NeuroRegulation

Using Neurofeedback to Lower Anxiety Symptoms Using Individualized qEEG Protocols: A Pilot Study

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Abstract

Introduction: Anxiety disorders affect approximately 40 million Americans ages 18 and over (NIMH, 2015). Although qualitative and small-scale quantitative neurofeedback (NF) studies show reduction in anxiety symptoms, large-scale studies and quantitative electroencephalogram (qEEG) driven protocols are non-existent. This retrospective pilot study intended to assess whether qEEG guided amplitude NF is viable in symptom reduction of anxiety. Methods: Nineteen clients were assessed for anxiety, 14 were included in the data. Demographics include age ranges from 11–61 (*M* = 31.71, *SD* = 16.33), 9 male and 5 female; six identified as Caucasian, five as Hispanic/Latino, and three Caucasian/Hispanic ethnicity. Pre- and post-assessments included the Zung Self-Rating Anxiety Scale, Screen for Child Anxiety Related Disorders (SCARED), and the Achenbach System of Empirically Based Assessment (ASEBA). Clients received 30-min qEEG guided NF treatment sessions, twice a week. The range of attended session was 7–28 (*M* = 12.93, *SD* = 6.32). Results: Enhancement in clients' well-being was evidenced by statistically significant improvement in symptom measures scores. Although improvements for the two most anxiety-related categories on the ASEBA were not significant, other anxiety-related categories did show significant improvement. Yet, qEEG findings were not statistically significant. Directions for future research are discussed.

Keywords: anxiety; anxiety symptoms; qEEG guided amplitude neurofeedback; neurofeedback; *z*-scores

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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 18% of the United States population, or 40 million individuals within a given year (NIMH, 2015). 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. Three of the most commonly diagnosed types of anxiety disorders are: generalized anxiety disorder, 6.8 million adult Americans; panic disorder, 6 million adult Americans; and social phobia, 15 million adult Americans (NIMH, 2015). Psychotherapy, cognitive behavioral therapy (CBT), exposure-based treatment, stress management techniques, meditation, and aerobic exercise are various therapeutic modalities that may or may not be used in conjunction with medication in the treatment of anxiety disorders (NIMH, 2015).

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: trouble falling asleep and staying asleep, fatigue, headaches, and muscle tension (NIMH, 2015). 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, is a method of self-regulation which uses a brain-computer interface to promote neural plasticity, by providing feedback to an individual about their brain's electrical activity at a specific scalp location in a specified frequency range (Cannon, 2015). NF has been used to lower anxiety symptoms in a variety of populations, as addressed throughout the following reviewed literature.

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. Post-baseline measures were also recorded 1 week after the last NF training occurred. The initial six sessions were used to increase the participant's 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 State-Trait Anxiety Inventory (STAI; Spielberger, 1983) in which a significant improvement in scores resulted. The pre- and post-mean 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.

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 (2002) checklist 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 from 12 to 15 Hz, beta from 15 to 18 Hz, theta from 5 to 8 Hz, and alpha between 8 and 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 a 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 = .0001). 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 heterogeneous group and no control group, as well as not utilizing the quantitative electroencephalography (qEEG) to determine protocols.

Singer (2004) used NF on two female dancers, 27 and 52 years of age, who had persistent levels of performance anxiety. A STAI 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. Post assessments 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.

Walker (2009) implemented a study based upon whether NF could lower anxiety symptoms for 19 clients diagnosed with post-traumatic stress disorder (PTSD). Four clients, who were originally diagnosed with PTSD and in the NF group, but had dropped out after the qEEG, were included in the control group. Each client received a qEEG using the NeuroGuide software. Results were compared to the Lifespan Normative database. Excessive high frequency beta (21–30 Hz) was then downtrained for five to seven 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 to 10 was also used to determine the presence of anxiety symptoms each participant had felt. The number of sessions per individual ranged from five to seven. Participants who had NF training had a significant reduction in self-rated anxiety with a pre-treatment score of 5/10 to 7/10, to a post-treatment score of 0/10 to 2/10, and 1 month after NF training the scores remaining between 0/10 to 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 to 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 fMRI's were identified using Wilcoxon's rank-sum test. The fMRI-NF group reported greater self-reported reduction in anxiety ($p = 0.02$) compared to the SNF group ($p = 0.45$). The fMRI-NF group had significant ($p < 0.05$) 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.

