An Open Clinical Trial Utilizing Real-Time EEG Operant Conditioning as an Adjunctive Therapy in the Treatment of Crack Cocaine Dependence

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ABSTRACT. This study investigated the treatment outcome of males dependent on crack cocaine participating in an inpatient treatment facility in which electroencephalographic operant conditioning training (EEG-OC) was added to the treatment protocol. Eighty-seven men were assessed twelve months after completion of the EEG portion of the program. Follow-up procedures of urinalyses, self-report measures, length of residence, and scores on a measure of depression were obtained and showed significant changes after treatment. The addition of EEG-OC to

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crack cocaine treatment regimens may promise to be an effective intervention for treating crack cocaine abuse and increasing treatment retention.

KEYWORDS. EEG, crack cocaine, substance abuse, biofeedback, treatment

INTRODUCTION

Substance abuse is one of the most significant problems facing the United States today (National Institute on Drug Abuse, 2002). The illegal drug market is fueled by criminal activity and represents a severe challenge to our courts, the law enforcement establishment, and our economy. The number of people in the criminal justice system because of drug related crimes continues to grow and society has been forced to increase expenditures to process criminals as well as build prisons to house and "rehabilitate" them (Montaldo, 2005).

Of the many addictive drugs that are widely available, cocaine is one of the oldest known and most addictive. Cocaine is labeled a Schedule II drug (DEA, 1970), meaning that it has high potential for addiction and abuse. In fact, cocaine is the most common drug problem of patients entering treatment for illicit drug use (National Institute on Drug Abuse, 1999). "Crack cocaine" is the name given to the freebase form of cocaine that has been processed from powdered cocaine hydrochloride to form a substance to be smoked. Two factors combine to make "crack" widely popular: (a) smoking crack can give a user a high in less than ten seconds, and (b) this form of cocaine is also less expensive than other psychogenic drugs. The National Institute on Drug Abuse (NIDA) states, "... cocaine abuse and addiction is a complex problem involving biological changes in the brain as well as a myriad of social, familial, and environmental factors" (NIDA, 2002). The widespread use of cocaine and its debilitating effects have stimulated extensive efforts to develop treatment programs.

Overall, the various treatment methods available for substance abuse have been inconclusive and generally depend upon the source and/or study. The first comprehensive national evaluation of community-based drug treatment programs was initiated by the Drug Abuse Reporting Program (DARP) from 1969 to 1974 (Simpson & Sells, 1990). These initial results found no significant differences in treatment approaches, but did find a recurring theme: the length of treatment was the only factor associated with positive drug treatment outcomes.

The second major addiction study was conducted from 1979 to 1981 by the Treatment Outcome Prospective Study (TOPS; Hubbard et al., 1989). One-year abstinence rates were greatest for cocaine users who stayed in treatment for a minimum of one month. They found similar results regarding the previous findings in that treatment modalities exhibited similar results when they were similar in duration. Both of the aforementioned studies allude to the importance of length of stay in treatment as a key variable in addiction treatments. Moeller et al. (2001) propose that one of the possible reasons for high relapse rates after treatment is related to the impact of impulsivity in cocaine users. This study also sites impulsivity and attention as significant predictors of high drop out rates in individuals seeking treatment for cocaine addiction. Similarly, Prichep, Alper, Kowalik, and Rosenthal (1996) and Prichep et al. (2002) found that brain function abnormalities and quantitative electroencephalographic (QEEG) subtypes were significantly related to length of stay in treatment in crack cocaine treatment. These important studies lead us to draw the conclusion that brain functioning may be a strong correlate of treatment retention.

Though studies vary in treatment efficacy reports, few studies have monitored the relapse to "gateway" drugs of abuse after crack cocaine treatment, such as resorting to alcohol or marijuana dependency. Nunes-Dinis and Barth (1993) reported that although cocaine use decreases during and after treatment, alcohol and marijuana use increases. While participants may have recovered fully from cocaine addiction, they may replace the cocaine with alcohol or marijuana. Subsequently, alcohol use has been shown to predict inability to achieve cocaine abstinence after treatment (Mengis, Maude-Griffin, Delucchi, & Hall, 2002). Studies have generally only addressed residual cocaine abuse at follow-up whereas other abusive patterns may have emerged from the beginning to the end of treatment.

