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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).

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Welcome to *NeuroRegulation* Volume 5, Issue 3. We appreciate your joining us for this issue.

NeurorRegulation and its editors are aware and concerned about the current issues facing neurofeedback, its organizations, and its practitioners. As with any organization, development and maturity come with much criticism and skepticism. The American Psychological Association (APA) underwent vast challenges, criticisms, and subsequent changes to become what it is today, yet there are persistent notions that “hard science” does not apply to psychological mechanisms. The International Society for Neurofeedback and Research (ISNR), the Association of Applied Psychophysiology and Biofeedback (AAPB), and the Biofeedback Certification International Alliance (BCIA) are organizations devoted to neurofeedback and its empirical status. It is very important that we focus on specific definitions, concepts, and standard metrics with well-defined parameters to further validate and replicate metrics used in current methods.

In the current issue Mark Jones and Heather Hitsman present data describing quantitative electroencephalography (qEEG)-guided neurofeedback for reducing symptoms of anxiety. Then, Ron Bonnstetter, Eric Gehrig, and Dustin Hebets present data examining gamma power asymmetry as an indication of response process validation. And finally, Ron Bonnstetter provides a book review of meditation and its effects on the brain and body.

NeuroRegulation appreciates these authors for their valuable contributions to the scientific literature for neurofeedback and learning. We strive for high quality and interesting empirical topics, which has led to this journal being indexed in **Scopus**, **Elsevier Embase**, and **DOAJ**. We encourage all those in the neurofeedback, biofeedback, and neuroscience disciplines to consider publishing with us. Our open-access format with no author processing fees and expedited publishing timelines (current average time from submission to publication is 50 days) makes *NeuroRegulation* a very favorable publication to submit your important work. We encourage researchers, clinicians and students to submit research findings, review articles, case reports, a new take on an important aspect of our field or a technical process, or even a review of a great book your colleagues should know about.

We thank you for reading *NeuroRegulation*!

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QEEG-Guided Neurofeedback Treatment for Anxiety Symptoms

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Abstract

Anxiety represents one of the most commonly diagnosed mental illnesses among adults in the United States, affecting an estimated 19.1% of the adult population annually, with a lifetime occurrence of 31.1% (NIMH, 2017). This retrospective study intended to assess whether qEEG-guided amplitude neurofeedback (NF) is a viable treatment for anxiety symptom reduction. Forty participants were assessed for anxiety using symptom and EEG measures. Demographics include age ranges from 19 to 62 (M = 37.7, SD = 13.87). Gender identification comprised 21 male and 19 female. Fifteen clients self-identified as White (Non-Latino; 38%), 14 as Latino/Latina (35%), and 11 did not self-report ethnicity (28%). Pre- and postassessments were given to the participants. Symptom assessments included the Zung Self-Rating Anxiety Scale and Achenbach System of Empirically Based Assessment (ASEBA) Adult Self-Report (ASR). A qEEG was used to determine protocols for each participant. Participants were scheduled to receive 30-min NF treatment sessions twice a week for one academic semester. The range of attended sessions was 7–19 (M = 12.72, SD = 2.78), where accurate number of session data was unavailable for four of the subjects. Symptom measures showed statistically significant improvement. Limitations include small sample size and no control group or sham NF group. Suggestions are included for future studies.

Keywords: anxiety; anxiety symptoms; qEEG-guided amplitude neurofeedback; neurofeedback

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Introduction

According to the National Institute of Mental Health (NIMH), anxiety disorders rank as the top leading diagnosis by clinicians within the mental health field. Anxiety disorders affect approximately 19.1% of the U.S. adults annually, with a lifetime prevalence of approximately 31.1% (NIMH, 2017). While the majority of Americans experience stress periodically within their lifespan, individuals diagnosed with anxiety have severe pervasive symptoms that interfere with their daily lives (NIMH, 2018). Psychotherapy, cognitive behavioral therapy (CBT), meditation, or support groups may be helpful in reducing symptoms (NIMH, 2018).

With the onset frequently developing during childhood, many anxiety disorders can be persistent if not treated and present more frequently in women at a 2:1 ratio (American Psychiatric Association, 2013). A variety of symptoms are reported by individuals with anxiety disorders including sleep problems, fatigue, muscle tension, or intense fear (NIMH, 2018). More severe symptoms can include sudden and repeated attacks of fear, pounding and racing heart, and purposely excluding oneself from certain people or places.

Literature Review

Various biofeedback modalities have been implemented by clinicians in the treatment of anxiety including electromyography (EMG), peripheral temperature, and electrodermal response (EDR) prior to neurofeedback's (NF) popularization (Price & Budzynski, 2009). NF, a subcategory of biofeedback, has been used to lower anxiety symptoms in a variety of populations, as addressed throughout the following reviewed literature.

Singer (2004) used NF on two female dancers, 27 and 52 years of age, who had persistent levels of performance anxiety. A State-Trait Anxiety Inventory (STAI; Spielberger, 1983) assessment was taken by each participant before a NF session and before each of their major dance performances. The course of NF treatment included 20 sessions at the time interval of 30 min per session. Sensors were placed on site locations T3 and T4, and thresholds were adjusted during each session dependent upon the participant’s response. Postassessments indicated a significant decrease in anxiety symptoms associated with performance. The trait anxiety portion of the first participant’s assessment indicated a decrease in score from 59 to 43.5, while the state portion underwent a decrease in score of 66 to 44. The trait anxiety portion of the second participant's assessment indicated a decrease in score as well, from 52 to 36, while the state portion underwent a decrease in score of 56 to 30. Limitations to this study included a small sample size, lack of individualized protocols, and no control group.

A study by Kerson, Sherman, and Kozlowski (2009) illustrates how the various modalities of earlobe temperature training, alpha suppression, and alpha symmetry training were used in eight adults who either were diagnosed with generalized anxiety disorder or presented with multiple anxious behaviors. Participants were assessed for high alpha frequency at the International 10-20 Electrode system sites Fp1, Fp2, F3, F4, F7, and F8. A 5-min baseline electroencephalogram (EEG) of the participants was recorded with their eyes open for the initial measurement and with their eyes closed for the secondary measurement. Postbaseline measures were also recorded 1 week after the last NF training occurred. The initial six sessions were used to increase the participants earlobe temperature. The following 6–16 sessions consisted of decreasing alpha magnitude by 10% in the anterior lobes for 30 or more minutes. Once alpha was suppressed, the protocol shifted to improvement of alpha symmetry by a 15% increment for 30 minutes or more during 8–32 sessions. All sessions were conducted on a biweekly basis. Continued assessment of participants was conducted throughout the study by means of the STAI, in which a significant improvement in scores resulted. The pre- and postmean change in EEG was 1.41 *z*-scores towards the mean. Limitations mentioned within the study include a limited amount of participants, lack of variance in protocols, and the lack of a control group.

Walker (2009) implemented a study based upon whether NF could lower anxiety symptoms for 19 clients diagnosed with posttraumatic stress disorder (PTSD). Four clients, who were originally diagnosed with PTSD and in the NF group but had dropped out after the quantitative electroencephalography (qEEG), were included in the control group. Each received a qEEG examination using the Neuroguide software and Lifespan Normative database. Excessive high frequency beta (21–30 Hz) was then downtrained for 5–7 sessions for each site that presented excessive high frequency beta;10 Hz activity was uptrained at the same sites. The sites were in various and multiple areas depending on where the excessive beta was located, as protocols were determined by a qEEG. A self-rated anxiety Likert scale from 1–10 was also used to determine the amount of anxiety each participant had felt. The number of sessions per individual ranged from 5–7. Participants who had NF training had a significant reduction in self-rated anxiety with a pretreatment score of 5/10–7/10 to a posttreatment score of 0/10–2/10, and 1 month after NF training the scores remained at 0/10–2/10. Subjects who did not have NF training had little or no reduction in self-rated anxiety 3 months after their qEEG. Limitations with this study include using a self-rating scale for anxiety rather than an evidence-based assessment.

A study by Scheinost et al. (2013) evaluated 10 subjects with contamination anxiety to undergo functional magnetic resonance imaging (fMRI) NF training and compared their neural connectivity with real-time functional magnetic resonance imaging (rt-fMRI). A matched control group of 10 subjects that received sham fMRI-NF (SNF) of their matched pair was used. Subjects had an initial fMRI to localize their activity in the orbitofrontal cortex (OFC) from contamination anxiety. They then met with a psychologist to discuss strategies for manipulating brain activity that could later be refined during fMRI-NF. There were eight sessions total where subjects were shown contamination-related photos and asked to rate their anxiety on a scale of 1–5. The first and the last session consisted of subjects being asked to implement the personal coping mechanisms which they would typically use to try to lessen their anxiety. The middle six sessions consisted of 90 min of fMRI-NF. The fMRI-NF sessions consisted of subjects receiving cues of when to increase activity their OFC area, when to decrease activity, and when to rest based on their OFC output. Resting cues included a neutral image.

