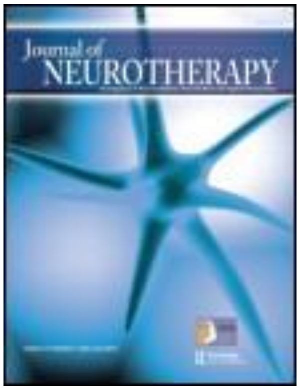

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The Impact of Neurotherapy on College Students' Cognitive Abilities and Emotions

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The Impact of Neurotherapy on College Students' Cognitive Abilities and Emotions

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ABSTRACT. *Background*. In past research, several case studies and five controlled-group studies explored the effect of electroencephalographic (EEG) biofeedback on intelligence, attention, and behavior in children diagnosed with attention deficit hyperactivity disorder, but no studies have explored the effects of EEG biofeedback in nonclinical adults on measures of response control, mood, emotional intelligence, and self-efficacy.

Method. Sixteen nonclinical college students were randomly assigned to receive Beta/Sensory Motor Rhythm EEG biofeedback to increase 12 to 15 Hz activity while inhibiting 4 to 7 Hz and 22 to 36 Hz activity. A control group received placebo EEG biofeedback. All participants completed pre- and postmeasures assessing intelligence scores, attention, impulse control, mood, emotional intelligence, and self-efficacy to assess the effect of EEG biofeedback.

Results. Results showed significant improvements in response control but no improvements in attention. Measures of intelligence and emotional functioning did not change after EEG biofeedback.

Conclusions. This study indicates that response control may improve in a few as 20 EEG biofeedback sessions. Implications and shortcomings discussed.

KEYWORDS. Neurofeedback, EEG biofeedback, students, response control

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INTRODUCTION

In the past 30 years, research has shown that electroencephalographic (EEG) biofeedback is an effective treatment for a variety of clinical disorders (see Hammond, in press). Multiple case studies and experiments demonstrated support for EEG biofeedback as an effective treatment for inattention, impulse control, and behavioral symptoms of attention deficit hyperactive disorder (ADHD; Monastra, et al., 2005). Other studies showed that EEG biofeedback and psychostimulant medication were equally effective in children diagnosed ADHD and behavioral symptoms of impulsivity, externalizing behaviors, and attention symptoms (Fuchs, Birbaumer, Lutzenberger, Gruzelier, & Kaiser, 2003; Monastra, Monastra & George, 2002; Rossiter & Vaque, 1995). Furthermore, such research indicates that improvements were maintained for patients receiving EEG biofeedback with or without psychostimulant medication, whereas individuals who did not receive EEG biofeedback did not show sustained changes when medications were removed (Monastra et al., 2005).

Research that compared the use of EEG biofeedback to a *waiting list* control group (all participants had ADHD diagnoses) found significant improvements in attention and intellectual performance for the EEG biofeedback group of patients (Linden, Habib, & Radojevic, 1996). Carmody, Radvanski, Wadhwani, Sabo, & Vergara (2001) demonstrated a significant reduction in impulsivity symptoms for EEG biofeedback-treated ADHD-diagnosed patients compared to a waiting listcontrol group of ADHD-diagnosed patients. In addition, Tinius and Tinius (2000) found that after 20 treatment sessions, significant gains in sustain attention occurred for individuals with a mild traumatic brain injury and ADHD-diagnosed individuals when compared to a healthy control group. These controlled-group studies, especially when considered with multiple EEG biofeedback supporting case studies, strongly indicate EEG biofeedback is an effective strategy for treating ADHD symptoms of inattention, impulsivity, and externalizing behaviors. No adverse effects were found in any of the noted research studies (Monastra et al., 2005).

This research is compelling regarding the clinical population; however, very limited research has been conducted regarding the potential impact of EEG biofeedback on nonclinical populations. Rasey, Lubar, McIntyre, Zoffuto, and Abbott (1996) explored the effects of EEG biofeedback on attention processing and intelligence for "normal" individuals. They found that "some 'normal' young adults can learn to increase EEG activity associated with improved attention" (pp. 17). However, their study included data from only 4 of 7 original participants because of noncompliance by 3 of the participants and did not include a no-treatment control group. Their research supports the idea that some undiagnosed individuals may show improvement in attention, but effects with an undiagnosed population may only occur with at least 30 sessions of EEG biofeedback. In addition, Rasey et al. (1996) did not explore factors other than attention.

