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Aim and Scope

NeuroRegulation is a peer-reviewed journal providing an integrated, multidisciplinary perspective on clinically relevant research, treatment, and public policy for neurofeedback, neuroregulation, and neurotherapy. The journal reviews important findings in clinical neurotherapy, biofeedback, and electroencephalography for use in assessing baselines and outcomes of various procedures. The journal draws from expertise inside and outside of the International Society for Neurofeedback and Research to deliver material which integrates the diverse aspects of the field. Instructions for submissions and Author Guidelines can be found on the journal website (http://www.neuroregulation.org).

NeuroRegulation

Volume 7, Number 4

2020

Contents

RESEARCH PAPERS

CORRESPONDENCE AND COMMENTARY

PROCEEDINGS

NeuroRegulation

Neurofeedback: An Examination of Attentional Processes in Adults with Self-Reported PTSD Symptoms

Lelah S. Villalpando[1], Connie J. McReynolds[2], Grace Lee[1], Susanne Montgomery[1], and David Vermeersch[1]*

[1]Loma Linda University, Loma Linda, California, USA
[2]California State University, San Bernardino, San Bernardino, California, USA

Abstract

Novel, effective, and accessible therapeutic interventions for treating posttraumatic stress disorder (PTSD) symptoms are in demand given the significant physical and psychosocial impairment associated with the disorder. Although PTSD is largely treated with cognitive behavioral therapy (CBT), treatment resistance, or nonresponse rates, continues to remain high. Research has shown talk therapies can trigger the limbic system, keeping it in a continual state of fight or flight. Consequently, many trauma survivors seek alternative treatments, such as EEG neurofeedback training. This study explored the relationship between trauma-related symptoms (i.e., inattention and impulsivity) and visual and auditory functioning in a population of veterans and nonmilitary adults who reported previously being diagnosed with PTSD by a mental health clinician. Results suggest that EEG neurofeedback therapy is clinically effective for improving visual and auditory attentional functioning in both veterans and nonmilitary adults. Improved attentional functioning is believed to boost organizational skills, decision-making, frustration tolerance, and comprehension. This is important given that two-thirds of veterans who complete CBT programs remain in the clinical range for PTSD with notable attention deficits. Treatment outcome research, such as this study, is vital to improve the effectiveness of therapeutic interventions for persons diagnosed with PTSD, particularly within specific populations that have high nonresponse rates, such as veterans.

Keywords: posttraumatic post disorder (PTSD); auditory processing; visual processing; neurofeedback; IVA-2 Continuous Performance Test

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***Address correspondence to**: Lelah S Villalpando, PhD Candidate, Loma Linda University, School of Behavioral Health, Department of Psychology, 11130 Anderson Street, Loma Linda, CA 92350, USA. Email: villalpando.lelah@gmail.com

Edited by:
Rex L. Cannon, PhD, SPESA Research Institute, Knoxville, Tennessee, USA

Reviewed by:
Rex L. Cannon, PhD, SPESA Research Institute, Knoxville, Tennessee, USA
Genomary Krigbaum, PsyD, University of Wyoming, Family Medicine Residency, Casper, Wyoming, USA

Introduction

During any given year, approximately eight million people in the U.S. meet criteria for posttraumatic stress disorder (PTSD). Although PTSD is gaining more public attention, treatment-resistant PTSD is not as widely talked about (Feduccia & Mithoefer, 2018). Approximately 70% of the world's population has been exposed to some type of traumatic event, with 5.6% meeting DSM-5 criteria for PTSD (Bomyea & Lang, 2012). Commonly used interventions for treating PTSD include various types of cognitive behavioral therapies (CBT), such as cognitive processing therapy (CPT), trauma-focused cognitive behavioral therapy (TF-CBT), and eye movement desensitization and reprocessing (EMDR). Although these interventions may be equally effective, there is a high dropout rate for these treatments, as well as high nonresponse rates (Litz et al., 2019).

Electroencephalographic (EEG) neurofeedback training is a readily available treatment that has been identified as effectively reducing PTSD symptoms by training individuals to self-regulate brainwave frequencies (La Marca et al., 2018;

Panisch & Hai, 2020). Neurofeedback therapy is administered through a brain-computer interaction (BCI) device, which provides a structured training program tailored to each participant. BCI devices have been used in a variety of settings and applied to diverse populations over the past three decades. For example, BCI devices utilizing neurofeedback therapy are used in physical rehabilitation hospitals to improve cognitive functioning in patients with a history of stroke and dementia (da Silva-Sauer, de la Torre-Luque, Silva, & Fernández-Calvo, 2019). In addition to physical disability, EEG neurofeedback is often used for performance enhancement or to treat clinical conditions, such as learning and memory, sustained attention, sleep, ADHD, PTSD, depression, and anxiety (van der Kolk et al., 2016).

Novel, effective, and accessible therapeutic interventions for treating PTSD symptoms are in demand at unprecedented levels given the significant physical and psychosocial impairment associated with the disorder, and the burden placed on both the individual and the healthcare system, including rising costs for ongoing care, loss of work, and disability benefits. In 2012, the VA spent approximately $3 billion and the Department of Defense (DOD) spent about $294 million on PTSD care for service members and veterans (Institute of Medicine, 2014).

Neurofeedback Therapy

The brain's activity determines the way a person experiences the world; everything that is felt and expressed is motivated by the sensory system. Neurofeedback therapy, or EEG biofeedback, was first introduced in the late 1950s by scientists who discovered that brain wave activity could be manipulated by using a simple reward system (Fisher, Lanius, & Frewen, 2016). Further studies indicated that modulating brain activity provided long-term neural-network stability and neuroprotection against various toxins and neurodegeneration (da Silva-Sauer et al., 2019). Neurofeedback therapy has gained recognition as an appropriate intervention for conditions ranging from PTSD, ADHD, learning disabilities, and emotional dysregulation (Hammond, 2011; McReynolds, Bell, & Lincourt, 2017; McReynolds, Britt & Villalpando, 2019; McReynolds, Villalpando & Britt, 2018).

To understand neurofeedback, and how it trains the brain using biofeedback, it is imperative to understand the basic fundamentals of brain waves. Brain waves are electrical impulses that fire when neurons communicate with each other (Broderick, 2015). Brain waves tell the story of how a person's brain is functioning, such as thought habits, mood, and stress levels. During a neurofeedback training session, brain waves indicate whether or not an individual is in a comfortable state (Fisher et al., 2016; McReynolds et al., 2017). The biofeedback generated on a computer screen showing brain activity will respond with a reward (e.g., video games, music, sound bites) when the brain waves indicate a desired state of arousal has been achieved. With repetition, much like exercise, the neural pathways are strengthened and trained to learn how to self-correct brain activity from a heightened state of arousal and inattention to a more relaxed state and better able to attend to external sensory stimuli (Butko & Triesch, 2007; Vignoud, Venance, & Touboul, 2018). Research indicates that individuals may experience an improvement in language and learning when sensory processing pathways are structurally strengthened (Boscariol et al., 2010). Additionally, studies have produced evidence that neurofeedback training may enhance neuroplasticity (Hammond, 2011; Quevedo et al., 2019).

Posttraumatic Stress Disorder

PTSD is a survival response pattern that occurs when a person has been exposed to actual or threatened death, serious injury, or sexual assault. It is characterized by nightmares, anxiety, fear in the absence of danger, recurrent re-experiencing of the event, avoidance of reminders of the trauma, emotional numbing, hyperarousal, and trouble concentrating (Feduccia & Mithoefer, 2018; Table 1).

The term known today as PTSD has been around for about 40 years, after it appeared in the 1980 version of the DSM-III. PTSD has been known by many different names throughout history, such as "combat hysteria," "shell shock," "soldier's heart," "battle hypnosis," and "war neurosis" (Crocq & Crocq, 2000). Psychiatrists in the early 1900s began comparing the behavioral traits of World War I soldiers with civilians who witnessed mass casualty man-made disasters (e.g., railway disasters following the introduction of steam-driven machinery during the Industrial Revolution). To the surprise of psychiatrists, they found similarities between cases of soldiers who had "war neurosis" and civilians who witnessed the man-made disasters. Similar symptoms identified among both soldiers and civilians were anxiety, fright brought about by loud

Table 1
DSM-5 General Diagnostic Criteria for PTSD

A. Exposure to actual or threatened death, serious injury, or sexual violence in at least one of the following ways:
    1. Directly experiencing a traumatic event
    2. Being a firsthand witness to a traumatic event
    3. Learning a traumatic event has occurred to a close family member or friend
    4. Experiencing repeated or extreme exposure to aversive details of traumatic events
B. Presence of at least one of the following intrusion symptoms that begin after the event occurred:
    1. Recurrent, involuntary, and intrusive distressing memories of the traumatic event(s)
    2. Recurrent distressing dreams that are related to the traumatic event(s)
    3. Flashbacks
    4. Intense or prolonged psychological distress when exposed to internal or external cues that resemble an aspect of the traumatic event(s)
C. Persistent avoidance of things associated with the traumatic event(s), beginning after the event (e.g., thoughts, feelings, people, places, activities, objects, situations)
D. Negative alterations in cognitions and mood associated with the traumatic event(s):
    1. Inability to remember important parts of the traumatic event(s)
    2. Persistent and exaggerated negative beliefs or expectations about oneself, others, or the world
    3. Persistent distorted cognitions about the cause or consequences of the traumatic event(s) that lead to blaming self or others
    4. Persistent negative emotional state (e.g., anger, guilt, fear)
    5. Markedly diminished interest in important activities
    6. Feelings of detachment from others
    7. Persistent inability to experience positive emotions (e.g., happiness, satisfaction, or loving feelings)
E. Marked alterations in arousal and reactivity associated with the traumatic event(s):
    1. Irritable behavior
    2. Reckless or self-destructive behavior
    3. Hypervigilance
    4. Exaggerated startle response
    5. Problems with concentration
    6. Sleep disturbance
F. Duration of symptoms is more than one month
G. The symptoms cause significant distress in social, occupational, or other important areas of functioning
H. The symptoms are not attributable to the effects of a substance or medical condition

Source: American Psychiatric Association, DSM-5, 2013.

sounds, nightmares, sudden muteness, deafness, tremors, and personality changes. By mid-20th century, psychiatrists understood the urgency for immediate treatment of “traumatic neurosis” symptoms, learning from WWI that when left untreated this condition could evolve into chronic and irreversible forms of somatic and psychological symptoms (Crocq & Crocq, 2000).

Persons with PTSD show high levels of both impulsivity and inattention. Being in a state of chronic hypervigilance creates strong thought patterns, or neural connections, of fight or flight; perceiving a threat of danger when there is no actual threat (Fisher et al., 2016). Neurofeedback helps regulate emotional and mental states through up-regulation of the prefrontal cortex, which leads to down-regulation of the amygdala (Herwig et al., 2019). While in this constant state of arousal, focused on negative and unpleasant perceived stimuli, an individual may miss other important pieces of information (e.g., pleasant and/or neutral stimuli) necessary to self-regulate.

Auditory Processing Difficulties

Auditory processing is much more than a measure of a person’s hearing ability; it is the way in which auditory information is received and interpreted specific to auditory sensory pathways (Taneja, 2017a). Auditory processing is a fundamental component of communication. One of the important roles auditory processing plays in communication is phonological awareness, in which sounds are linked to letters, letters are encoded to form words, and words form sentences. Once all of this information has been processed and interpreted, the receiver can use the information to form a response. When the auditory processing system is impaired, as is often the case in persons struggling with PTSD, information heard is often not interpreted accurately (Solberg Økland, Todorović, Lüttke, McQueen, & de Lange, 2018).

Auditory processing difficulty (APD) does not pertain to hearing loss as measured in standard audiological screenings; rather, it is the manner in which the brain processes auditory stimuli (McReynolds et al., 2018; McReynolds et al., 2019). APD can be identified at any age. Causes can be either developmental or acquired through TBI, stroke, neurodegeneration, exposure to neurotoxic substances, or even aging (Musiek et al., 2010; Taneja, 2017b). Reportedly, approximately 5% of school-aged children and 76% of adults struggle with some level of impaired auditory processing (Taneja, 2017b).

Although the underlying etiology of APD is controversial, deficits in performance are well documented including difficulty comprehending speech in the presence of background noise (Choudhury & Sanju, 2019; McReynolds et al., 2018; McReynolds et al., 2019; Thomas & Mack, 2010). Individuals with APD have difficulty identifying phonemes and linking them to their representative letters, which subsequently interferes with comprehension and storage of information being received through auditory channels (Thomas & Mack, 2010). This chronic distortion of information on a daily basis can negatively impact quality of life, effective communication, academic success, and overall mental health and well-being. Studies have shown people with APD often experience significant levels of frustration, irritability, and clinical depression (Serafini, Engel-Yeger, Vazquez, Pompili, & Amore, 2017).

Impaired auditory processing makes it difficult to attend to target stimuli (e.g., conversations, spoken instructions, introductions to new people) in the presence of competing background noise. Processing auditory information is quite complex, involving both serial and parallel processing (i.e., the dorsal stream processes spatial information and the ventral stream processes nonspatial information, respectively; Li et al., 2018; Recanzone & Cohen, 2010). The auditory system involves shared processing with higher order cognitive structures and other sensory systems (e.g., executive functioning, memory, language, and attention). APD is manifested in a myriad of ways and may have different presentations in each individual due to the complex nature of the auditory nervous system.

Since the brain uses multiple sensory systems that work together to process information (Ghazanfar & Schroeder, 2006), APD symptoms often overlap with those observed in individuals with other sensory deficits, such as visual processing difficulties (Musiek et al., 2010), and are also prevalent in PTSD populations (McReynolds et al., 2017; see Table 2 for examples of identified difficulties in individuals with APD).

Visual Processing Difficulties

Visual processing is not a measure of nearsightedness or farsightedness, rather it is the manner in which the brain, not the eyes, processes visual stimuli (McReynolds et al., 2018). Visual processing involves comprehension of visual information, such as written letters, symbols, images, and spatial localization of objects (Janarthanan, 2017).

Table 2
Symptoms of Auditory Processing Difficulties

- Poor listening skills (e.g., frequently being told to pay attention when requests are being made)
- Miscommunication that causes problems with partners, family, friends, and co-workers
- Difficulty following verbal multi-step directions that result in stress at home and work, due to failing to complete seemingly simple routine tasks
- Listening to the television at a high volume, but still having difficulty understanding what is going on
- Easily distracted by background sounds in the environment
- Difficulty following long conversations (e.g., feeling as though something was missed)
- Difficulty following conversations among a group of people (e.g., trouble distinguishing and tracking content of multiple conversations, as well as difficulty task switching between listening and responding)
- Trouble understanding verbal math problems, even though written math skills may be strong
- Difficulty remembering spoken information (e.g., frequently asking others to repeat what was said)
- Difficulty taking notes and/or summarizing spoken content
- Difficulty in focusing, sustaining, or dividing attention
- Difficulty with reading and/or spelling

Source**:** DeAngelis, 2018; McReynolds et al., 2017; Thorne & Debener, 2014.