Between-group differences in fMRIs were identified using Wilcoxon's rank-sum test. The fMRI-NF group reported greater self-reported reduction in anxiety ($p = .02$) compared to the SNF group ($p = .45$). The fMRI-NF group had significant ($p < .05$) neural changes compared to the SNF group as recorded by the last fMRI taken several days after the last fMRI-NF session. The fMRI-NF group had significant decrease in connectivity for the brain regions associated with emotion processing, including the insula and adjacent regions, the hippocampi, parahippocampal and entorhinal cortex, the right amygdala, the brain stem in the vicinity of the substantia nigra, the temporal pole, superior temporal sulcus, thalamus and fusiform gyrus. The fMRI-NF group also had an increased degree of connectivity that was seen in prefrontal areas associated with emotion regulation and cognitive control, including right lateral prefrontal cortex and bilateral portions of Brodmann's area 8. This study illustrated how changes directly resulting from fMRI-NF were possible and how structural changes can last days after a fMRI-NF session. This study also supported the idea of finding and confirming a localized area related to a symptom and using that area for fMRI-NF. Limitations to this study include low number of fMRI-NF sessions and a small sample size.

A study conducted by Cheon et al. (2015) researched NF implemented on 77 adults diagnosed with various psychiatric disorders within a psychiatric setting. The following disorders are listed in order of prevalence according to the research: depressive disorders, anxiety disorders, sleep disorders, somatoform disorders, adjustment disorders, bipolar disorder, schizophrenia, attention-deficit/hyperactivity disorder, alcohol dependence, game addiction, and impulse control disorder. Protocols were designed depending on the participant's chief complaint (e.g., anxiety, emotional instability, lethargy, etc.), the opinion of the attending psychiatrist, neuropsychiatric evaluation results, and the subjective symptom rating scale. The Clinical Global Impression-Severity Scale (CGI-S; Busner & Targum, 2007) and the Hill–Castro Checklist (Hill & Castro, 2002) were also implemented on a weekly basis as a measure of treatment effectiveness. NF protocols included training sensorimotor rhythm (SMR), beta, and/or also contained alpha-theta training. The various frequency bandwidths which were rewarded during training, included SMR between 12–15 Hz, beta between 15–18 Hz, theta between 5–8 Hz, and alpha between 8–12 Hz. The individualized site locations in which training was implemented included Fp1, Fp2, F3, F4, F7, F8, T3, T4, C3, C4, P1, P2, O1, O2, and Oz based on the International 10–20 Electrode system. Alpha-theta training was conducted at the PZ site location. Protocols were evaluated and finalized during weekly NF meetings which included a team of three psychiatrists trained in NF, as well as a trained NF therapist. The number of appointments for client's training ranged from 1 to 20 or more sessions. The Hill–Castro Checklist score showed an improvement in multiple symptom areas including anxiety ($p < .001$). The pre- and post-CGI score showed a significant reduction in the severity of symptoms ($p < .001$). Limitations mentioned within the study included having a heterogenous group and no control group, as well as not utilizing the qEEG to determine protocols.

Dreis et al. (2016) published a pilot study of NF provided to 14 anxious clients at a university-based community counseling center, showing significant improvements in symptoms measured by the Zung Anxiety Scale and Achenbach System of Empirically Based Assessment (ASEBA) checklists. This study is a continuation of that pilot.

These studies illustrate how NF can be a viable tool in lowering anxiety symptoms. They each have their strengths and limitations. A substantial limitation is either using the same protocol for each patient and/or using a protocol based on symptoms alone. Hammond (2010) expresses the importance of using a qEEG to identify heterogeneity in brain wave patterns, finding comorbidities, and looking for effects from medication.

The correlation between frontal alpha symmetry, negative affect and anxiety was studied by Mennella et al. (2017), comparing two neurofeedback treatments of F4-F3 alpha asymmetry with Fz alpha uptraining on respective groups of 16 right-handed females each. The findings indicated a significant increased frontal alpha asymmetry, which correlated with symptom improvements, as compared to the midfrontal alpha group.

Krigbaum and Wigton (2014) argue the importance of qEEG-guided and *z*-score NF as it allows the clinician to develop a more individualized treatment plan which encompasses a qEEG baseline, clinical status, and history of the client. Wigton and Krigbaum (2015) further assert how 19-channel *z*-score NF (19ZNF) protocols facilitate identifying the link between localized cortical dysfunctions and connectivity issues associated with mental health symptoms. In this modality, qEEG metrics are compared to a normative database to create *z*-

scores; then, those *z*-scores are incorporated into the NF protocol in real time during the session. This allows for pretreatment assessment, a helpful tool in measuring progress with the client, and combining real-time assessment with the operant conditioning of NF. Thus, 19ZNF training is used to bring these scores closer to the mean, otherwise known as *normalizing*. Moreover, 19ZNF protocols also reduce the number of sessions which is more economical for the clients. Wigton and Krigbaum's pilot study used 19ZNF to train the deviant *z*-scores.

Unlike Wigton and Krigbaum (2015), this research is a study which used single-channel amplitude training, rather than *z*-score training, for three reasons: (1) it is commonly used by many practitioners, (2) it is a straightforward method for students in training to learn before advancing to other modalities, and (3) the numerous one-channel amplitude training studies which exist in the literature, as reviewed by Wigton (2014). Therefore, based on the literature review, this study sought to assess whether individualized qEEG-guided amplitude NF is a viable treatment for anxiety symptom reduction.

Methods

Clients

Clients contacted the Sarabia Family Counseling Center at the University of Texas at San Antonio (UTSA) to receive therapy and NF treatment free of charge. Clients learned about the clinic through community referral sources and/or university media relations. Upon calling, clients were screened by master- or doctoral-level students in the UTSA Department of Counseling to determine if they met the criteria for receiving NF treatment, including primary anxiety symptoms, availability, and age requirements. If the individual satisfied the clinical criteria, as well as the required biweekly availability and willingness to complete the treatment requirements on an ongoing basis, the clients were then scheduled to meet with a NF student clinician. Prior to completing any formal assessments of anxiety, student clinicians acquired a comprehensive informed consent from each client. As retrospective research, the study was deemed to be exempt from review by the UTSA Institutional Review Board.

Demographics include age ranges from 19 to 62 (M = 37.7, SD = 13.87). Gender identification comprised 21 male and 19 female. Fifteen clients self-identified as White (Non-Latino; 38%), 14 as Latino/Latina (35%), and 11 did not self-report ethnicity (28%). Pre- and postassessments were given to the participants. Symptom assessments included the Zung Self-Rating Anxiety Scale and ASEBA Adult Self-Report (ASR). A qEEG was used to determine protocols for each participant. Participants were scheduled to receive 30-min NF treatment sessions twice a week for one academic semester.

Therapists

The student clinicians consisted of master and doctoral-level students within a program certified by the nationally accredited Council for Accreditation of Counseling and Related Education Programs (CACREP). These students are also in the supervision phase of pursuing their Board Certification in NF (BCN); thus, they were overseen by a certified and licensed supervisor. Students had previously completed the required graduate curriculum, which met the blueprint required by the Biofeedback Certification International Alliance (BCIA; www.bcia.org).

Measures

A within-subjects research design was implemented which included the following precondition and postconditional assessments: the Zung Self-Rating Anxiety Scale for adults, the age-appropriate self-reports for the Achenbach System of Empirically Based Assessment (ASEBA), and qEEG. The symptom measurements were selected on the bases of their focus on anxiety symptoms, widespread acceptance in the therapeutic community, and standardization.

The qEEG measures assessed patterns in the EEG and qEEG, such as attenuated alpha, fast alpha tuning, excess beta and/or high beta along the midline, and hypercoherent frontal alpha.

