shall, notwithstanding, continue in full legal force and effect.

I further understand that Genevieve Bendeck, Northwest University, and Burrell Behavioral Health makes no representations or warranties on the results that I may or may not obtain after going through the Nuerofeedback Neuro-training. As a result, I agree not to pursue a claim against the aforementioned individuals and companies if I am dissatisfied with the results of my Neuro-training.

I agree that this acknowledgment of risk and hold harmless is effective for as long as I participate in the program.

_________________________ ___________________________ ____________

Client Printed Name **Client Signature** **Date**

Parent (if Applicable): _______________________________________

Appendix J

CERTIFICATE

OF COMPLETION

PHRP Online Training, Inc. certifies that

Genevieve Bendeck

has successfully completed the web-based course "Protecting Human Research Participants Online Training."

Date Completed: **2020-09-03** Certification Number: **2855916**

PHRP
Protecting Human
Research Participants
Online Training