The Drug Abuse Services Research Study (1993) reported that patients admitted to substance abuse programs seek treatment an average of 1.9 times per year, indicating the lack of effectiveness of current treatment programs. Other sources state cocaine abuse relapse rates are nearing 80% post-treatment (Alterman et al., 1998; Higgins et al., 1995; Kang et al., 1991). Research investigating the clinical effectiveness of treatment for cocaine addiction is vital, together with addressing the adoption

and implementation of novel treatment interventions. Roman and Johnson (2002) stated that it is imperative to denote the extent to which these novel approaches can alter or enhance existing techniques and programs, such as group therapies or 12-step programs. Roman and Johnson (2002) further add that one of the barriers to the development of innovative treatments is resistance from those who are "intensely socialized into the extant treatment techniques and feel both personally identified and strongly committed to those practices."

Given the lack of support for the effectiveness of current treatments for crack addiction, efforts to find alternative treatment modalities are receiving more attention than ever. EEG operant conditioning (EEG-OC), also known as EEG biofeedback, neurotherapy, or neurofeedback, has been demonstrated as effective in the treatment of alcoholism, as evidenced by Peniston and Kulkosky's research efforts (1989, 1990). EEG-OC is based on operant learning principles, wherein identified EEG activity is reinforced or inhibited to induce changes in brainwave patterns (La Vaque, 1999). To date, most research with alpha-theta EEG-OC has addressed alcohol addiction. With cocaine being the most common drug problem of patients entering treatment for drug abuse (NIDA, 2001), research in the treatment of this population is warranted.

Few studies to date have addressed EEG-OC as a treatment for polysubstance abuse and/or other drugs of abuse, such as heroin, cocaine or crack cocaine. Kaiser, Othmer, and Scott (1999) addressed polysubstance abuse in a controlled study utilizing the Peniston protocol. Their comparison and experimental group received traditional addiction treatment called the Minnesota Model (Doweiko, 2002). In addition to the Minnesota Model, the experimental group also received 50 sessions of a modified Peniston protocol. Specifically, they eliminated the pre-EEG feedback hand warming sessions and replaced them with approximately 20 sessions of inhibit 4-7 Hz (theta) and enhance 12-18 Hz (sensory motor rhythm) training at sites C3 and C4, per the International 10-20 system. To date 80 subjects have completed the study and post-treatment MMPI-2 results indicate significant improvement on six of the MMPI-2 basic clinical scales (1, 2, 3, 8, and 0) compared to the no-EEG biofeedback control group. Scott and Kaiser (1998) surmise that EEG biofeedback treatment is valuable in addition to conventional addiction treatments, as measured by MMPI-2 changes. To date the authors are reporting 67% of the control group has relapsed, but only 35% of the treatment group has relapsed at the one-year follow-up.

The current study is a five-year research project developed and funded by the Southwest Health Technology Foundation (SHTF). The study operates under the supervision of the Institutional Review Board (Committee for the Protection of Human Participants) of the University of Texas Health Science Center in Houston, Texas. It is currently underway at the Open Door Mission (ODM) in Houston.

The ODM invited SHTF to use its clientele as a research base beginning in 1999. Using funds raised by the ODM and SHTF, the EEG-OC program was provided at no cost to the students within the addiction recovery program. The goal of this study was to analyze the effectiveness of the "Open Door" mission program augmented with EEG-OC in the treatment of crack cocaine addiction. EEG-OC was provided to students within the first three months of participation in the ODM program with the goal of preparing students for the additional program services, assisting in the management of drug and situational related anxiety. Given the previous literature results, SHTF identified five major areas to monitor for treatment progress: (a) increases in treatment retention, (b) reductions in substance abuse [cocaine, alcohol, and marijuana], (c) homelessness, (d) unemployment, and (e) criminal activity. To be considered a "success" at one year follow-up, participants must have had: (a) current living arrangements [not currently homeless], (b) no substance abuse [including alcohol, marijuana, and crack], (c) no subsequent involvement with the criminal justice system, and (d) current employment or student status.

