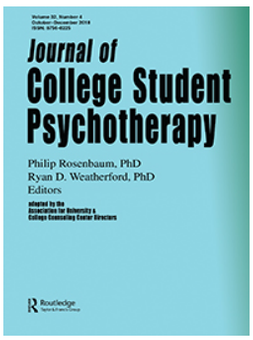

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The Effects of Neurofeedback on Depression, Anxiety, and Academic Self-Efficacy

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ABSTRACT

This preliminary study examined the effects of 16 sessions of neurofeedback (NF) training protocol on levels of depression, anxiety, and academic self-efficacy in college students with attention deficit hyperactivity disorder (ADHD). Results identified that NF was a viable option for mitigating depression and anxiety symptoms as well as increasing academic self-efficacy scores in college students with ADHD, based on their scores over time. Implications for college counselors are presented.

KEYWORDS

Attention deficit hyperactivity disorder; neurofeedback; college students; depression; anxiety; self-efficacy

Approximately 6–8% of adults in the United State have a diagnosis of Attention Deficit Hyperactivity Disorder (ADHD; Buchanan, 2011). Moreover, 11% of children in the United States have an ADHD diagnosis, with 66% of those with ADHD diagnoses retaining their symptoms into adulthood (Faraone, Biederman, & Mick, 2006). Children with ADHD are more likely to struggle academically and require exceptional education services as compared to children not diagnosed with ADHD (Loe & Feldman, 2007). Further, children with ADHD show deficits in executive functioning, leading to a lack of planning, organizing, or problem solving (Biederman et al., 2004). In addition to issues with academic achievement and cognitive functioning, children with ADHD tend to struggle with social and emotional issues that may also persist into adulthood, manifesting in various psychological disorders (e.g., depressive disorders; Gaultney, 2014).

Adults with ADHD are at higher risk for stress, marijuana dependence, and work impairment including workplace injuries (Authors, 2018; Canu, 2007; Combs, Canu, Broman-Fulks, Rocheleau, & Nieman, 2015). Unlike children, adults with ADHD are able to choose work environments that are conducive to their ADHD symptoms and thus cope with their symptomology by compensating for it in their daily lives. Though college students with

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ADHD have similar flexibility and freedom as adults which may provide a method of coping with their ADHD symptoms, some college students with ADHD may be unable to cope with their ADHD symptoms in the same way as other adults because they are in educational systems that require students to manage multiple activities and deadline-related tasks. As a result, according to Anastopoulos et al. (2016), many college students with ADHD have increased incidence of mood disorder comorbidity (i.e., anxiety and depression), social and sleep disorders, and academic difficulties (Buchanan, 2011; Gaultney, 2014). Specifically, college students with an ADHD diagnosis are at higher risk of experiencing depression (Nelson & Gregg, 2012; Patros et al., 2013). Also, Harrison, Alexander, and Armstrong (2013) found that college students who exhibit high levels of depression and axiety, are more likely to exhibit ADHD symptomology or have an ADHD diagnosis and stress the importance of assessing college students for comorbid ADHD when depressive and axiety symptoms are present and vice versa. College students with ADHD also experience unique forms of anxiety as it pertains to their academic performance, which interferes with their overall self-efficacy (Harrison et al., 2013). Thus, college students with ADHD are in need of an intervention to mitigate their anxiety and depressive symptoms, as well promote their academic self-efficacy.

Universities generally have structures in place to assist college students diagnosed with ADHD which may include services provided by learning centers or offices of disability services to assist in study habits or providing additional time on testing, or mental health counseling services that provide counseling, Cognitive Behavioral Therapy groups, or coaching (Ahmann, Tuttle, Saviet, & Wright, 2018). Additionally, universities may provide physician services and medication prescriptions through student health services. A major challenge with pharmacological intervention for ADHD symptoms, however, is the risk of side effects. Stimulant medications such as Ritalin or Adderall (most often used in the treatment of ADHD) carry with them side effects including headaches and appetite changes. These side effects lead to a lack of medication adherence in college students (Cunill, Castells, Tobias, & Capellà, 2016) or self-medicating with alternative substances to cope with ADHD symptoms. Thus, an intervention that may treat college students with ADHD without producing adverse side effects is necessary.

Neurofeedback (NF) is a training protocol in which individuals receive feedback on the electrical activity in their brain. As biofeedback (e.g., heart-rate monitoring or deep breathing for relaxation) seeks to provide voluntary control over automatic bodily functions, NF operates in a similar manner. NF is the process of gathering data on brainwave activity (often through the placement of electrodes on an individual's scalp) and providing feedback (audio or visual) to the individual based on the electric activity in the brain. As certain levels of electrical activity are associated with states of arousal,

focus, or even sleep, NF practitioners and researchers seek to provide feedback to the brain on maladaptive patterns of electrical activity in order to help train individuals to voluntarily increase or decrease electrical activity in order for the brain to operate more efficiently. NF is different from pharmacological interventions in that the side effects of NF are limited to increased feelings of tiredness, and the benefits can be self-sustaining for the long-term.