Instrumentation

The qEEGs were acquired via 19-channel recordings in the eyes-closed and eyes-open conditions in a resting state, using a BrainMaster (BrainMaster Technologies, Inc., Bedford, OH) Discovery 24 high-impedance amplifier and Neuroguide (Applied Neuroscience, Inc., Largo, FL) software. Recordings utilized correctly sized Electro-Cap (Electro-Cap International, Inc., Eaton, OH) 10-20 electrode appliances which were fitted as per manufacturer's guidelines and ear-clip leads placed. Preparation of electrodes was performed in a manner adequate to achieve impedance levels of less than 5 kohms (Jones, 2015). NF was provided utilizing BrainMaster Atlantis two-channel amplifiers and BioExplorer (Cyberevolution, Inc., Seattle, WA) software. Electrode site preparation was done by cleaning the site, ground, and reference locations with rubbing alcohol and abrading using PCI prep pads and Nuprep. Gold-plated electrodes were attached to the clients using Ten-20 paste. Impedance measurements were taken to ensure that interelectrode impedance was less that 5 kohms (Jones, 2015).

Protocols

Clients agreed to attend a minimum total number of 15 NF training sessions that were to be held at the same time, twice per week, and free of charge. Participants were instructed to discontinue the consumption of caffeine or any other nonessential substances on treatment days, prior to their session. At least a 24-hour window prior to the qEEG recording was suggested for clients to restrict consumption for nonessential substances, unless otherwise medically directed. All medically directed substances were factored into qEEG interpretation and protocol development.

The range of attended sessions was 7–19 (M = 12.72, SD = 2.78). An accurate number of session data was unavailable for four of the subjects. The training protocols consisted of amplitude uptraining and/or downtraining of selected frequency bands based on qEEG findings. Protocol selections were based on current research and reflect markers found to be associated with anxiety issues (Dantendorfer et al., 1996; Demerdziev & Pop-Jordanova, 2011; Gold, Fachner, & Erkkilä, 2013; Gunkelman, 2006; Heller, Nitschke, Etienne, & Miller, 1997; Johnstone, Gunkelman, & Lunt, 2005; Price & Budzynski, 2009; Savostyanov et al., 2009; Siciliani, Schiavon, & Tansella, 1975; Stern, 2005, p. 196; Tharawadeepimuk & Wongsawat, 2014; Walker, 2009).
Based on the preferences of the clients and clinical judgment of the practitioners, feedback was presented using a variety of formats: games, animations, sounds, and analog presentations (such as the size of boxes representing the amplitude of the respective bandpass filtered EEG signals). Thresholds were set manually at the beginning of the session based on the aimed percentage of a successful reward rate of approximately 50% of the time. Periodic adjustments were made to the threshold settings within and between sessions as needed to shape behavior towards the client's specific treatment goals. Records were made for each session, which included frequency bands, threshold settings, session average amplitude levels, type of feedback utilized, and significant details from client reports and clinician impressions. EEG data was recorded for each session.

Statistical Analysis

The statistical analysis for the symptom measure assessments were paired t-tests using IBM SPSS Statistics Version 25. Means were compared for pre–post scores on the Zung Anxiety Scale and the ASEBA scales most pertinent to anxiety symptoms: Anxious/Depressed, Anxiety Problems (DSM), and Total Problems. The Total Problems Scales was selected as it represents a wide-range sampling of other scales to reflect overall severity.

Results

Symptom Measures

All grouped, averaged pre–post comparisons of the Zung Anxiety Scale resulted in improvements. A cumulative summary of these results are presented in Table 1. On the Zung Anxiety Scale, for all subjects, the mean of the prescores was 44.90 (SD = 8.32) and the mean of the postscores was 37.18 (SD = 8.19). The t-test yielded a statistically significant improvement, with t(df) = 7.750(39), p < .001, d = 1.23.

On the ASEBA, a statistically significant improvement was measured in three scales deemed most pertinent to the study: Anxious/Depressed, Anxiety Problems (DSM), and Total Problems. The results are presented in Table 2.

Table 1
Zung Anxiety Scale

	Pre *M* (*SD*)	**Post *M* (*SD*)**	***t*(df)**	***p***	***d***
Zung Anxiety Scale	44.90(8.32)	37.18(8.19)	7.750(3)	< .001	1.23

Note. n = 40.

Table 2
Achenbach Behavior Checklist (Adult Self-Report)

Category	Pre *M* (*SD*)	Post *M* (*SD*)	*t*(df)	*p*	*d*
Anxious/Depressed	68.93(10.84)	59.90(11.52)	3.872(39)	< .001 **	1.23
Anxiety Problems (DSM)	65.73(7.85)	61.60(8.49)	3.277(39)	.002 *	1.61
Total Problems	64.68(10.84)	60.79(11.52)	4.381(39)	< . 001 **	2.00

Note. *$p < .01$, **$p < .001$. $n = 40$.

As the number of sessions per client varied, an opportunity existed to compare number of sessions with reductions symptom measures. The Zung Anxiety Scale changes (pre to post) are plotted on a scale of number of sessions in Figure 1. Based on the sixth order polynominal trendline of improvements in the Zung Anxiety Scale measures, it may be inferred that symptom reduction was associated most highly with 11–14 sessions of treatment.

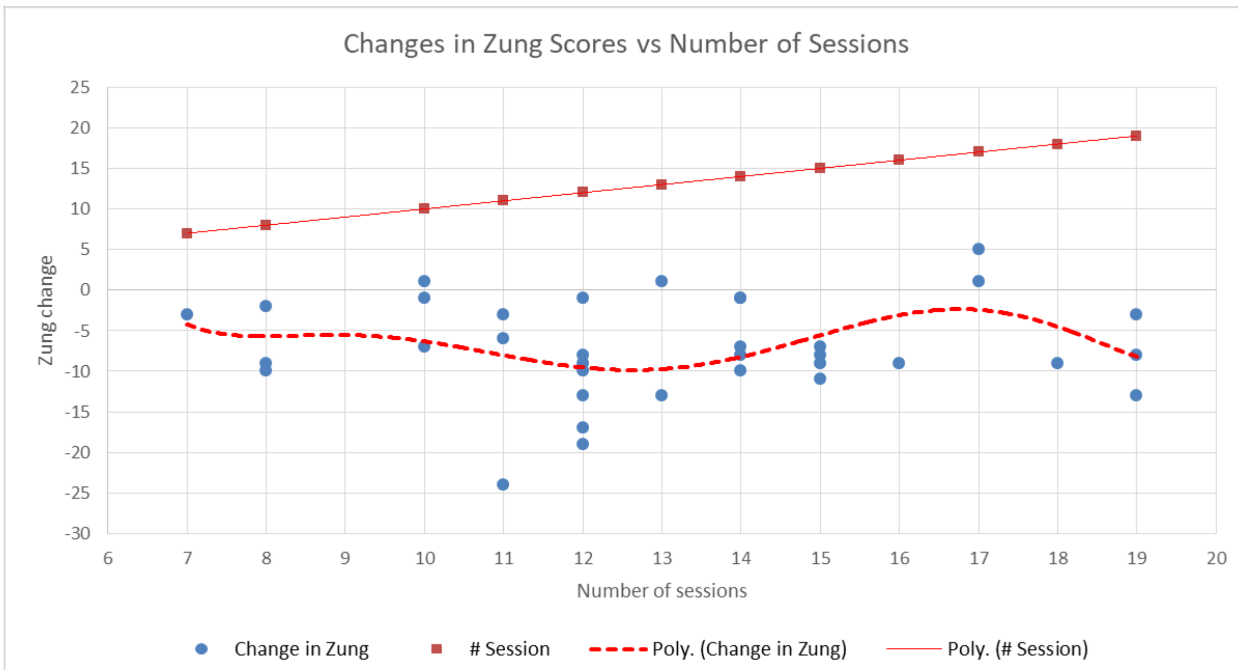

Figure 1. Scatter plot of changes in Zung Anxiety Scale scores (pre to post) by number of sessions. Lower scores reflect improvement.

Discussion

Symptom improvement was made evident with various assessments including the Zung Anxiety Scale and ASEBA. Taken together, the symptom scales present evidence of a significant improvement in clients' anxiety symptoms and sense of well-being.

Due to accreditation restrictions at the university-based counseling center in which the study was conducted, no treatment sessions may be provided between semesters. As a result, the number of sessions was limited to what may be provided during a semester. Therefore, the design was built around the time available for pre- and postassessments and the beginning and end of the semester, respectively, and treatment provided in the intervening weeks. While the results based on an average of approximately 12 sessions were significant, it remains unknown what additional improvements may have been achieved with more treatment sessions. The scatter plot in Figure 1, however, may indicate that 12 sessions may be an adequate number of treatment events to achieve a significant result.