Other studies have explored the effects of EEG biofeedback on task performance. A study by Egner and Gruzelier (2003) demonstrated that EEG biofeedback positively impacted individuals' musical performance. Egner and Gruzelier (2004) used protocols of midline PZ, CA and combined C4, C3, and PZ in their research, and the combination of C4, C3, and PZ was used to test music performance, with marginal improvement in music ratings.

Egner and Gruzelier (2004) examined three groups, two of which used neurofeedback. Group 1 had midline training (CZ) to enhance Sensory Motor Rhythm (SMR) (12–15 Hz) and inhibit theta (4–7 Hz) and high beta (22–30 Hz), Group 2 had the same midline training (CZ) to enhance low beta (15–18 Hz) with the same inhibits, and Group 3 had nonneurofeedback training. Groups 1 and 2 had 10 weekly sessions of neurotherapy for 15 min, whereas Group 3 completed a similar number of nonneurotherapy weekly sessions. All three groups had pre and posttesting using the Test of

Variables of Attention (TOVA) and a divided attention test. Groups 1 and 2 also completed a task that elicited event-related potentials. The TOVA data showed some marginal improvement in Group 1's ability to discriminate targets. Group 2 showed a significant decrease in response times on the TOVA. The divided attention task test showed that Group 1 exhibited a significant improvement in participants' ability to discriminate targets as well as reduced omission and response time variability. All groups showed a reduction in response times. The authors concluded that neurofeedback training to enhance amplitude in SMR and low beta may lead to significant"specific effects on cognitive-behavioral and electrocortical measures of attention processing" (Egner & Gruzelier, 2004).

Given the limited amount of research on the effects of EEG biofeedback on nonclinical populations, the narrow scope of studies exploring the effects of EEG biofeedback on the *normal* population, and the demonstrated effectiveness of EEG biofeedback on attention, impulsivity, intelligence, behavior, and performance in clinical populations, we explored the effects of EEG biofeedback in nonclinical adults. Specifically, the objective of this study was to determine the effects of EEG biofeedback on nonclinically diagnosed young adults' attention, impulsivity, intellectual functioning, mood, emotional intelligence, and general self-efficacy.

We hypothesized that individuals' receiving EEG biofeedback would demonstrate improved attention, response control, and intellectual performance. In addition, it was hypothesized that individuals receiving EEG biofeedback would show improvements in mood, emotional intelligence, and self-efficacy when compared to individuals who did not receive EEG biofeedback.

METHOD

Participants

The participants were 32 psychology student volunteers ranging in age from 19 to 38 years (28 female, 4 male; M age $= 21.3$, $SD = 4.24$) from a public, midwestern university. Participants were randomly assigned to either the experimental or control condition. A brief description and inclusion criteria for participation were described. Inclusion criteria were (a) no current mental health diagnosis, (b) no history of major mental illness (e.g., bipolar disorder, schizophrenia, or schizoaffective disorder), (c) no current medications for mental illness, (d) no current diagnosis or history of epilepsy or a seizure disorder, and (e) no history of EEG biofeedback treatment. Students were also informed they could earn $50 for participation in the study. Interested students met with researchers, and the students confirmed they met criteria for the study, signed a consent form, and completed the pretest measures with a research assistant. Participants were then scheduled twice-weekly session times to participate in the research. All participants were randomly assigned to either the control or EEG biofeedback group. Group assignment was random, but all men were in the control condition.

Institutional Review Board approval was obtained prior to the study, and all participants were debriefed following completion of their postmeasures. The control group participants were informed that they had not received EEG biofeedback. The control condition included 16 students (12 female, 4 male; M age $= 21.0$) who did not receive EEG biofeedback but were told they were receiving it. The experimental condition included 16 students (16 female, 0 male; M age $= 21.6$) who received SMR EEG biofeedback training at C3–C4, a bipolar sensor placement with C3 being the active site and C4 the referential site. The ground was an A1 sensor placement. The A1 site was chosen for consistency only.