Visual processing difficulties (VPD) is the brain's inability to accurately process visual stimuli (McReynolds et al., 2018; McReynolds et al., 2019). Similar to the auditory processing system, the visual processing system is highly complex, involving other sensory structures and higher order cognitive processing (Ghazanfar & Schroeder, 2006). As such, VPD may be misdiagnosed or go undetected all together when relying solely on standard vision screens (Janarthanan, 2017). Symptoms of VPD frequently overlap with those observed in individuals with other sensory difficulties, such as, auditory processing difficulties (Musiek et al., 2010), and are often found in persons with PTSD (McReynolds et al., 2017; see Table 3 for examples of identified difficulties in individuals with VPD).

There are eight types of visual processing concerns that have been identified by neuroscientists; individuals can have one or more at the same time (Janarthanan, 2017). People who score low in visual processing on the Integrated Visual and Auditory Continuous Performance Test – Version 2 (IVA-2 CPT) may manifest some of the following symptoms.

Visual perception concerns

Individuals with this type have a difficult time distinguishing the difference between similar letters, symbols, shapes, or objects. During reading and writing tasks, an individual may have trouble with letters such as d and b or p and q (Janarthanan, 2017).

Visual figure-ground discrimination concerns

Individuals with this type have trouble pulling contours and shapes from the contextual background. This makes it difficult to identify a specific piece of information on a piece of paper, which may cause an increase in anxiety (Janarthanan, 2017).

Visual sequencing concerns

Individuals with this type struggle with interpreting the order of words, images, and symbols. This makes reading a frustrating task because words and letters may become misinterpreted or reversed, and lines are often skipped or repeated (Janarthanan, 2017).

Visual-motor handling concerns

Individuals with this type have trouble coordinating visual feedback with execution of body movements. For example, it would be difficult to copy an image from a book because the image would be perceived, interpreted, and replicated based on distorted visual-motor processing abilities. Other identifying markers for visual-motor handling deficits are clumsiness and bumping into things (Janarthanan, 2017).

Long- or short-term visual memory concerns

Individuals with this type may have difficulty remembering things that were initially perceived visually. This can make it hard to recall anything that was read, such as details of a story or detailed instructions (Janarthanan, 2017).

Visual spatial concerns

Individuals with this type have problems identifying the spatial localization of objects in relation to self and other objects. This makes it difficult to interpret maps and keep track of time (Janarthanan, 2017).

Visual closure concerns

Individuals with this type have trouble decoding an object if it is missing a part or a drawing that is not complete, such as a bus missing tires or a picture of a person without facial features. This creates problems with spelling and reading because the predictive nature of visual information processing is obstructed if a word is missing a letter (Janarthanan, 2017).

Table 3
Visual Processing Difficulties

• Easily distracted by irrelevant visual stimuli • Difficulty extracting meaning and emotion from written communication and images (e.g., emails, texts, written instructions, signs, pictures) • Trouble with visuo-spatial object rotation and distance perception, which makes things like map reading and catching a ball difficult (i.e., identifying oneself in relation to another object)	• Difficulty remembering written information (e.g., appointments, payment due dates, information on flyers, lists) • Difficulty following written multi-step directions that result in stress at home and work, due to failing to complete seemingly simple routine tasks (e.g., making/completing to-do lists, reading/following instruction manuals, making a grocery list but forgetting it at home and not remembering what was on it)

Source**:** McReynolds et al., 2018; Sandford & Sandford, 2015.

Letter and symbol reversal concerns

There are two types of reversal deficits, static reversals and kinetic reversals. Static reversals occur when letters are written in the wrong direction (e.g., b and d; p and q; 5 and 2). Kinetic reversals occur when words are written as a mirror image of the target word (e.g., ton, not; was, saw). Letter and symbol reversal production usually resolves around age 7 (Janarthanan, 2017).

Research Hypotheses

The purpose of this study is to evaluate the clinical effectiveness of neurofeedback therapy on various trauma-related symptoms—specifically, response control and impaired attention—by measuring visual and auditory functioning in adults with PTSD who either reported having military background or no military background. It was hypothesized that the IVA-2 CPT, a global measure of visual and auditory processing, would show a significant improvement in response control and attention after 20 sessions of training. It was also hypothesized that there would be no difference in treatment outcomes among military and nonmilitary adults with PTSD symptoms, as measured by the Prudence and Vigilance scales.

IVA-2 CPT Assessment Tool

The IVA-2 CPT provides a BCI diagnostic tool for trained clinicians to identify visual and auditory processing deficits, as well as strengths. Test–retest reliability has been established, with a reported range of 0.66–0.75 for auditory quotient scores (inattention) and 0.37–0.41 for response control quotient scores (impulsivity; Sandford & Sandford, 2015). To date, research has not widely established a correlation between visual and auditory processing difficulties and the role they play in an individual's susceptibility to developing PTSD or nonresponse to treatment. However, a recent study (McReynolds et al., 2017) uncovered some degree of a positive relationship between PTSD symptoms and visual and auditory processing difficulties, such that, as visual and auditory processing difficulties were reduced (i.e., improved attention), PTSD symptoms were also reduced (i.e., improved feelings of general well-being).

Materials

J&J EEG stations were used to collect the EEG signals. Impedance was measured to meet the manufacturer's requirements prior to the beginning of each training session. Training was completed using the SmartMind 3 artifact corrected neurofeedback system with a two-channel EEG station (BrainTrain, Inc., North Chesterfield, VA) which continuously filters out frequently occurring, very brief EMG artifacts in real time without interrupting the training program.

Neurofeedback exercises were provided in game-like format that utilized both visual and auditory reinforcement, as well as graphs and numerical scores to provide positive reinforcement. The first step in the training session was to collect an individual's baseline EEG data in order to determine *z*-score feedback goals for each individual. Based on each individual's performance, they were provided clinically relevant feedback and adjustments were made to the training protocol to optimize their performance. All EEG data were automatically recorded.

Neurofeedback Participants

The participants for this study were retrospectively identified, using a stratified random sampling method, from an archival database of adults who previously received individualized neurofeedback training within a university-based clinic setting. Only those adults who completed 20 neurofeedback treatment sessions, self-reported as being previously diagnosed with PTSD (confirmed by a licensed clinical psychologist in a university-based setting), and disclosed military status were selected for this study (see Table 4 for demographic details).

Neurofeedback treatment was provided for 33 adults who reported being previously diagnosed with PTSD and reported either military or no military experience (n = 21 US military, 20 males, 1 female; n = 12 nonmilitary, 6 males, 6 females) who completed a total of 20 half-hour sessions of neurofeedback treatment.

Participants were not compensated to participate in the neurofeedback training. This study was approved by the California State University San Bernardino Internal Review Board. Participants were provided with an informed consent process at the initial intake interview, which was conducted by a licensed clinical psychologist.

Neurofeedback Treatment Protocol

Each participant received an individualized neurofeedback treatment plan based on areas of visual and auditory processing strengths and weaknesses in accordance with software specifications. Treatment was administered on a

Table 4
Demographic Frequencies (N = 33)

Variable		*n*	%
Sex			
	Male	26	78.8
	Female	7	21.2
Age			
	17 – 30	6	18.2
	31 – 44	9	27.3
	45 – 58	8	24.2
	59 +	10	30.3
Groups			
	Military background with PTSD	21	63.6
	No military background with PTSD	12	36.4
IVA-2 CPT Measures			
	Auditory Attention Quotient (AAQ)	33	100.0
	Visual Attention Quotient (VAQ)	33	100.0
	Auditory Response Control Quotient (ARCQ)	33	100.0
	Visual Response Control Quotient (VRCQ)	33	100.0

one-to-one basis, in a private room, within a university clinic setting. Therapeutic goals targeted reduction of mental stress related to PTSD symptoms by strengthening visual or auditory attentional functioning. During the first training session, EEG data were collected in accordance with software specifications from each participant at baseline to determine treatment plan and goals. Training parameters were then individually tailored for each participant according to baseline performance.

Neurofeedback Treatment Protocol

Each participant received an individualized neurofeedback treatment plan based on areas of visual and auditory processing strengths and weaknesses in accordance with software specifications. Treatment was administered on a one-to-one basis, in a private room, within a university clinic setting. Therapeutic goals targeted reduction of mental stress related to PTSD symptoms by strengthening visual or auditory attentional functioning. During the first training session, EEG data were collected in accordance with software specifications from each participant at baseline to determine treatment plan and goals. Training parameters were then individually tailored for each participant according to baseline performance.

Treatments were administered using the SmartMind 3 artifact corrected neurofeedback system with a two-channel EEG station (BrainTrain, Inc., North Chesterfield, VA). Artifact correction lends a unique real-time quality to the SmartMind 3 neurofeedback system by filtering out brief facial activity, frequently occurring eye blinks, and eye movement, without interrupting the training program (Sandford & Sandford, 2015). Treatment was administered through a BCI device, utilizing visual and auditory reinforcement as well as graphics and a scoring system to generate positive reinforcement through a feedback loop.

During each training session, neural activity is monitored and recorded from electrodes placed on the scalp. Visual and auditory biofeedback are displayed on a computer monitor in live time, using a simple video game format, which is designed to alter neural signals and activity (Sandford & Sandford, 2015).

Test Procedures

Prior to beginning neurofeedback training, each participant underwent an initial comprehensive intake conducted by a licensed clinical psychologist. Following the intake assessment, during the same visit, participants were administered the IVA-2 CPT. Participants who were too severely impaired in attentional functioning to validly respond to either visual or auditory IVA-2 test stimuli were given a score of zero for these responses, per test interpretation protocol (Sandford & Sandford, 2015). Immediately upon completion of testing, a comprehensive report was generated, identifying areas of visual and auditory processing strengths and weaknesses. The clinician reviewed the report with the participant to provide feedback and psychoeducation and to formulate a treatment plan.

Participants were scheduled to attend two half-hour EEG neurofeedback sessions per week over the course of 10 weeks. After completing 20 neurofeedback sessions, the IVA-2 test was readministered.

Measures

Integrated Visual and Auditory Continual Performance Test – Version 2

The IVA-2 CPT has been found to be a reliable and valid measure of visual and auditory attention processing. It is a test of impulsivity and attention that measures responses to 500 intermixed visual and auditory stimuli, which takes about 15 minutes to complete. All scales are reported as standard scores and have a mean of 100 and a standard deviation of 15 (see Appendix A for descriptions of IVA-2 visual and auditory attention and response control scales). There are two validity measures built into the IVA-2 to ensure comprehension of test instructions and consistent response patterns (Sandford & Sandford, 2015). The global measures of attention used for this study are the Visual Attention Quotient (VAQ) and the Auditory Attention Quotient (AAQ; see Appendix B for descriptions of IVA-2 visual and auditory attention and response control measures).

Visual Attention Quotient (VAQ)

This measure of attention is made up of three primary visual scales: Vigilance, Speed, and Focus. The Vigilance scale measures errors of omission, the Speed scale measures response time to visual test targets, and the Focus scale measures inconsistency of response time to visual test targets (Sandford & Sandford, 2015).

Auditory Attention Quotient (AAQ)

This measure of attention is made up of three primary auditory scales: Vigilance, Speed, and Focus. The Vigilance scale measures errors of omission, the Speed scale measures response time to auditory test targets, and the Focus scale measures inconsistency of response time to auditory test targets (Sandford & Sandford, 2015).

Auditory Response Control Quotient (ARCQ)

This measure of response control is made up of three primary auditory scales: Prudence, Consistency, and Stamina. The Prudence scale measures errors of commission, which indicates level of impulsivity and ability to inhibit responses to auditory stimuli. The Consistency scale measures the ability to stay on task by analyzing the general variability of response times. The Stamina scale is used to identify mental fatigue by monitoring auditory processing speed over time and comparing the mean reaction times of correct responses between the beginning portion and end portion of the IVA-2 test (Sandford & Sandford, 2015).

Visual Response Control Quotient (VRCQ)

This measure of response control is made up of three primary visual scales: Prudence, Consistency, and Stamina. The Prudence scale measures errors of commission, which indicates level of impulsivity and ability to inhibit responses to visual stimuli. The Consistency scale measures the ability to stay on task by analyzing the general variability of response times. The Stamina scale is used to identify mental fatigue by monitoring auditory processing speed over time and comparing the mean reaction times of correct responses between the beginning portion and end portion of the IVA-2 test (Sandford & Sandford, 2015).

Data Analyses

Before running the analyses, tests for multivariate normality, multicollinearity, and outliers were conducted. Outliers were labeled using a boxplot and the interquartile range (IQR); data were transformed and normalized using winsorization (Shete et al., 2004). Using an alpha criterion of .05, a Bonferroni correction was applied across all analyses, determining an alpha of .01 to be adequate in reducing the chance of making a familywise Type I error.

Results

Descriptive statistics for each one-tailed paired-samples *t*-test analysis, including pre- and posttreatment IVA-2 scores, are presented in Table 5 (Attention scales) and Table 6 (Response Control scales). To test the first hypothesis, a series of one-tailed paired-samples *t*-tests were conducted to test for differences between the means of each Attention and Response Control Quotient scale (AAQ, VAQ, ARCQ, VRCQ) at baseline and after 20 sessions.

Table 5
Paired sample one-tailed t-tests comparing Mean (SD) IVA-2 Attention Quotient scale scores between baseline and after 20 neurofeedback sessions (N = 33)

IVA-2 Attention Scales	Baseline *M(SD)*	20 Sessions *M(SD)*	Score Change	*p* value	Cohen's *d*
Visual Attention Quotient Score (VAQ)	85(24)	97(18)	12	.000	.57
Auditory Attention Quotient Score (AAQ)	84(22)	94(16)	10	.002	.52

Note. A Bonferroni correction has been applied for multiple comparisons.

Table 6
Paired sample one-tailed t-tests comparing Mean (SD) IVA-2 Response Control Quotient scale scores between baseline and after 20 neurofeedback sessions (N = 33)

IVA-2 Response Control Scales	Baseline *M(SD)*	20 Sessions *M(SD)*	Score Change	*p* value	Cohen's *d*
Visual Response Control Quotient Score (VRCQ)	92(22)	96(18)	4	.184	.20
Auditory Response Control Quotient Score (ARCQ)	94(19)	97(14)	3	.166	.18

Note. A Bonferroni correction has been applied for multiple comparisons.

As a group (i.e., both military and nonmilitary adults with PTSD), the individuals in this study initially presented with impaired visual and auditory functioning. After 20 half-hour neurofeedback treatment sessions, both their visual and auditory attention abilities improved, falling within the normal range (i.e., defined as a standard score of 77 or higher; Sandford & Sandford, 2015). On average, change-score differences between pre- and posttreatment IVA-2 attentional scales (i.e., VAQ and AAQ) were clinically significant ($M = 11$, $SD = 16$; $M = 10$, $SD = 18$, respectively), which is defined as a change-score of 8 points or more (McReynolds et al., 2018; McReynolds et al., 2019; Sandford & Sandford, 2015).