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. Protocols based on symptoms alone and/or using the same protocol for each patient bypasses the time, cost, and training of running a qEEG (Thompson & Thompson, 2003). Hammond (2010) expresses the importance of using a qEEG to identify heterogeneity in brain wave patterns, finding comorbidities, and looking for effects from medication.

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, history, and clinical status of the client. Wigton and Krigbaum (2015a) 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 pre-treatment 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 (2015a), this research is a pilot study which used single-channel qEEG guided 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- or two-channel qEEG-guided amplitude training studies which exist in the literature, as reviewed by Wigton and Krigbaum (2015b). Therefore, based on the literature review, this retrospective pilot study sought to assess whether individualized qEEG-guided protocol amplitude NF is viable in symptom reduction of anxiety-related disorders.

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 clinically licensed, doctoral-level students in the UTSA Department of Counseling to determine if they met the criteria for anxiety-spectrum disorders. 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.

The pilot study started with 19 clients that were seen over a period between one or two semesters; however, the average number of sessions that clients acquired was approximately 12.9 sessions. In order to preserve our sample size we relaxed the inclusion criteria to a minimum of seven sessions per client. Three clients were excluded from the study because they dropped out without completing the full round of sessions or completing the final assessments. The data sets of two clients were excluded from the study; of the two clients that were excluded, one client had previously received a regimen of NF treatment and the other admitted to daily use of cannabis. A total of 14 clients are represented in the data. Of the included clients, demographics consisted of 9 males and 5 females. Clients ranged in age from 11 to 61 years of age with the average age being 31.71 (*SD* = 16.33) years of age. Six clients identified as Caucasian, five as Hispanic/Latino, and three identified as mixed Caucasian and Hispanic ethnicity (see Table 1).

Table 1
Client Demographics

Client #	Age	Gender	Ethnicity	Number of Sessions
1	17	M	Hispanic	14
2	20	F	Hispanic	26
4	48	F	Hispanic	28
6	52	M	Caucasian	12
7	15	F	Caucasian	10
8	50	M	Caucasian	14
10	21	M	Hispanic	8
11	11	M	Hispanic Caucasian Mix	11
12	37	M	Hispanic Caucasian Mix	8
13	26	F	Hispanic	7
14	18	M	Hispanic Caucasian Mix	10
15	25	M	Caucasian	12
16	61	F	Caucasian	11
17	43	M	Caucasian	10

Therapists

The student clinicians consisted of master's-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, were overseen by a certified and licensed supervisor. Students had previously completed the required didactic coursework that is recognized by The Biofeedback Certification International Alliance (BCIA; http://www.bcia.org).

Measures

A within-subjects research design was implemented, which included the following pre-conditional and post-conditional assessments: the Screen for Child Anxiety-Related Disorders (SCARED) for children and adolescents, 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 deviances from a normative database, which were then used to develop individualized protocols for training. Pre- and post-assessment comparisons were made using *z*-score changes, where improvement is assumed when scores move toward the mean ($z = 0$). Some of the challenges related to this form of measure are discussed below, but *z*-score comparisons provide one form of common reference with which to compare individualized protocols across the treatment group (Wigton & Krigbaum, 2015a).