NF has shown effectiveness in alleviating ADHD symptoms in children with ADHD with Cohen's *d* effect sizes ranging from .80 (Leins et al., 2007) to 2.08 (Duric, Assmus, Gundersen, & Elgen, 2012). In addition, the effects of NF training last as long as five years after the conclusion of the intervention (i.e., Baehr, Rosenfeld, & Baehr, 2001). Moreover, researchers have sought to lessen individuals' symptoms of depression and anxiety with NF interventions. Specifically, NF interventions may be effective in training the mechanisms in the brain that researchers have linked to depression (i.e., asymmetry in frontal alpha wave activity; Hammond, 2005). Similarly, NF interventions show promise in decreasing symptoms of generalized anxiety, phobic anxiety, Obsessive Compulsive Disorder (OCD), and Post Traumatic Stress Disorder (PTSD; Moore, 2000). We sought to add to the ADHD and NF literature by expanding the existing research to college students with ADHD (a far less studied population), thus addressing the needs of college students with ADHD as they pertain to comorbid depressive and anxiety symptoms as well as academic self-efficacy.

Method

The purpose of our pilot study was to investigate the effects of NF training on college students with ADHD levels of depressive symptoms, anxiety, and academic self-efficacy. The research question guiding our preliminary investigation was: Are there mean rank differences in college students diagnosed with ADHD scores on the *Beck Depression Inventory-II* (BDI-II; Beck, Steer, & Brown, 1996), the *Beck Anxiety Inventory* (BAI; Beck & Steer, 1990), and the *Self-efficacy for Learning Form-Abridged* (SELF-A; Zimmerman & Kitsantas, 2005, 2007) over time when receiving a NF intervention? The data gathered to answer this research question are unreported data from a previous work that examined the effects of NF on college students' ADHD symptoms (Authors, 2018).

We used a quasi-experimental, time-series design (Shadish, Cook, & Campbell, 2002) to answer our research question. We recruited participants from college campuses in the central region of a Southeastern state in the United States. We ensured our participants met our inclusion criteria (i.e., over the age of 18, able to provide proof of an ADHD diagnosis, currently a college student) by screening via a telephone intake interview. Eligible participants received 16 total sessions of the NF training intervention over the course of eight to ten weeks. Research assistants (RAs), as well as the first

author conducted the NF sessions. The RAs were trained by the second author, a certified NF provider. We collected data at four points throughout the pilot study: (a) baseline data collection conducted prior to the intervention (pre), (b) midpoint data collection after eight sessions (four weeks) of the intervention (mid), (c) post data collection after the intervention (the end of session 16; post), and (d) follow-up data collection four weeks after the final intervention session (FU).

Participants

Participants in our pilot study were 11 college students diagnosed with ADHD by their mental health professional. Participants self-selected to participate in the pilot study and provided proof of an ADHD diagnosis in the form of a treatment summary. Four participants presented with ADHD, Combined type (314.01, F90.2) as their diagnosis, one participant presented with ADHD with hyperactivity as their diagnosis, and the other six participants' treatment summaries did not specify the type of ADHD diagnosis. Eight participants reported using medication as a means by which they managed their ADHD symptoms, with one additional participant having reported beginning a medication regimen after the first week of NF sessions. Participant ages ranged from 18 to 27 years of age; three participants (27%) identified as males, and eight participants (73%) identified as female. Students were enrolled in undergraduate (n = 8) and graduate (n = 3) level programs. Nine participants (82%) identified as White (non-Hispanic), one participant (9%) as Hispanic, and one participant (9%) as Biracial.

Measures

The data collection packets included three measures: (a) the BDI-II (Beck et al., 1996), (b) the BAI (Beck & Steer, 1990), and (c) the SELF-A (Zimmerman & Kitsantas, 2005), which were completed at the four points of the preliminary investigation. At the first data collection point, participants also completed a *Psychosocial Inventory*.

Psychosocial inventory

The *Psychosocial Inventory* was adapted from an inventory used by the university-based community counseling and research center (UBCCRC) where the data were collected. The *Psychosocial Inventory* included questions about the participants' demographic information (i.e., age, gender, ethnicity, contact information) in addition to brief questions about their main concerns as related to their ADHD symptoms and what they were doing to manage their ADHD symptoms. Additionally, the *Psychosocial Inventory* included questions about participants' physical health history (i.e., present and past

illnesses, presence of an electronic medical implanted device, or skin allergies). The *Psychosocial Inventory* also included questions about participants' emotional history and substance abuse, serving as a further means of screening for current suicidal behaviors and/or substance abuse.