The variety of sessions per client reflects an additional factor of the study as a retrospective analysis. The researchers were somewhat at the mercy of clients who had varying degrees of motivation and means to complete a full regimen of sessions. For example, some clients struggled with transportation challenges, employment issues and/or schedules, and lack of family support. That sessions were conducted during daytime hours on week days only compounded some of these challenges.

A small sample size and the lack of a sham/control group were roadblocks to an effective research design in some aspects of the study. Given that the study was retrospective, clients were seeking treatment with a valid expectation of receiving bona fide therapy. In addition, the resources and purpose of the program were not compatible for a controlled study.

A pre–post measure of physiological changes would have strengthened the research design. Due to the wide variability in protocols and qEEG findings, significant challenges existed for quantifying specific treatment effects which may then be assessed at a group level. As the program moves forward—and with additional equipment—pre–post ERP findings will be incorporated as one way to measure physiological changes.

There was variability in the skill and experience levels of the student counselors. Students were at various levels in their studies within their degree program and in the NF program. Controls for the effect of student bias and skill level differences were: supervision from the professor who monitored the treatment via informal verbal reports from students and clients, session notes, closed-circuit television, and weekly case conferences.

Client variables that were not controlled for which may have influenced treatment outcomes include adjunct therapies (previously or concurrently used), medications, familial/financial/extraneous life stressors and major life events, injuries/illnesses, changes in sleep, and other therapeutic lifestyle changes (i.e., diet, exercise, and medication). Some of the clients in the study were taking psychotropic medications, such as benzodiazepine-class anxiolytics and SSRIs. While these effects on the EEG were assessed as part of the qEEG analysis, they remain as a confounding variable for treatment outcomes.

Training was conducted using amplitude measures and monopolar site placements only. While this was by design, it excluded other forms of NF which may be based on connectivity measures and multiple site placements.

Finally, it is worth emphasizing that the setting of the study is a community counseling center, located on a university campus, operated as part of a graduate counseling educational program. As such, the prevailing values in the treatment are (1) the well-being and therapeutic needs of clients and (2) the learning opportunities for students. It became obvious to the professor and students that these priorities, at times, took precedence over a purely NF-based research design in ways that may have compromised the acquisition of “clean” data.

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NeuroRegulation

Response Process Validation Protocol Using Neurophenomenological Gamma Asymmetry

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Abstract

In the process of designing a continuous improvement process for a set of personal attribute self-reporting assessments, an opportunity was seen to combine assessment analytics with brain activity to capture decision-making pathways while responding to assessment items. This pilot triangulation process is designed to address response process validation, as described by the American Psychological Association, to begin to better understand whether the responder is following the intended purpose of the assessment. **Method:** The protocol involves collecting electroencephalographic (EEG) data, using standardized low-resolution brain electromagnetic tomography (sLORETA) to analyze and view voxel images of real-time brain activity collected while a participant responds to assessment items. This analysis examines gamma asymmetry in the frontal lobes, as well as opens the door to further wave comparisons in the future. **Conclusions:** The protocols used to expose the mindset of assessment responders will be shared, as well as pilot insights gained as a result of this imaging process. By collecting images from the moment of stimulus exposure to the moment that the respondent selects a Likert scale answer, insights are gathered that include: how final answers compare to brain processing data, brain decision-making pathways when exposed to reverse or double negative assessment items, exposure of brain processing when faced with socially loaded statements, resulting brain processing of neutrally scored stimulus, and insights gained when all of this data is crosswalked against quantitative item analysis of population data such as interitem correlations and item factor loading based on exploratory factor analysis.

Keywords: gamma asymmetry; response process validity; industrial/organizational psychology; organizational neuroscience; sLORETA; approach-avoidance; data triangulation

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The American Psychological Association (APA) Handbook of Testing and Assessment in Psychology states that assessment response processes require the collection of evidence demonstrating that the test taker is cognitively processing and properly interpreting the intended purpose of test items (Sireci & Sukin, 2013). This form of validation evidence is used to demonstrate that the assessment directs participants to engage in specific behaviors deemed necessary to complete the designed purpose of the assessment items.

For instance, if an assessment is designed to measure self-reported behaviors, instructions should clarify the mindset required to fulfill that task. Here is an example of revised introductory instructions from our Style Insights behavioral assessment (TTI Success Insights, 2018).

> The Style Insights Instrument is designed to identify observable human behavior. This assessment consists of 24 sets of descriptors. The descriptors are designed to reflect a range that describes you. The order that you use to select items is up to you. Please do not overanalyze, use your first impression. There are no right or wrong answers. Please complete the assessment in one sitting. While there is no

> time limit, the typical individual takes approximately 10 minutes.

While the instructions may lay the groundwork for directing the mindset of a respondent and are a crucial component, the APA handbook goes on to point out just how difficult a task this request is to accomplish. They state that:

> Gathering validity evidence based on response process is perhaps the most difficult validity evidence to gather because it involves demonstrating that examinees are invoking the hypothesized constructs the test is designed to measure in responding to test items. As the Standards describe [2], “Theoretical and empirical analyses of the response processes of test takers can provide evidence concerning the fit between the construct and the detailed nature of performance or response actually engaged in by examinees.” Gathering this type of evidence is difficult because one cannot directly observe the cognitive processes going on within people’s heads as they respond to test items. Although some studies have used MRI to see which regions of the brain are activated when responding to tasks, most studies of response processes use indirect means such as cognitive interviews, think-aloud protocols, focus groups, or analysis of answer patterns and item response time data and attempt to set the stage with introductory statements of purpose (Sireci & Sukin, 2013, p. 76).

Until recently this validation requirement has been virtually impossible to accomplish neurologically. There have been magnetic resonance imaging (MRI) studies that show regions of the brain that activate when responding to various stimuli (Owen, Borowsky, & Sarty, 2004), but MRI only shows resulting brain activity based on blood flow and is, therefore, unable to detect the moment by moment decision-making pathways leading to the respondent’s cognitive processing. In addition, MRI is uncomfortable for many participants, can be emotionally upsetting due to prolonged confinement, is expensive to operate and virtually impossible to design protocols that allow a client to observe a stimulus and respond in real time.

Electroencephalography (EEG), on the other hand, measures voltage fluctuations within specific neural networks or regions, thus recording the brain’s spontaneous electrical activity and thereby exposing real-time brain decision-making pathways. In June 2015, Target Training International (in conjunction with Thomas Collura, PhD) was issued a patent on their Validation Process for Ipsative Assessments (Bonnstetter, Bonnstetter, Hebets, & Collura, 2015). The patent abstract reads:

> This invention is a validation process for ipsative assessments. Respondents are connected to an electroencephalograph (EEG) and some or all of the ipsative assessment questions are asked again while connected to the EEG. The EEG measuring frontal lobe responses in terms of gamma waves is compared with the assessment questions. Positive responses provide one frontal lobe response in terms of gamma waves, negative or false answers provide a different gamma response and neutral questions provide a neutral gamma response. Reading the responses then tells whether the respondent initially responded with integrity (Bonnstetter, Bonnstetter, et al., 2015, p. 1).

Detailing the protocols used for our internal response validation is beyond the scope of this paper but can be assessed by reading (Bonnstetter, Bonnstetter, et al., 2015; Collura, Wigton, Zalaquett, Chatters-Smith, & Bonnstetter, 2016; Collura, Zalaquett, Bonnstetter, 2014; Collura, Zalaquett, Bonnstetter, & Chatters, 2014).

In general, the Gamma for Ipsative Validation using Electroencephalography (GIVE) process accesses asymmetric gamma wave bursts in the prefrontal cortex to validate the underlying subconscious decisions behind these self-reported responses, at the very moment of decision-making. As stated in the patent:

> Until now no process has linked these specific types of self-reports to actual brain activity. The new process uses asymmetric wave analysis resulting from a stimulus to validate the underlying mental decisions behind these reported responses at the very moment of decision-making, thus exposing the true thoughts behind their responses and documenting potential abnormalities between their pre-assessments and their actual brain activity. This process provides evidence that an evoked emotionally laden response results in corresponding brain activity and documents both the intensity of human emotional response as well as the directionality of the response” (Bonnstetter, Bonnstetter, et. al., 2015, p. 7–8).

Figure 1 is an example of frontal lobe gamma asymmetry with approach, neutral, and avoidance responses. The orientation of the brain is facing forward such that the right hemisphere is on the left side of the image. Red colors indicate an increase in gamma activity, blue colors indicate a decrease in gamma activity, and green colors are indicative of little or no activation.

