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Automated Neurofeedback Brain-training as a Primary PTSD Intervention

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Abstract

Neurofeedback brain-training has a significant presence in the literature for its efficacy in alleviating the symptoms and behavioral manifestations of PTSD, with no enduring negative side-effects. It is considered a behavioral intervention in that it teaches the brain to better manage its own brain-wave activity, leading to reduction of 80-85% of symptoms in the first 30-40 training sessions. Brain-training has shown efficacy in improving recovery from anxiety, depression, insomnia, addictions, emotional and cognitive dysregulation, attention, impulse control and many more co-occurring symptoms of PTSD. Barriers to broad-based implementation in both clinical and subclinical settings include cost of equipment, lengthy, in-depth training requirements, and a lack of clear guidance in developing and implementing brain-training protocols specific to each individual's brain-phenotype. Automated Psychophysiological assessment and EEG Biofeedback training systems demonstrate equal efficacy as clinician-guided EEG Systems. We propose that Automated EEG Biofeedback systems have evolved to differentiate and train a multiplicity of brain-phenotypes related to PTSD. Further, these systems decrease the cost of brain-training significantly, reduce the training requirements for brain-trainers, and significantly increase the effectiveness of all other behavioral and pharmacological interventions. We propose that automated brain-training can be more broadly implemented in clinical and sub-clinical settings as a primary behavioral intervention for PTSD.

Introduction

Post-traumatic stress disorder (PTSD) is a widespread debilitating disorder with substantial negative affects in academic, employment, social, emotional, health dimensions, and quality of life (Asnaani Reddy, & Shea, 2014; Irish et al., 2013; Pagotto, et al., 2015). From the neurological perspective, PTSD is best described as a complex dysregulation of neurological function of intrinsic connectivity networks (ICN). EEG activity in these networks become dysregulated as a result of trauma. Whether or not PTSD is acute or chronic is dependent on the ability of these networks to return to a more regulated state, spontaneously, or through treatment interventions. Psychopharmacological therapies attempting to regulate these networks have failed to produce efficacious and enduring outcomes, or significant reduction in diagnosis of those treatment of PTSD. Similarly, psycho-social treatments currently used in treating PTSD only benefit about half of those treated, with most continuing to have substantial residual symptoms negatively impacting their life (Gapen et al, 2016, van der Kolk et al, 2016)

Neuro imaging and EEG Brain-mapping research over the past three-decades has produced significant insight into ICN involvement in PTSD and other related and non-related mental health disorders. The Arousal Model developed from these studies identify eleven universal brain-phenotypes involved in nearly all mental health disorders. These brain-phenotypes, subtypes of mental health disorders describe symptom and behavioral manifestations of regional brain over-arousal, under-arousal, or instability. (Gunkelman & Cripe, 2008; Amen, 2015). In PTSD, dysregulation of three intrinsic connectivity networks are identified: The Central Executive Network (CEN), the Salience Network (SN), and the Default Mode Network (DMN).

The CEN, including the right inferior parietal lobule and the right inferior frontal gyrus, is crucial to executive functioning and verbal learning. The Salience Network (SN) consists of the dorsal anterior cingulate cortex and the frontoinsular cortex, directs behavior to the most important stimuli. The Default Mode Network (DMN) consists of the anterior and posterior medial cortices and lateral parietal lobes. The DMN affects autobiographical memory, referential processing, and social cognition (Lanius, Frewen, Tursich, Jetly, & McKinnon, 2015).

The PTSD phenotype demonstrates a pattern of low arousal in the CEN, accompanied by higher arousal in the DMN. Dysregulation of the SN maintains the condition of pre-frontal under-arousal and limbic-system over-arousal in PTSD populations. The extensive body of neuroimaging studies is revelatory for understanding the underlying neurological imbalances involved in PTSD, for predicting medication efficacy and especially for understanding the importance of automated neurofeedback as a primary intervention for PTSD.

Our purpose in this article is to provide an overview the literature on the effectiveness of neurofeedback as a PTSD intervention, specifically by addressing intrinsic connectivity network dysregulation. Next, we will describe evolvement of automated NFB assessment and interventions, potential side effects, and contraindications. I will review the research support for brain-training in various addiction and mental health populations. Finally, strategies for integrating automated brain-training systems in clinical and subclinical settings is explored.