The beck depression inventory

The BDI-II (Beck et al., 1996) is a 21-item, self-report measure of depressive symptoms. The BDI-II matches the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV; American Psychiatric Association, 1994) diagnostic criteria for depression. The BDI-II includes items assessing respondents' levels of distress in different areas (e.g., sadness, sleep patterns, and suicidality). Total scores for the BDI-II were used in data analysis. Internal consistency reliability of the BDI-II is strong, with a Cronbach's alpha (α) of 0.92 for a clinical sample and 0.93 for a nonclinical college student sample. Test-retest reliability of the BDI-II showed a strong correlation (r = 0.93) when administered a week apart.

The beck anxiety inventory

The BAI (Beck & Steer, 1990) is a 21-item self-report measure of anxiety symptoms. BAI items measure distress in different areas (e.g., feeling frightened, or feeling fear of the worst happening). The BAI is scored by summing the total numbers that correlate to the responses the participants choose. The greater the sum, the more symptoms of anxiety present. The BAI psychometric properties were examined on a clinical outpatient population (N = 1,086) that was diagnosed with mood disorders by meeting the DSM-III or DSM-III-R criteria. The internal consistency was high, with an alpha of 0.92. Test-retest reliability was evaluated with a week between administrations; correlations were moderate, with a correlation coefficient of 0.75.

The self-efficacy for learning form-abridged

The SELF-A (Zimmerman & Kitsantas, 2005, 2007) is a 19-item self-report measure of self-efficacy for self-regulated learning. The SELF-A measures students' perceived responsibility and ability to take control of their learning, including items that ask about students' ability to take notes in class or, if they do not understand something, their ability to get the information they need. The answers are on a 100-point scale, from 0 – I definitely cannot do this, to 100 – I definitely can do this. Respondents recorded the number that corresponds to their beliefs in their ability to complete the stated task. Zimmerman and Kitsantas (2005), Zimmerman & Kitsantas (2007)) have yet to complete reliability and validity analyses on the SELF-A scale; however, they report that the communalities of the items in the factor analysis were all above 0.9, indicating that the items relate well to one another. Further, the authors compared students' responses on the SELF-A to their teachers'

perceptions of the students' self-efficacy via the *Perceived Responsibility for Learning Scale* (Zimmerman & Kitsantas, 2007) and found a strong relationship between the students' responses and teachers' perceptions (r = 0.71), thus supporting the concurrent validity of the SELF-A scores.

Procedures

We collected data for this pilot study over a 12-week period including 8–10 weeks of NF sessions and a post-NF follow-up four weeks after the conclusion of sessions. Participants completed 1–2 sessions of NF each week (in some cases, participants had scheduling difficulties and had to cancel sessions, leading to only receiving one session in one week) and completed assessments (a) before the first session of NF (pre), (b) after receiving NF in the eighth (mid) and sixteenth sessions (post), and (c) four weeks after the last session of NF (FU). In addition, the participants received $10.00 gift cards at each of the four data collection intervals as incentives for participating. To conduct the neurofeedback sessions, we used the NeurOptimal Neurofeedback training software. Using this systems requires a NeurOptimal System obtained from the NeurOptimal website, headphones (for the participants to hear the music), electroconductive paste, electrode sensors, and an amplifier (each of which come standard with the purchase of a NeurOptimal system). Training for how to use the NeurOptimal system can also be obtained through the NeurOptimal company and website. NF training sessions lasted for 33.5 minutes, as this is the standard length of time for sessions in the NeurOptimal software; the system automatically stopped itself when the session was over. Treatment fidelity was ensured, as the NF system operated the same way every session. According to the Zengar Institute, the NeurOptimal system operates in the following manner:

> NeurOptimal monitors the electrical activity of your brain, reminding your brain about what it's actually doing so your brain can function more optimally. When brain activity shows signs of turbulence, the music within the NeurOptimal NF software is momentarily interrupted. This subtle cue alerts your brain that it is operating inefficiently. With repeated training sessions, the brain learns to "reset" itself and function more smoothly. All of this learning is non-invasive and happens outside your conscious awareness. Over time, NeurOpitmal adjusts itself automatically in response to your brain's activity, individualizing the training microsecond by microsecond to your own brain's functioning. (Zengar, 2016, retrived from: http://www.zengar.com/the-brain-neuroptimal)

A common effect of NF is a feeling of being tired; therefore, we suggested that if participants were feeling tired, they sit in the waiting room of the UBCCRC for 10–15 minutes before leaving.