VAQ scores were found to be significantly higher after 20 sessions of neurofeedback treatment from a mean of 86 (slightly to moderately impaired) to 97 (average), an 11-point increase, $t(32) = -4.06$, $p < .001$, Cohen's $d = .52$. AAQ scores were found to be significantly higher after 20 sessions of neurofeedback treatment from a mean of 84 (mildly impaired) to 94 (average), a 10-point increase, $t(32) = -3.21$, $p < .01$, Cohen's $d = .52$. Both scales of attentional functioning had effect sizes in the medium range demonstrating the clinical efficacy of neurofeedback as a therapeutic intervention for individuals diagnosed with PTSD and presenting with attentional deficits. There were no significant differences between the Visual (VRCQ) and Auditory (ARCQ) Response Control scale scores before treatment and after treatment, *p*s > .10 ($M = 4$, $SD = 18$ and $M = 3$, $SD = 18$, respectively).

To test the second hypothesis that there would be no difference in treatment outcomes among military and nonmilitary adults diagnosed with PTSD, a 2x2 between-subjects factorial repeated measures MANCOVA with Bonferroni correction was performed, predicting posttreatment (i.e., 20 sessions of neurofeedback) IVA-2 scale scores (i.e., AAQ, VAQ, ARCQ, VRCQ) from group type (i.e., military vs. nonmilitary adults), controlling for age and gender.

Table 7
MANCOVA Results

Predictor	*df*	Multivariate *F*	Wilks' **λ**	Partial η^2	*p* value
Group	1, 31	.592	.938	.062	.626
Time	1, 31	1.728	.944	.056	.199
Group * Time	1, 31	.045	.998	.002	.834

Note. A Bonferroni correction has been applied for multiple comparisons. Group = military vs. nonmilitary; Time = pre- and posttreatment of 20 neurofeedback sessions.

As can be seen in Table 7, results indicated that whether or not a person diagnosed with PTSD had military experience was not a significant predictor of overall neurofeedback treatment outcome, $F(1, 31) = .592$, Wilks' lambda = .938, partial η^2 squared = .062, $p > .07$.

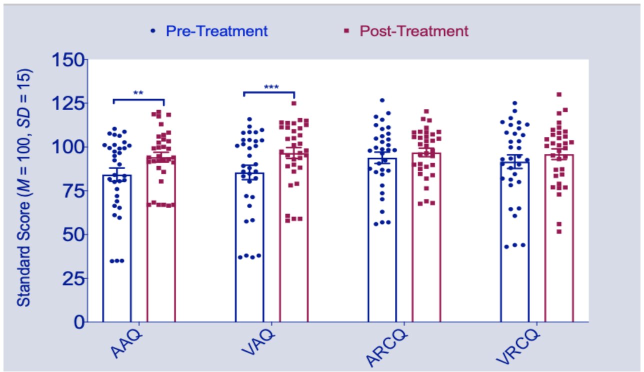

Figure 1. Pre- and posttreatment outcomes. Visual and auditory attention and response control scale score changes between baseline and after 20 neurofeedback sessions. ** $p < .01$, *** $p < .001$ denotes statistical significance between pre- and posttreatment.

Discussion

Findings from the current study indicate that neurofeedback treatment was effective in improving visual and auditory attention for individuals diagnosed with PTSD, regardless if they had military experience or no military experience. To test the first hypothesis, a series of one-tailed paired samples *t*-test were performed to compare the change scores between pre- and posttreatments of 20 neurofeedback sessions, as measured by the IVA-2 on the Auditory Attention Quotient (AAQ), Visual Attention Quotient (VAQ), Attention Response Control Quotient (ARCQ), and Visual Response Control Quotient (VRCQ) scales. To test the second hypothesis, a 2x2 between-subjects factorial multivariate analysis of covariance (MANCOVA) with Bonferroni correction was performed on four dependent variables (i.e., VAQ, AAQ, VRCQ, ARCQ).

Hypothesis one was partially supported because, the change-scores between pre- and posttreatment on the IVA-2 attentional measures of visual and auditory processing (VAQ and AAQ) indicated statistically significant improvement, while the change-scores between the pre- and posttreatment IVA-2 Visual (VRCQ) and Auditory (ARCQ) Response Control scales did not indicate a significant difference. It should be noted that the data on both response control scales showed an upward change-score trend.

The second hypothesis was supported because there was no difference between treatment outcomes among military and nonmilitary adults diagnosed with PTSD, following 20 sessions of neurofeedback, across all visual and auditory attention and response control scales. Neurofeedback was similarly effective for both military and nonmilitary adults, with the greatest amount of improvement in auditory and visual attention abilities (Figure 1).

Of interest, although both groups had statistically similar treatment outcomes on the VAQ and AAQ (i.e., baseline scores were in the impaired range, and posttreatment scores were in the average range), the military group achieved higher change scores overall than the nonmilitary group, such that military adults had lower IVA-2 scores at baseline and higher IVA-2 scores posttreatment than nonmilitary adults. Conversely, on the ARCQ and VRCQ, the nonmilitary group had lower baseline scores and higher IVA-2 scores posttreatment than the military group. Overall, both groups showed similar rates of improvement across all visual and auditory scales, between baseline scores and scores after 20 sessions. These data indicate that 20 sessions of EEG neurofeedback training were similarly effective for both military and nonmilitary adults diagnosed with PTSD.

Through the use of repetition and reinforcement, neurofeedback training creates and strengthens visual and auditory neural connections in the prefrontal cortex. The prefrontal cortex makes key contributions to the limbic system, which is involved in generating emotional responses (Arnsten, 2009; Broderick, 2015; Van Eylen, Boets, Steyaert, Wagemans, & Noens, 2015), such as the fight or flight response. The prefrontal cortex is the part of the brain responsible for executive functioning, which includes prediction outcomes, determining good and bad, social inhibition, differentiation among conflicting thoughts, determination of future consequences, and interpretation of one's reality (Arnsten, 2009).

Through the strengthening of visual and auditory processing pathways in the prefrontal cortex, neurofeedback trains individuals to self-regulate physiological responses triggered by the limbic system (e.g., stress and anxiety). The more times a brain completes a specific task, the stronger the neural connections become in that pathway each successive time. This is known as the Hebbian synaptic plasticity theory, which suggests neurons that fire together, wire together by regulating and adapting a neuron's intrinsic excitability (Butko & Triesch, 2007).

The aftermath of a traumatic event can result in new neural networks forming, which maintain states of fearfulness, rage, and shame, in perpetuity. The repetitive firing of these networks define trauma, triggering chronic activation of the limbic system. Neurofeedback disrupts and weakens those harmful connections by creating new neural patterns. Improving visual and auditory functioning provides faster cognitive processing of environmental cues, which lends the ability to consider more options of how to respond. Response control and paying attention are stabilizing factors in executive functioning, allowing the limbic system to relax (van der Kolk, 2014).

Healthy executive functioning provides the capacity to organize and plan, to weigh the consequences of one's behaviors, to be cognitively flexible, and to regulate one's emotions. Improving visual and auditory processing systemically affects executive functioning and limbic system activation (van der Kolk, 2014). For this reason, individuals with impaired visual and auditory functioning may not respond to traditional CBT programs by sheer virtue that they lack the fundamental capacity to participate in treatment. Participation in treatment involves higher order complex functioning, such as, learning coping mechanisms, identifying triggers, self-regulation, organization and planning, and regular attendance. Lacking these basic underpinnings of executive functioning, while engaging in trauma reprocessing, can severely activate the limbic system. Without the skills to self-regulate, once the limbic system is activated, a person may experience intense flashbacks, anxiety, and emotional distress for several days following therapy (Fisher et al., 2016). Neurofeedback training offers the brain the ability to self-regulate and achieve a state of stability, while simultaneously weakening the neural networks created by shame, fear, and rage.

Limitations

Limitations of this study include that the sample was retrospectively identified, participants reported prior PTSD diagnosis, and there was an unequal male to female ratio due to the archival nature of the study. Future studies should examine if improvements in attentional abilities postneurofeedback are associated with reduced PTSD symptoms. Some studies (e.g., McReynolds et al., 2017) have supported this conclusion. Given the critical need for effective, affordable, and accessible PTSD services, future research should aggressively strive to identify factors that influence PTSD treatment response. These data will provide critical information necessary to improve interventions and services for individuals with PTSD.

Conclusion and Future Directions

The results of this study suggest that EEG neurofeedback therapy is clinically effective for improving visual and auditory attentional functioning in both military and nonmilitary adults. This is crucial information because there continues to be high levels of treatment nonresponse and dropout rates among veterans with PTSD who are participating in CBT based programs. Two-thirds of veterans who complete CBT programs remain in the clinical range for PTSD, with notable attention deficits (Bomyea & Lang, 2012). Additionally, it is estimated that over 80% of returning combat veterans who enroll in college on the GI Bill do not complete their degrees. Reportedly, factors contributing to this dropout rate include problems focusing and paying attention (van der Kolk, 2014). The burden placed on both the individual and the healthcare system, including costs for ongoing care, loss of work, and disability benefits, are rising at an unprecedented rate. In 2012, the VA spent approximately $3 billion and the DOD spent about $294 million on PTSD care for service members and veterans (Institute of Medicine, 2014). Treatment outcome research, such as this study, is vital to improve the effectiveness of therapeutic interventions for persons diagnosed with PTSD, particularly within specific populations that have high nonresponse rates, such as veterans.

Many PTSD experts recommend sequenced or phase-based therapeutic interventions that target symptoms which are correlated with PTSD prior to using trauma-focused treatments (Cloitre et al., 2012; Haagen, Smid, Knipscheer, & Kleber, 2015). Phase-based interventions are important to consider because, without first addressing processing deficits and lack of capacity to self-regulate, harm to the patient can result. Neurofeedback therapy builds a stable cognitive foundation through strengthening visual and auditory neural pathways and enhances the brain's capacity to self-regulate; this is achieved without using talk therapy, accessing traumatic memories, or activating distressing emotions (da Silva-Sauer et al., 2019; McReynolds et al., 2017).

EEG neurofeedback training may be a fundamental component for the treatment of military adults with PTSD. The mechanisms of EEG neurofeedback are currently being studied in the field (da Silva-Sauer et al., 2019; Hammond, 2011; McReynolds et al., 2017, 2018; van der Kolk, 2014), making it a viable option as a first-line intervention for people diagnosed with PTSD. Future work is needed to explore ways to enhance treatment outcome through complementary pairing of EEG neurofeedback training with other therapeutic interventions. Knowledge regarding the mechanisms (e.g., use of neuroimaging, calcium based pre- and postsynaptic neuron activity, spike-timing-dependent plasticity; Schaefer et al., 2000; Vignoud et al., 2018) by which neurofeedback intervention is effective would assist in developing an individualized treatment plan that includes an appropriate level of sequenced engagement based on capacity (e.g., neurofeedback training, self-regulation, skill building, behavioral activation, trauma reprocessing).

Examining the mechanisms of therapeutic treatment is necessary for the proper treatment of impulsivity and inattention, in the context of trauma, and will play a large role in preventing patient harm. Activation of specific mechanisms may be detrimental to the mental health of persons who lack the cognitive capacity to self-regulate, which is why research needs to be conducted on an individual-level treatment basis through randomized control trials (RCTs; Bomyea & Lang, 2012). Strengthening the visual and auditory pathways, and improving executive functioning through neurofeedback training, may influence how well a person responds to trauma reprocessing and to what extent they can achieve homeostasis after being severely dysregulated from talk therapy (Fisher et al., 2016). Targeting and improving visual and auditory processing deficits through neurofeedback training may not only predict treatment outcome for subsequent trauma-focused therapies but may also predict how well a person will function in relationships, in school performance, and at work (Fisher et al., 2016; McReynolds et al., 2018; McReynolds et al., 2019).

Given the critical need for effective, affordable, and accessible PTSD services, future research should aggressively strive to identify factors that influence PTSD treatment response, as well as determine which underlying mechanisms and individual characteristics explain how these factors operate. One way to do this would be to explore treatment outcomes when combining neurofeedback training with trauma-focused therapy (e.g., using neurofeedback training as a prerequisite to talk therapy). Strengthening the visual and auditory processing pathways through EEG neurofeedback training, may increase the chances for a nonresponder to successfully engage in, and benefit from, trauma-focused treatment protocols.

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Appendices

Appendix A
Description of IVA-2 visual and auditory primary scales

Attention Scales	IVA-2 Description of Primary Attention Scales
Vigilance	Measure of inattention as evidenced by two different types of errors of omission
Focus	Reflects the total variability of mental processing speed for all correct responses
Speed	Reflects the average reaction time for all correct responses
Response Control Scales	IVA-2 Description of Primary Response Control Scales
Prudence	Measure of impulsivity and response inhibition as evidenced by three different types of errors of commission
Consistency	Measures the general reliability and variability of response times and is used to help measure the ability to stay on task
Stamina	Compares the mean reaction times of correct responses during the first 100 trials to the last 100 trials; this score is used to identify problems related to sustaining attention and effort over time

Source: Sandford & Sandford, 2015.

Appendix B
Description of IVA-2 visual and auditory global composite measures

IVA-2 Measures	IVA-2 Description of Measures
AAQ Auditory Attention Quotient	Based on equal measures of auditory Vigilance, Focus, and Speed scales
ARCQ Auditory Response Control Quotient	Derived from auditory Prudence, Consistency, and Stamina scales
VAQ Visual Attention Quotient	Based on equal measures of visual Vigilance, Focus, and Speed scales
VRCQ Visual Response Control Quotient	Derived from visual Prudence, Consistency, and Stamina scales

Source: Sandford & Sandford, 2015.

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Care for Parkinson's Disease Patients in Pakistan: A Call for Help During the COVID-19 Pandemic

Soha Zahid[1], Sajjad Ali[2], and Areeb Mohsin[1]*

[1]Department of Medicine, Jinnah Medical and Dental College, Karachi, Sindh, Pakistan
[2]Department of Medicine, Ziauddin University, Karachi, Sindh, Pakistan

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***Address correspondence to**: Mr. Sajjad Ali, Department of Medicine, Ziauddin University, 4/B, Saharah-e-Ghalib, Block 6, Clifton Karachi–7500, Sindh, Pakistan. Email: sajjad110@live.com

Edited by:
Rex L. Cannon, PhD, SPESA Research Institute, Knoxville, Tennessee, USA

Reviewed by:
Rex L. Cannon, PhD, SPESA Research Institute, Knoxville, Tennessee, USA
Randall Lyle, PhD, Mount Mercy University, Cedar Rapids, Iowa, USA

Parkinson's disease (PD) is an idiopathic disorder of the extrapyramidal system. As the coronavirus disease 2019 (COVID-19) pandemic unfolds, the continuity of essential services for neurodegenerative disorders and similar chronic health problems is a significant concern especially for South Asian regions, including Pakistan. Reportedly, Pakistan has about 450,000 PD patients afflicted with PD, which accounts for about 219 PD patients per 100,000 individuals (Hussain et al., 2017). As COVID-19 is still prevalent throughout the country, it might contribute to a coexisting burden of PD on our healthcare systems.