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, Ohio) Discovery 24 high-impedance amplifier and NeuroGuide (Applied NeuroScience, Inc., Largo, Florida) software. Recordings utilized correct size Electro-Cap (Electro-Cap International, Inc., Eaton, Ohio) 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 5,000 Ω (Jones, 2015). NF was provided utilizing BrainMaster Atlantis two-channel amplifiers and BioExplorer (CyberEvolution, Inc., Seattle, Washington) software. Electrode site preparation was done by cleaning 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 insure that interelectrode impedance was less than 5,000 Ω (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 non-essential substances that may alter the qEEG significantly, such as supplements or medications. At least a 24-hour window prior to the qEEG recording was suggested for clients to restrict consumption for non-essential substances, unless otherwise medically directed. All medically directed substances were factored into qEEG interpretation and protocol development.

Collectively, participants underwent an average of 12.93 sessions of NF with a range of 7 to 28 total sessions. Participants that did not meet our original set threshold of 15 sessions were included due to the aspect of increasing our client size for a sufficient statistical interpretation. A total of 181 sessions were completed between all of the participants (see Table 1). These 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; Demerdzieva & Pop-Jordanova, 2011; Gold, Fachner, & Erkkilä, 2013; Gunkelman, 2006; Gurnee, 2000; Heller, Nitschke, Etienne, & Miller, 1997; Johnstone, Gunkelman, & Lunt, 2005; Machleidt, Gutjahr, Muegge, & Hinrich, 1985; 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 analogical 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.

Table 2
Training Sites and Frequency Bands for Each Client

Client #	EC/EO	Site	Band1 Decrease	Band2 Increase	Band3 Decrease	Combined Sites
1	EO	Pz		8–12		
2	EO	F2	5–7	10–12	20–25	Fz/F4
4	EO	Pz	7–9		25–29	
6	EO	Pz	7–12		17–22	
7	EO	CPz			21–27	Cz/PZ
8	EO	Cz	7–9	12–15	19–24	
10	EO	Fz	5–9	12–15	25–30	
11	EO	Cz	20–25		25–30	
12	EO	Cz	3–6		25–30	
13	EO	Cz	4–7		18–25	
14	EO	Cz	3–5	12–15	20–25	
15	EO	Cz	1–5	12–15	25–30	
16	EO	Fz	3–5	12–15	8–11	
17	EC	Pz		8–10	25–30	

Note. Combined sites = two 10/20 sites adjacent to selected 10/10 site. Client number column omits clients whose data was excluded.

Statistical Analysis

The statistical analysis for the symptom measure assessments were paired *t*-tests using IBM SPSS Statistics Version 22. Quantitative analysis was performed using NeuroGuide software, which was exported in by topographical and tabular form. Further analysis was done using Microsoft Excel 2010 and IBM SPSS Statistics Version 22. Computations were done for the frequency bands trained for each client. Given sites, number of bands, and frequency range of bands were unique to each client (see Table 6), it was not feasible to compare simple amplitude changes across clients. As such, the absolute values of the positive and negative *z*-scores were used instead as a way to compare a common metric of pre- and post-changes across clients. The process involved calculating *z*-scores using NeuroGuide software, exporting the results in tabular form using 1 Hz bins, transforming the *z*-scores to use absolute value, then averaging the transformed values for the respective frequency band(s) used for each client. If more than one frequency band was trained at a time (such as downtraining and/or uptraining), the *z*-score values for the bands trained were then averaged for each client and the statistical analysis was completed between the pre- and post-assessments as a group using paired *t*-tests. As opposed to merely averaging the absolute power at each of the treatment sites, *z*-score results were used in order to provide a common measure that was applicable across all frequency bands. Due to the 1/frequency characteristic of the EEG spectrum, with typical alpha peaks, power measures are not consistent across the frequency spectrum. In addition, alpha power measures typically vary significantly between eyes-closed and eyes-open recording conditions. For example, if the power of the frequency band of 8–12 Hz changes by 1 μV, such a change may not be comparable to a 1 μV change in the frequency band of 20–25 Hz.

Results

Symptom Measures

All grouped averaged pre-post comparisons of the three assessments resulted in improvements. A cumulative summary of these results are presented in Table 3.