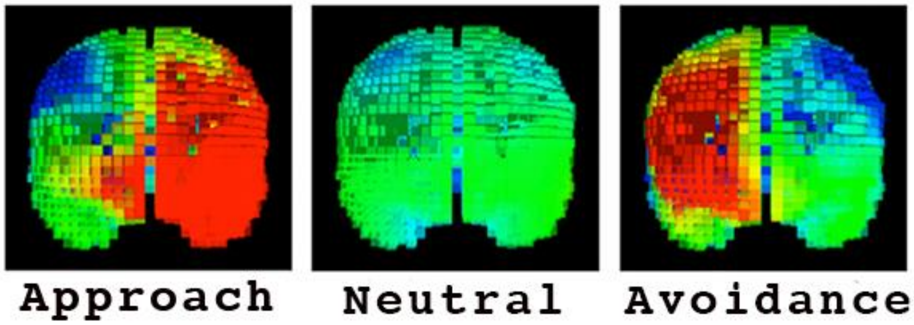


Figure 1. Frontal Lobe Gamma Asymmetry Summary.

At this point it is important to draw attention to the last patent sentence quoted above, "This process provides evidence that an evoked emotionally laden response results in corresponding brain activity and documents both the intensity of human emotional response as well as the directionality of the response" (Bonnstetter et al., 2015, p. 8).

Figure 2 depicts data from one of our behavioral assessment frames. In this example, the respondent first took our online assessment and, as shown, ordered the four behavioral choices from 1 to 4, with 1 being the most like them and 4 being the least descriptive of their behavioral style. Within two weeks of the initial assessment, they were placed in our EEG lab and given the same task with their brain activity being collected in real time.

The frontal lobe images in Figure 2 show classic asymmetry acceptance and avoidance responses to the stimuli. Their number 1 choice (the item that was "most like them") has a left dominant gamma wave activity that depicts acceptance of the concept while their number 4 choice clearly shows a right-side reaction, depicting avoidance. It is also interesting to note that 2 and 3 have very little gamma activity to the stimuli and a mixed asymmetry.

Figure 2. Sample Survey Responses and Corresponding Brain Images.

The significance of this data lies in the fact that this process lies at the heart of our ongoing efforts for continuous improvement by learning about our assessments in ways that open new insights daily. For example, our internal study of our behavior assessment shows that we can match the most liked respondent's choice to brain activity 86% of the time and we are able to match the least liked items 97% of the time. This gives us insights into how our brain is much clearer regarding our dislikes than our likes, which is valuable information as we work toward continuous improvement and also provides direct insights into the respondents' mental processing.

While the application on ipsative assessments in our initial work with behaviors was only interested in identifying decision-making directionality (see Figure 2), Likert-scaled assessments allow the ability to expose not only acceptance or rejection but also provide insights into the degree or intensity of the decision process.

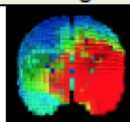
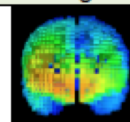
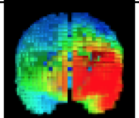
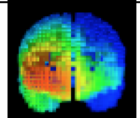
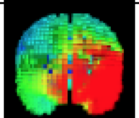
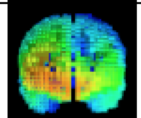
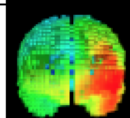
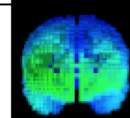
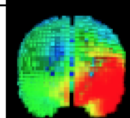
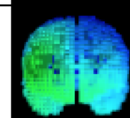
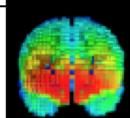
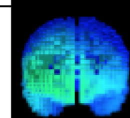
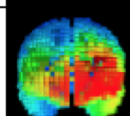
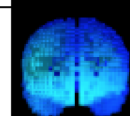
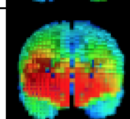
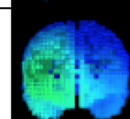
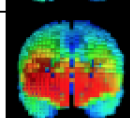
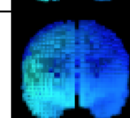
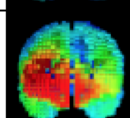
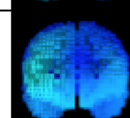
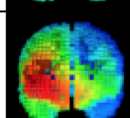
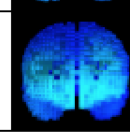
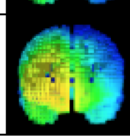
As can be seen in Figure 3, reproduced from Bonnstetter, Hebets, and Wigton (2015), not only do we see right and left prefrontal cortex asymmetry and the visual expression of intensity, we find a list of qEEG (quantitative electroencephalograph) data that provides a measure of the emotional response intensity for each soft skill stimuli. These quantitative values are the average of the ROI (region of Interest) voxels for the right and left frontal lobes. A measure of acceptance versus avoidance is calculated in the form of a numeric difference, termed the Approach-Avoidance-Differential (AAD), indicating the relative amount of energy in the right frontal lobe ROI, compared to the left. The AAD calculation is the average of the right hemisphere ROI, voxels minus the average of the left hemisphere ROI voxels (1,088 voxels per hemisphere). A negative value indicates greater left hemisphere activation and implies approach (i.e., a sense of accepting thoughts, feelings, and behavior) towards the stimulus word; a positive value indicates greater right hemisphere activation and implies avoidance (i.e., a sense of aversion) against the stimulus word; and a value near zero implies a neutral response.

Figure 4 describes the process used to collect brain activity data from our TTI Success Insights Emotional Quotient. The 57 assessment items are presented one at a time, just as they are presented in the online assessment platform. Each assessment item is on the screen for 2.8 s to capture initial emotional reactions, followed by a second screen that reiterates the stimuli and provides a six-choice Likert scale that ranges from *very inaccurate* to *very accurate*. This second screen remains active until the respondent clicks on their answer at which time a blank screen appears for a random period of two to five seconds. After the rest period, a new item stimulus is introduced.

The EEG amplifier was the Discovery 24E (BrainMaster Technologies, Bedford, OH) with a sampling rate of 1,024 samples per second (data rate to the computer of 256 samples per second), an A/D conversion of 24-bit resolution, EEG bandwidth of 0.43–80 Hz, and input impedance of 1,000 Gohm. EEG is acquired with the BrainAvatar software (BrainMaster Technologies, Bedford, OH) with linked ears reference; electrode impedance is adjusted to be below 10 kohm.

During the stimuli presentation, two auxiliary channels of the amplifier were used to record event start and stop markers. These markers were generated using a predesigned random set of emotional intelligent questionnaire stimuli built into an E-Prime 2.0 software (Psychology Software Tools, Inc., Sharpsburg, PA). Prior to presenting the stimuli, 2 min of eyes-open and 2 min of eyes-closed EEG were collected for further analysis and to document baseline status.

Frontal Gamma Asymmetry in Response to Soft Skills Stimuli in a Single Case (Participant #1)

Rank Order	TriMetrix® DNA Soft Skill	AAD	Gamma Image	Rank Order	TriMetrix® DNA Soft Skill	AAD	Gamma Image
1	Presenting	-0.91		13	Teamwork	0.19	
2	Diplomacy	-0.89		14	Management	0.31	
3	Customer Service	-0.86		15	Conflict Management	0.27	
4	Self-Management	-0.40		16	Analytical Problem Solving	0.11	
5	Interpersonal Skills	-0.37		17	Decision Making	0.09	
6	Employee Development/ Coaching	0.21		18	Creativity/ Innovation	0.10	
7	Continuous Learning	-0.39		19	Personal Effectiveness	0.07	
8	Planning/ Organizing	0.66		20	Futuristic Thinking	0.19	
9	Persuasion	0.58		21	Leadership	0.21	
10	Written Communication	0.47		22	Negotiation	0.15	
11	Empathy	0.32		23	Flexibility	0.03	
12	Goal Orientation	0.17					

Note. AAD = Approach-Avoidance-Differential. The colors correspond to brain activity, gamma frequency; with red being the highest and dark blue the lowest. The right side of the image is the participant's left hemisphere.

Figure 3. Source: Bonnstetter, Hebets, & Wigton, 2015.

Figure 4. Sample Stimuli Screen Presentation.

Although complete descriptions of resulting insights are not the focus of this paper, the authors will discuss several examples depicting this imaging process and how it connects to response process validation.

During postprocessing analysis, averaged voxel values and sLORETA images are matched to the individual emotional quotient stimuli and compared to the final selected item answer. The ROI for analysis is identified as "frontal lobe," as predefined in the BrainAvatar imaging software (as designated by the Key Institute sLORETA model) and includes only the left and right frontal lobes for this first round of analysis. For purposes of remaining on task, the authors are only addressing the sLORETA imaging data at this time. However, additional insights are emerging as the authors cross-reference the images with the previously performed population statistical analysis including item analysis and factor loading.

