Published in final edited form as:
Am J Drug Alcohol Abuse. 2012 March ; 38(2): 146–154. doi:10.3109/00952990.2011.643986.

Measures of attentional bias and relational responding are associated with behavioral treatment outcome for cocaine dependence

Kenneth M. Carpenter, Ph.D.[*],
Columbia University and New York State Psychiatric Institute

Diana Martinez, M.D.,
Columbia University and New York State Psychiatric Institute

Nehal P. Vadhan, Ph.D,
Columbia University and New York State Psychiatric Institute

Dermot Barnes-Holmes, Ph.D., and
National University of Ireland, Maynooth

Edward V. Nunes, M.D.
Columbia University and New York State Psychiatric Institute

Abstract

Background—Psychosocial interventions for substance dependence have demonstrated efficacy. However, the mechanisms by which specific intervention strategies exert their effect have not been clearly identified.

Objective—This study investigated the prospective relationships between two psychological processes, an attentional bias towards cocaine stimuli and beliefs about the consequences of cocaine use, and treatment outcome.

Method—Twenty-five cocaine dependent participants enrolled in a 6-month outpatient treatment program that included voucher incentives for abstinence. All participants were asked to complete two implicit assessment procedures, a Drug Stroop protocol and an Implicit Relational Assessment Procedure (IRAP), as well as explicit measures of cocaine craving and the consequences of cocaine use, prior to beginning treatment. Pearson-correlation coefficients tested the prospective relationships between treatment outcome and the implicit and explicit assessments.

Results—Stronger implicit beliefs about the positive effects of cocaine use prior to treatment were associated with poorer treatment outcome when an escalating voucher incentive program was in place. Further, an attentional bias for cocaine-related stimuli was associated with better treatment outcome when an escalating voucher incentive program was removed. No association between cocaine use beliefs and treatment outcome was found when beliefs were measured with self-report instruments.

Conclusions and Scientific Significance—These findings highlight the potential utility of performance based measures for delineating the psychological mechanisms associated with variation in response to treatment for drug dependence.

Correspondence should be sent to the first author at 1051 Riverside Drive, Box 120, New York, NY 10032, 212-923-3031. carpent@nyspi.cpmc.columbia.edu.

Declaration of Interest
The authors report no conflict of interest. The authors alone are responsible for the content and writing of this manuscript.

Keywords

Cocaine dependence; Treatment; Attentional Bias; Implicit Cognition; IRAP

Introduction

Psychosocial interventions for substance use disorders can facilitate behavior change (1). However, treatment specific mechanisms have yet to be identified (2), which suggests that treatments may exert their influence through pathways common to different intervention strategies. The actions of attending and deriving relations have been implicated in the development and maintenance of behavioral disorders (3,4), including drug dependence (5,6) and correspondingly may be two overarching psychological mechanisms by which counseling-based interventions influence drug use behavior.

Substance users are more likely to attend to stimuli related to their substance of choice compared to non substance users (5) and relatively stronger attentional biases towards drug-specific stimuli are associated with worse treatment outcome (7,8). Incentive-motivational theories of drug use postulate that attentional-biases towards drug-associated cues are primarily driven by reward-based mechanisms (9). In line with this perspective, counseling strategies have been developed to help individuals become more attentive to the circumstances surrounding their substance use (e.g. identify people, places, things, or triggers) in order to implement alternative behavioral responses (10,11) or employ attentional training exercises to shift attending behavior away from drug related stimuli (i.e. reduce attentional bias) to disrupt the incentive-motivational process promoting drug use (12). In contrast, the presence of an attentional bias may be influenced by an individual's goals to avoid further substance use (5). That is, the stimuli may not initiate an appetitive process but promote an avoidance or fear-based process. This notion is supported by findings demonstrating an attentional bias among cocaine-dependent participants relatively motivated to avoid substance use (i.e. seeking treatment) but not among non-treatment seeking cocaine-dependent individuals (13). Thus, the presence of an attentional bias under these circumstances may highlight an important shift in the motivational processes called forth in the presence of drug related stimuli.

Drug and alcohol users derive relationships between their substance use and the occurrence of specific consequences, which can differ in both degree and valence. These differences predict variation in substance-related attentional bias (14) as well as substance use in non-dependent (15) and dependent populations (16). Further, the degree to which individuals derive relationships between their substance use and negative consequences prior to beginning treatment predicts reduced use in both alcohol (17) and cocaine (18) abusers. These findings suggest that effective Motivational Interviewing and CBT counseling strategies, such as building a discrepancy and working through a functional analysis, respectively, may build upon pre-established beliefs about the negative effects of substance use rather than develop new, or modify, pre-established relationships. Overall, it is believed that counseling strategies that can influence the types of stimuli individuals attend to and the relations individuals derive between their substance use and its consequences can facilitate a better understanding of the circumstances promoting drug use, provide a context for altering the positive incentive value of substance use, and help reduce the frequency of drug use behavior.