On the Zung Anxiety Scale, for 11 adult clients, the mean of the pre-scores was 46.00 (*SD* = 9.07) and the mean of the post-scores was 38.83 (*SD* = 7.37). The *t*-test yielded a statistically significant improvement, with $t(10) = 4.59$, $p < 0.001$. While nine clients reported a decrease in their scores, 2 of the 11 clients, reported an increase. See Table 4 for the pre-post scores for each client.

For the SCARED, for three minor clients, the mean of the pre-scores was 37.22 (*SD* = 14.47) and the mean of the post-scores was 21.33 (*SD* = 13.65). The *t*-test resulted a statistically significant improvement, with $t(2) = 27.71$, $p < 0.001$. All clients had improved self-report scores. See Table 5 for the individual pre-post scores.

On the ASEBA, for all categories averaged, the mean of the pre-scores was 63.27 (*SD* = 6.51) and the mean of the post-scores was 59.33 (*SD* = 6.35). The results of the *t*-test was a statistically significant improvement, with $t(17) = 8.75$, $p < 0.001$. Moreover, scores on all 18 categories of the ASEBA improved; see Table 6 the pre-post scores for each category. Improvements in the categories most specific to anxiety symptoms, that is, Anxious/Depressed and Anxiety Problems, were not statistically significant. The checklists do, however, assess for symptoms frequently associated with anxiety, such as withdrawal, somatic issues, thought problems, internalizing, and avoidance; and improvements in these areas were statistically significant.

Table 3
Group Averaged Pre-Post Assessment Results

Assessment (*n*)	Pre-scores *M* (*SD*)	Post-scores *M* (*SD*)	*t*(df)	*p*
Zung Anxiety Scale (*n* = 11)	46.00 (9.07)	38.82 (7.37)	4.59(10)	< 0.001
SCARED Scale (*n* = 3)	37.22 (14.47)	21.33 (13.65)	27.71(2)	< 0.001
ASEBA Across All Categories (*n* = 14)	63.27 (4.88)	59.33 (4.67)	8.76(17)	< 0.001

Table 4
Zung Anxiety Scale

Client #	Pre-scores	Post-scores
2	60	51
4	56	39
6	38	30
8	44	36
10	42	33
12	42	33
13	35	37
14	44	45
15	62	52
16	40	34
17	43	37
Mean (*SD*)	**46.00** (9.07)	**38.83** (7.37)

Note. $t(10) = 4.59$, $p < 0.001$.

Table 5
SCARED Scale

Client #	Pre-scores	Post-scores
1	28	12
7	30	15
11	54	37
Mean (*SD*)	**37.22** (14.47)	**21.33** (13.65)

Note. $t(2) = 27.71$, $p < 0.001$.

Table 6
Achenbach Behavior Checklists (ASEBA)

Category	Pre	Post	*t*(df)	*p*
Anxious/Depressed	69.57	66.86	1.212(13)	.247
Withdrawn	66.21	61.64	2.329(13)	**.037**
Somatic Complaints	65.14	60.71	2.74(13)	**.017**
Thought Problems	66.29	57.86	3.042(13)	**.009**
Attention Problems	69.07	63.43	2.112(13)	.055
Aggressive Behavior	61.79	56.93	2.62(13)	**.021**
Rule-breaking Behavior	60.00	55.43	4.738(13)	**< .001**
Intrusive	44.07	43.14	1.153(10)	.276
Internalizing	69.36	64.93	2.174(13)	**.049**
Externalizing	59.71	54.07	2.713(13)	**.018**
Critical Items	52.57	49.14	3.612(10)	**.005**
Total Problems	65.79	60.79	2.557(13)	**.024**
Depressive Problems (DSM)	69.50	68.79	0.306(13)	.764
Anxiety Problems (DSM)	65.36	64.64	0.49(13)	.632
Somatic Problems (DSM)	62.36	59.21	1.717(13)	.110
ADHD Problems (DSM)	66.29	63.00	1.47(13)	.165
Avoidant Personality Problems (DSM)	66.00	61.93	2.194(13)	**.047**
Antisocial Personality Problems (DSM)	59.79	55.36	3.169(13)	**.007**
Category Mean (*SD*)	**63.27(6.50)**	**59.33(6.34)**		

Note. Bolded values are statistically significant.