All participants were told they were receiving EEG biofeedback, and similar sensor placements and preparation procedures were used with all participants to control for any placebo effects or other confounding variables. All participants attended one baseline session lasting approximately 12 min, then attended 19 twice-weekly sessions lasting 20 to 25 min per session within a 12-week period, for a total of 20 sessions. Although we would have preferred to have participants engage in 30 to 40 sessions of neurotherapy, limitations regarding participants' availability in one semester resulted in the use of 20 sessions in this study. Thirty-nine participants originally volunteered for this research, but 7 discontinued participation because of scheduling conflicts, and their data were discarded.

Materials

All participants completed all pre- and postmeasures in the sequence; the measures are described in this section. Participants completed all self-report forms independently after completing the Integrated Variables of Attention + Plus (IVA + Plus) and an intellectual test with a research assistant in the pre- and posttest procedures. The intellectual tests (Kaufman Brief Intelligence Test 2 [K-BIT 2]; Kaufman & Kaufman, 2004) and Wide Range Intelligence Test (WRIT; Glutting, Adams & Sheslow, 2000) were completed per standardized procedures with research assistants administering the tests individually with each participant. These two intellectual tests were used and randomly alternated in attempts to prevent practice effects of retaking the same test within a 12-week period.

Demographics Form. The demographic form included information on age, gender, academic year and grade point averages, college major, and any history of emotional problems or mental health diagnosis. Any history of counseling or current use of psychotropic medication was also included in the demographic information as a double check for exclusionary criteria.

IVA + Plus. The IVA + Plus (Sandford & Turner, 2004) is a standardized continuous performance test used primarily to measure Response Control (response accuracy, impulsivity, and fatigue) and Attention in age ranges 6 to adult. It combines auditory and visual stimuli using a variety of computer-displayed patterns to which participants must respond. The IVA + Plus analysis provides two main global full-scale composite quotient scores (Full Scale Response Control Quotient and Full Scale Attention Quotient [FSAQ]), along with primary Visual and Auditory subscales. The Full Scale Response Control and FSAQ, along with the Visual and Auditory subscales of Response Control and Attention were used in this study to measure impulse control and attention related to auditory and visual stimuli. The instructions for this test are integrated into the computer program; hence, participants were directed to the computer, seated with headsets, and requested to complete the procedure as indicated by the computer prompts.

K-BIT 2. The K-BIT is a standardized, individually administered intelligence test used to measure verbal (crystallized), nonverbal (fluid), and overall (general) intelligence of individuals ranging in age from 4 through 90 years. It yields Verbal Scale, Nonverbal Scale, and IQ Composite Scores. The K-BIT is recommended for use to identify individuals' estimated intellectual functioning, demonstrating a reliability quotient ranging from .89 to .96 on the IQ Composite Scale (Kaufman & Kaufman, 2004). This study utilized the IQ Composite Score to measure participants' overall intelligence. Research assistants individually administered the K-BIT to randomly assigned participants.

WRIT. The WRIT is a standardized, individually administered intelligence test used to measure verbal (crystallized), visual (fluid), and overall (general) intelligence of individuals' ranging in age from 4 through 85 years. It yields a Verbal Scale, Visual Scale, and General IQ Scores. The WRIT is used to establish individuals' estimated intellectual functioning, with the average reliability coefficient for the General IQ Scale being .95 (Glutting et al., 2000). This study utilized the General IQ Scale to measure participants' general intelligence. Research assistants individually administered the WRIT to randomly assigned participants.

Bar-On EQi-S Emotional Intelligence Questionnaire. This questionnaire is a brief, standardized, self-report questionnaire for measuring emotionally intelligent behavior when a more detailed assessment is not necessary. The Short Version is based on the Bar-On model of emotional intelligence. This model indicates emotional intelligence pertains to the emotional, personal, and social dimensions of general intelligence and involves abilities and competencies related to understanding oneself and others, relating to peers and family, and adapting to changing environmental situations and demands (Bar-On, 2002).

Self-Efficacy Questionnaire. This questionnaire is a 23-question measure used to assess individuals' self-efficacy regarding their personal belief about their ability to initiate and persist in behavior (self-efficacy; Sherer et al., 1982). This scale was established to measure individuals' General Self-Efficacy and individuals' Social Self-Efficacy. The 23 questions are answered on a 14-point Likert scale.

Brief Mood Introspection Scale. This is a brief self-report scale used to measure individuals' perceptions of their current mood state (Mayer & Gaschke, 1988). For the purposes of this study, a small wording change was made to promote self-report of participants' general mood states over the 2 weeks prior to taking the Brief Mood Introspection Scale.