The present study investigated the prospective relationships between an attentional bias towards cocaine stimuli, the derived relations between cocaine use and positive and negative consequences, and treatment outcome. Understanding the specific processes promoting

attentional biases and how derived relations between substance use and its consequences impact attentional biases and treatment outcome may help identify individual level factors that account for the significant variation in treatment response (19). Since there is evidence that the association between substance use outcome beliefs and treatment outcome may be dependent upon the assessment methods employed (20), the present study utilized both explicit and implicit measures of cocaine effect beliefs.

Method

Participants

The study was approved by the IRB of the New York State Psychiatric Institute. All participants were active cocaine users seeking treatment at Columbia University's Substance Treatment and Research Service (STARS) as part of a study investigating the neurobiological correlates of behavior change during treatment for cocaine dependence (21). Participants responded to print and radio advertisements distributed throughout the New York City area. The screening evaluation included the Structured Clinical Interview for DSM-IV disorders (SCID-IV), an independent psychiatric evaluation, and a medical exam. Individuals were eligible to participate if they were between the ages of 21 and 45, met criteria for a current DSM-IV diagnosis of cocaine dependence, and could demonstrate 14 days of abstinence from cocaine prior to the neurobiological assessment procedures. Participants who could not provide 14 days of abstinence from cocaine prior to initiating the study were offered a two-week inpatient stay to satisfy this requirement. Exclusion criteria included currently meeting criteria for other Axis I DSM-IV disorders, lifetime criteria for dependence on a psychostimulant other than cocaine, reporting the current use of psychotropic medication or the use of opiates, sedative-hypnotics, or cannabis more than twice per week, and/or the presence of severe medical (e.g. hypertension, active hepatitis) or neurological illnesses.

Twenty-five participants completed a baseline assessment session, met inclusion criteria, and gave informed consent to participate in the study. On average, the sample was 37 years of age (SD=7.1), predominantly male (88%) and was racially mixed (36% Caucasian, 28% African-American, 24% Hispanic, and 3% other). Sixteen percent of the participants reported not graduating high school, 48% reported having a high-school or equivalent diploma, and 36% reported having more than a high-school education. On average, cocaine was first used at the age of 22 years (SD= 6.7 years) and was being used on 13 of the 30 days prior to screening (SD= 9.0 days). Approximately 35% reported intranasal cocaine use, 15% reported smoking cocaine, and 47% reported using both administration routes. One participant was not able to read and thus did not complete a majority of the assessment instruments. Five individuals did not complete the Implicit Relational Assessment Procedure (IRAP) and self-report instruments but did complete the Drug Stroop assessment. All assessments (IRAP, Drug Stroop, Cocaine Effects Questionnaire, and CCQ) were conducted during the first week of treatment prior to beginning the counseling sessions.

Treatment Program

The 24-week outpatient program used the Community Reinforcement plus vouchers treatment approach (22). The counseling program had two phases (i.e. weeks 1 to 12 and 13 to 24). During phase-one participants were scheduled to attend the clinic three times per week. Participants met with their counselor one hour on two of these visits to develop the behavioral skills needed to decrease cocaine use and increase alternative non-drug use behaviors.

Urine samples were collected on each visit. Participants earned voucher points worth $0.25 for every sample that tested negative for cocaine. Participants also received a $10 bonus for every three consecutive cocaine-free urine samples. The number of voucher points earned started at 10 and escalated by 5 points with each consecutive cocaine metabolite-free urine. Missed clinic appointments and cocaine positive-urine samples reset the voucher earnings to the starting value, although participants did not lose the amount of points they had earned prior to the reset. Participants could reclaim their voucher point maximum by providing 5 consecutive cocaine free urines. All urine samples were collected under the observation of a staff member, and were immediately tested (chromatographic immunoassay) for the presence or absence of benzoylecgonine using the standard NIDA cutoff (300 ng/mL). All participants received immediate feedback on the urine analysis and their cumulative voucher earnings at each clinic visit. A maximum of $997.50 in vouchers could be earned for submitting cocaine free urines on all 36 scheduled treatment visits over the course of 12 weeks.

During phase-two, participants were scheduled to attend the clinic twice per week and met once per week with their counselor for approximately one hour. The escalating voucher system was discontinued; instead a New York State lottery ticket was earned for each cocaine-free urine. Counseling sessions were audio taped and reviewed by a supervising psychologist for fidelity and supervisory purposes.