Quantitative EEG Results

While not all clients realized improvements in *z*-scores, the difference between pre- and post-measurement showed a decrease in absolute *z*-score values, averaged across all cases, from 1.21 (*SD* = 0.73) to 1.10 (*SD* = 0.62). The improvement was not statistically significant, however. Table 7 provides the pre-post average *z*-scores for each client. It should be noted that one-channel amplitude training was employed as the method of NF, not *z*-score training.

Table 7
Results Pre-Post qEEG Z-scores

Client #	Pre-scores *z*-score	Post-scores *z*-score
1	1.51	0.77
2	1.67	2.32
4	0.77	1.29
6	1.33	1.50
7	0.77	1.44
8	0.70	0.70
10	0.84	0.32
11	2.91	0.49
12	0.75	1.08
13	2.54	2.37
14	0.60	0.89
15	1.10	0.90
16	0.64	0.55
17	0.77	0.72
Mean (*SD*)	**1.21 (0.73)**	**1.10 (0.62)**

Note. *Z*-score pre-post difference was not statistically significant.

Discussion

Symptom improvement was shown with various assessments including: the self-report ASEBA, Zung Anxiety Scale, and SCARED. While two of the most anxiety-specific categories of the ASEBA yielded improvements that were not statistically significant, other anxiety-related categories resulted in significant improvement, and overall the improvement in averaged scores across categories were statistically significant. Taken together, the symptom scales present evidence of a significant improvement in the client's sense of wellbeing.

Interestingly, two categories of the ASEBA that showed robust improvement were Rule-Breaking and Antisocial Personality. A number of researchers have examined the comorbidity of anxiety disorders and Antisocial Personality Disorder or Conduct Disorder, with some evidence of a correlation (Galbraith, Heimberg, Wang, Schneier, & Blanco, 2014; Goodwin & Hamilton, 2003; Hodgins, De Brito, Chhabra, & Côté, 2010). This relationship may serve as an added dimension to the ongoing study based on this pilot, or as an additional focus of research.

The parent rating version of the SCARED was administered, but results presented some problems in interpretation. In one instance, the parents rated their child in opposite ways—one parent reported a large improvement, while the other parent reported a large worsening of symptoms. In this case there was significant parental conflict and one parent divulged that they were divorcing. Due to the confounding nature of the parental reports, only self-reports on the assessments were included for analysis. Parental ratings can be included as the size of the sample increases in the future.

A small sample size and the lack of a control group was a roadblock to an effective research design in some aspects of the study. There were also limitations based on clients receiving therapeutic care (as self-reported) and experimenter bias/skill level. This experimenter bias could have resulted in a response-expectancy effect (Kirsch, 2009). Furthermore, some clients experienced confounding life stressors that could have influenced treatment and medication effects that were not present during the pre- and post-qEEG. Treatment was provided to clients who clearly had characteristics that compromised the quality of data that might be gained from them. They included clients who were inconsistent in attendance, exhibited substance abuse issues (data was excluded), experienced significant life events (such as relational or financial crises), or had mental or medical disorders that possibly reduced the effect of the treatment. This may have resulted in spending a portion of the sessions engaged in active listening and numerous client-centered or CBT therapeutic interventions in different ways and to various extents with the clients. The relative merits of various strategies of controlling for these variations in the future are being considered.