MATERIALS AND METHODS

Participants

Participants were recruited from the ODM drug rehabilitation program entitled "Door Way." The ODM is a faith-based, 120-bed homeless and drug treatment facility located in Houston providing daily meals and beds to area and transient homeless persons. The Door Way program is a nine-month drug rehabilitation center, providing religious studies, as well as educational, vocational, basic health, and biofeedback services. The Door Way program does not utilize traditional substance abuse treatment modalities such as individual, group, and family therapies nor adherence to twelve-step programs. The mission also contracts with Harris County nurses to provide basic health care, including first aid and communicable disease testing. On average, the program can accommodate 80 "students" at one time as permanent residents.

Students are required to attend 15 religious study classes per week, as well as to maintain designated responsibilities within the property, from kitchen duties to landscaping. After the first two months or completion of biofeedback offered by SHTF, students are eligible to attend GED or computer training classes. Vocational training is offered towards the end of the nine-month program. To be eligible for the study participants had to meet criteria for substance abuse disorder for cocaine/crack cocaine, as diagnosed by the DSM-III-R (APA, 1987). Additionally, participants had to have the cognitive ability to provide educated informed consent, as well as the absence of schizophrenic or active seizure disorders. Informed consent, in a form approved by the University of Texas Health Science Center, Houston, was obtained from all participants prior to participation with copies provided when requested. From April 1999 to April 2000, 34 participants were paid $250 each for follow-up completions. Funds were provided by the Open Door Mission, but after April 2000 no other follow-up compensation was offered.

Four hundred and thirty (430) crack-addicted participants were assessed as eligible for participation in this study over the last four years. Two hundred and twenty-four participants (48%) dropped out before the completion of all 30 EEG-OC sessions (*mean* = 10.2 sessions), 20 dropped out before treatment began (4.6%), and 8 opted out of participation (1.7%). These participants were not followed after leaving the program. Subsequently, data was analyzed for the remaining 178 DSM-IV cocaine-dependent males residing in the Door Way drug treatment program that had completed all 30 sessions. Nearly half of the original 178 participants who completed the program (49%) were located for one-year follow-ups. Table 1 presents the demographic characteristics for the sample.

Participants averaged 40.4 years of age ($SD = 7.57$) and 11.5 years of education ($SD = 2.18$). Sixty-four percent of participants reported previous incarcerations (*mean* = 2.8 times, $SD = 3.85$), with 84.7% of those classified as drug offenses. Two-thirds reported daily crack-cocaine use ($n = 117$) and one quarter reported weekly use ($n = 45$), for a high abuse severity for 92.6% of participants. Nearly 81% of participants were African-American. Self-reports indicated an average of 12.6 ($SD = 6.42$) years of crack cocaine addiction, with 60% of participants reporting polysubstance abuse. Eighty-four percent (84%) were unemployed at intake and 85.9% of participants reported a history of previous treatment episodes (*mean* = 3.6, $SD = 3.81$).

TABLE 1. Subject Characteristics ($n = 178$)

Variable	%	*Mean*	*SD*	Range
Age		40.49	7.57	[21-65]
Education		11.5	2.18	[5-18]
Previous treatment episodes		3.59	3.81	[0-16]
Years of crack abuse		12.66	6.42	[1-40]
Incarcerations	64.5	2.8	3.85	[1-25]
Ethnicity				
Black	80.7			
White	15.3			
Military history	29.2			
Employed	15.7			
Homeless	60.0			
Daily crack use	66.9			
Weekly crack use	25.7			
Drug related incarcerations	84.7			

Equipment

The CapScan EEG/EMG C-80 Biofeedback System (American Biotech Corporation, Ossining, NY) was utilized with all participants involved in this investigation. The CapScan is a computerized biofeedback data acquisition system. Its primary use is to facilitate voluntary control and monitoring of brain wave physiological states to allow implementation of neurotherapy protocols. The CapScan is a single amplifier, real time feedback system. Raw EEG is sampled at 128 bits per second, utilizing a fast Fourier transform (FFT) filter device. The digital filtering of white noise as well as low level AC biopotentials allows the EEG signal to be appropriately processed before analog to digital conversion. The filters are designed to measure and feedback a range of 1-40 Hz EEG and 1-200 Hz EMG. Data integration allows for monopolar and bipolar hook-ups, with ground and reference electrodes designed for ear lobe attachment. Scalp electrode placement was based on the International 10-20 Electrode System.