Beck Depression Inventory–II (BDI–II). The BDI–II is a 21-item, standardized self-report form used to measure the severity of depressive characteristics in individuals 13 years of age and older. It was revised from the original BDI developed in 1961 to assess depressive symptoms corresponding with the *Diagnostic and Statistical Manual of Mental Disorder* (4th ed.) (Beck, Steer, & Brown, 1996). This study used the BDI–II to assess any direct effects of EEG biofeedback on depressive symptoms.

The IVA + Plus was administered immediately after completion of the demographics, prior to the other measures in order to minimize any effects of boredom or being tired from other measures. To prevent any practice effects, researchers alternated the use of the K-BIT 2 and the WRIT, so if a participant completed the K-BIT as a pretest measure, the participant completed the WRIT as a posttest measure and visa versa. The construct validity correlation between the K-BIT 2 and WRIT in the study was .611 and significant at the .001 alpha level. The construct validity between these two tests is similar to those described by Kaufman and Kaufman (2004), indicating that these tests measure similar constructs.

EEG Biofeedback (Neurofeedback) Training. The equipment and protocol as described in this section were used with both the experimental and control groups. Both groups were given the same instructions at the beginning of the project, with the Informed Consent, and at each session. The control group had no auditory feedback but watched the same rotation of games operated off a previously recorded EEG of one of the researchers. Control group participants were told they were receiving EEG biofeedback but were not as the Pro Comp was in the "off" position. EEG Spectrum equipment and Neurocybernetics EEGer Neurofeedback Software Version 4.1.4G were used in this study. EEG was recorded from C3–C4, located along the Nasion-Inion line 20%left and right of CZ. At the time of this study there was no known research on the placement of the ground having a significant effect on training results, so a ground ear-clip sensor placed at A1 for consistency across participants. A Pro Comp differential amplifier (Thought Technology Ltd.; Montreal, Quebec; http://www.thoughttechnology.com/index.htm) acquired signal at 256 Hz. Impedance was kept below 20 Ohms. This impedance level was based on the current engineering standards of the amplifier manufacturers. The parameters for the Training band were 12.0 to 15.0 Hz, whereas the Low and High Inhibit Bands were 4.0 to 7.0 Hz and 22.0 to 36.0 Hz, respectively.

The use of bilateral sensor placement (C3–C4) was based on both sites having equal opportunity to record the EEGs of interest. Egner and Gruzelier's (2003) significant findings of within-session increases in low beta amplitude and decreases in the inhibited theta and high beta resulted in the suggestion by the authors that enhancing 12 to 15 Hz aids the maintenance of working memory utilized in semantic working memory. Clinical practice by one of the authors of this article (Pat Gerdes, LISW) also supports the effects described previously. The use of bilateral sensor placement (C3–C4) was based on both sites having equal opportunity to record the EEGs of interest. The differential amplifier (Goff, 1974) reflects the difference in the two sites (C3–C4) and filters out artifact.

The low beta (12–15 Hz) was trained in this study based on the (Egner & Gruzelier, 2003) results of improved task performance, and the Egner and Gruzelier (2004) study, which showed that SMR training significantly improved the response time variability, as well as a reduction in omission errors. Vernon et al. (2003) also used low beta training in one of three groups tested that compared pre- and postsemantic memory performance. In their study, the only group that showed significant improvement in working memory was the low beta group, which suggested enhanced cognitive performance. Because this study was looking at healthy college students' intellectual functioning, attention, and impulse control, the low beta (12–15 Hz) was the area of interest for our research.

Procedures

Upon arriving for their sessions, all participants had EEG biofeedback sensors placed at C3–C4 position by a researcher and began their session. All participants watched visual feedback games, which were rotated on a weekly basis for both experimental and control groups. Both groups were told they were receiving EEG biofeedback. The control group had electrodes attached, but the differential amplifier was not activated; therefore, no EEG signal was received by the equipment. Instead, the control group watched a game operated by the recording of an EEG previously made by one of the researchers. The control group also had no audio feedback during sessions. The experimental group had both audio and visual feedback with differential amplifier activated and EEG feedback received.