The neurological effects of COVID-19 are thoroughly explored along with the effect this may have on patients with neurodegenerative disorders. There is existing evidence of SARS-CoV-2 easily linking with the central nervous system (CNS) through hematogenous or axonal path of olfactory neuroepithelium. Reports indicate that SARS-CoV-2 can reach brain cells, adversely affecting the symptomatology of PD patients (Victorino, Guimarães-Marques, Nejm, Scorza, & Scorza, 2020). A higher proportion of Parkinson's patients experienced new or deteriorating motor (63%) and nonmotor (75%) symptoms during the COVID-19 pandemic (Brown et. al., 2020). Reportedly, as PD escalates during the sixth or seventh decade of life, it can also be correlated with enhanced symptoms of COVID-19. Along with PD, multiple comorbidities are commonly associated, leading to an overall immunocompromised patient who is more prone to show higher severity of COVID-19 symptoms. In support, studies suggest that the longer the PD duration, the risk of pneumonia increases and so does the need for management through supplemental oxygen, or hospitalization (Brown et. al., 2020). Furthermore, there are secondary potential aggravated effects of the COVID-19 pandemic on PD patients, such as stress, anxiety, and self-isolation, as well as the effects of the lockdown on sustained immobility.

The benefits of exercise for people with PD are well known. Physical exercise helps to reduce the worsening of PD symptoms and related tension, so encouraging domestic workouts such as online Zoom Pilates or dance lessons can be very useful in preserving optimal well-being throughout the pandemic. In addition, a palliative care strategy should be developed to provide relief from physical, mental, and spiritual distress, as the COVID-19 pandemic has definitely intensified the suffering of patients.

In primary and secondary healthcare systems of Pakistan, elective activities were delayed due to age-related measures. This created a hindrance for PD patients in accessing vital medications that can limit their aggravated symptoms. Even though telemedicine services were introduced, it was either not accessible due to compromised financial support or poor internet connectivity (Elbeddini, To, Tayefehchamani, & Wen, 2020). As COVID-19 cases rose in Pakistan, hospitals were trembling under the patients' weight. If not diagnosed with COVID-19, PD patients reported disrupted medical care, limited exercise and social activities, and, in turn, worsened PD motor and nonmotor symptoms. Patients who experienced these interruptions or who underwent self-isolation reported worsening of Parkinson's symptoms.

Disease outbreaks significantly threaten the healthcare system in a developing country like Pakistan. The situation is further compounded by the shortage of basic health services, inadequate health policy, and poor governance. Statistically speaking, the number of individuals living with PD will rise as Pakistan is currently under attack by the second wave of COVID-19, leading to higher financial and social costs. Up until now, no such studies have been conducted in Pakistan on PD patients during this pandemic. However, care should be taken to avoid adding undue stress to individuals living with PD, in the absence of compelling evidence, and at the same time catering to patients suffering from COVID-19.

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KEYNOTE PRESENTATIONS

Neuro and Biofeedback in Neurological Rehabilitation: An Integrative Approach

Leon Morales-Quezada
Spaulding Neuromodulation Center, HMS, Boston, Massachusetts, USA

Neurological rehabilitation can improve function, reduce symptoms, and improve the well-being of the patient suffering from diseases, injury, or disorders of the nervous system. A variety of techniques or methods are used for neurological rehabilitation, from physical and speech therapies to advanced robot-based treatments. Applied psychophysiology offers an alternative for patients to improve their neurological deficits; neuro and biofeedback can be applied in the clinical settings to facilitate cognitive and motor functions, or to be used as adjunct intervention for symptoms and conditions associated to neuropathology such as seizures, depression, or autonomic dysfunction.

In his talk, Dr. Morales-Quezada will present the principles of neuroplasticity behind neurological rehabilitation, and how to implement neuro/biofeedback interventions in a third-level rehabilitation hospital. Functional diagnostics and multidisciplinary management will also be covered in this talk.

Neuromodulation Techniques for Altering Brain Plasticity and Cognition

William Jamie Tyler
Arizona State University, Tempe, Arizona, USA

Noninvasive neuromodulation systems and devices are used every day around the world for research, to treat medical indications, to enhance human performance, and in other consumer wellness and electronics applications. Our scientific, technical, and engineering efforts have led to the development and deployment of several distinct methods, which will be discussed. Transcranial focused ultrasound (tFUS) provides the highest spatial resolution of all the noninvasive neuromodulation methods. It also enables the focal, noninvasive neuromodulation of deep-brain circuits in humans. Translational efforts have shown promise that tFUS can provide therapeutic benefits for several mental health conditions. We will discuss recent evidence and emerging indications for the use of tFUS in modulating brain plasticity, sensory awareness, decision-making, and mood. Other bottom-up methods targeting brainstem nuclei of the reticular activating system will be discussed. These transdermal electrical nerve stimulation methods include trigeminal nerve stimulation and transdermal auricular vagus nerve stimulation (taVNS), which have been shown to modulate sympathetic tone and enhance brain plasticity by affecting the activity of the locus coeruleus and norepinephrine signaling. We will describe collective efforts using trigeminal nerve stimulation and taVNS to provide active control of sympathetic nervous system activity for regulating alertness, attention, stress, anxiety, learning, and sleep/wake cycles. In all cases we will discuss the central role of quantitative psychophysiological and neurophysiological biomarkers in the iterative development, validation, and verification of these noninvasive neuromodulation methods. Emerging machine learning and artificial intelligence methods now promise to mine large data sets from similarly connected biosensors in real-world environments. Therefore, we will discuss how these approaches are being integrated with noninvasive neuromodulation methods in open-loop and closed-loop manners to develop personalized approaches, advance our understanding of brain and behavior, and enable the optimization of human health and performance. Finally, we will discuss modern regulatory, ethical, and legal considerations for the investigation, use, and commercialization of noninvasive neurotechnologies intended to modulate or measure human brain activity in various applications.

Neuromodulation Techniques for Altering Brain Plasticity and Cognition

Marty Teicher
McLean Hospital, Belmont, Massachusetts, USA

Exposure to childhood adversity markedly increases the risk of developing mood, anxiety, personality, substance abuse, and psychotic disorders. Recent studies suggest that clinical sequelae may stem, at least in part, from enduring adverse effects on brain development. Generally, early onset and longer duration of abuse have been associated with greater brain changes, but this is an oversimplification. It appears that stress-susceptible brain regions have their own unique sensitive periods (or windows of vulnerability) to the effects of early stress. Further, evidence also suggests that maltreated and nonmaltreated individuals with the same DSM diagnoses are clinically, neurobiologically, and genetically distinct. We refer to the disorder in the maltreated cohort as an *ecophenotype* and show that it is associated with earlier age of onset, more severe course, more comorbid diagnoses, and poorer response to first-line treatments. A key challenge has been to understand why some individuals appear to be resilient to the psychiatric sequelae of abuse, particularly as they show the same basic array of alterations in stress-susceptible brain regions as comparably maltreated individuals with severe psychopathology. Our recent studies of brain network architecture have identified additional alterations in the brains of maltreated individuals that enable them to effectively compensate and to obtain high levels of mental health. This leads to a new understanding of how recovery occurs and how effective treatments may work—which is not to reverse the effects of maltreatment, but to foster compensatory resilience by altering the connectivity of specific brain regions.

Stress and Stress-Activated Viruses in Public Health, Mental Health and Anticipatory Pathology

Roulett Smith
Humanized Technologies, Palo Alto, California, USA

Processes of evolution are among the most awesome developments during the 4.5+ billion years associated with the existence of this Earth. Among the many forces contributing to evolution are climate, tectonic plate movements, and stresses on evolved group behaviors (including common sense). This presentation will focus on the potential public health and mental health consequences of the extraordinary stresses associated with two rare and intertangled contemporaneous events requiring common sense; to wit, the COVID-19 pandemic and outbursts of rage, social unrest, and mass demonstrations associated with George Floyd's death.

For living systems (whether in plants, animals, or other living systems) "fight or flight" mechanisms (and their underlying behaviors and responses to stress) are among the obvious contributors to evolutionary developments. In animals, the autonomic nervous system consists of sympathetic and parasympathetic components. Fight and/or flight mechanisms are associated with the sympathetic nervous system and its associated increases or decreases in various stress hormones (e.g., cortisol/glucocorticoids, catecholamines, thyroid, growth hormone, prolactin, vasopressin, gonadotropins, insulin, etc.). The parasympathetic nervous system regulates relaxation and slows high-energy functions.

Stress also is associated with structural changes. For example, in brain chronic stress can lead to both neurogenesis and cell death in the hippocampus, increases in myelin-producing cells, reduction in gray matter (responsible for high-order cognitive functions), brain shrinkage, losses in short-term and spatial memories, and increased risks for mental illness.

Most reports on the COVID-19 pandemic focus on at-risk subpopulations. These include travelers on ocean liners or military/naval vessels; homeless persons; essential employees; senior citizens (in senior housing, hospice, or nursing facilities); persons in prisons and detention centers; persons with intellectual disabilities; and persons with various comorbidities. It now is anticipated that the COVID-19 pandemic will give rise to more than 13 long-term effects on mental health (e.g., depression, posttraumatic stress disorder [PTSD], anxiety disorders, shame, avoidance disorders, burnout, alcoholism and substance abuse, isolation and estrangement, loss of identity or purpose, suicide, etc.). Common sense issues also may affect public and mental health.

During this pandemic, a cohort of youngsters is especially noteworthy for outbreaks of Kawasaki-like autoimmune presentations. This finding suggests that childhood stresses (whether directly or indirectly involving the COVID-19 virus) may be triggering a stress-activated virus known to be associated with

Kawasaki disease. This further suggests that separate stress-activated viruses also may be significant and evolutionary cofactors in the COVID-19 pandemic. Indeed, my earlier research from the 1980s reveals that small RNA particles (snRNPs) encoded by stress-activated gamma herpes viruses (e.g., the Epstein-Barr virus, as well as selected other stress-activated viruses) may be transmissible and infectious (i.e., autovirulence). Autovirulence can give rise to transcription and/or translation errors for host genes (GERRs) and a plethora of downstream disorders.

To date, GERRs are responsible for virtually all autoimmune disorders, many congenital disorders, autism spectrum disorders, many trinucleotide repeat (TNR) disorders, and male homosexuality. Hence, one now can anticipate that the extraordinary stresses associated with the COVID-19 pandemic and concurrent mass demonstrations may give rise to novel future pathologies and other evolutionary outcomes.

In summary, social, physical, environmental, political, and molecular biological factors associated with the COVID-19 pandemic and mass demonstrations may be generators of genetic diversity … both in the COVID-19 virus and in evolution. We also explore the implications of these consequences … including common sense.

Recent Psychophysiological Advances of "Spontaneous" Reading

Giuseppe Augusto Chiarenza
Centro Internazionale dei Disturbi di Apprendimento Attenzione Iperattività (CIDAAI), Milano, Italy

The study of goal-directed behavior in normal and dyslexic subjects during spontaneous reading was the guiding thread of my research in the field of neuroevolutionary disorders. Reading can be defined as an *active* perceptual process of gathering information from the external world that involves attention, memory, articulation, planning, and intention. In this sense, reading can be considered a behavior teleologically purposive. Unfortunately, most of the experimental reading conditions have been restricted to automatic presentation of stimuli on a computer screen where the subjects had to *passively* look or read silently. Furthermore, there are no studies describing the modifications of the brain electrical activity when the subjects in a self-paced condition read single letters aloud. This meant that the components related to planning and intention were not examined. For this purpose, the chronology of movement-related potentials during skilled actions will be presented which shows that dyslexia is not only a defect of the auditory and/or visual perceptual processes but may also be considered as a praxic disorder in which praxic abilities, such as motor programming, sequential and sensory-motor integration, and error system analysis show reduced efficiency. Furthermore, when comparing the reading-related potentials (RRPs) during passive and self-paced condition, significant differences emerge regarding the time course and spatial distribution on the scalp of these potentials. Self-paced reading aloud is characterized by the most numerous and significant modifications of RRPs morphology in all the cerebral areas. The self-paced condition and the acquisition of extra cerebral signals, as subjects' voice, EMG activity of forearm and of lips, allowed to identify the potentials occurring before, during, and after reading and the cerebral areas mostly involved in each of these periods. The potentials belonging to the prelexical period are undoubtedly related to perceptual analysis of stimuli, while those occurring during the lexical and postlexical periods likely represent reafferent activity for the control of linguistic processes.

Important and significant differences have also been described when comparing different clinical subtypes of dyslexia. This was possible thanks to the direct self-paced reading and spelling test developed by Chiarenza (2010), inspired by the reading and writing model proposed by Boder (1973). Boder described three main subtypes of dyslexia: dysphonetic dyslexia (DD), dyseidetic, mixed and besides a fourth group defined nonspecific reading delay (NSRD). The subtypes are identified by an algorithm that considers the reading quotient and the percentage of errors in the spelling test. Thanks to this precise clinical distinction, it was possible to observe that the dysphonetic subjects compared to the subjects with nonspecific reading delay had significant higher activity in delta and theta bands in the frontal, central, and parietal areas bilaterally. The hypothesis that there is a timing defect at the basis of dyslexia is confirmed by the study of the effective and directed connectivity. Two very important areas perform as hubs in the information flow: one is the left calcarine sulcus, which is more active in the DD group, and the second is the left rolandic operculum, which is more active in the NSRD group. In the DD group, the calcarine sulcus is sending information to the right postcentral gyrus, the left paracentral gyrus, the right angular gyrus, and the right supplementary motor area. This flow of information occurs in almost all frequency bands, including delta and theta band. Slow connections may indicate less efficient or even pathological information flow. In conclusion, dyslexia can be defined, from a psychophysiological point of view, as a cerebral dysregulation in all frequency bands that affects programming, planning, fast processing, and integration of sensory information. All these phenomena occur at different levels of the central nervous system and at different times.

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Regulating Posttraumatic Stress Disorder Symptoms with Neurofeedback: Regaining Control of the Mind

Ruth Lanius
University of Western Ontario, Ontario, Canada

Objective. The default mode network (DMN) and salience network (SN) have been shown to be dysregulated in posttraumatic stress disorder (PTSD). Restoring aberrant connectivity within these networks with electroencephalogram neurofeedback (EEG-NFB) has been shown previously to be associated with decreased PTSD symptoms. Here, we conducted a double-blind, sham-controlled randomized clinical trial of alpha-rhythm EEG-NFB in participants with PTSD (n = 36) over 20 weeks. Our aim was to provide mechanistic evidence underlying clinical improvements by examining changes in network connectivity via fMRI.

Methods. We randomly assigned participants with a primary diagnosis of PTSD to either the experimental group (n = 18) or sham-control group (n = 18). We collected resting-state fMRI scans pre- and post-NFB intervention, for both the experimental and sham-control PTSD groups, where we additionally compared baseline connectivity measures pre-NFB to age-matched healthy control participants (n = 36).

Results. We found significantly decreased PTSD severity scores in the experimental NFB group only, when comparing post-NFB (d = 0.91) and 3-month follow-up scores (d = 1.05) to baseline measures. Interestingly, we found evidence to suggest a normalization of DMN and SN connectivity post-NFB in the experimental group only. Both decreases in PTSD severity and NFB performance were correlated to decreased insula connectivity with the SN in the experimental group. Critically, 61.1% of individuals in the experimental group no longer met criteria for PTSD after treatment, in comparison to 33.3% in the sham-control group.

Conclusion. The current study shows mechanistic evidence for therapeutic changes in DMN and SN connectivity that are known to be associated with PTSD psychopathology. The current intervention appears well tolerated with no participant dropouts and may prove to be a highly beneficial adjunct treatment for PTSD.