Data analysis

Friedman's Test (Friedman, 1937, 1940) was conducted for the purpose of exploring differences in the participants' total BDI (depression), BAI (anxiety), and SELF-A (academic self-efficacy) scores over time. Analyzing our data with the Friedman's ANOVA allowed for examination of the mean rank differences in a dependent variable between three or more groups in a sample in which the assumption of normality has been violated (as is the case in our sample, due to the small sample size; Daniel, 1990). Further, when conducting analyses using ANOVA, post hoc analyses are necessary to determine where differences lie within the groups being examined. We used Wilcoxon post hoc tests to determine where differences lie between groups in the cases when significance was found in the Friedman analyses. When we conducted the post hoc tests, a Bonferroni adjustment was implemented because six post hoc tests were run on the same datasets ($\alpha = .0083$). Significance was also reported at the $p < .05$ level for the post hoc tests because effect sizes (reported as sizes of positive and negative ranks below) provided support of a significant change in scores over time in cases that were significant at the $p < .05$ as well (Shadish et al., 2002).

Results

Depression

The BDI-II (Beck et al., 1996) total scores were used to evaluate participants' levels of depression over time during NF training. A statistically significant difference was found in depression scores over time ($\chi^2_{(3)} = 13.165$, $p = .004$) with pre BDI-II scores ranking highest ($MR = 3.45$), mid BDI-II scores ranking second highest ($MR = 2.64$), FU BDI-II scores ranking third highest (MR = 2.05), and post BDI-II scores ranking lowest ($MR = 1.86$; See Table 1). Post hoc Wilcoxon tests were conducted to examine specific differences between groups. A significant difference existed between the pre BDI-II ($M = 10.55$, $SD = 9.66$) and mid BDI-II scores ($M = 7.09$, $SD = 8.58$; $Z = -2.196$, $p = .028$) with mid depression scores ranking lower than pre scores in seven cases, mid scores ranking higher than pre scores in two cases, and two ties. Pre depression scores were different from post-depression scores ($M = 5.82$, $SD = 7.69$) as well, ($Z = -2.194$, $p = .028$) with post scores ranking lower than pre scores in nine cases, post scores ranking higher than pre scores in one case, and one tie. The final significant difference was found between the pre and FU ($M = 5.64$, $SD = 6.86$) groups ($Z = -2.194$, $p = .028$), with FU scores lower than pre scores in nine cases, FU scores higher than pre scores in one case, and one tie. No significant differences were found between the mid depression and post-depression groups ($Z = -1.612$, $p = .107$); however, post scores ranked lower than mid scores in six cases,

Table 1. Descriptive statistics for the BDI-II, BAI, and SELF-A.

Descriptive Statistics	*M*	*SD*	*Median*	*Mean Rank*	Range	Min.	Max.
BDI-II							
Pretest	10.55	9.658	9	3.45	27	0	27
Midpoint	7.09	8.584	5	2.64	28	0	28
Posttest	5.82	7.692	4	1.86	26	0	26
Follow Up	5.64	6.860	2	2.05	20	0	20
BAI							
Pretest	13.18	13.273	8	3.45	42	1	43
Midpoint	8.91	10.737	4	2.55	31	2	33
Posttest	6.91	7.176	4	1.91	21	1	22
Follow Up	8.18	12.552	3	2.09	43	1	44
SELF-A							
Pretest	111.500	26.036	109	1.27	85.0	74.0	159.0
Midpoint	123.545	31.793	120	2.45	90.5	76.0	166.5
Posttest	127.455	29.874	132	2.68	85.0	84.0	169.0
Follow Up	132.909	29.156	134	3.59	92.0	82.0	174.0

and post scores ranked higher than mid scores in one case, with four ties. Further, no significant difference was found between mid-scores and FU scores ($Z = -.509$, $p = .611$); yet, FU scores ranked lower than mid scores in five cases, FU scores ranked higher than mid scores in two cases, and there were four ties. Finally, no significant difference was found between post and FU scores ($Z = -.135$, $p = .893$), with FU scores ranking lower than post scores in two cases, FU scores ranking higher than post scores in three cases, and six ties (See Table 1). The largest effect sizes were between the pre and post assessment points, and pre and FU assessment points, with post and FU scores ranking lower than pre scores in nine cases, and one case each of pre scores ranking higher than post and FU scores. The largest effect size identifies that the greatest decreases in depression scores occurred between the pre and post, and pre and FU assessment points.

Anxiety

The BAI (Beck & Steer, 1990) total scores were analyzed to examine differences in participants' self-reported levels of anxiety over time. A significant difference was found in anxiety scores over time ($\chi^2_{(3)} = 10.078$, $p = .018$), with pre BAI scores ranking highest ($MR = 3.45$), mid BAI scores ranking second highest ($MR = 2.55$), FU BAI scores ranking third highest ($MR = 2.09$), and post BAI scores ranking lowest ($MR = 1.91$). Post hoc Wilcoxon tests were conducted to examine specific differences between groups. A significant difference existed between the pre BAI ($M = 13.18$, $SD = 13.27$) and mid BAI scores ($M = 8.91$, $SD = 10.74$; $Z = -2.501$, $p = .012$), with mid anxiety scores ranking lower than pre scores in nine cases, mid scores ranking higher than pre scores in one case, and one tie. Pre anxiety scores were different from post anxiety scores ($M = 6.91$, $SD = 7.18$) as well