Upon completion of the final biofeedback session, participants were asked to schedule a time to complete the posttreatment measures. Participants completed posttreatment measures at their scheduled times, then were debriefed and reminded they would be sent compensation for their completion of the study.

RESULTS

A 2 (group: control, treatment) $\times$ 2 (training: pre-post) multivariate analysis of variance (MANOVA) for the IVA FSAQ and the Full Scale Response Quotient (FSRQ) was completed to determine if the neurofeedback group performed better compared to the control group. The MANOVA found a significant main effect of training (Wilks's $\Lambda = .74$). The main effect of group (Wilks's $\Lambda = .95$) and the interaction were not significant (Wilks's $\Lambda = .99$). For the main effect of training, on the IVA Full Scale Response Control, $F(1, 30) = 6.66$, $p < .015$, the treatment group showed a significant increase from pre- to posttreatment, whereas control groups showed no change. The main effect of training for the IVA FSAQ was not significant, $F(1, 30) = 2.19$, *ns*.

A 2 (group: control, treament) $\times$ 2 (training: pre–post) MANOVA for Response Control Auditory, Response Control Visual, Visual Attention, and Auditory Attention found the main effect of treatment (Wilks's $\Lambda = .96$) was significant, whereas the main effect of group (Wilks's $\Lambda = .66$) and the Group $\times$ Training interaction (Wilks's $\Lambda = .96$) were not significant. For the main effect of treatment, the treatment group showed significantly higher scores on the Response Control Auditory Quotient, $F(1, 30) = 4.97$, $p < .05$, and Response Control Visual Quotient, $F(1, 30) = 6.83$, $p < .05$, subscales of the IVA + Plus at posttreatment, but the control group showed no change at posttreatment (see Table 1).

A 2 (group: control, treatment) $\times$ 2 (treatment: pre–post) MANOVA for Total IQ, Emotional IQ, BDI, and Brief Mood Scales was completed. There was no significant main effect of group or treatment. The Group $\times$ Treatment interaction was not significant. See Table 2 for means and standard deviations for these variables.

TABLE 1. Means and standard deviations of intellectual and emotional psychological tests.

IVA Subscale	Control	Neuro
Full Scale Response Control Quotient		
Pre	87.69 (17.7)	95.56 (17.4)
Post	91.19 (16.5)	104.19 (11.6)[a]
Full Scale Attention Quotient		
Pre	94.50 (24.0)	100.00 (24.7)
Post	97.69 (17.7)	106.94 (17.6)
Auditory Response Control Quotient		
Pre	88.19(16.5)	95.69 (15.0)
Post	92.31(16.2)	103.69 (12.3)
Visual Response Control Quotient		
Pre	90.13 (17.8)	96.69 (19.0)
Post	92.06 (15.1)	104.38 (11.2)[a]
Auditory Attention Quotient		
Pre	93.81 (33.8)	101.38 (24.8)
Post	94.13 (26.2)	104.89 (26.8)
Visual Attention Quotient		
Pre	89.69 (30.2)	86.63 (39.0)
Post	83.63 (33.2)	94.44 (34.7)
Sustained Auditory Attention Quotient		
Pre	95.69 (23.5)	102.50 (19.1)
Post	95.75 (19.6)	105.19 (18.4)
Sustained Visual Attention Quotient		
Pre	94.75 (20.7)	96.69 (29.2)
Post	100.56 (17.2)	107.50 (16.7)

Note. Standard deviations are in parentheses.
[a]Significantly different from pretest group.

DISCUSSION

The results showed that SMR EEG biofeedback may affect some characteristics of nonclinical individuals in as few as 20 sessions. Specifically, the data supported the hypothesis that EEG biofeedback improves individuals' response control with participants who received the EEG biofeedback demonstrating significant improvements on the FSRQ (response accuracy, impulsivity, and fatigue) of the IVA + Plus, whereas those in the control group did not show such changes. Similarly, the EEG biofeedback participants showed significant improvements in response control on the Response Control Visual and Auditory subscales of the IVA + Plus.

The aforementioned findings provide empirical support for the use of SMR EEG biofeedback with healthy adults to improve response control even if there is no obvious impairment, which is consistent with the idea of peak performance. This finding also suggests that the improvements in response control include responses to auditory and visual stimuli, suggesting that the EEG neurofeedback training effects are consistent across both visual and auditory brain processes. These findings could be strengthened in future studies by using more than one measure of response control factors. Perhaps self-report scales, task observation, or another additional continuous performance measure could be used to enhance the evidence that SMR EEG biofeedback effects change in healthy individuals' response control.