Figures 5–7 provide several sample outputs from a pilot TTI Success Insights Emotional Quotient assessment, based on data from the participant's exposure to slide 1. A similar processing protocol is used for the second slide data that will not be presented in these examples, partly because we are seeing most, if not all, of the gamma processing during this first phase. The actual item statement being used as the sample stimuli is unimportant to understanding the process and to some extent represents proprietary information.

Because of varying baselines between individual participants and therefore creating difficulty with image comparisons, all images are from the same respondent. Note that BrainAvatar has the ability to draw from the sLORETA data and create eight images per second output. As a result, Figures 5–7 contain 22 sequenced images drawn from exposure to the first 2.8-s slide. After analyzing hundreds of stimuli output, we find that in general these 22 images can be further broken down into three separate mental processing zones. While at present the authors are unaware of any supporting literature for these separations, we find that in general the first six or seven set of 0.125-s images depict the time required for the person to read and comprehend the stimuli. This zone segment varies based on the length of the trigger statement, key words within the stimulus, and individual participant uniqueness. During this zone, we often see initial emotional gamma asymmetry within the frontal lobes.

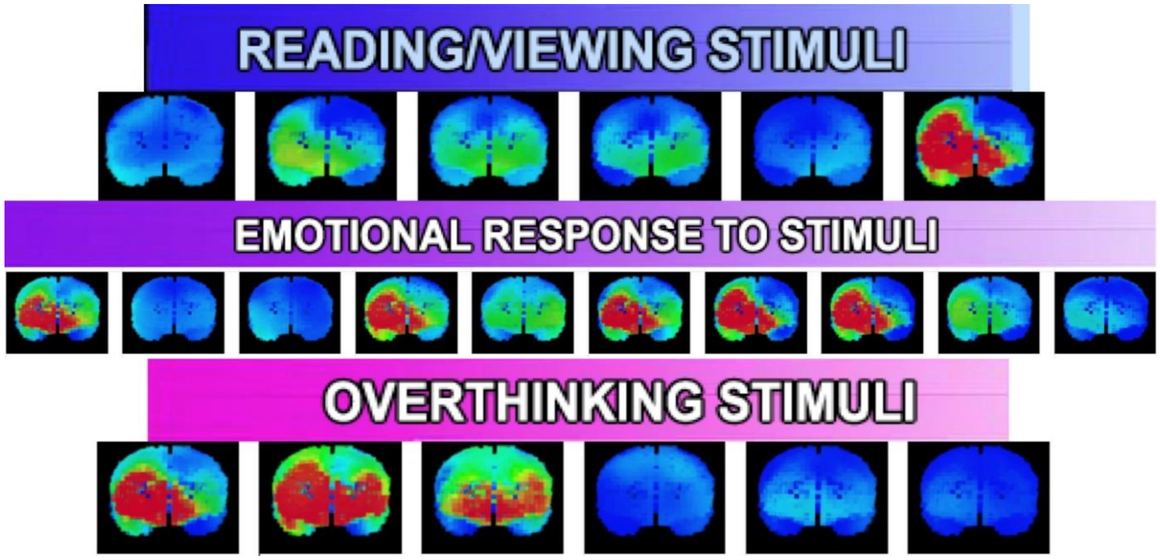


Figure 5a. Brain Disagreement with Entered Statement Response, Example 1.

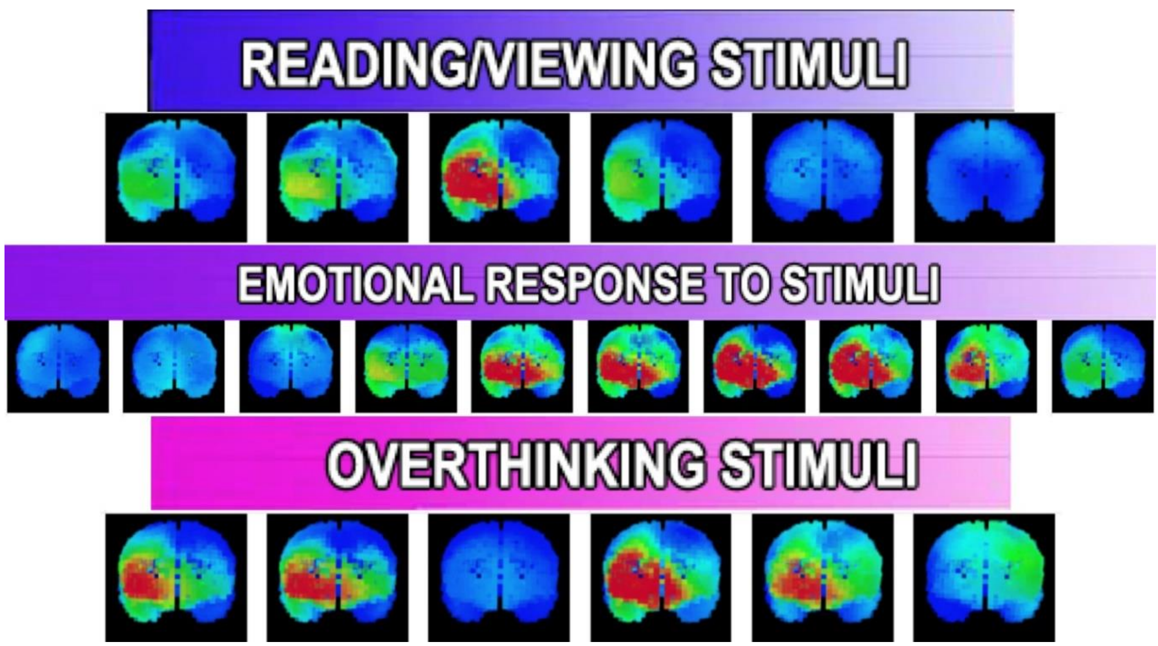


Figure 5b. Brain Disagreement with Entered Statement Response, Example 2.

Both examples in Figure 5 depict a mismatch between the brain reaction and the final marked answer by the participant. Notice the sixth image in Example 1 and the third image in Number 2. Both are right gamma flares that indicate an avoidance, and yet their actual answer was that the statement was *very accurate*. This right dominance continues throughout all three zones of processing. We are not suggesting that the person is not being honest, but when examining the actual item statement and cross-matching with exploratory factor analysis, both of these items may be exposing a socially acceptable response over a personally descriptive reply. In other words, the item may need to be improved to better align with the intended item purpose.

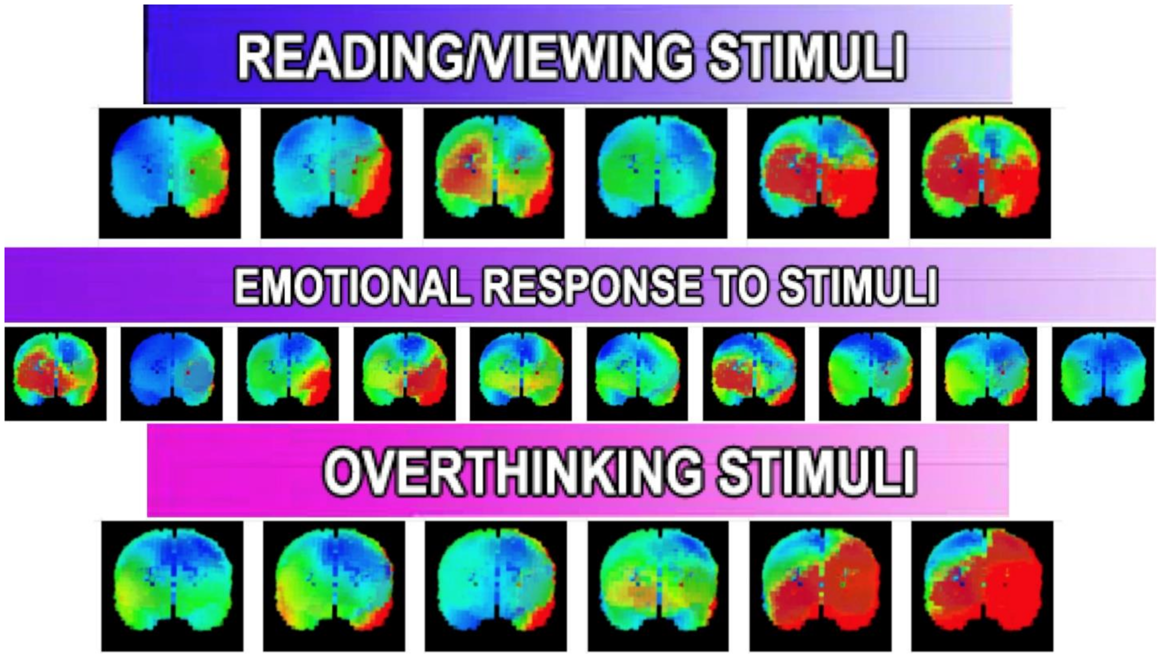


Figure 6a. Confusing Statements, Example 1.