($Z = -2.407$, $p = .016$), with post scores ranking lower than pre scores in nine cases, post scores ranking higher than pre scores in two cases, and no ties. The final statistically significant difference was found between the pre and FU ($M = 8.18$, $SD = 12.55$) groups ($Z = -2.308$, $p = .021$), with FU scores lower than pre scores in eight cases, FU scores ranking higher than pre scores in two cases, and one tie. No significant differences were found between the mid anxiety and post anxiety groups ($Z = -1.367$, $p = .172$); yet, post scores ranked lower than mid scores in seven cases, post scores ranked higher than mid scores in two cases, and there were two ties. Further, no statistically significant difference was found between mid-scores and FU scores ($Z = -0.665$, $p = .506$); nevertheless, FU scores ranked lower than mid scores in seven cases, FU scores ranked higher than mid scores in three cases, and there was one tie. Finally, no statistically significant difference was found between post and FU scores ($Z = -.178$, $p = .858$), with FU scores ranking lower than post scores in four cases, FU scores ranking higher than post scores in five cases, and two ties (See Table 1). The largest effect sizes were between the pre and mid assessment points with mid scores ranking lower than pre scores in nine cases and one case of pre scores ranking higher than mid scores. The largest effect size identifies that the largest decrease in BAI scores occurred between the pre and mid points.

Academic self-efficacy

The SELF-A (Zimmerman & Kitsantas, 2005) total scores were used to evaluate differences in participants' academic self-efficacy over time throughout the intervention. When inputting the SELF-A scores to the dataset, we transformed the raw scores (each item was on a scale from 0–100%) to scores from 0–10. That is, if a participant reported 67% confidence on an item, we inputted the score as 6.7, and total scores were computed by totaling the item responses for all 19 items. There was a significant difference in self-efficacy scores over time ($\chi^2_{(3)} = 18.361$, $p < .001$). The mean ranks for each group increased over time (Pre $MR = 1.27$, Mid $MR = 2.45$, Post $MR = 2.68$, FU $MR = 3.59$), suggesting that academic self-efficacy improved over time. Post hoc Wilcoxon tests were conducted to examine specific differences between groups. A significant difference existed between the pre SELF-A ($M = 111.5$, $SD = 26.04$) and mid SELF-A scores ($M = 123.55$, $SD = 31.79$; $Z = -2.179$, $p = .029$), with mid efficacy scores ranking lower than pre scores in two cases, mid scores ranking higher than pre scores in nine cases, and no ties. Differences were also found between the mid and FU groups ($Z = -1.989$, $p = .047$), with FU scores ranking lower than mid scores in two cases, FU scores ranking higher than mid scores in eight cases, and one tie. The final significant difference was found between the post and FU groups ($Z = -2.146$, $p = .032$), with FU scores ranking lower than post scores in

two cases, FU scores ranking higher than post scores in nine cases, and no ties. Differences were found at the Bonferroni corrected alpha level of $p < .0083$ between pre efficacy and post efficacy scores ($M = 127.46$, $SD = 29.87$; $Z = -2.759$, $p = .006$), with post scores ranking lower than pre scores in one case, and post scores ranking higher than pre scores in ten cases. Moreover, a significant difference was found between pre and FU ($M = 132.91$, $SD = 29.16$) groups ($Z = -2.934$, $p = .003$), with FU scores ranking higher than pre scores in all 11 cases. No significant difference was found between the mid efficacy and post efficacy groups ($Z = -1.176$, $p = .240$); yet, post scores ranked higher than mid scores in six cases, post scores ranked lower than mid scores in four cases, and there was one tie (See Table 1). The largest effect size was between the pre and FU assessment points, with FU scores ranking higher than pre scores in all 11 cases. The largest effect size identifies that the greatest increase in SELF-A scores occurred between the pre and FU assessment points.

Discussion

Our findings indicate that there were significant improvements in participants' scores in depression ($\chi^2_{(3)} = 13.165$, $p = .004$), anxiety ($\chi^2_{(3)} = 10.078$, $p = .018$), and academic self-efficacy ($\chi^2_{(3)} = 18.361$, $p < .001$) over time. On the BDI-II, participants' scores ranked slightly higher from post to FU. Yet, more than half ($n = 6$) of participants' BDI-II scores remained the same from post to FU, suggesting that more than half of participants reported neither higher nor lower levels of depression four weeks after NF sessions were over. Our results differ slightly from those of Baehr et al. (2001); their study included three adults receiving at least 27 sessions of NF who were assessed with the BDI (Beck, Steer, & Garbin, 1988). Participants' reports of their depressive symptoms remained stable one, three, and five years after receiving NF, suggesting that NF may provide stable effects for as long as five years. As the participants in our pilot study only received 16 sessions of NF, the slight increase in depressive symptoms may be a result of not receiving enough NF sessions for there to be a sustained reduction in depressive symptoms. Our findings align with research identifying NF as an effective intervention in reducing depressive symptoms in adults (e.g., Cheon, Koo, & Choi, 2016).