Outcome Measures

The primary outcome measure for this study was a urine toxicology screen obtained at twelve-month follow-ups. ProXam urine assays were used, which detect active metabolites associated with crack-cocaine ingestion as well as marijuana use. Participants were monitored by researchers to ensure authenticity of urine specimens. Baseline and post-treatment self-report measures were the Beck Depression Inventory (BDI; Beck & Steer, 1987), Clinical Anxiety Scale (CAS; Thyer, 1992), and an intensive social history questionnaire, including drug use behavioral measures. Post-treatment abstinence was assessed with a self-report questionnaire (contact the corresponding author for a copy of these two questionnaires). The BDI is a 22-question, self-report inventory with an internal consistency of .89 when employed with crack cocaine users (Falck, Wang, Carlson, Eddy, & Siegal, 2002). Falck et al. report that the BDI may be a suitable tool since it has an acceptable level of internal consistency when employed with crack users. The CAS is a 25-question, self-report inventory measuring symptoms of anxiety and stress. At 12 month follow-up, questionnaires were completed on site at the time of urinalysis. Finally, length of stay was measured in number of days of residence within the mission setting. Initial entry was documented at point in time of acceptance into the Door Way drug treatment program, which was measured at an average of one-week post mission arrival. The last day of stay was documented by Door Way staff when the subject moved out of the residential program.

Treatment Sessions

Treatment sessions followed a modified "Peniston protocol" format (Peniston & Kulkosky, 1989). The major difference between the protocol described here and Peniston's was that temperature biofeedback training was not used for initial sessions. Instead, a 4-8 Hz inhibit coupled with a 13-15 Hz enhancement utilizing an FP1/T4 bipolar hookup was substituted for the temperature training sessions. Rationale for the first change is based on the premise that temperature feedback has been demonstrated to reduce 4-8 Hz (theta) and enhance 13-15 Hz (SMR beta), as well as incite relaxation training (Kaiser et al., 1999). The theta-down, beta-up protocol was used until a drop in theta (generally 25% decrease) amplitudes was detected and maintained (ranging from session 5 to session 8), at which point the second phase of training consisting of alpha-theta sessions utilizing an O1 hookup began. Alpha-theta sessions were accompanied by a relaxation and drug rejection scenario script (available from the corresponding author on request). All participants received identical script content and administration. Sessions were conducted in functionally identical treatment rooms.

EEG-OC Training

Participants received a brief demonstration of the equipment prior to beginning training. After introduction to the technique, all participants received 30 sessions of EEG-OC, averaging three sessions a week. Session progress was interpreted and related to participants by SHTF biofeedback providers. During treatment, participants were left alone in the biofeedback rooms, and practitioners observed session progress through the door window. Biofeedback specialists only entered the treatment rooms in the event of equipment malfunction or if the subject was not receiving the appropriate amount of feedback.

Sessions 1 through 7 (on average) were eyes-open sessions consisting of inhibiting theta (4-8 Hz) and enhancing beta (13-15 Hz). Visual feedback was presented in the form of dynamic circles, driven by increases and decreases in brain wave amplitudes. Auditory feedback was delivered through headphones only when the subject's theta had dropped below a predefined threshold and their beta had exceeded a predefined threshold. Thresholds were set by the therapist according to previous ses-

sion measurements, maintaining approximately 75 to 80% beta reinforcement and 75 to 80% theta inhibit. Thresholds varied among participants due to variables such as skull thickness or brain function. Theta and beta tones were discriminated by pitch, the theta tone being lower than the beta. After the threshold had been reached, the tones gradually increased in volume.