Neuroimaging and EEG research provides many new clues to the underlying etiology of PTSD and the frequently co-occurring symptoms related to other brain-wave imbalances. In fact, it is only through *seeing* and *hearing* brain activity that a comprehensive Arousal model has developed that provides a framework for both diagnosing and treating the broad range of PTSD symptoms. Brain imagining techniques have developed at a significantly rapid pace over the past 3 decades, leading to a much more comprehensive understanding of the effects of regional brain arousal levels: under-aroused, over-aroused, or unstable, on mental health symptoms. Researchers have now identified Eleven universal brain-phenotypes that describe out-of-balance arousal levels implicated in nearly all mental health disorders. Seven individual brain-phenotypes have been identified related to ADHD specifically, with seven phenotypes identified for Anxiety/Depression, six phenotypes for Addiction, and six phenotypes for Eating Disorders. There is considerable overlap between the PTSD symptoms and phenotypes related to other mental health disorders. Identifying the individual brain-phenotype involved in PTSD, and other disorders, is a critical first step in diagnosis, and is necessary for predicting medication efficacy (Amen, Hanks, & Prunella, 2008).

Limbic-System Hijacking

In PTSD, as well as addictions, there is an unhealthy relationship between the brain-waves Alpha in our prefrontal cortex, and Theta in the Limbic System. Changes in the ratio of these brain waves are triggered by sensory memory inputs. Sensory memory systems record input throughout our life, some pleasant, some unpleasant. In times of trauma, some of those sensory memories can become linked to the limbic system memory, which is a much more biological memory. In addictions, the limbic system memory remembers how good it felt, how much relief was provided. In the case of PTSD, the limbic system, remembers how bad it felt. When triggered, the limbic system memory activates the autonomic fight-or-flight response, showing up in brain waves as an escalation of Theta, the rhythm that largely drives the limbic system. Needing more energy to maintain this state of alert, the brain shifts (steals) energy from elsewhere. In the case of both addictions and PTSD, the brain steals energy from the pre-frontal cortex rhythm Alpha. One can imagine, that without enough Alpha pre-frontally, that portion of the brain doesn't have sufficient energy to do its job sufficiently. Some of the most important prefrontal left functions are cognition, impulse control, emotional regulation, and decision making. Prefrontal right functions include empathy, compassion, self-care.

This makes a lot of sense physiologically. The thalamus, the brains gatekeeper of sensory information, is very close to the limbic system, and very distant, relatively, to the prefrontal cortex. The limbic system gets the information first, and results in what has been called "limbic system hijacking." When we monitor this brain process with electroencephalograph (EEG) we see Theta taking control of the brain, draining energy from Alpha in the prefrontal cortex. Literally, the part of the brain we need for good recovery does not have the energy it needs to do its job. From the neurofeedback perspective, limbic system hijacking represents dysregulation of the brain-reward circuitry and provides the basis for development of brain-training protocols specific to correcting this dysregulation, Alpha/Theta training.

Until recently, assessing brain-phenotypes for PTSD and other mental health disorders required extensive clinical training and experience. Accurate assessment has traditionally relied on quantitative Electroencephalograph (qEEG) evaluation. qEEG systems listen to the various components of brain-wave activity. The most comprehensive qEEG systems analyze data obtained from 19-channels on the scalp where brain-wave signals are known to rise sufficiently to be *heard* by sensors placed on those locations. The signals are amplified, and the data is compared against norms of normal brain activity. The data produces graphics that can identify over 5,100 components of brain activity including arousal levels, connectivity, coherence, and brain-injury. Unfortunately, recording and interpreting the qEEG requires complex interpretations of baseline Electroencephalograph (EEG), participants' presenting symptoms, between-session changes in symptoms, and within session reward criteria. Complex neurofeedback systems, and the necessary skills and knowledge to effectively operate them are typically well beyond operational capacity of most mental health providers, let those assisting PTSD survivor's in non-clinical environments.

A second form of assessing brain-phenotypes, psycho-physiological assessment, demonstrates equal efficacy in reducing PTSD symptoms (Keith, Theodore, Rapgay, Schwartz, & Ross, 2015) and other brain-phenotype imbalances (Scott, 2018). Psycho-physiological assessments more coherently identify both PTSD and other co-occurring mental health symptoms then the DSM-V and ICD-10 include, thereby providing a broader understanding of the underlying brain-arousal levels and their implications for both assessment and treatment. Rather than identifying single features of a specific diagnostic category, psychophysiological assessments provide a more comprehensive perspective on all the mental health issues that may impede cognitive processing, social engagement, emotional stability, and quality of life for those with PTSD symptoms. Technological development within the neurofeedback field now provides guided semi-automatic psychophysiological assessment and training hardware/software with demonstrated equal efficacy when compared with more complex clinical guided neurofeedback (Keith et al., 2015). Automated assessment and brain-training hardware/software provides practical, safe, and effective brain training tools that can be readily implemented a broad range of clinical and sub-clinical settings.