Our participants' BAI scores at FU were not as high as they were at the midpoint or at the outset of the pilot study; however, almost half ($n = 5$) of participants' scores were higher at FU than they were at post, suggesting that almost half of the participants experienced an increase in symptoms of anxiety after concluding NF sessions. Additional FU assessments at longer intervals would have allowed us to determine whether participants' reports of anxiety symptoms would steadily increase or plateau. The participants' slight

increase in reporting of anxiety symptoms after the last NF sessions may have been impacted by the relaxing nature of the NF training process. Gracefire and Durgin (2012) found that participants felt calmer in as little as one session of NF; yet, reports of symptoms of anxiety do not change after one session. In other words, individuals may experience a calmness associated with receiving NF, resulting in reporting more symptoms of anxiety after not receiving NF for 4 weeks. As the BAI includes items focusing on both somatic and emotional symptoms of anxiety, participants may have experienced a reduction in the somatic symptoms of anxiety because of feeling calmer after NF sessions. However, after ending NF sessions, the somatic symptoms of anxiety may return. Further, Kerson, Sherman, and Kozlowski (2009) found that in eight participants, both state and trait anxiety were reduced following an average of 28.75 sessions of a NF intervention, and after a six-month FU, participants' scores improved from the pre assessment, suggesting that NF is effective in reducing anxiety in adults and has lasting results. Again, as with depressive symptoms, the participants in our pilot study may have had results that are more lasting at FU if they had received additional NF sessions.

We also found a steady increase in mean rank scores over time in participants' academic self-efficacy scores, indicating an improvement in self-reported efficacy in academic tasks. Specifically, the largest effect size was observed between the pre and FU assessment times, as all 11 participants scored higher on academic self-efficacy at FU than they did at the outset of the pilot study. Our results relating to college students' academic self-efficacy scores and NF are unique, as no other studies have examined differences in academic self-efficacy with a NF intervention in college students with ADHD. Fritson, Wadkins, Gerdes, and Hof (2007) included a self-efficacy scale in their study that examined the effects of a NF intervention on cognitive abilities and emotions in a nonclinical college student sample, finding no differences in self-efficacy scores. Our pilot study differs from Fritson and colleagues' study in that our sample included college students who were at higher risk of having low academic self-efficacy, and the measure used in our study assessed academic self-efficacy, as compared to generalized self-efficacy. Academic self-efficacy may be more relevant to the college student population and more accurate for the college student sample in our current pilot study. Our results add to the NF literature on college students and self-efficacy by providing support that academic self-efficacy can improve with 16 sessions of a NF intervention.

Implications

Implications from this preliminary investigation begin with providing introductory support for the use of NF for depression and anxiety symptoms and

academic self-efficacy in college students with ADHD. Although this preliminary study included methodological flaws pertaining to the sample size, lack of control group, and mixed sample (those who used medication and those who did not), the study serves as a springboard off which more research on NF as an intervention for college students with ADHD can be built. Future empirical support for the effectiveness of NF with college students with ADHD may influence public policy relating to treatment options offered at colleges and universities, leading to NF as a supplement to counseling and medication. Moreover, our results serve as a catalyst through which counselors can learn more about how electrical activity in the brain influences behavior, especially in college students with ADHD. The Council for the Accreditation of Counseling and Related Educational Programs (CACREP) has stressed the importance of counseling practitioners understanding the "biological, neurological, and physiological factors that affect human development, functioning, and behavior" (CACREP, 2016; p. 11). Practitioners may benefit from understanding NF training and the potential for this intervention to reduce college students' depression and anxiety scores as well as to increase their academic self-efficacy.

To integrate NF into counseling sessions, college counselors may offer NF as an alternative or as a supplement to counseling. Providing a session of NF before a psychotherapy session or scheduling clients to attend NF between psychotherapy sessions may potentially increase clients' ability to focus in session or become more self aware in session, thus improving the quality of the psychotherapy occurring within the sessions. Costs associated with purchasing a NeurOptimal system can range from $10,000 to $25,000 depending on the system bundle purchased. The optimal number of NF sessions required has yet to be determined in the NF literature as the number of sessions may vary from individual to individual. Training requirements in NF vary based on the type and protocol of NF used. For the NeurOptimal system (used in the current pilot study), practitioners can be trained online by attending a training webinar. Certification as a NF provider through the Biofeedback Certification National Alliance (BCIA) is also an option. College counseling centers may also acquire a NF system to provide the service to students by purchasing a system through the NeurOptimal website and ensuring counseling center staff are trained to operate the system to avoid negative effects due to improper administration (Hammond & Kirk, 2007).