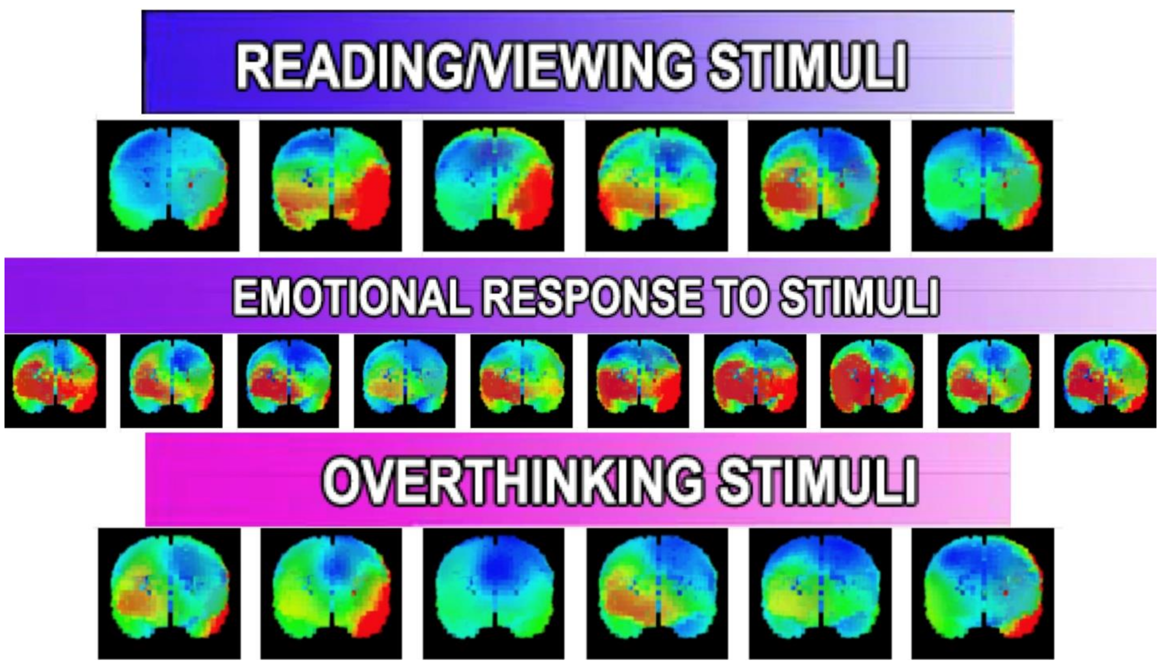


Figure 6b. Confusing Statements, Example 2.

In Figure 6 examples, we see very different brain reactions. Both of these sets of images represent a response to negatively stated stimuli, better known as a reversed item or a double negative. While we will not debate the pros and cons of statements that attempt to address what you are NOT to get at what you are, it is important to recognize that the brain processes this request very differently and, as a result, the item may need further consideration.

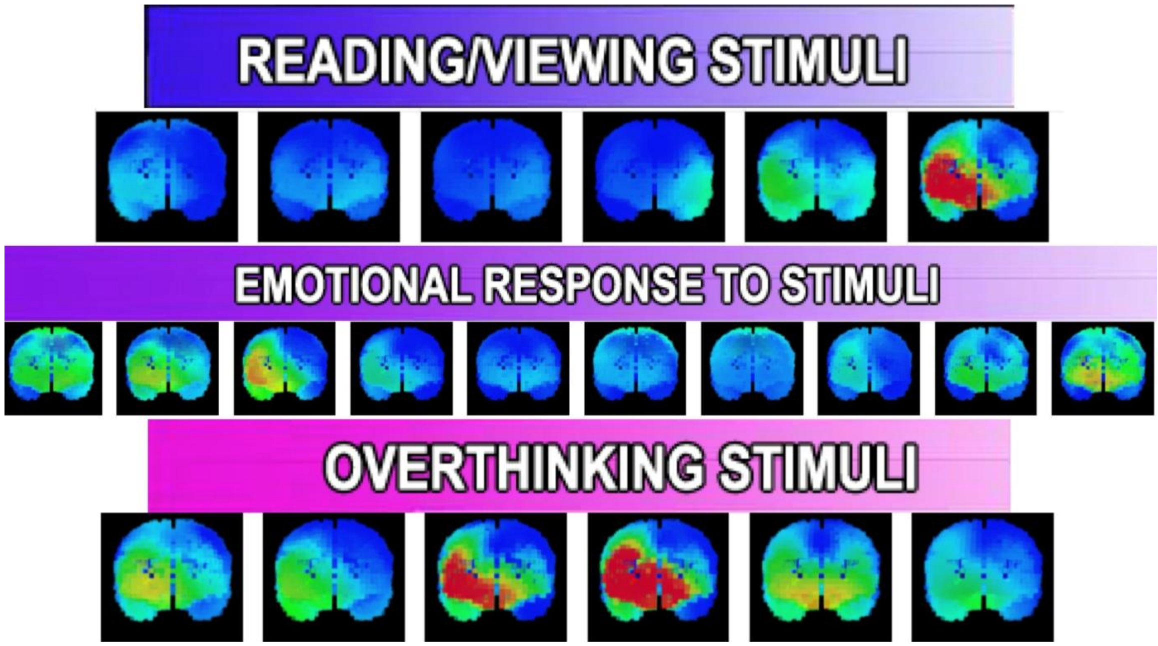


Figure 7a. Neutral Gamma Response, Example 1.

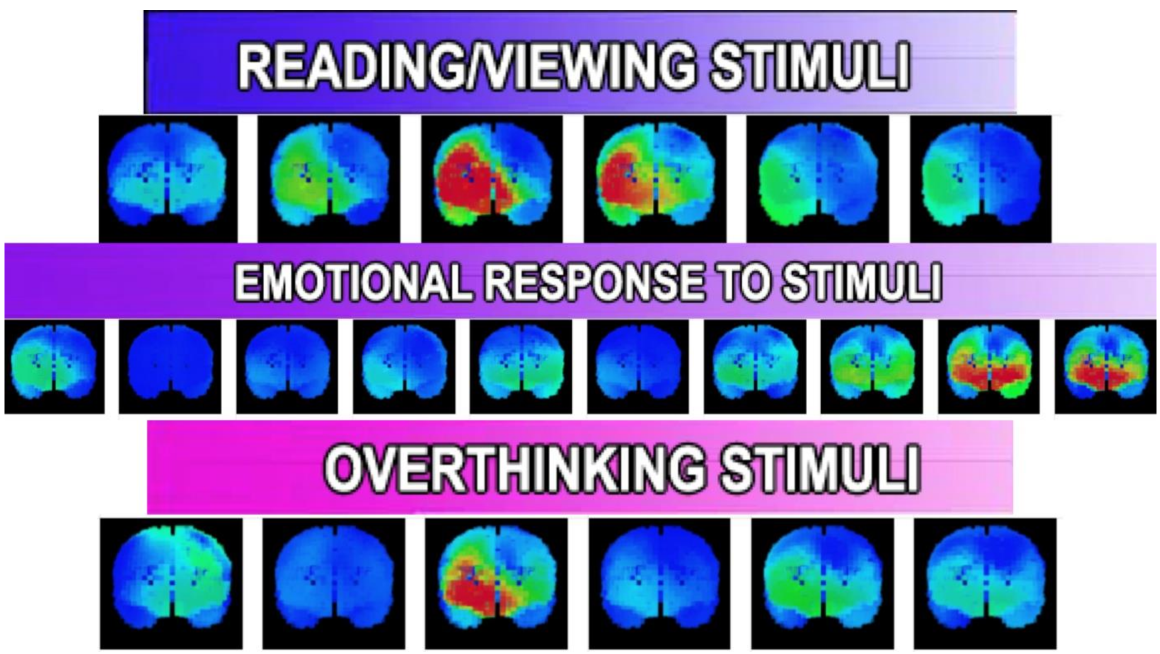


Figure 7b. Neutral Gamma Response, Example 2.