At approximately session 8, the training protocol switched to enhancing theta (4-8 Hz) and enhancing alpha (8-12 Hz) amplitudes. No visual feedback was provided given the sessions were eyes-closed. Auditory feedback was delivered through headphones only when the subject's theta or alpha amplitude had exceeded a predefined threshold. Again, thresholds were set by the therapist according to previous session measurements, maintaining approximately 75% alpha to 25% theta feedback. Alpha and theta tones were discriminated by pitch, the alpha tone being higher than the theta. After the threshold had been reached, the tones gradually increased in volume. Total session involvement ranged between 35 to 45 minutes. Session one lasted for 10 minutes, sessions two through seven lasted for 20 minutes, and the remaining sessions (alpha/theta sessions) were 30 minutes in length.

RESULTS

Abstinence Measures

Figure 1 shows self-reported drug and alcohol use for the 12-month follow-up. One-year follow-up of 87 participants who completed treatment indicated 49.4% of participants reported no crack use 12 months after completion of EEG-OC sessions. Forty percent (40%) of participants used crack one to nine times after completion during a lapse, but were clean at follow-up. The remaining 10.4% reported using crack more than 20 times over the previous year indicating a full relapse to crack cocaine addiction. Self-reports indicated that 90% of the men did not use alcohol or marijuana during the previous twelve months. Forty-five percent (45%) of those who used anything returned to treatment. Table 2 identified reported crack cocaine use compared to urinalysis results.

There was no evidence of denied verified use of cocaine confirmed by urine toxicology results (98% agreement). The 10.8% of positive U/A screens parallels the 10.4% of participants who reported full relapse at twelve months. Of the 40.1% who reported a lapse back to crack use (as defined by singular use [one to nine times] not relapse into addiction) but reported being clean at follow-up, 39.2% exhibited negative crack co-

FIGURE 1. Self-reported frequency of crack, alcohol, and marijuana use at 12-month follow-up. ($n = 87$)

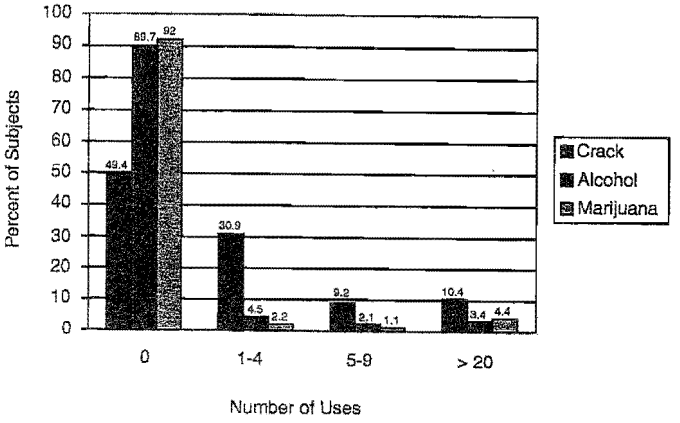
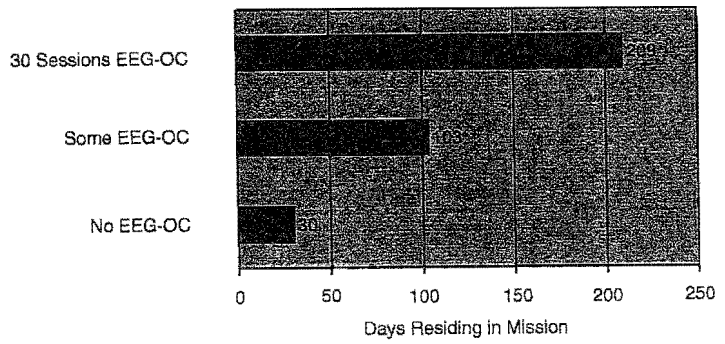


TABLE 2. Self-Reported Crack Usage Over Previous 12 Months Compared to One-Year Follow-Up.

Urinalysis Results ($n = 87$)	Subjects with Negative U/A	Subjects with Positive U/A
Subjects who reported non-use	49.4% ($n = 43$)	0.0% ($n = 0$)
Subjects who reported use	39.1% ($n = 34$)	11.5% ($n = 10$)

FIGURE 2. Treatment length in days (retention) for 0EEG-OC group compared to length of stay prior to implementation of treatment (No EEG-OC).



caine analyses, indicating that U/A results corroborated self-reports of crack use exceedingly well.