Quantitative designs are descriptive or experimental in nature. A descriptive study establishes only associations between variables and an experimental usually establishes causality. Unfortunately, many variables were not accountable or annotatable. One such effect was positive reinforcement. The presentation and style of secondary reinforcers varied based on student-clinician decisions and were not directly addressed in this study. Operant and classical conditioning techniques were employed to make the feedback as much of a positive reinforcement as possible. This included

the selection of feedback type based on client preference. Some clients expressed preferences for one or more of available options or classes of options, which included: games, animations, sounds (including music), or analogical feedback (such as boxes that grow and shrink in size based on which wave analysis was trained). Positive reinforcement was also provided via verbal prompts and coaching. As the study progresses in the future with additional clients, it may be possible to analyze these variations for significant differences in treatment outcomes.

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. Some students had significant experience with NF, while most were novices. Student counselors who were taking an advanced NF course, as an elective to their counseling degree program, saw clients in the counseling department's center. In addition to an introductory course, some of the students had completed one or two semesters of advanced practical and theoretical applications in NF. During the previous courses, the students had worked with one or more NF software systems, had practiced performing NF on other students, and had NF procedures designed for themselves, which were based on qEEG analysis. Some of the students had completed counseling skills courses, practicum and internship hours, while others were novices to counseling. In one case, the student had been the counselor for the client they were seeing for NF treatment as part of a counseling practicum course one semester prior. Controls for the effect of student bias and skill level differences were: supervision from the professor who monitored via informal verbal reports from students and clients, session notes, closed-circuit television, and weekly case conferences.

"Neurofeedback training is all about learning. Each person's rate of learning is unique; some respond more quickly than others do" (Demos, 2005, p. 127). As such, a combined client-centered and quantitative approach is best used in the future. In this case, a quasi-experimental approach needs to be designed. Clients would need to previously be scored on self-efficacy, anxiety scores, and education of basic NF principles. If all scales can be quantified, then limitations, placebo effect, and counselor technique can be assessed during the design phase, and several uncontrolled variables can be at least factored. Excluding students from treating clients with whom they have any previous clinical or personal relationship (e.g., previous student and talk therapy clients they may have had in practicum or internship portions of degree path).

Other client variables to control for, as affecting possible treatment outcomes, would include: adjunct therapies (concurrently used or attending), medications, familial/financial/extraneous life stressors and major life events, injuries/illnesses, changes in sleep, and other therapeutic lifestyle changes, that is, diet, exercise, meditation. Future considerations need to assess whether counselor-client therapeutic modalities need to be standardized amongst clinicians to established protocols of breathing techniques, mindfulness, and meditation in hopes of decreasing variability.

A few 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. As the study continues with the addition of more clients each semester, accounting for this variable will make statistical analysis more robust. This will be accomplished by (1) setting up a comparison between medicated and non-medicated clients, and (2) excluding medicated client data.

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. As noted above in the results section, while *z*-score calculations were used in the statistical analysis of EEG changes, the training did not utilize *z*-score training, but qEEG-guided protocols. Two clients, for example, were given posterior alpha enhancement training based on qEEGs that reflected the low-amplitude fast phenotype. One of these clients had a fast alpha peak frequency, showing an elevated *z*-score in the 11–12 Hz range with normal *z*-scores for 8–10 Hz. But, the protocol for this client included uptraining 8–10 Hz (and downtraining 25–30 Hz). In this case, it was expected that the absolute *z*-score might actually show an increase, which turned out to be the case. Although the client successfully modified the amplitudes of both frequency bands, with accompanying symptom improvement, these results present a confounding factor in the *z*-score analysis. The study may have also been strengthened by the addition of a learning curve. This will be added in future analyses.

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. Students in the NF program are taught an integrative model of NF and psychotherapy; as such, they naturally carried this approach into their sessions with clients. 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. It is hoped that as the study continues, the ongoing addition of more clients and students will enable the clearer identification of the sole effects of NF. Nonetheless, the study may replicate the common practices of most NF practitioners and hold value in that regard.

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