Figure 7 exposes the brain response to an item that was rated neutral on the survey. Notice the lack of gamma response which may indicate a lack of emotional connection to the participant. While a neutral survey may be an accurate answer for an individual, it may also be an indicator of an item with low discrimination. Sets of images such as these in Figure 7 are flagged for further examination to check for either low factor loading or poor item analysis.

Conclusion

While response process validity continues to be a challenging assessment design hurdle, this process of using sLORETA imaging from EEG data with qEEG analysis and matching these insights to the population assessment analytics are opening new assessment item discussions that both affirm many statistical findings and offer new intriguing explanations regarding respondent mental processing.

At present, this protocol has yielded several insights as we compare item response to actual brain activity, including:

1. Confirmation between survey response and neurological processing
2. Items that may have socially acceptable or "correct" answers and that therefore fail to match brain-processing imagery
3. Mixed brain response to confusing and reverse or double negative assessment items, and
4. Reduced activation for a set of assessment items that many times also exhibit low statistical discrimination.

We are entering a new era where industrial and organizational assessments can be revisited and refined to go beyond the simple exposing of symptoms to bringing to light the causes behind the assessment answers. The day may come when we are able to help people deal with implicit memories, differentiate personal beliefs from socially acceptable responses, and have meaningful conversations about responses that either do or don't match their assessment answers. In the meantime, this additional tool is helping to build and refine assessment tools in ways never before possible.

Author Note

The authors of the paper are employed by Target Training International Success Insights.

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NeuroRegulation

Book Review – *Altered Traits: Science Reveals How Meditation Changes Your Mind, Brain, and Body*

by Daniel Goleman and Richard J. Davidson. Penguin Random House, LLC, New York, NY, 2017, 336 pages, ISBN-10: 9780399184383.

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I am convinced that we spend the first half of our life collecting experiences and the second half trying to figure out how they all fit together to make new meanings. *Altered Traits* by Daniel Goleman and Richard Davidson represents one of those books that, at least for me, helped connect pieces of a puzzling personal and professional journey.

I have prided myself as being a lifelong scientist and science educator and as a result have attempted to live my life with logic and decisions based on facts. But I was brought up in a fundamental and very religious culture. While I fought most of the perceived dogma being presented, I could not ignore that many of those around me seemed to effortlessly remain in a blissful, loving space, perpetually at ease and exhibiting an ineffable state of mental calmness that I lacked. How did they accomplish this? And, more importantly, would I have to give up "thinking" to obtain this new mindset?

These questions have haunted me most of my life, but in recent years I have seen that these two mindsets may not be as far apart as I once thought. In fact, these two worldviews might even complement each other! Thomas Kuhn in his publication, *The Structure of Scientific Revolutions*, points out that the field of science can shift abruptly as novel ideas and radically innovative paradigms force new ways of thinking. I believe we are in the midst of such a shift in the field of psychology that may hold the key to unlocking hidden potential of the human mind.

In recent years I have spent countless hours reading and researching two somewhat different fields of study, decision-making neurological pathways and how emotions influence those decisions. My work has focused around two key authors, Daniel Goleman and Richard Davidson. While I attempted to figure out how these two bodies of knowledge might interact, I have to admit that I thought I was unique in my quest of formulating connections.

I could never have guessed that my two heroes were not only experts in their own arenas but were lifelong friends who shared undergraduate experiences that shaped both of their careers and who now in their waning professional years decided to expose to the world their mutual passion by writing a book that brings the founder of emotional intelligence and the pioneer of frontal lobe asymmetry together to develop a scientific understanding of meditation as a tool for maximizing human potential.

While the story of their early experience sets the stage for why they both have such a personal passion for the role of meditation, *Altered Traits* ties scientific evidence to these centuries-old practices in ways that makes one sit up and take note. The book is a blending of shared personal experiences, explanations that expand one's understanding of the meaning and forms of meditation, and lastly a review of compelling research findings that simply cannot be ignored.

Defining the Concept

It is important to understand that with mindfulness the meditator simply notes without reactivity whatever comes into mind, such as thoughts or sensory impressions like sounds, and then effortlessly lets them go. This results in a disciplined mind that is able to be free of negative emotions. One of the most widely quoted definitions comes from Jon Kabat-Zinn: "The awareness that merges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience." As Epictetus, a Greek philosopher wrote, "It's not the things that happen to us that are upsetting but the view we take of those things. Therefore, the goal is to become aware of awareness."

Examples of Research Findings Discussed

As I read this book, I found the following bulleted findings noteworthy. I have provided the page numbers so you can quickly locate any reference you might wish to expand upon.

- With practice, this is not a short-term fix, but results in neuroplasticity and a renewed mental balance (p. 51).
- Eight weeks of a variety of mindfulness seemed to enlarge a region in the brain stem that correlated with a boost in well-being on Ryff's test (p. 57).
- Meditating sped up the recovery rate, and seasoned meditators recovered quickest (p. 63).
- Differing types of meditation produce unique results. Therefore, all studies must routinely identify the specific type of meditation being studied (p. 68).
- Getting detailed information about the total lifetime hours of a meditator's practice should be a standard operating procedure in every research design (p. 70).
- Documenting involvement in retreats as well as the different types of meditation is crucial because retreats seem to have different and unique impacts (p. 70).
- The more experienced among the Zen students not only were able to bear more pain than could controls, they all displayed little activity in executive, evaluative, and emotion areas during the pain—all regions that ordinarily flare into activity when we are under such intense stress (p. 90).
- A study of the role of resilience found that the stronger a person's sense of purpose in life, the more quickly they recovered from a lab stressor (p. 92).
- Loving-kindness acts quickly, in as little as eight hours of practice. The longer people practice, the stronger these brain and behavioral tendencies toward compassion become (p. 121).
- A study of breath rate translates into more than 2,000 extra breaths for the non-meditators in a single day—and more than 800,000 extra breaths over the course of a year. These extra breaths are physiologically taxing and can exact a health toll as time goes on (p. 179).
- Yogis had elevated gamma oscillations, not just during the meditation practice periods for open presence and compassion but also during baseline measurements before any meditation was performed. This electrifying pattern was in the EEG frequency known as high-amplitude gamma, the strongest, most intense form (p. 232).
- On average the yogis had 25 times greater amplitude gamma oscillations during baseline compared with the control group (p.233).

Concluding Comment

Meditation is still considered by many a "new age remedy" that lacks scientific evidence. Even the authors acknowledge that "an absence of evidence is not evidence of absence." The roots of our conviction lay in our own experiences in meditation retreats, the few rare beings we had met who seemed to embody altered traits, and our reading of meditation texts that pointed to these positive transformations of being" (p. 288).

From an academic point of view, even this book and the research shared adds up to a set of questionable empirical evidence that at times clearly lacks impartiality. The challenge is clear. Many of the readers of this book review have encountered similar barriers as we pursue fields of study and protocols that lack widespread acceptance.

We must remember that leaders of parades have a wonderful view of the future, while they also make a rather obvious target for criticism.

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NeuroRegulation

Erratum to: Do Better in Math: How Your Body Posture May Change Stereotype Threat Response

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The original published version of this manuscript included numerical errors on page 70, in the Procedure subsection of the Method section.

The original text read:

> To assume the collapsed position, they were asked to slouch and look down while slightly rounding the back. For the erect position, they were asked to sit upright with a slight arch in their back, while looking upward. After experiencing both postures, half of the students sat in the collapsed position while the other half sat in the upright position. While in this position, they were asked to rapidly subtract the number 7 from **843** sequentially for **15** s. A counterbalancing scheme was used where they were then asked to switch positions. Those who were collapsed switched to sitting erect, and those who were erect switched to sitting collapsed. They were then to rapidly subtract the number 7 from 843 sequentially for **15** s.

The initial starting number to subtract 7 from 843 was incorrect. The number was 964. In addition, the time for each condition was 30 s, not 15 s.

The corrected text reads:

> To assume the collapsed position, they were asked to slouch and look down while slightly rounding the back. For the erect position, they were asked to sit upright with a slight arch in their back, while looking upward. After experiencing both postures, half of the students sat in the collapsed position while the other half sat in the upright position. While in this position, they were asked to rapidly subtract the number 7 from **964** sequentially for **30** s. A counterbalancing scheme was used where they were then asked to switch positions. Those who were collapsed switched to sitting erect, and those who were erect switched to sitting collapsed. They were then to rapidly subtract the number 7 from 843 sequentially for **30** s.

This numerical error and correction have no effect on the findings or conclusions. The authors regret any confusion that this error may have caused.

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