PLENARY SESSION PRESENTATIONS

Automatic De-artifacting in Normative qEEG Databases: Does Reality Follow the Hype?

Marco Rotonda[1] and Antonia Thelen[2]
[1]eemagine Imaging Medical Solutions GmbH, Berlin, Germany
[2]ANT neuro GmbH, Berlin, Germany

Introduction. Advances in the field of automated de-artifacting algorithms for electroencephalographic (EEG) signals have provided powerful tools to significantly speed up data processing (Blum, Jacobsen, Bleichner, & Debener, 2019; Delorme, Sejnowski, & Makeig, 2007; Makeig, Bell, Jung, & Sejnowski, 1996; Mullen et al., 2015; Nolan, Whelan, & Reilly, 2010). Nonetheless, the efficacy of such, sometimes preimplemented algorithms in marketed solutions for qEEG analysis still needs to be addressed. Here, we directly compared the performance of automatic algorithms implemented in different normative qEEG databases (DBs) currently available on the market (Neuroguide, qEEG-Pro, and iMediSync) with a manual artifact-rejection approach.

Materials & Methods (1). Raw, eyes-closed resting-state EEG data from four exemplar subjects were fed into the preimplemented, automated artifact-detection, and rejection or correction pipelines of the three DBs. Additionally, manual artifact-detection and rejection was performed separately. Thereafter, the absolute power values for five different frequency bands (FBs; delta, theta, alpha, beta1, beta2) were computed at each electrode position (19 channels, 10/20 layout) within each DB. The resulting values were assessed in a mixed-design ANOVA (within-subject factors: 2 (automated cleaning vs. manual rejection) x 3 (DBs) x 5 (FBs); between-subject factor: electrode).

Results (1). Results suggested significant effects between DBs, which were driven by the amplitude of the absolute power values computed. Specifically, we found a main effect (ME) for DB and FB.

Additionally, we found significative interactions between DB x Cleaning, Cleaning x FBs and DB x Cleaning x FBs.

Interim Conclusion (1). Taken alone, these results provide striking evidence that artifact-detections algorithm implemented in the selected DBs hugely impact data interpretation and can hence eventually diverge diagnostic interpretations when absolute power values are taken into consideration.

Materials & Methods (2). In order to correct for normalization biases across DB outputs in the current analyses, absolute power measures were transformed into *z*-score values across the whole dataset. Hereby, we sought to eliminate false positives in our statistical evaluation due to the different implementation of the power computation algorithms between DBs (White, 2003).

Results (2). The mixed-design ANOVA suggested significant differences as a function of Electrode (DB x Electrode; FBs x Electrode).

Interim Conclusion (2). These results suggest that normalization processes can effectively reduce erroneous statistical differences due to differential implementation amplitude computations. Nonetheless, significant Electrode x DB interactions persist.

General Discussion. Taken together, these preliminary findings underline the existent pitfalls regarding de-artifacting algorithms across DBs. Specifically, differential implementation of absolute power value computation greatly diverges between the present DBs investigated (similar: White, 2003; contrary: Thatcher & Lubar, 2009, and Keizer, 2018). Moreover, normalization of the data still produced significant differences across DBs.

Conclusion, Open Questions, and Future Directions. Several open questions remain to be addressed. First, the impact of differential cohorts employed between DBs for normalization processes has not been directly assessed in the present study. Second, whether automatic de-artifacting algorithms consistently outperform manual data cleaning needs to be further investigated. Third, the qualitative differences of the automatic de-artifacting algorithms employed by different DBs need further comparisons. We are aware of the limited sample size and aim at increasing the sample size.

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Combining Bio- and Neurofeedback with Virtual Reality in the Treatment of Anxiety: Current Applications, Research Findings, and Future Directions

Jeff Tarrant
NeuroMeditation Institute, Eugene, Oregon, USA

Virtual reality (VR) is a computer-generated environment that simulates a realistic experience in three-dimensional space. While this technology has been primarily associated with the video game industry, it is increasingly being utilized as a clinical intervention for a variety of medical and mental health concerns (Rizzo & Koenig, 2017). As a mental health intervention, VR has primarily been used as a sophisticated addition to exposure therapy in the treatment of phobias (e.g., fear of heights, flying, etc.; Lamson, 1994; Rothbaum et al., 1995).

In part, the success of these programs appears to be based on the understanding that immersive environments, such as those provided in VR, can generate strong feelings of "presence" (Riva, Waterworth, Waterworth, & Mantovani, 2011; Riva &

Waterworth, 2014; Waterworth & Riva, 2014; Waterworth, Waterworth, Mantovani, & Riva, 2010). "Presence," in this context, is defined as the subjective feeling of being in another place and is a crucial element in exposure and distraction-based therapies. Because VR is immersive, it should not be surprising that this format can provide more presence than two-dimensional scenes (Chirico et al., 2017).

Based on this understanding, some VR programs have created specific environments designed to induce a relaxation response. These programs tend to layer elements that have demonstrated effectiveness in stress management programs, such as exposure to nature, mindfulness, and soothing music (Tarrant, Viczko, & Cope, 2018). Not surprisingly, some companies have created VR and augmented reality (AR) systems that interface with various bio- and neuromodulation techniques, including EEG and HRV. Early research suggests that this combination may provide a powerful tool to assist those working to manage clinical anxiety disorders.

In this presentation, we will explore consumer and clinical programs that combine bio/neurofeedback with both VR and AR as intervention for chronic stress and anxiety. The presenter will summarize results and limitations of four original studies demonstrating the impact of therapeutic VR/AR experiences on brainwave activity, anxiety, and mood states. These studies have demonstrated that a brief mindfulness in nature VR experience can significantly shift brainwave patterns associated with the stress response while a control condition does not (Tarrant et al., 2018). Other results have demonstrated significant increases in subjective feelings of calm and happiness while significantly reducing feelings of tension, anger, and depression. Early results combining VR and AR with a consumer grade EEG headband have demonstrated shifts in frontal asymmetry (Tarrant & Cope, 2018), as well as increased motivation and likelihood of future use. In addition to clarifying the current state of this work, the presentation will explore future directions, integration of VR with clinical neurofeedback systems, and strategies for using consumer-based programs as adjunctive training for specific client populations.

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Counteracting Our Current Happiness Deficit by "Happitation" Via Neurofeedback

Jonathan Cowan[1] and Estate Sokhadze[2]

[1]Peak Achievement Training, Goshen, Kentucky, USA

[2]University of South Carolina School of Medicine, Greenville, South Carolina, USA

There is a basic truth we often forget: We can create happiness directly from within ourselves. Relatively few people, except for those exposed to positive psychology techniques, know how to control the transition between an ordinary mood and a very happy one.

Learning to do this well and sustain it is very valuable in general, but particularly so now, when the COVID-19 crisis has taken away so many of our sources of happiness and other positive feelings—and may continue to do so indefinitely. The best way to deal with this "happiness deficit" is to learn to make the neuropsychological transition in brain function to activate the brain's reward systems, based primarily on increasing dopamine function. This self-control can be learned by generalizing a particular type of neurofeedback training—enhancing the Neureka! rhythm—to other situations in our life by a simple practice we call "Happitation." This transition starts with a deep inhalation, followed by coupling the exhalation with the practice of the skill of enhancing Neureka! output, remembered from Neureka! and Focus training sessions on the Happi Trainer. By repeating this a number of times, a feeling of extreme happiness can be created and sustained, even while other activities are being performed.

We believe that control of this transition is natural and based primarily on changing basic biological systems, which are more powerful sustainers of mood than psychological practices, although these certainly can be taught together. Our studies of neurofeedback combining single-pointed Focus via our InhibitAll protocol with enhancing clarified 40 Hz. rhythm—Neureka!—have shown that we can enhance happiness for at least four months after just twelve 25-min sessions of training. We also demonstrated pre- to posttraining improvements in both attention and memory, which we believe are predominantly due to Neureka! The combination of these three improvements is exactly what would be expected from enhanced dopamine levels in the prefrontal cortex and elsewhere.

This training study built on a group of three experiments which demonstrated a more specific relationship between Neureka! levels and positive feelings, including happiness, love, satisfaction, joy, gratitude, mindfully watching, anticipating something good, and Aha! There were negative relationships between Neureka! and stress, disappointment, and boredom. Counteracting these three are particularly important now.

Neurofeedback trainers should recognize that there is an increased demand for training that will teach people to be happy whenever they want to create it from within themselves. Although this direct teaching of the most important goal in life stated by many Eastern sages has been elusive, recent progress in neurofeedback makes Happitation training very possible on a widespread scale.

It also offers a new therapeutic approach for decreasing the addict's dependence on outside sources for the creation of their happiness. This is a real key to counteracting addiction.

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Exploratory Study of Loreta *Z*-Scored Neurofeedback and Homeostatic Learning in a Group with Mild Traumatic Brain Injury (MTBI) and Post-Concussion Syndrome (PCS)

Rex Cannon[1], Nanja Schorel[2], and Rianne Schorel[2]
[1]SPESA Research Institute, Knoxville, Tennessee, USA
[2]Move the Brain, Zeist, Netherlands

Introduction. Persistent symptoms after mild traumatic brain injury (mTBI) are often debilitating to the individual. This postconcussion syndrome (PCS) can impact social, emotional, and functional domains, thereby increasing financial and resource burdens on healthcare systems and individuals. Debate continues concerning the etiology of PCS and how to best diagnose and treat the symptoms that can persist for months to years after the initial injury (D'Souza et al., 2015; Datta, Pillai, Rao, Kovoor, & Chandramouli, 2009; Duff, 2004; Iverson, 2019; Kennedy, Quinn, Tumilty, & Chapple, 2017; Kenzie et al., 2018; Khong, Odenwald, Hashim, & Cusimano, 2016). Recent data have explored cortisol in relation to mTBI and continued symptoms, with notable differences in these populations.

Methods. This study examines data for 17 clients (5 male), mean age 34.88, *SD* 11.07 with a diagnosis of PCS according to ICD-10 criteria (World Health Organization, 1992) that completed a holistic program with neurofeedback as a primary intervention.

LORETA *z*-score training was conducted twice per day for 10 days in conjunction with other program components (Cannon et al., 2007; Cannon et al., 2014; Thatcher, 2000; Thatcher et al., 2001). Program measures for outcomes were morning cortisol levels, the Dutch version of brief symptom inventory (BSI) and LORETA electrical neuroimaging. We utilized paired comparisons to contrast data across three time points. Nonparametric statistical analyses of functional LORETA images were performed for each contrast using voxel-wise randomization for within subject contrasts (paired *t*-tests) with a threshold $p < .05$.

Results. For this group of clients there was a decrease in morning cortisol levels at 10-day posttraining and at 30-day follow-up. Clinical scales on the BSI showed significant decreases at both 10-day and 30-day follow-up measures. LORETA contrasts showed significant changes in Brodmann Areas (BA) 9, 36, 47, 19 and 6. Cortical-cortisol associations showed significant elevations in delta at BA 9 pretraining. While at post and follow-up there appears to be a more diffuse integration of cortico-cortisol relations.

Conclusions. Holistic approaches with neurofeedback may offer the potential to aid individuals in reducing symptoms and improving functional domains, as well as improving approach related behaviors and executive functions as associated with frontal lobes. Larger sample size and randomized controlled trials are goals for future research as well as developing standard procedures for discovery of bio/psychometric combinations to aid in differentiating PCS from other syndromes.

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Infraslow Neurofeedback, the Latest Research

Mark Llewellyn[1], Tyson Perez[2], and Jerin Mathew[2]
[1]Neurofeedback Services of NY, New York, New York, USA
[2]University of Otago, Dunedin, New Zealand

Infraslow fluctuation training (ISF) was recently tested in a randomized, double-blind, placebo-controlled study that explored the therapeutic effects on obese women with food addiction (Leong et al., 2018). The success of that project heralded an increase in interest in and studies on ISF training recently. This presentation will summarize the research results of three current studies, one on bipolar ISF training that involves two channels (Smith, Collura, Ferrera, & de Vries, 2014) and a 19-channel variation: ISF sLORETA.

In our most recently completed study (in press) we compare the impact of ISF bipolar training and Sensory Motor Rhythm (SMR) neurofeedback on the autonomic nervous system (ANS). This randomized study is the first to test a proposed mechanism of action for distinct forms of neurofeedback training. We used peripheral biofeedback devices to measure the autonomic impact of both interventions on subjects with anxiety disorders.

Additionally, we will report on two studies of another form of ISF training: ISF sLORETA training. In collaboration with Dr. Dirk De Ridder, and in consideration of the current neuroscience of pain, we have developed a neurofeedback protocol for chronic pain. This innovative design is currently being tested in another "Gold Standard" (randomized, double-blind, sham-controlled) study. The protocol and research design have been published in *NeuroRegulation* (Mathew, Adhia, Smith, De Ridder, & Mani, 2020). We will report on phase one of a three-phase research design that will involve approximately 100 subjects upon completion.
The final study we report on in this presentation is ISF sLORETA for affective disorders. Recent literature has proposed a central autonomic network (CAN) in cortex that impacts autonomic nervous system function. It theorizes that the CAN is centrally involved in all aspects of human behavior and is therefore a critical component of psychopathology (Beissner, Meissner, Bär, & Napadow, 2013; Thayer & Lane, 2000). Also a randomized, double-blind, sham-controlled study, the affective disorder project targets both the central hubs of sympathetic and parasympathetic function in cortex. These are primary ROIs within the CAN structure. With an innovative design the ISF sLORETA protocol attempts to regulate these hubs by assuming disordered activation patterns.

The functional architecture of the brain is coordinated by infraslow frequencies. ISF coordinates both the connections within and decoupling between active behavioral networks (Palva & Palva, 2012). This slow regime, described as < 0.1 Hz, was first linked with behavior by Nina Aladjalova in the 1950s in the Soviet Union. Aladjalova associated infraslow activity with parasympathetic, reparative response (Aladjalova, 1957). Recently, there has been a dramatic increase in research of human behaviour and the infraslow frequencies. Studies of ISF and ADHD, pain, and sleep, to name just a few, have been published (Alshelh et al., 2016; Broyd, Helps, & Sonuga-Barke, 2011; Lecci et al., 2017).