Treatment Retention

Figure 2 shows a comparison of the mean number of days in treatment for clients who received EEG-OC versus those who entered the ODM program before the addition of EEG-OC.

On average, participants receiving EEG-OC sessions stayed in treatment 103 days longer compared to those who did not. Of those who completed all 30 sessions ($n = 178$), treatment retention increased to 209 days. Similarly, before neurotherapy, the addiction program was "graduating" 12 men per year from their nine-month drug treatment program, which increased to an average of 12 graduates per month due to more men staying long term in the program. Fifty-seven percent (57%) of EEG-OC participants who completed the program continued in treatment until the nine-month program graduation.

One-year follow-ups of 87 participants who completed all 30 EEG-OC sessions indicated that 92.0% of participants were maintaining a regular residence, compared to 40.0% at intake. At intake, only 16.7% of participants were employed or in school or training–a sharp distinction

TABLE 3. T-Test Results of Change in Average Depression and Anxiety Scores ($n = 178$) at Treatment Completion and 12-Month Follow-Up.

Treatment Completion

Variable	Intake Score	Post Score	Change	t value	p
Depression	19.49	6.80	−12.69	15.84	.0005
Anxiety	22.26	10.34	−11.92	12.08	.0005

12-Month Follow-Up

Variable	Intake Score	12 Month Score	Change	t value	p
Depression	19.49	5.76	−13.73	7.38	.0005
Anxiety	22.26	9.64	−12.62	5.68	.0005

between the 90.8% that were employed or in training at one-year follow-ups. Eighty-eight percent (88%) had no subsequent arrests twelve months post-treatment, with only 2 out of 87 participants being re-arrested for drug violations.

Psychological Measures

Table 3 shows the results of t-tests analyzing improvements in depression and anxiety measures for participants between intake and treatment completion and intake and one-year follow-up. The table indicates that depression scores significantly decreased from pre-treatment to the completion of 30 EEG-OC sessions ($t[156] = 15.84, p < .0005$), and decrease remained significant from intake to 12 months post-treatment ($t[156] = 12.08, 9 < .0005$). Results were similar for the anxiety measure from pre- to post-30 sessions ($t[41] = 7.38, p < .0005$) and pre-treatment to 12-month follow-up ($t[44] = 5.68, p < .0005$).

DISCUSSION

These results showed that when EEG training was added to an addiction recovery program for male cocaine users the relapse rate was 51.6% after 12 months (49.4% had no use). Forty percent (40%) used cocaine less than nine times in a 12-month period. This is a significant decrease in relapse rates compared to conventional forms of substance abuse treatment that report 65 to 70% relapses within the first year after treatment (McKay, Atterman, Rutherford, Cacciola, & McLellan, 1999). Furthermore, participants with high-severity problems, as defined by weekly or daily use, have significantly higher rates of relapse, though the current findings were based on over 90% high-severity participants. Given the discrepancy between "lapse" and "relapse" in the addiction literature, it is important to recognize the large gap in number of uses reported. At follow-up, participants regularly reported no uses, or one through nine uses; in fact, 30.4% of the participants who used crack cocaine after treatment reported using one, two, three or four times. After self-reports of nine uses, the number jumped to 20 times or greater, moving into the upward range of more than 100 uses. Marlatt (1985) calls the initial return to the addictive behavior a "lapse" and distinguishes it from the destructive loss of control of complete "relapse." Lapse can be considered a normal part of the recovery process, not a complete failure. It is a way to test newly learned coping skills and override old behavioral patterns.