Limitations and recommendations for future research

Our study employed a one group, time series research design, thus having the inherent limitation of the lack of a control group. Shadish et al. (2002) note that designs without a comparison group lack the ability to state a causal relationship between the intervention (NF) and the results. Our findings should be interpreted under the consideration of our methodological limitations (e.g., lack

of comparison group, small sample size). Our results may not be generalized to individuals not represented in our sample, as the majority of our sample identified as female and our sample lacked racial diversity. Further, due to scheduling difficulties, some participants received NF at varying intervals throughout the course of the study. We ensured that each participant received the same total number of sessions throughout the entirety of the study, but future studies should ensure more stringent treatment fidelity. An additional limitation to the study was the lack of homogeneity of medication usage in the sample. We included participants who had been taking medication at the outset of the study as well as those who were not taking medication. Future research could separate those who take medication and those who do not in the analysis of the results of the study. The results of our preliminary study lack generalizability due to methodological limitations, however, the findings of our study suggest that future research should be conducted to provide further evidence of neurofeedback's efficacy in mitigating symptoms of ADHD in college students.

There were limitations to the internal and external validity of our preliminary investigation, which we could not control, such as attrition. However, future research can begin to address the limitations of our study by including a larger sample size and a control group in order to increase generalizability to a larger population and increase the ability to assert causality between NF and the changes in symptoms. Moerever, future research should include stronger methodology by ensuring there is no variance in the number of sessions each participant receives each week in an effort to maintain treatment fidelity and consistency. Further, future research should examine the impact of differences in gender, race, socioeconomic status and other variables on changes over time, providing an invaluable contribution to the NF and ADHD in college student literature. Future research could also compare the impact of NF in college students with ADHD in comparison to psychotherapy, psychopharmacological interventions, and a mixture of NF and both psychotherapy and medication to examine the impact each intervention has on participants' depression, anxiety, and academic self-efficacy scores.

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References

Ahmann, E., Tuttle, L. J., Saviet, M., & Wright, S. D. (2018). A descriptive review of ADHD coaching research: Implications for college students. *Journal of Postsecondary Education and Disability*, *31*(1), 17–39.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders: DSM-IV*. Washington, DC: Author.

Anastopoulos, A. D., DuPaul, G. J., Weyandt, L. L., Morrissey-Kane, E., Sommer, J. L., Rhoads, L. H., … Gudmundsdottir, B. G. (2016). Rates and patterns of comorbidity among first-year college students with ADHD. *Journal of Clinical Child & Adolescent Psychology*, 1–12.

Authors. (2018).

Baehr, E., Rosenfeld, J. P., & Baehr, R. (2001). Clinical use of an alpha asymmetry neurofeedback protocol in the treatment of mood disorders: Follow-up study one to five years post therapy. *Journal of Neurotherapy*, *4*(4), 11–18. doi:10.1300/J184v04n04_03

Beck, A. T., & Steer, R. A. (1990). *Manual for the Beck Anxiety Inventory*. San Antonio, TX: Pearson.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Beck depression inventory-II manual*. San Antonio, TX: Pearson.

Beck, A. T., Steer, R. A., & Garbin, M. G. (1988). Psychometric properties of the beck depression inventory: Twenty-five years of evaluation. *Clinical Psychology Review*, *8*(1), 77–100. doi:10.1016/0272-7358(88)90050-5

Biederman, J., Monuteaux, M. C., Doyle, A. E., Seidman, L. J., Wilens, T. E., Ferrero, F., … Faraone, S. V. (2004). Impact of executive function deficits and attention-deficit/hyperactivity disorder (ADHD) on academic outcomes in children. *Journal of Consulting and Clinical Psychology*, *72*(5), 757. doi:10.1037/0022-006X.72.5.757

Buchanan, T. (2011). Attention deficit/hyperactivity disorder and well-being: Is social impairment an issue for college students with ADHD? *Journal of Postsecondary Education and Disability*, *24*(3), 193–210.

Canu, W. H. (2007). Vocational safety preference of college men with and without attention-deficit/hyperactivity disorder: An exploratory study. *Journal of College Counseling*, *10*(1), 54–63. doi:10.1002/(ISSN)2161-1882

Cheon, E. J., Koo, B. H., & Choi, J. H. (2016). The efficacy of neurofeedback in patients with major depressive disorder: An open labeled prospective study. *Applied Psychophysiology and Biofeedback*, *41*(1), 103–110. doi:10.1007/s10484-015-9315-8

Combs, M. A., Canu, W. H., Broman-Fulks, J. J., Rocheleau, C. A., & Nieman, D. C. (2015). Perceived stress and ADHD symptoms in adults. *Journal of Attention Disorders*, *19*(5), 425–434. doi:10.1177/1087054712459558

Cunill, R., Castells, X., Tobias, A., & Capellà, D. (2016). Efficacy, safety and variability in pharmacotherapy for adults with attention deficit hyperactivity disorder: A meta-analysis and meta-regression in over 9000 patients. *Psychopharmacology*, *233*(2), 187–197. doi:10.1007/s00213-015-4099-3

Daniel, W. W. (1990). *Applied nonparametric statistics*. Boston, MA: PWS-KENT Publishing Company.