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Neurofeedback in Healthy Elderly at Risk of Cognitive Decline

Mauricio Gonzalez-Lopez
Sociedad Mexicana de Bio y Neurofeedback, Juriquilla, Querétaro, Mexico

Age is the main risk factor for the incidence of neurocognitive disorders. Past research has shown that quantitative electroencephalography (qEEG) might be a good tool to assess the risk of developing future cognitive decline in a healthy elderly population, and specifically an excess of theta activity (4.0–8.0 Hz) has been observed (Prichep et al., 2006, Prichep, 2007). Based on this rationale we have explored whether an excess of theta activity, even when all neuropsychological variables seem normal, might discriminate in neurobiological terms between two populations of healthy elderly. For this reason, we explored with several neurobiological tools, such as event-related potentials and magnetic resonance imaging, whether these two populations would differ, in order to provide: a) a rationale for a neurofeedback treatment and b) neurophysiological tools to assess the efficacy of a specific neurofeedback protocol. Therefore, with this two-fold objective in mind, we present two sets of comparisons: 1) the results of the neurophysiological comparison between a group considered to be at risk of cognitive decline (i.e., those that presented an excess of theta activity compared to a normative database) and a control group with normal EEG; and 2) the neuropsychological results and EEG changes after a neurofeedback protocol that aimed to normalize these theta excesses, as well as the comparison with a placebo group. We observed a difference in psychophysiological terms between the Risk group (before treatment) and the Control group, when considering biological measures but not psychometric and neuropsychological tools. Moreover, we observed differences posttreatment between the Neurofeedback and the Placebo (Sham) group. We also present preliminary results of a sLORETA treatment, which aimed to normalize the most abnormal current sources in the theta band. This evidence contributes to the idea that normalizing an abnormal excess of theta activity might have beneficial effects on cognition in this elderly subgroup, and quantitative and normative EEG might be a low-cost and viable tool for the early identification of risk of cognitive decline.

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Noninvasive Brain Stimulation Interventions to Elevate Neurofeedback Outcomes – PBM, TDCS, TACS, TMS, and Others

Lew Lim
Vielight, Inc., Toronto, Ontario, Canada

Hypothesis. Noninvasive brain stimulation (NIBS) interventions can potentially elevate neurofeedback (NFB) outcomes. They include photobiomodulation (PBM) and transcranial electrical stimulation (TES) methods, especially transcranial direct current stimulation (tDCS) and alternating current stimulation (tACS); as well as magnetic-based transcranial magnetic stimulation (TMS). However, up-to-date objective comparative analyses are needed for informed decisions.

Supporting Evidence to Date. Literature are largely inconclusive, pointing to the need for more investigations. TMS and to a lesser extent, tDCS have credible evidence to indicate as treatment of depression, but there is little consensus for other neurological and neuropsychiatric conditions (Lefaucheur et al., 2014). A reason is the lack of understanding the mechanisms of action of these modalities (Terranova et al., 2019). In the case of PBM, the mechanisms are clearer but has relatively lighter empirical data (Giordano et al., 2017). However, emerging evidence demonstrate consistent frequency-dependent response from the brain to PBM (Zomorrodi, Loheswaran, Pushparaj, & Lim, 2019). New clues are provided in the modulation of the default mode network (DMN; Saltmarche, Naeser, Ho, Hamblin, & Lim, 2017; Zomorrodi et al., 2019), which points to networks for future PBM research.

Methods. The method here is combines literature review with controlled studies data. An ongoing study is investigating healthy participants treated with PBM induced at an oscillation of 10 Hz to the default mode network versus alternatives. Another investigates a larger variety of oscillations from 0 Hz to 200 Hz, along with antiphase inductions between selected regions of the brain.

Results. The new PBM results will be compared to earlier PBM as well as tDCS, tACS, and TMS data. This would lead to further understanding of PBM compared to or combined with other NIBS interventions.

Conclusions. The findings from the subject investigations will be promising in advancing the understanding the various NIBS to potentially elevate NFB practice outcomes.

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Solving the Mystery: When Children and Adolescents Fail Treatment, Parents Want Answers

Ronald Swatzyna and Meredith Hoffman

Houston Neuroscience Brain Center, Houston, Texas, USA

When a child fails to respond as hoped to medication or treatment, their parents want answers. Rarely is neurofeedback their first choice, but it is often their last hope. By the time they consider neurofeedback, most have failed several medication attempts, behavior intervention, and parent training. The reason why so many children fail to get their issues resolved may be due to an inadequate diagnostic process. In the field of mental health, diagnoses are primarily based on the report of symptoms from either the patient, parents, or both, and a psychiatrist's or therapist's observations. A psychiatric diagnosis is currently the most widely used basis for medication and treatment selection; however, the brain is seldom investigated directly as a source of those symptoms. The National Institute of Mental Health (NIMH) Research Domain Criteria Project (RDoC) was created to elicit scientific research into neurological abnormalities that can be linked to psychiatric symptoms for the purpose of predicting medication and treatment response. One such neurological abnormality that has been the focus of many studies over the last three decades is isolated epileptiform discharges (IEDs) in patients without seizures. Zimmerman and Konopka (2014) found that IEDs are associated with greater affective dysregulation and more severe psychiatric symptoms. They found high rates of IEDs have been found in specific diagnostic categories such as panic and anxiety disorders, mood disorders, schizophrenia, eating disorders, personality disorders, and violent behavior. Additionally, high rates of IEDs have been found specific to childhood disorders such as ADHD (Kanazawa, 2014; Lee, Choi, Yoon, & Bahn, 2015; Milichap, Stack, & Millichap, 2011; Swatzyna, Tarnow, Roark, & Mardick, 2017a) and Autism Spectrum Disorder (Chez et al., 2006; Mulligan & Trauner, 2013; Reinhold, Molloy, & Manning-Courtney, 2005; Swatzyna 2017b; Yasuhara, 2010). We present the findings of our systematic review of the literature and compare them to our cross-sectional analysis in order to determine prevalence rates of IEDs within diagnostic categories. Our study found a consistent high prevalence of IEDs specifically for ADHD (majority > 25%) and ASD (majority > 59%). If children and adolescents have failed multiple medication attempts, and more than one-third of them have IEDs, then an EEG would be justified within the RDoC paradigm. Identification of IEDs is critical to the success of neurofeedback in two ways. First, medications such as stimulants, antidepressants, and antipsychotics all lower seizure threshold and make these brains more unstable/pathologic, thus thwarting neurofeedback efforts. Second, IEDs are either artifacted out or averaged out in making the qEEG brain maps. The foci of the IEDs have to be known so that appropriate neurofeedback protocols can be designed. Just training the background fails to address the primary cause of the child's symptoms. Having the EEG read by a neurologist who is a board-certified encephalographer is not only justified in children and adolescents who have tried and failed past medication attempts but is an ethical responsibility.

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Standardization and Personalized Medicine Using Quantitative EEG in Clinical Settings

André Keizer
qEEG-Pro, Eindhoven, Netherlands

Two major trends have been dominant in healthcare in recent years. First, there is a growing consensus that standardization of healthcare procedures and methods can result in improved effectiveness and safety of treatments. There has been a great effort to implement more standardization in diagnosing and treating medical conditions. For example, the World Health Organization initiated the High 5s Project in 2007, which aimed to facilitate the development, implementation, and evaluation of Standard Operating Protocols (SOPs; https://www.who.int/patientsafety/topics/high-5s/en/) for medical treatments in order to increase patient safety. Second, there is increased interest in "personalized medicine," which refers to the tailoring of treatments to individual patients. Personalized medicine has gained considerable traction, mainly as a result of rapid developments in genetic research (Hamburg & Collins, 2010; Jameson & Longo, 2015) and novel methods for analyzing big data (Alyass, Turcotte, & Meyre, 2015). In the current presentation, I will discuss both standardization and personalized medicine in its historical context, how it is applied in different medical fields, and, most importantly, how these trends apply to the field of quantitative EEG (qEEG). There are two important topics that relate to the use of qEEG in clinical practice that need to be addressed in the context of standardization. The first topic relates to the way resting state EEG data is de-artifacted. Traditionally, EEGs are de-artifacted manually by trained EEG technicians or EEG researchers. However, in recent years standardized and automated de-artifacting procedures are increasingly being used in scientific research and in clinical practice. The advantages of these procedures over manual de-artifacting will be discussed. The second topic relates to the use of normative databases in order to assess clinically meaningful deviations of a patient's EEG. The results of a systematic comparison between two commonly used qEEG databases show that these databases produce very comparable results, illustrating not only the validity and reliability of both databases, but also the opportunity to move forward to a standardized use of qEEG in clinical practice. The standardization of qEEG analyses enables valid and reliable use of qEEG for diagnostic procedures, to guide personalized treatment protocols and to assess treatment effectiveness. Finally, the standardization of qEEG interpretation as both a diagnostic and treatment selection tool provides an example of how qEEG can merge both personalized medicine and standardization in the treatment of psychological disorders.

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The Reality of the Unreal: Dissociation and Dissociative Disorders

Ainat Rogel and Diana Martinez
Boston NeuroDynamics, Brookline, Massachusetts, USA

Dissociation and dissociative disorders (DD) are among of the most overlooked conditions and challenging therapies, despite their high prevalence. The nature of the symptoms and the fact that the symptoms often accompany many other disorders and are often misdiagnosed are some of the reasons for these claims. Dissociation/DD are among the oldest described psychiatrist conditions. They have a long history and are one of the oldest described psychiatrist conditions. They were first described in the late 18th century, and since then they were accompanied by controversy that extended from professional debates to social, political, and cultural domains. This presentation follows the model that Dissociation/DD are related to trauma and developmental trauma. This model is supported by up-to-date scientific data. However, this model is controversial and not fully accepted. The presentation will discuss a general overview of other relevant models for dissociation/DD. The first goal of this presentation is to unpack the theoretical aspects of dissociation/DD as well as highlighting the clinical aspects of working with people with dissociation/DD. The second goal is to describe subjective assessments as well as objective measurements. The presentation starts with a historical background, models and diagnosis of dissociation/DD and the way they evolved over time as well as pointing out the controversy and the inconsistency over the different models and diagnosis. The presentation continues with the clinical presentations of dissociations/DD and the different diagnosis that are related to it. While the presentation will focus on the relationship between dissociation/DD and trauma, the background will include other modalities. The presentation continues with scientific, clinical, and epidemiological data. The major part of the presentation discusses clinical approaches and challenges of working with clients with dissociation/DD and how to address these unique challenges. Both subjective measurements as well as objective measurements such as EEG and physiological activities will be covered. The presentation concludes with a discussion of future steps clinically as well as in research to improve the outcome of the treatment.

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Visualizing Neurological Decision-Making Pathways to Help Clients Understand Self

Ronald Bonnstetter[1] and Thomas Collura[2]
[1]TTI Success Insights, Scottsdale, Arizona, USA
[2]BrainMaster Technologies, Inc., Bedford, Ohio, USA

While neuroscience and mental health professionals acknowledge the role of emotions in decision-making, application of this knowledge is hampered by the lack of a common language and a model that illustrates the potential neurological pathways. By better understanding the brain's decision-making process and the role of emotions in those decisions, we can begin to expose the moment-by-moment dynamics of human behaviors and the role played by precognitive thoughts. Armed with this knowledge, we may be able to help individuals recognize and reflect on decisions in a more logical manner. This presentation will offer insights into how humans react to personal triggers in a conversation, thus exposing underlying precognitive beliefs and related emotions that ultimately lead to our behaviors and decisions. We will highlight the protocols used to generate these modified event-related potentials with a focus on gamma frontal lobe asymmetry as well exposing the asymmetry of Brodmann's areas 9 and 10 as primary emotional processing areas and Brodmann's areas 44 and 45 as secondary emotional processing resource. Changes in these Brodmann areas, as a participant processes a new stimulus, will be presented using quantitative analysis and will serve as validation of the resulting parallel sLORETA visual maps.

The ultimate takeaway from this presentation is the creation of a model that illustrates the potential neurological pathways and produces a minimal model that attempts to account for the emotional states and decision processes. When the transitions are viewed in a particular format that accentuates the contributions of the targeted brain locations, a digital code emerges. When a left or right sensory or perceptual area becomes active, then the corresponding portions of the activation model are considered to have a role in the current processing. In addition, the spontaneous categorization of inputs that the model associates with this processing is an example of an adaptive process that exposes an essential survival mechanism that is part of our evolution as a species.

Administering these protocols in real-world contexts, such as during coaching sessions, job interviews, and possibly even in psychotherapeutic milieus (given proper ethical constraints), are promising areas for additional study and promise to impact and potentially expose hidden decision-making mechanisms of the preconscious mind.

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Neurofeedback in ADHD: Rating the Evidence, APA Guidelines, and a Multicenter Replication Study of qEEG-informed Neurofeedback

Trevor Brown
neuroCare Group, East Melbourne VIC, Australia

Introduction. Precision medicine is uncovering ways to stratify treatment; for example, qEEG recently demonstrated the ability to inform the likelihood of Sertraline versus rTMS response in major depressive disorder (MDD; Wu et al., 2020). Within the neurofeedback field, qEEG assessment can uncover previously unknown sleep-related vigilance regulation difficulties impacting executive function in ADHD cases. The patient's EEG "informs" which standard neurofeedback protocol will be most effective. Thus, qEEG-informed neurofeedback allows personalized intervention, stratifying to the most likely effective protocol. To date, clinical effectiveness data for qEEG-informed neurofeedback have only been published in a small sample of 21 ADHD patients (Arns, Drinkenburg, & Kenemans, 2012). Recent research (Krepel et al., 2020, presented as the principal study) replicated this effectiveness in a new sample of 114 patients treated with qEEG-informed neurofeedback, from a large multicentric dataset and investigated potential predictors of neurofeedback response.

Methods (of principal study). A sample of 114 patients were included as a replication sample. Patients were assessed with ADHD-RS, PSQI, qEEG and ERPs, then assigned to a standard neurofeedback protocol (SMR, TBR, or SCP neurofeedback) in combination with coaching and sleep hygiene advice. The ADHD-RS and PSQI were assessed at baseline, every 10th session, and at outtake. Response was defined as ADHD-RS > 25% reduction (R25), > 50% reduction (R50), and remission. Predictive analyses were focused on predicting remission status.

Results (of principal study). In the current sample, response rates were 85% (R25), 70% (R50), and remission was 55%. Clinical effectiveness was not significantly different from the original 2012 sample. Nonremitters exhibited significantly higher baseline hyperactivity ratings. Women who remitted had significantly shorter P300 latencies and boys who remitted had significantly lower individual Alpha Peak Frequencies (iAPF).

Discussion. In the principal study, clinical effectiveness was replicated, suggesting it is possible to assign patients to a protocol based on their individual baseline qEEG to enhance signal-to-noise ratio. Furthermore, remitters had lower baseline hyperactivity scores. Likewise, female remitters had shorter P300 latencies, whereas boys who remitted have a lower iAPF. This latter finding is intriguing, since low iAPF was earlier found to predict nonresponse to MPH (Arns, Gunkelman, Breteler, & Spronk, 2008), thus offering opportunities to use this biomarker to stratify between treatments. The data suggests initial specificity in treatment allocation, yet further studies are needed to replicate the predictors of neurofeedback remission. A comparison of clinical effectiveness versus RCT efficacy in neurofeedback will lead to a discussion of proposed APA guidelines for rating future evidence (Arns et al., 2020).