A previous study (Rasey et al., 1996) suggested that changes in attention processes in healthy adults may require at least 30 sessions of EEG biofeedback, but no other group-controlled studies have specifically explored impulse control measures for nonclinical populations. Because EEG biofeedback participants' attention scores did not show significant change in this study, our

TABLE 2. Means and standard deviations of intermediate visual and auditory continuous performance subscales.

Psychological Test	Control	Neuro
Intelligence Quotient		
Pre	104.63(11.1)	102.81 (10.9)
Post	106.13(10.8)	106.00 (12.5)
Emotional IQ		
Pre	101.13 (10.2)	102.44 (12.5)
Post	96.38 (12.6)	98.81 (14.6)
BDI		
Pre	5.69 (3.5)	9.13 (10.6)
Post	7.75 (5.9)	8.31 (9.6)
Self-Efficacy		
Pre	10.77 (1.2)	10.39 (1.8)
Post9.77 (1.1)	9.99 (1.9)	
Brief Mood Scale		
Pre	6.31 (4.2)	6.94 (2.1)
Post	6.19 (1.7)	5.13 (4.7)

Note. Standard deviations are in parentheses. BDI = Beck Depression Inventory.
[a]Significantly different from pretest group.

results suggest further empirical support of previous findings by Rasey et al. found that a greater number of sessions may be necessary for attention processes of healthy adults to be impacted by EEG biofeedback. However, given that the baseline attention scores were higher than the baseline response control, there could have been a ceiling effect that affected the ability for attention to change significantly in this population.

Additional findings did not support our hypotheses that individuals' intelligence scores, mood, emotional intelligence, and self-efficacy would improve because of EEG biofeedback. The findings related to intelligence are consistent with Rasey et al. (1996) in which they found no patterns of change in intellectual scores pre and post 20 sessions of neurotherapy with healthy college students. However, in addition to the possible need of more training sessions to impact the intellectual scores of healthy adults, the lack of relatedness of the scales used in this study may have contributed to a lack of findings regarding IQ. Future studies should likely use only one IQ measurement scale, as the practice effects would likely be minimal.

Our results regarding mood, emotional intelligence, and self-efficacy are not surprising. However, no previous controlled-group studies have directly explored the effects of EEG biofeedback on mood, emotional intelligence, and self-efficacy characteristics in healthy adults, so these findings contribute to the literature on the effects of EEG biofeedback on nonclinical adults. A concern related to a lack of changes in mood, emotional intelligence, and self-efficacy could be that floor effects may have inhibited the chance of finding significant changes. Given this possibility, future studies might establish or use scales that measure such characteristics on a broader scale (i.e., not use a clinical scales such as the BDI).

Another factor that may have affected the possibility of finding changes on emotional and efficacy scales is external stressors such as expectations and time in the semester. The student population in this study would have likely been under much less stress/duress at the beginning of the study simply because of fewer school-related demands; however, during the postmeasures, students were preparing for final exams and had stressors related to ending a semester of school. The increased stress during the postmeasures may have negatively impacted the measures. Although no studies have shown significant differences regarding gender differences in response to EEG biofeedback or gender difference in performance on the measures used in this study, consideration might be given to the fact that all men were in the control group. Hence, gender may have served as a confound. Future studies might be sure to balance genders within their experimental and control groups. Although this research contributes to the EEG biofeedback literature regarding nonclinical adults, the findings also create implications for future research to further explore the effects of using the bilateral protocol C3–C4 (12 Hz–15 Hz), the number of sessions necessary for change in healthy adults, and preventive interventions for individuals who experience mild problems with impulse control.

In summary, the results support EEG biofeedback as a viable procedure to improve response control (improve response accuracy, decrease impulsivity, and decrease fatigue) in young, healthy adults. Specifically, other populations that might benefit from EEG biofeedback and might be included in future research are high school dropouts, sexually impulsive individuals, or individuals with nonclinical habit behaviors such as gambling.