Neurofeedback Brain-Training (NFBT) is a form of evidence-based behavioral therapy that uses a computer-human interface to receive, interpret, and provide feedback of brain electrical energy to the trainee. This form of operant conditioning facilitates the brain's neuro-plasticity, its ability to rapidly change and reorganize neural pathways in response to brain-training. NFBT has been broadly recognized as effective in alleviating brain imbalances implicit in a broad range of mental health disorders, including PTSD. NFBT is safe, with the only reported common side effects of mild headaches and/or slight disorientation. Approximately 75-80% of brain-trainees successfully learn how to train their brain-waves, typically eliminating 80-85% of symptoms related to their brain phenotype (Shepard, 2008, Valenzuela, 2016).

NFBT, in nearly every study, has been recommended as an excellent candidate as a PTSD intervention. It is non-invasive, has few reported short-term side effects, and no reported enduring side-effects. Unlike other PTSD therapeutic models, NFBT directly addresses and alleviates arousal dysregulation by training the brain to better manage its own arousal states. NFBT has been demonstrated to improve scores on the MMPI (Peniston and Kulkosky, 1991; Peniston, Marrinan, Deming & Kulkosky, 1993), reduce anxiety levels (Nicholson et al, 2016), increase emotional regulation, and decreases dissociative symptoms (Nicholson et al, 2017). Clinically significant reductions of PTSD symptoms have been reported by Gerin, et al (2016) and van der Kolk et al. (2016) after NFBT.

Though nearly all reports of NFBT's benefits in PTSD treatment yield positive outcomes, a primary concern is the lack of cohesiveness in identifying, using, and researching the broad spectrum of protocols utilized in NFBT (Panisch & Hai, 2018). As previously discussed, methodological evaluation of brain-phenotypes has been largely restricted to clinician administered qEEG analysis, with most training conducted with variations of Alpha/Theta training. More recent developments in phenotype models demonstrate regional arousal levels implicated in PTSD (Amen, 2015). Assessing the multiplicity of brain-phenotypes is beyond the scope and practice of most clinicians, even many experienced neurofeedback therapists. Designing and implementing treatment protocols that address the multiplicity of symptoms is also beyond the experience scope of all but the most experienced neurofeedback therapists. Further, clinician guided NFBT requires ongoing evaluation of in-session, and between-session changes that typically identify over zealous brain-training.

Nearly all previous positive studies demonstrating NFBT's efficacy in alleviating PTSD symptomology and improving long-lasting EEG patterns have relied on complex neurofeedback systems requiring extensive training and experience, with accumulated understanding of neurophysiology. The complexity of systems, skills, and knowledge required for its clinical and sub-clinical applications has limited more broad spread application of this behavioral training method.

Pioneer neurofeedback researcher and therapist Bill Scott recognized the multiplicity of brain-phenotype symptoms early in NFBT's history. In addition to creating the only 3-dimensional visual feedback instrument, a fractal image of the brain's total EEG, Scott developed NFBT's first, and as far as we know, only automated brain-training system, BrainPaint. The BrainPaint system is a widely used, automated phenotype-based assessment and training human-computer interface. Its design includes a 90-question Symptom Checklist 90-R which can be used in assessment as well as research applications. Additionally, the automated assessment includes symptom assessment for each of the phenotypes associated with anxiety, depression, addictions, and eating disorders. Once the trainer completes the automated assessment, the automated system produces recommended training protocol suggestions that have demonstrated efficacy in others with related brain-phenotypes.

Scott's automated NFBT system converges the long history of neurofeedback's demonstrated efficacy in symptom relief in a broad range of mental-health disorders with the emerging understanding of brain-phenotypes. Though BrainPaint has been widely used in research and clinical settings with great efficacy, little literature yet exists on its unique ability to assess and train to specific brain-phenotype arousal levels. Only one study has been conducted comparing clinician guided NFBT with automated neurofeedback. Keith et al. (2015) demonstrated that automated systems have equal efficacy in positive outcomes as clinician guided NFBT. Developments in automated NFBT systems provide an advantage in that they directly assist neurofeedback practitioners in assessing and training Arousal levels in those regions identified by the trainee's individual brain phenotype.