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A Way of Treating Very Severe Psychiatric Clients Who Showed Extremely High Amplitude of Theta Waves

Miyako Tazaki
Faculty of Medicine, Toho University, Tokyo, Japan

Some of the clients who had a long history of psychiatric disorders showed extremely high amplitude of theta waves, such as more than 60 to 200 μV, so we have developed an effective procedure to treat them with neurofeedback. These clients usually had a long history of shopping doctors for more than five years for not having improved with only psychiatric drugs, and they had usually been diagnosed with various psychiatric disorders, anxiety, developmental disorders, and schizophrenia. With my clinical experience, a high amplitude of theta waves may be caused by the inflammation of brain cells induced by a leaky brain induced by leaky gut syndrome caused by gluten allergies, ticks, infection diseases, electromagnetic wave, and PTSD with dissociation disorders. Among 658 clients, 75% of them had been diagnosed as to have the leaky gut syndrome. Therefore, in our practice, we at first evaluate brain waves, secondly conduct counselling on their personal and family histories, and thirdly ask about their lifestyle, food intake, exercise habits, and personal relationships, then educate on nutrition and exercises, as well as conduct cognitive behavior therapy. Then, we usually refer them first to an internal medicine doctor who could diagnose and treat leaky gut syndrome, prescribe medication as well as supplement to detoxify and nourish the brain, and, if necessary, refer to a clinician of Self-Ego Unification Therapy invented in Japan to treat dissociation disorders. For clients who had recovered from their leaky gut syndrome, their amplitude of theta waves decreased to less than 20 μV, and within less than five sessions they lost their abnormal symptoms. In our experience, three clients who diagnosed as schizophrenia got jobs. Our recent procedure is first to eliminate factors to decrease theta waves, and then to provide NFT being backed up by two theories depending on their emerging area of psychiatry; one is the neuroinflammation theory that psychiatric disorders are caused by inflammation of brain cells, and the other is the connectome disorder theory that psychiatric disorders are caused by disorders of brain connectomes.

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Affective Virtual Reality Game for Depression Symptoms Detection Using Psychophysiological and Behavioral Measures

Christopher Baxter[1], Estate Sokhadze[2], and Yi (Joy) Li[1]
[1]Kennesaw State University, Kennesaw, Georgia, USA
[2]University of South Carolina School of Medicine in Greenville, Greenville, South Carolina, USA

Since its inception, virtual reality (VR) technology has become not only an important medium of entertainment but also a useful tool in therapeutic intervention research. VR provides a fully immersive experience with the possibility of triggering strong and more specific emotional reactions, all within a safe environment. While this has led to interests in applications of VR as a therapeutic intervention (Freeman et al., 2018; Grochowska, Jarema, & Wichniak, 2019), the application of VR as a diagnosing tool of mental disorders has not been thoroughly investigated yet. In our current research study, we have developed an affective VR system that aims to induce different types of emotional reactions in users. By instilling a sense of presence in the users through immersion and interaction (Baños et al., 2005; Sugiura, 2013), the system is able to impact on current user emotions. Three emotional-laden VR game scenes were carefully designed and developed with controlled variations in order to elicit targeted emotions. Physiological signals collected from an E4 wearable device (Empatica, Boston, MA) were used to monitor and analyze the dynamic emotional status. Based on our previous research (Li, Elmaghraby, El-Baz, & Sokhadze, 2015; Sokhadze et al., 2017), we assume these emotional states will be different between the emotionally impaired groups and the control group. A mini psychomotor VR game followed immediately after each scene and was designed to test users' motor reaction time under the emotional impact. A pilot study has been conducted where participants divided into two categories: those with self-reported depression symptoms and those without any known mental illness or any depression symptoms. Results from collected postexperiment surveys show that the three affective game scenes are able to trigger targeted emotional reactions in all participants. Recorded physiological data shows that participants with self-reported depression symptoms exhibited higher skin conductance levels (SCL) and higher heart rates than individuals with no known mental illnesses symptoms. Recorded VR game exposure times show that participants with self-reported depression took longer to complete each scene than individuals with no known mental illnesses. The times necessary to complete the VR game were similar across both categories.

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Effect of Audio-Visual Brain Entrainment on Anxiety, General Health, Stress, Quality of Sleep and Work Productivity and Activity Impairment: A Pilot Study with Telemarketers

Rodolfo Borges Parreira[1], Noemy Ferreira de Castro[1], Maria Luisa Ramos Mendes[1], Afonso Inoue Shiguemi Salgado[2], Patrick Porter[2], and Francisco Cidral-Filho[2]

[1]Residence Program in Manipulative, Complementary and Integrative Physical Therapy, Salgado Institute of integral Health/Philadelphia University Center, Londrina, Brazil

[2]Integrative Health School, USA

The objective of this study was to investigate the effect of audio-visual brain entrainment on anxiety, general health, stress, quality of sleep, and work productivity and activity impairment of telemarketers. The study was conducted at the Salgado Institute of Integrative Health, Londrina, Paraná, Brazil, and the protocol was approved by the Institutions Ethics Committee. Sample size consisted of 13 telemarketers (3 males and 10 females). Audio-visual brain entrainment was delivered with a BrainTap headset (BrainTap, New Bern, NC) in 20-min sessions, three times a week for 6 weeks. The sessions consisted of binaural beats at 18 to 0.5 Hz, isochronic tones at 18 to 0.5 Hz, and visual entrainment through light-emitting diodes at the wavelength of 470 nm that were placed on a visor flickering at 18 to 0.5 Hz over the eyes of the participants. The following questionnaires were applied at baseline and after 6 weeks: The Hamilton Anxiety Rating Scale (HAM-A) that measures the severity of anxiety symptoms; the General Health Questionnaire (GHQ-12), a screening device for identifying minor psychiatric disorders; the Perceived Stress Scale (PSS-10), the most widely used psychological instrument for measuring the perception of stress; the Pittsburgh Quality of Sleep Index (PQSI), that scores sleep quality; and the Work Productivity and Activity Impairment Questionnaire (WPAI), that measures impairments in work and activities. Audio-visual brain entrainment positively affected all scores: HAM-A (22.95%); GHQ-12 (10.93%); PSS-10 (16.86%); PQSI

(14.51%); as well as WPAI (absenteeism, 41.66%; presenteeism, 56.25%; work productivity, 56.22%; and activity Impairment due to health, 76%).

Conclusion. Although results did not achieve statistical significance when compared to baseline, audio-visual brain entrainment positively affected scores related to anxiety, general health, stress, quality of sleep, as well as work productivity and activity impairment of telemarketers. A larger sample size study is necessary to statistically confirm the effects of audio-visual brain entrainment.

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Effects of Neurofeedback on Electroencephalographic Functional Connectivity in Children with Specific Learning Disorder with Impairment in Reading

Lucero Albarran
Universidad Nacional Autónoma de México, Mexico City, Mexico

Specific learning disorder with impairment in reading (RD) is a neurodevelopmental disorder characterized by alterations of the normal pattern to acquire reading academic skills, including the ability to read words accurately and fluently with reading comprehension. Several EEG studies have reported abnormalities in children with RD. The most frequently reported is a higher theta absolute power and lower alpha activity compared to children with typical development of the same age. Regarding the interhemispheric coherence measure, children with RD show higher values in delta (1.5–3.5 Hz), theta (4.0–7.5 Hz) and beta (13.0–19.5 Hz) frequency bands and lower values in alpha (8.0–12.5 Hz) frequency band than children with adequate academic performance.

Neurofeedback (NFB) has been demonstrated to be an effective treatment in RD children by reinforcing theta/alpha ratio reduction. Its efficacy is based on a cognitive-behavioral improvement and normalization of the EEG frequency.

The aim of this research is to explore if this neurofeedback protocol produces not only a reorganization of the EEG frequency but also a reorganization of EEG connectivity (coherence measures) in children with RD. Ten subjects between the ages of 8 and 10 years were evaluated by structured psychological interview, psychometric, neuropsychological tests, EEG at resting state, and neuropediatric evaluation. All subjects fulfilled the criteria for RD diagnosis and presented a delay of EEG maturation. Participants received NRA treatment using the NFB protocol to decrease theta/alpha ratio. The treatment consisted of thirty 30-min sessions, at a frequency of three times per week. Significant differences were found when pre-versus posttreatment comparisons were performed. These differences included theta/alpha ratio decrease, an improvement in reading comprehension, and a reduction of the interhemispheric frontal coherence.

Conclusions. These preliminary results demonstrate that NFB treatment, in addition to having an impact on the EEG frequency and the school performance of children with RD, has a positive effect on the EEG coherence values.

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Evaluating the Effect of Cranial Electrotherapy Stimulation on Attention and Sleep in ADHD

Erika Rachel Skerrett, Genna Mulvey, Victor Landry, and Genomary Krigbaum
Grand Canyon University, Phoenix, Arizona, USA

This quantitative double-blind, pretest–posttest experimental study examined two research questions in a sample of adults diagnosed with ADHD in the Niagara Region of Ontario, Canada. The questions were: If cranial electrotherapy stimulation (CES) increases auditory and visual attention on the IVA-FSAQ, to what extent does it? And, if CES increases sleep quality on the PSQI, to what extent does it? Sleep problems are common in individuals with ADHD (Sciberras et al., 2017; Wajszilber, Santiseban, & Gruber, 2018). First line treatment for ADHD has been primarily pharmacological (Cortese et al., 2018). Impaired sleep also causes problems with EF (Wilckens, Woo, Kirk, Erickson, & Wheeler, 2014). There was a gap in knowledge regarding the linkages between attention and disordered sleep. Understanding the impact of CES on attention and sleep quality was worthy of further investigation. Fifteen participants were randomly assigned to sham or active device conditions and used CES for 60 min each day for 5 weeks. A two-way mixed MANOVA demonstrated a statistically significant multivariate effect for the main effect of time $F(2, 12) = 7.09$, $p = .009$; Wilks' = .541. There was no statistically significant multivariate effect for the main effect of device group or for the interaction between time and device group. Effect sizes were large to very large, and it is likely that a larger sample size would have revealed more conclusive results regarding the interaction between time and device group. Qualitative data assisted to explain the findings. Sham participants engaged in extraneous activities that could improve sleep during the study. Results support the use of CES as an adjunctive sleep aid in adults suffering from ADHD.

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Evoked and Induced Gamma Oscillations as Biomarkers of Transcranial Magnetic Stimulation Outcomes in Children with Autism Spectrum Disorder

Manuel Casanova[1], Mohamed Shaban[2], Mohammed Ghazal[3], Ayman El-Baz[4], Emily Casanova[1], Estate Sokhadze[1]
[1]University of South Carolina School of Medicine-Greenville, Greenville, South Carolina, USA
[2]University of South Alabama, Mobile, Alabama, USA
[3]University of Abu Dhabi, United Arab Emirates
[4]University of Louisville, Louisville, Kentucky, USA

Autism spectrum disorder (ASD) is a behaviorally diagnosed neurodevelopmental condition of unknown pathology. Research suggests that abnormalities of brainwave oscillations may provide a biomarker to the condition. More specifically, irregularities of gamma oscillation have been offered as a correlate to the perceptual and cognitive impairments observed in ASD. In this study, evoked and induced gamma frequency oscillations in response to a visual classification task (oddball test with Kanizsa figures) were analyzed and compared in 19 ASD (ADI-R diagnosed, 14.2 ± 3.61 years old, 5 girls) and 19 (14.8 ± 3.67 years old, 5 girls) age/gender matched neurotypical individuals. The ASD group was treated with low frequency rTMS (1.0 Hz, 90% motor threshold, 18 weekly sessions) targeting the dorsolateral prefrontal cortex (DLPFC). Within any given burst, gamma oscillations do not resemble sinusoidal waveforms of steady amplitude. Instead, their amplitude fluctuates with a variability readily detected by envelope analysis. In this study, we have found that demodulation of gamma oscillations provides information of clinical relevance in the spectral analysis of brainwaves. In autistic subjects, as compared to neurotypicals, significant differences in event-related evoked and induced gamma oscillations were evident in a higher ascending and descending slope magnitude of both evoked and induced gamma oscillation waveforms pre-TMS, especially in response to nontarget cues. In addition, recordings after TMS treatment in our autistic subjects revealed a significant reduction of gamma responses to task-irrelevant stimuli. Participants committed less errors during post-TMS test. Behavioral questionnaires (ABC, RBS-R) showed decrease of irritability, hyperactivity, and repetitive behaviors scores. The use of a novel metric for event-related gamma oscillations (i.e., envelope analysis using wavelet transformation) and measurements of its decay allowed us to characterize the impedance of the originating neuronal circuit. The dampening of gamma oscillations is dependent on the inhibitory tone generated by networks of interneurons. The results suggest that the decay of gamma oscillations may provide a putative biomarker reflective of the excitatory/inhibitory balance of the cortex and a putative outcome measure for TMS-based neuromodulation interventions in autism.

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Feasibility Study of Ambulatory Monitoring of Autonomic Activity in Girls With Rett Syndrome

Caroline Buchanan[1], Jennifer Stallworth[1], Alan Percy[2], and Estate Sokhadze[3]
[1]Greenwood Genetic Center, Greenwood, South Carolina, USA
[2]University of Alabama, Birmingham, Alabama, USA
[3]University of South Carolina School of Medicine–Greenville, Greenville, South Carolina, USA

Rett syndrome (RTT) is a severe but rare neurodevelopmental disorder caused by pathogenic variants in the methyl CpG-binding protein 2 gene (MECP2) occurring in 1 of 10,000 girls (Neul et al., 2010). Evaluation of autonomic activity in children with RTT is challenging due to stereotyped behaviors presenting with repetitive involuntary hand movements. According to parental reports, sleep disturbances and a range of emotional, behavioral,

and autonomic dysregulation present in children with RTT are the main factors affecting their quality of life (Boban, Leonard, Wong, Wilson, & Downs, 2018; Killian et al., 2016; Lane et al., 2011). Autonomic dysfunction is likely to have a significant functional impact on such symptoms as repetitive rocking, screaming, agitation and anxiety (Carroll, Ramirez, & Weese-Mayer, 2020; Kumar et al., 2017; Singh, Lanzarini, & Santosh, 2019; Weese-Mayer et al., 2008). The study examined the feasibility of using an E4 ambulatory autonomic monitoring device (Empatica, Boston, MA) to evaluate heart rate (HR), electrodermal activity (EDA) and skin temperature (TEMP) during 24 to 72 hours recording in girls with confirmed RTT ($N = 10$, 3–12 years old, mean 6.3 years). Caregivers were instructed to place the E4 device on their child's wrist and record sessions for at least 24 hours, and, if possible, to have several sessions recorded. An array of HR, EDA, and TEMP measures were evaluated from the collected 26 qualifying overnight and daytime in-home ambulatory recordings in 10 girls with RTT. Although hand stereotypies are present in the majority of children with RTT, they do not occur during sleep (Merbler, Byiers, Garcia, Feyma, & Symons, 2018), and the intensity of hand movements varies. Examinations of recordings allowed separation of data into three conditions according to movement intensity assessed by a built-in accelerometer of the E4 device: sleep and day nap (Zero), low level (Low) and high level (High) of hand stereotypies. After debugging of movement-related artifacts in HR, EDA, and TEMP, the segments selected according to movement activity states (Zero, Low, High) were averaged according to condition and compared using paired sample *t*-test. Statistical analysis of EDA showed significant differences between Zero and Low conditions ($t = 2.42$, $p = .036$) and trend to lower EDA in High as compared to Low activity ($t = 2.20$, $p = .052$). TEMP was significantly higher during sleep as compared to both waking conditions ($p < .001$), while HR was lower in Zero as compared to both Low ($t = 5.64$, $p < .001$) and High ($t = 5.11$, $p = .001$) intensity movement conditions. Recording of EDA in individuals with RTT is very rare and was reported only for pain experienced during blood draw (O'Leary et al., 2017). Recording EDA from the E4 sensors placed on the wrist had lower absolute values but was informative to detect dynamics during sleep and stereotyped movements. In future studies, we plan to correlate autonomic measures with behavioral questionnaire scores and clinical severity in each subject with RTT. Our results confirm feasibility of in-home physiological recording and ability to detect variations of autonomic measures in girls with RTT. Study was supported by the International Rett Syndrome Foundation grant.