Overall, these findings suggest that the combination of electroencephalographic operant conditioning (EEG-OC) and faith-based programs is effective in the treatment of crack cocaine addiction. Similarly, the lack of post-treatment alcohol and marijuana use at twelve months is significant, given that many prior cocaine addicts substitute other drugs for their addiction. The observed BDI reductions are significant in light of research that suggests the prevalence of depression among crack users is higher than has been reported in the past (Falck et al., 2002). Anxiety reduction is important in that it has been shown to be a predictor of relapse in alcohol dependency, which can lead to subsequent cocaine use (Willinger et al., 2002). Goeders (2002) reported similar data and suggests that stress reduction can possibly help reduce cravings and promote abstinence in individuals seeking relief from cocaine addiction. Richard, Montonya, Nelson, and Spence (1995) similarly report that therapies that alleviate anxiety, depression and other effects associated with drug addiction recovery are beneficial adjuncts to treatment. Richard et al. (1995) also found that EEG-OC was among a group of adjunct therapies that improved attendance rates and therefore indirectly contributed to successful treatment. EEG-OC appears to be a powerful adjunct, with research evidencing decreases in anxiety and depression, as well as increasing treatment retention.

There are limitations of this project. First, no control was included in the initial experimental design; therefore, no direct attribution of treatment modalities can be assessed. Implementing a control was initially difficult for a few reasons. First, participants in such close living quarters readily converse about their treatment sessions. Students who received EEG-OC would eventually speak with those who did not, and this subject insight would lead to self-fulfilling prophecies of treatment success. Another difficulty was related to ethical considerations. The ODM invited SHTF to provide treatment to all students. The ODM believes very strongly in the efficacy of the EEG-OC and therefore, did not consent to allowing a subset of its students to be in a control group. Though there was no control group, the data does show the synergy of the available components within the ODM program is effective in reducing crack cocaine addiction. There is also evidence of reductions in criminal behavior, homelessness, and unemployment, as well as increases in treatment retention with the addition of EEG-OC.

Another limitation is the reliance upon self-report measures. Self-report validity studies have varied in conclusions; however, it is noted that when there are no contingencies for reported use, self-report data is fairly accurate (Amsel, Mendell, Matthias, Mason, & Hocherman, 1976; Bonito, Nurco, & Schaffer, 1976; Milby & Stainback, 1991; Schumacher et al., 1995). In the current study at the ODM, there were no contingencies upon self-reported drug use. Also, data was collected in a non-threatening manner and confidentiality was assured, two other components that have been shown to improve self-report validity (Weatherby et al., 1994).

Additionally, nearly 50% of the participants who completed the program were not located for the one-year follow-up. Most follow-ups were completed when participants returned to the mission setting for social events or even to return to treatment. Phone contacts were obtained, but given the transient nature of the population, only a handful of participants were located. Therefore, it is a possibility that a large number of available follow-ups were not located due to: (a) a complete relapse to drug use, or (b) because they are no longer abusing drugs, but are working full-time. As mentioned earlier, participants were no longer offered compensation for completion of follow-ups after 2000. Without an incentive, few participants would be willing to sacrifice their work hours even if located.

Last, the initial design of the study itself is a limitation. EEG-OC protocols were not significantly individualized for each subject's personal

needs. For instance, outside of a research setting, a practitioner may choose to work at different scalp sites with different brain wave bandwidths according to symptom reports. This study specifically tested a version of the Peniston protocol with crack cocaine abuse. Furthermore, given the large number of participants and the treatment setting itself, the EEG-OC practitioners were not able to remain in the treatment rooms with the participants during training. Therefore, no feedback was available during sessions, including changing of thresholds or even preventing a subject from sleeping during the learning process.

Given the success of the Open Door drug abuse treatment program, interpreted carefully with the aforementioned limitations in mind, it is imperative to address which intervention components are attributing to the positive results, and by doing so allow scientific research to bridge the gap to clinical utility. As mentioned before, this project, as a treatment outcomes study, cannot assign outcome to any particular modality. However, one can assess individual components of the program from prior literature and ascertain what may be attributing to the overall success of the ODM.

First, the Door Way program is a faith-based treatment facility. Faith-based programs have been shown to be successful in addiction recovery. The role of religion has a long-standing place in addiction recovery, though little scientific research has validated its contribution.

Second, ODM is a long-term residential (LTR) treatment program. Long-term residential treatment programs have been shown to have good treatment results in comparison to brief out- or in-patient programs (NIDA, 2001).