Scott's development and continued enhancements to his BrainPaint platform provide the ability to more easily identify individual arousal levels from reported symptoms and behavioral manifestations. The computerized evaluation, incorporated into the BrainPaint software to evaluate individualized brain-arousal levels, can be completed by the trainer and trainee in approximately 30-minutes. With children, the trainer and trainee's parents complete the evaluation, with the child present. Once the evaluation questions are answered, the system produces brain-training protocol suggestions specific to each individual's phenotype, and brain-training can commence immediately. We propose that a trained behavioral interventionist can easily implement the BrainPaint evaluation in clinical and sub-clinical settings. BrainPaint's automated production of individualized training protocol suggestions eliminates the skills/knowledge requirements of most NFBT systems. Automated NFBT systems typically reduce the complexity of technical aspects of administering NFBT by using three-sites only for most training protocols. Phenotypes identified by Amen (2015) for ADHD, anxiety, and depression are trained with eyes-open training at two sites along the Sensory Motor Strip with the Brainpaint system, with demonstrated equal efficacy to more complex 19-site NFBT training (Keith et al, 2015). Phenotypes related to PTSD, addictions, and personality disorders are trained at one location at the back of the scalp, where Alpha and Theta brain-waves can be identified and trained in eyes-closed modality. This feature enables much easier technical administration of brain-training, reducing much of the complexity of NFBT to pasting sensors to the trainee's scalp and ears, and coaching them to train their brains.

Scott also had the foresight to include several behavioral and psychiatric evaluation tools within the Brainpaint platform that have great utility in demonstrating, to the client, and in supporting research, positive gains of neurofeedback. These tools are also helpful in determining appropriate training termination points, in that they will identify when a client plateau's in their training. The BrainPaint system includes a Continuous Performance Test (CPT) that reliably assesses attention, focus, and impulse control. BrainPaint's CPT can be used pre-during-and post training. For evaluation and research, we recommend the CPT every 5-10 sessions. BrainPaint also includes an automated in-session and between-session evaluation, helpful in identifying overzealous or under zealous training protocols, able to make immediate changes to training intensities, on-the-fly. Session-by-session tools to evaluate significant negative effects of neurofeedback which, when appropriate, offer the opportunity to further enhance the training protocol, reducing any identified negative effects. Finally, all clinical and non-clinical trainers will appreciate the semi-automatic production of treatment goals.

Scott has developed and included a list of several hundred phenotype related behavioral goals that can be used as is or adapted on-the-fly for each client. Goal setting assists the neurofeedback process by providing specific behavioral measurements that the client can report improvements/declines in their next session. As progress towards each goal moves towards attainment, trainer and trainee can identify further goals that might be achieved through additional training or move towards termination of the current cycle of NFBT.

Scott's BrainPaint system is likely one of the more widely used neurofeedback systems, and as previously discussed, is the only automated NFBT system with demonstrated efficacy in both research and clinical settings. Though little research has been conducted in the broader scope of brain-phenotype directed training, Keith et al (2015) demonstrated that this system was equally effective in both assessing and training in a population of addicted individuals with co-occurring ADHD symptoms.

We have used BrainPaint in clinical and non-clinical settings to assess and train over 200 individuals, from nearly all the eleven known brain-phenotypes. PTSD symptoms are the predominant issues in our veteran clients, while anxiety, depression, and addiction predominate our adult non-veteran clients. Occasionally, we have trained PTSD symptoms out of our child and adolescent clients, though that population primarily presents with ADHD.

Our clients typically experience the reduction in symptomology in the first few sessions, congruent with Scott's reporting, with 80-85% symptom reduction occurring between sessions 20-40. Congruent with McReynolds et al (2017) reporting, our clients report that symptom reduction continues past termination of NFBT, which leads us to believe that near-complete symptom reduction is possible for nearly all mental health disorders when phenotype based NFBT is administered.

Sub-clinical application of Neurofeedback

Currently, there is no licensing requirement to perform neurofeedback, and is regulated under the scope-of-practice of state-licensing boards. As a behavioral intervention, it can be learned and implemented by a broad scope of current clinical and non-clinical level behavioral interventionists. There is a national certification board that reviews applicant's experience and education. Certification is available at two levels, technician, and therapist, requires 36-hours of CEU's in specific areas of knowledge pertinent to the field, and clinical supervision (BCIA.org). BrainPaint provides a ready-to use and implement system on a leased basis, providing great flexibility for the development and maintenance of a cost-effective behavioral intervention program. Trainers are provided a System and Operations manual that can typically be completed in 10-hours or less, and BrainPaint conducts a weekly support webinar attended by BrainPaint trainers worldwide.

Conclusion: We propose that Automated Neurofeedback Brain-training systems have evolved both towards practical application and demonstrated efficacy and safety to further explore their use as a primary behavioral intervention in sub-clinical settings. The BrainPaint automated system reduces training requirements, purchase of complex NFBT assessment and training systems, and provides a ready-to-use NFBT system with wide applicability in clinical and subclinical settings. Its system includes tools that can and should be used in evaluating a phenotype approach to NFBT, and can be implemented easily, affordably, and safely.

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