REFERENCES

Bar-On, R. (2002). *EQi: S: Bar-on emotional quotient inventory: Short (Technical manual)*. New York: Multi-health Systems.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *BDI-II manual*. San Antonio, TX: Harcourt Brace.

Carmody, D. P., Radvanski, D. C., Wadhwani, S., Sabo, M. J., & Vergara, L. (2001). EEG biofeedback training and attention-deficit/hyperactivity disorder in an elementary school setting. *Journal of Neurotherapy*, *43*(3), 5–27.

Egner, T., & Gruzelier, J. H. (2003). Ecological validity of neurofeedback: Modulation of slow wave EEG enhances musical performance. *Cognitive Neuroscience and Neuropsychology*, *14*(9), 1221–1224.

Egner, T., & Gruzelier, J. H. (2004). EEG biofeedback of low beta band components: Frequency-specific effects on variables of attention and event-related brain potentials. *Clinical Neurophysiology*, *115*, 131–139.

Fuchs, T., Birbaumer, N., Lutzenberger, W., Gruzelier, J. H., & Kaiser, J. (2003). Neurofeedback treatment for attention-deficit/hyperactivity disorder in children: A comparison with methylphenidate. *Applied Psychophysiology and Biofeedback*, *28*(1), 1–12.

Glutting, J., Adams, W., & Sheslow, D. (2000). *WRIT: Wide Range Intelligence Test manual*. Wilmington, DE: Wide Range.

Goff, W. R. (1974). Human average evoked potentials: Procedures for stimulating and recording. In R. F. Thompson & M. M. Thompson (Eds.), *Bioelectric recording techniques: Part B. Electroencephalography and human brain potentials* (pp. 101–156). New York: Academic.

Hammond, D. C. (in press). Comprehensive neurofeedback bibliography: 2007 update. *Journal of Neurotherapy*, *11*(3).

Kaufman, A. S., & Kaufman, N. L. (2004). *Kaufman brief intelligence manual* (2nd ed.). Shoreview, MN: AGS Publishing.

Linden, M., Habib, T., & Radojevic, V. (1996). A controlled study of the effects of EEG biofeedback on cognition and behavior of children with attention deficit disorder and learning disabilities. *Biofeedback and Self-Regulation*, *21*(1), 35–49.

Mayer, J. D., & Gaschke, Y. N. (1988). The experience and meta-experience of mood. *Journal of Personality and Social Psychology*, *55*, 102–111.

Monastra, V. J., Lynn, S., Linden, M., Lubar, J. F., Gruzelier, J., & LaVaque, T. J. (2005). Electroencephalographic biofeedback in the treatment of attention- deficit/hyperactivity disorder. *Applied Psychophysiology and Biofeedback*, *30*(2), 95–114.

Monastra, V. J., Monastra, D. M., & George, S. (2002). The effects of stimulant therapy, EEG biofeedback, and parenting style on the primary symptoms of attention- deficit/hyperactivity disorder. *Applied Psychophysiology and Biofeedback*, *27*(4), 231–249.

Rasey, H. W., Lubar, J. F., McIntyre, A., Zoffuto, B. S., & Abbott, P. L. (1996a). EEG biofeedback for the enhancement of attentional processing in normal college students. *Journal of Neurotherapy*, *1*(3), 15–21.

Rossiter, T. R., & Vaque, L. (1995). A comparison of EEG biofeedback and psych- stimulants in treating attention deficit/hyperactivity disorders. *Journal of Neurotherapy*, *1*, 48–59.

Sandford, J. A., & Turner, A. (2004). *IVA + Plus: Integrated visual and auditory performance test*. Toronto, Canada: Brain Train, Inc.

Sherer, M., Maddux, J. E., Mercadante, B., Prentice-Dunn, S., Jacobs, B., & Rogers, R.W. (1982). The self-efficacy scale: Construction and validation. *Psychological Reports*, *51*, 663–671.

Tinius, T. P., & Tinius, K. A. (2000). Changes after EEG biofeedback and cognitive retraining in adults with mild traumatic brain injury and attention deficit hyperactivity disorder. *Journal of Neurotherapy*, *4*(2), 27–44.

Vernon, D., Egner, T , Cooper, N., Compton, T., Neilands, C., Sheri, A., et al. (2003). The effect of training distinct neurofeedback protocols on aspects of cognitive performance. *International Journal of Psychophysiology*, *47*(1), 75–85.