Third, the program offers EEG-OC, which has had positive outcomes in the treatment of addictions. Furthermore, the EEG-OC increased the length of retention in treatment three fold, culminating in three months on average, which has become the gold standard in addictions treatment. The significant increase in length of stay from pre to post EEG-OC introduction may also be attributable to the comorbidity of ADD/ADHD and substance abuse. As mentioned earlier, Moeller et al. (2001) proposed that impulsivity and attention were significant predictors of high drop out rates as well as continued drug use in individuals seeking treatment for cocaine addiction. Given that treatment of addictions generally involve interventions that are cognitive and/or spiritual (identifying maladaptive behavior patterns, managing stress, etc.), the ability to comprehend, learn, and apply the information presented in treatment entails cognitive function. Difficulty attending to these tasks might inhibit individuals from profiting from substance abuse treatments, and they would have a

greater chance of dropping out of treatment and relapsing (Horner, 1999).

Cocaine abuse is a complex process involving biological, behavioral, and social factors. Therefore, cocaine treatment itself needs to address a myriad of issues. One important direction for EEG-OC research may be to address which component of the addictions process is being changed. One possibility may be located in the area of attention deficits. Problems in attention and impulsivity have been noted to be significantly greater in cocaine users when compared to non-users. Several studies to date have identified attentional processing difficulty in patients living in controlled environment cocaine treatment facilities (currently abstinent). Beatty, Katzung, Moreland, and Nixon (1995) found cocaine abusers to perform poorer than non-abusers on attentive tasks, such as Trails A and B, Digit Symbol, and Arithmetic tasks of the WAIS-R. O'Malley, Adamse, Heaton, and Gawin (1992) found inconsistent results overall, but did report cocaine abusers perform poorer on tests such as Digit Symbol and Arithmetic subtests. Gillen and Hesselbrock (1992) noted that information processing speed was slower in cocaine users, but sustained attention was unimpaired. Rosseli and Ardila (1996) compared cocaine users to controls and found that users were more impaired on tests addressing attentional variables as well. Horner (1999) reports that all tasks in which cocaine dependent patients demonstrated impairment were sensitive to speed of information processing. He also notes that most tasks requiring motor speed, executive functions, or calculation ability were also impaired.

EEG-OC has been shown to improve attention and concentration in individuals (Lubar & Shouse, 1976; Cartozzo, Jacobs, & Gevirtz, 1995; Scheinbaum, Zecker, Newton, & Rosenfeld, 1995). Therefore, it is possible that EEG operant conditioning in actuality is improving the ability of an addict to attend to rehabilitative interventions, and at the same time decreasing impulsivity related to dropout rates and relapse. For a program to be effective, drug treatment facilities need to incorporate a variety of services. Nunes-Dinis and Barth (1993) suggest that these services could include education, vocational training, medical services, social support, and counseling. Conventional programs with one-month stays and without the above services provided as follow-up components have not been shown to be effective (NIDA, 2001).The Door Way long-term residential drug treatment program has incorporated education, vocational training, and social support into its treatment program.

Currently, SHTF is implementing a controlled study within the ODM. The goal of this study is to assess treatment retention, attention, im-

pulsivity, and cognitive differences in control and experimental groups with EEG-OC as the independent variable. The difficulty in setting up a controlled, single-blind study has deterred researchers in the past from executing well-designed, scientific studies with EEG feedback. SHTF has devised an "apparatus control" design to control for treatment novelty, therapeutic time, and Hawthorne effects. The apparatus control group will be hooked up to the EEG equipment exactly the same as the experimental group. Sessions will parallel real feedback sessions, with the only difference being that no visual or auditory *feedback* is provided. Participants are still instructed to watch the screen during eyes-open sessions, but a static brain wave spectrum recording is presented. The principle behind this idea is that to provide "sham" feedback is in fact to provide feedback, though non-contingent on brain activity. Therefore, holding true to operant conditioning principles, during sham feedback the subject would in fact learn to associate the tonal/visual feedback with brain functioning, which could reinforce inappropriate responses. The development of this research design has incorporated an intensive evaluation of possible placebo effects of biofeedback, with the main goal being to research the measurable effects of EEG-OC as a valuable adjunct in the treatment of crack cocaine addiction.

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