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Individualized Neurofeedback Treatment for Anxiety and Related Symptoms

J. Ross Spears, Cerise Edmonds, J. Claire Gregory, Devon Romero, and Mark Jones
University of Texas at San Antonio, San Antonio, Texas, USA

Working within the mental health profession, clinicians might encounter individuals who struggle with various anxiety symptoms. Anxiety has a variety of forms. Anxiety can negatively impede on daily functions and roles. Existing in research are several approaches using biofeedback as an intervention for treating anxiety (Jones & Hitsman, 2018). Neurofeedback, a facet of biofeedback, reveals itself as a promising avenue for treating and correcting unwanted symptoms of anxiety as well as other diagnoses (Cheon et al., 2015; Kerson, Sherman, & Kozlowski, 2009; Mennella, Patron, & Palomba, 2017; Scheinost et al., 2013; Wang et al., 2019; Zhao et al., 2018).

Our poster presentation will present findings from our retrospective study that integrated a within-subjects research design using individualized neurofeedback protocols for anxiety. This presentation has three primary aims. The first is to disseminate findings from our retrospective study that examined the effects of quantitative electroencephalography (qEEG) guided amplitude neurofeedback treatment for anxiety and related symptoms. The current sample includes fifty-two adult clients assessed for anxiety using qEEG and symptom measures (Zung Self-Rating Anxiety Scale [SAS] and the Achenbach System of Empirically Based Assessment Adult Self-Report [ASR]) collected pre- and post-intervention. Clients (N = 52) range in age from 19 to 59 (M = 36.4, SD = 12.6) with 53.8% (n = 28) of clients self-reporting as male. The self-reported ethnic composition of the sample was 50% (n = 26) Non-Hispanic, 44% (n = 23) Hispanic/Latino, and 6% (n = 3) chose not to respond. On the SAS, for all subjects, the mean of the pre-scores was 45.62 (SD = 8.49) and the mean of the post-scores was 39.50 (SD = 9.40). A paired samples t-test yielded a statistically significant improvement, with $t(51) = 6.3$, $p < .001$, $d = 1.11$. On the ASR, a statistically significant improvement was also measured in seven of the eight syndrome scales. In addition, a statistically significant improvement was measured for total problems and critical items. The second aim is to discuss predictors of SAS outcomes assessed in the first aim. Regression analyses identified total problems, substance use, and level of education as predictors of anxiety symptoms as measured by the SAS following individualized neurofeedback treatment. Finally, our third aim is to present findings from a subsample of these clients with assessments completed at three time points (pre, post, and follow-up). This subsample consisted of 21 clients with ages ranging from 20 to 56 (M = 38.8, SD = 12.39). Analyses revealed statistically significant improvement from pre to post and sustained outcomes from post to follow-up. Implications of these findings and future research will be discussed.

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Neurofeedback Training for Improving Attention in Amphetamine Addict

Hsin-Yi Chiang[1], Hsueh-Chen Lu[2]
[1]Kaohsiung Municipal Kai-Syuan Psychiatric Hospital, Kaoshiung City, Taiwan
[2]California School of Professional Psychology, Alliant International University, California, USA

Introduction. Amphetamine dependence was found to be associated with poorer performance on attention/concentration and ability to discriminate targets from nontargets on the Continuous Performance Test (CPT; Ersche & Sahakian, 2007; McKetin & Mattick, 1997). Eyes-open beta-sensorimotor response (SMR) amplitude uptraining is known to be an effective way to improve focusing on attentional ability (Hong & Lee, 2012). This case study investigated the effects of beta-SMR neurofeedback training on attention in a patient who is a chronic amphetamine user.

Case Description. The patient is a 53-year-old Taiwanese female who had been addicted to amphetamine for at least 30 years and suffered chronic spondylolisthesis pain for over 7 years. She reported using amphetamine to manage her pain and improve her work performance. However, her amphetamine dependence problem and chronic pain contributed to her depression, anxiety, insomnia, impairments at work, and reduction of her ability to work. She had not received medication management for her problems with amphetamine dependence, mental health problems, and chronic pain. She was referred from an outpatient psychiatric program to receive beta-SMR neurofeedback training combined with relaxation training to improve her mental health problems, substance use, and chronic pain issues. She received beta-SMR neurofeedback training at the central area (Cz) to increase her beta and SMR amplitude twice per week for 2 months (1 hour/time), and she practiced diaphragmatic breathing relaxation skills to improve her emotional and sleep problems. Her attention, impulse control, and emotional problems were assessed pre- and postneurofeedback training with Conners' Continuous Performance Test-II (CPT-II), Adult ADHD Self-Report Scale (ASRS), the Beck Depression Inventory-II (BDI-II), and the Beck Anxiety Inventory (BAI). After 2 months (12 hours) of beta-SMR neurofeedback training, her attention problems, impulsivity, depression, anxiety, and subjective experience of chronic pain all showed clinically significant improvement.

Discussion. The present case study supports the efficacy of a beta-SMR neurofeedback training as an adjunctive therapy in an outpatient drug treatment program, and supportive data were provided through attention and psychological assessments. Future research should include multiple cases to examine the efficacy of beta-SMR neurofeedback training for chronic amphetamine users.

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Neuromodulation of Event-Related Gamma Oscillations in Children with Autism

Estate Sokhadze[1], Mohamed Shaban[2], Mohhamed Ghazal[3], Ayman El-Baz[4], and Manuel Casanova[5]
[1]University of South Carolina School of Medicine-Greenville, Greenville, South Carolina, USA
[2]University of South Alabama, Mobile, Alabama, USA
[3]University of Abu Dhabi, United Arab Emirates
[4]University of Louisville, Louisville, Kentucky, USA
[5]University of South Carolina School of Medicine–Greenville, Greenville, South Carolina, USA

Oscillatory activity in the gamma band of the EEG has been related to cognitive functions such as attention, learning, and memory (Kaiser & Lutzenberger, 2003; Kahana, 2006). Abnormalities of high frequency EEG oscillations in gamma range have been associated with binding problems present in autism and other psychiatric conditions (Brock, Brown, Boucher, & Rippon, 2002). Several lines of evidence suggest that the cortical excitatory/inhibitory (E/I) imbalance observed in autism spectrum disorder (ASD) is the result of an inhibitory deficit. An abnormal E/I bias provides a pathophysiological mechanism capable of explaining the complex phenotype of ASD. Abnormalities of E/I ratio in ASD were discussed in several reviews (Rubenstein & Merzenich, 2003; Uzunova, Pallanti, & Hollander, 2016). Gamma-band abnormalities have been reported in many studies of autism (Rojas & Wilson, 2014) and were often associated with perceptual and cognitive functions that are compromised in autism. Low frequency repetitive transcranial magnetic stimulation (rTMS) over the dorsolateral prefrontal cortex (DLPFC) has been proven to normalize gamma oscillation abnormalities, executive functions, and repetitive behaviors in high functioning (ASD) individuals (Oberman et al., 2016; Sokhadze et al., 2016). In this study, gamma frequency oscillations in 35–45 Hz range in response to task-relevant and task-irrelevant illusory Kanizsa figures (Kanizsa, 1976) were analyzed and compared in 19 ASD (ADI-R diagnosed, 14.2 ± 3.61 years old) and 19 (14.8 ± 3.67 years old) gender-matched neurotypical children. The ASD group was treated with 18 weekly 1.0 Hz frequency rTMS (90% motor threshold). In autistic children, as compared to neurotypicals, at the baseline test, significant differences in event-related gamma oscillations were evident at the frontal sites (F3, F4, F7, F8) in a form of a higher amplitude to both rare target (e.g., at F3 EEG site, by 0.92 ± 1.17 uV, $p < .01$) and rare nontarget illusory figures (1.05 ± 1.01 uV, $p < .001$). Recordings of event-related gamma oscillations after TMS treatment in our autistic subjects revealed a significant reduction in the latency of positive ascending slope of gamma oscillation peak along with an increase in latency of the negative descending slope of the gamma oscillation burst. Differences between latencies of ascending and descending slopes post-TMS course decreased in response to all type stimuli. The results were interpreted as reflective of increased inhibitory tone suggesting that low frequency rTMS treatment course in autism normalizes the gamma oscillations by increasing the inhibitory tone of the cortex. The present study contributes to a proposal that beneficial effects of rTMS in behavioral outcomes could be mediated by improvements in gamma band (35–45 Hz) oscillatory activity. The results suggest that the analysis of various metrics of gamma oscillations may serve as a basis for development of biomarkers of the excitatory/inhibitory balance of the cortex and provide with valuable outcome measures for neuromodulation-based interventions in autism.

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Posttraining Registration of an SMR/theta Protocol with Neurofeedback

Legna Alejandra Lazo Sánchez[1], Fructuoso Ayala Guerrero[1], and Diana Amparo Martínez Huerta[2]

[1]Faculty of Psychology, National Autonomous University of Mexico, Mexico City, Mexico

[2]Boston Neurodynamics, Brookline, Massachusetts, USA

The literature reports that it is possible to modify the pattern of electroencephalographic (EEG) activity using neurofeedback techniques; however, such findings continue to have limitations. One of the most widely used clinical protocols is to increase the sensorimotor rhythm (SMR) and simultaneously decrease theta activity with the aim of increasing attention performance and reducing hyperactive and impulsive behaviors. The SMR band is characterized by a frequency of 12–15 Hz and is the expression of synchronized oscillatory activity, reflected in the sensory motor cortex; it is associated with body movement and concentration capacity (Gruzelier, Inoue, Smart, Steed, & Steffert, 2010). The neurogenesis of SMR emanates from the ventrobasal nucleus of the thalamus, which is generally associated with conduction of broad somatosensory information. During the production of conditioned SMR, the firing patterns of the ventrobasal nucleus change from rapid, nonrhythmic (tonic) discharges to bursts of rhythmic and systematic discharges, which in turn are associated with suppression of somatosensory information passing (Sterman & Egner, 2006). Theta waves have a frequency of 4–8 Hz and are considered slow activity waves that are involved with sleep as well as with some dysfunctional mechanisms such as distraction and inattention (Koudelková & Strmiska, 2018; Demos, 2005). This is a pilot study of a doctoral thesis. The purpose of this study was to evaluate the efficacy of SMR/theta training in neurofeedback through a posttraining registry where the participant evokes the trained rhythms without looking at the screen after 25 training sessions in five healthy volunteers. In this study we worked with five healthy volunteer participants between 21 and 30 years old. The neurofeedback protocol SMR/theta used consisted of 25 sessions lasting 30 min. Subsequently, a posttraining registry was carried out to evaluate the learning obtained after the protocol. Participants were asked to replicate the learned brain state without having access to the feedback screen. With the following conditions: Closed eyes, Opened eyes, Training 1, Rest 1, Training 2, and Rest 2. During the posttraining registration, significant differences were obtained in the average amplitudes between each of the recording phases for the theta frequency band, decreasing when the target task was performed and

increasing during the rest phase specifically between Training 1 and Rest 1, $Z(1, 5) = -2{,}023$, $p = .043$; as well as Training 2 and Rest 2, $Z(1, 5) = -2{,}023$, $p = .043$. In the case of electrical activity SMR no significant differences were found between the different phases of the records; however, it is important to note that the trend of the data kept increasing throughout the entire record. The behavior of the SMR and theta wave patterns is as expected according to the reported literature (Aliño Costa, 2017; de Zambotti, Bianchin, Magazzini, Gnesato, & Angrilli, 2012).

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Prefrontal Neurofeedback Training Outcomes in Children with Autism Spectrum Disorder with Comorbid Attention-Deficit/Hyperactivity Disorder

Estate Sokhadze[1], Desmond Kelly[2], and Manuel F. Casanova[1]

[1]University of South Carolina School of Medicine–Greenville, Greenville, South Carolina, USA

[2]Prisma Health-Upstate, Greenville, South Carolina, USA

Neurofeedback (NFB) is recognized as one of the most established neurotherapy methods in ADHD (Arns et al., 2020) and is considered as the potentially effective method for EEG self-regulation in children with autism spectrum disorder (ASD). There are numerous reports of high comorbidity of these two disorders (Sinzig, Vinzelberg, Evers, & Lehmkuhl, 2014) and the number of children with ASD and ADHD is increasing after recent changes in DSM-5 that allowed this form of dual diagnosis. It should be noted that most studies of neurofeedback focus on posttreatment behavioral evaluations and EEG outcomes and do not analyze dynamics of EEG and autonomic activity during individual training sessions. Meanwhile, there are certain feasibility issues in continuing NFB in children with dual diagnosis that are considered as nonresponders. This brings on a need for identification of reliable predictors of successful outcomes considering the required number of sessions in the NFB course. Some EEG, cardiorespiratory, and electrodermal indices are candidate predictors of neurofeedback training outcomes and may serve as potential moderators. We proposed that 24 sessions of prefrontal neurofeedback training in treatment responders will be accompanied by intended changes in targeted EEG bands and ratios of individuals bands (e.g., theta/beta ratio), as well as by changes in electrodermal and cardiorespiratory indices. Outcome measures were based on EEG, ECG, pneumogram and skin conductance indices and parental behavioral ratings. The protocol used a training for wide band EEG amplitude suppression (sometimes referred to as “squash”) with concurrent upregulation of the 40 Hz-centered gamma. In this pilot study we enrolled 12 children diagnosed both with ASD and ADHD (11.3 years, *SD* = 1.4, 3 girls). For each session of neurofeedback, qEEG analysis at the training site was completed to determine the relative power of the individual bands (theta, beta, and gamma) and their ratios (theta/beta) within and between sessions. We analyzed Aberrant Behavior Checklist (ABC; Aman & Singh, 1994) and ASEBA (Achenbach & Rescorla, 2012) ratings by parents. Nine subjects were defined as responders. Regression analysis revealed significant linear increase of skin conductance level (SCL) along with decrease of respiration rate during each successful neurofeedback session during successful training sessions defined by targeted changes of EEG measures of interest. Heart rate variability (HRV) measures showed certain trends during sessions but did not reach significance level. According to parental reports hyperactivity subscale scores of ABC and ASEBA DSM-oriented scores of attention-related problems showed significant decrease. Psychophysiological measures such as SCL, respiration, and HRV represent useful markers of attention and emotional engagement of children with ASD and ADHD during neurofeedback and can be used as predictors of successful performance during sessions and behavioral outcome of the intervention. The study extends our prior studies (Sokhadze, Casanova, Wang, Tasman, & Kelly, 2019; Wang et al., 2016) using similar protocol by extending

number of training sessions from 18 to 24 and by adding concurrent psychophysiological monitoring through the course of training and supports rationale for more extensive use of autonomic measures for interpretation of moderators and mediators of neurofeedback intervention.

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