Duric, N. S., Assmus, J., Gundersen, D., & Elgen, I. B. (2012). Neurofeedback for the treatment of children and adolescents with ADHD: A randomized and controlled clinical trial using parental reports. *BMC Psychiatry*, *12*(1), 107–114. doi:10.1186/1471-244X-12-107

Faraone, S. V., Biederman, J., & Mick, E. (2006). The age-dependent decline of attention deficit hyperactivity disorder: A meta-analysis of follow-up studies. *Psychological Medicine*, *36*(1), 159–165. doi:10.1017/S003329170500471X

Friedman, M. (1937). The use of ranks to avoid the assumption of normality implicit in the analysis of variance. *Journal of the American Statistical Association*, *32*(200), 675–701. doi:10.1080/01621459.1937.10503522

Friedman, M. (1940). A comparison of alternative tests of significance for the problem of m rankings. *The Annals of Mathematical Statistics*, *11*(1), 86–92. doi:10.1214/aoms/1177731944

Fritson, K. K., Wadkins, T. A., Gerdes, P., & Hof, D. (2007). The impact of neurotherapy on college students‘ cognitive abilities and emotions. *Journal of Neurotherapy*, *11*(4), 1–9. doi:10.1080/10874200802143998

Gaultney, J. F. (2014). College students with ADHD at greater risk for sleep disorders. *Journal of Postsecondary Education and Disability*, *27*(1), 5–18.

Gracefire, P., & Durgin, G. (2012). Combining sLORETA and 19-channel live z-score training: Targeting hibeta in brodman areas to reduce symptoms of anxiety. *Neuroconnections, Winter*, 30–33.

Hammond, D. C. (2000). Neurofeedback treatment of depression with the Roshi. *Journal of Neurotherapy*, *4*(2), 45–56. doi:10.1300/J184v04n02_06

Hammond, D. C., & Kirk, L. (2007). Negative effects and the need for standards of practice in neurofeedback. *Biofeedback*, *35*(4), 139–145.

Harrison, A. G., Alexander, S. J., & Armstrong, I. T. (2013). Higher reported levels of depression, stress, and anxiety are associated with increased endorsement of ADHD symptoms by postsecondary students. *Canadian Journal of School Psychology*, *28*, 243–260. doi:10.1177/0829573513480616

Hirschfeld, R. M. (2001). The comorbidity of major depression and anxiety disorders: Recognition and management in primary care. *Primary Care Companion to the Journal of Clinical Psychiatry*, *3*(6), 244–254.

Kerson, C., Sherman, R. A., & Kozlowski, G. P. (2009). Alpha suppression and symmetry training for generalized anxiety symptoms. *Journal of Neurotherapy*, *13*(3), 146–155. doi:10.1080/10874200903107405

Leins, U., Goth, G., Hinterberger, T., Klinger, C., Rumpf, N., & Strehl, U. (2007). Neurofeedback for children with ADHD: A comparison of SCP and theta/beta protocols. *Applied Psychophysiology and Biofeedback*, *32*(2), 73–88. doi:10.1007/s10484-007-9031-0

Loe, I. M., & Feldman, H. M. (2007). Academic and educational outcomes of children with ADHD. *Journal of Pediatric Psychology*, *32*(6), 643–654. doi:10.1093/jpepsy/jsl054

Moore, N. C. (2000). A review of EEG biofeedback treatment of anxiety disorders. *Clinical EEG and Neuroscience*, *31*(1), 1–6.

Patros, C. H., Hudec, K. L., Alderson, R. M., Kasper, L. J., Davidson, C., & Wingate, L. R. (2013). Symptoms of attention-deficit/hyperactivity disorder (ADHD) moderate suicidal behaviors in college students with depressed mood. *Journal of Clinical Psychology*, *69*(9), 980–993. doi:10.1002/jclp.21994

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston, MA: Houghton Mifflin & Company.

Zimmerman, B., & Kitsantas, A. (2007). Reliability and validity of self-efficacy for learning form (SELF) scores of college students. *Zeitschrift Für Psychologie/Journal of Psychology*, *215*(3), 157–163. doi:10.1027/0044-3409.215.3.157

Zimmerman, B. J., & Kitsantas, A. (2005). The hidden dimension of personal competence: Self-regulated learning and practice. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 509–526). New York, NY: Guilford Publications.