Measures

Treatment Outcome—The primary outcome variables were: 1). the percentage of therapy visits attended (total number attended/total number scheduled), 2) the total amount of voucher earnings earned (dollar amounts for phase-one; the number of lottery tickets earned during phase-two), and 3) the total percentage of urines testing negative for cocaine. Since the voucher incentives and the frequency of therapy sessions differed over the course of treatment, the outcomes were calculated separately for each phase of treatment. Entering phase two of the treatment was also coded (i.e. yes or no) and analyzed as an outcome variable. Scheduled urine samples that were not collected were coded as cocaine positive.

Drug Stroop—The drug stroop task requires participants to respond to the color (blue, red, green, yellow) of a drug related or neutral (non-drug related) word by pressing the same colored key on a response pad as quickly and accurately as possible (7) . For each trial, a fixation-cross appeared in the center of the monitor screen for 1000ms and was then replaced by a colored word. Each word remained on the screen until the participant responded or for a maximum time period of 6000ms. Two blocks of 50 trials, for a total of 100 words (20 words for each for heroin, cocaine, marijuana, mixed drug, and neutral word groups), followed 16 practice trials. A 5-minute rest period was programmed into the task following the completion of the first block of 50 words. The primary measure was interference from cocaine related words, which was calculated for each participant by subtracting their average response time on neutral words from their average response time to the cocaine words. Positive values (i.e. slower responding to the cocaine words) are interpreted as reflecting an attentional bias towards cocaine related stimuli.

Implicit Relational Assessment Procedure (IRAP; 23,24)—The IRAP was employed as an implicit measure of an individual's beliefs about the positive and negative consequences of cocaine use. The IRAP was utilized because it offers numerous advantages over other implicit measurement procedures. In terms of the present study, it provided an assessment of four different implicit relations regarding cocaine use (see below), thus offering a non-relativistic assessment of implicit beliefs unlike other implicit assessment procedures. The IRAP also has the potential to assess the flexibility with which individuals

hold particular beliefs about cocaine use by requiring participants to respond in both a consistent and inconsistent manner across all presented items.

The IRAP is a computer-based task in which participants were asked to respond quickly and accurately in ways that may be similar or dissimilar to their established beliefs about cocaine use. Data collection coincided with the availability of an early version of the IRAP program (v2005). Participants were exposed to two practice blocks and six test blocks. Each block presented the same 12 trials. For each trial, a category label was presented at the top of the screen (the words 'With Cocaine' or 'No Cocaine'), one of 12 target phrases in the center (i.e., Positive Phrases: I am sexier, I am in-control, I am friendlier, I am nicer, I am talkative, I have no pain; Negative Phrases: I am jumpy, I am paranoid, I am alone, I am tense, I am mean, I want to fight), and the two response options, 'true' and 'false', in the bottom corners (see Figure 1). All the stimuli were presented simultaneously and remained visible until the participant made a response. Selecting a correct term removed all the stimuli from the screen for 400ms and the next trial was then presented. Selecting the incorrect term produced a red 'X', which remained on the screen until the participant selected the correct response term.

A correct response was defined in terms of whether the participant was completing a consistent block or inconsistent block of trials. During a consistent block, participants were required to respond to the four trials types in the following manner: 'with cocaine' trials as having positive consequences (e.g. 'with cocaine' – 'I am sexier' – *true)* and no negative consequences (e.g. 'with cocaine' – I am tense- *false*) and 'no cocaine' trials as having negative consequences (e.g. 'no cocaine' – 'I am alone – *true*) and no positive consequences (e.g. 'no cocaine' – 'I am friendlier' - *false)*. During an inconsistent block the feedback contingencies were reversed and participants were required to respond to 'with cocaine' trials as having no positive consequences (e.g. 'with cocaine' – 'I am sexier' – *false*) and having negative consequences ('with cocaine' – I am tense- *true*) and 'no cocaine' trials as having positive consequences (e.g. 'no cocaine' – 'I am friendlier' - *true)* and no negative consequences (e.g. 'no cocaine' – 'I am alone' – *false*). Thus, each block containing the four trial types (Figure 1), could be characterized as being pro-cocaine (consistent blocks) or anti-cocaine (inconsistent blocks) depending on the feedback contingencies in place. The pro-cocaine block (defined here as consistent-relations) was presented first to half the participants and the anti-cocaine (defined here as inconsistent-relations) block presented first to the other half. The target phrases for each item were taken from items most strongly related to the positive and negative cocaine effect factors on the Cocaine Effects Questionnaire (18).

For the first two practice blocks, participants were informed that it was a practice phase and the experimenter remained in the room to answer any questions during this part of the assessment and observe the participants' engagement with the task. After completing the two practice blocks all participants moved into the test phase of the assessment irrespective of their performance during the practice blocks. The location (bottom right and bottom left) of the two response options for each item (e.g. 'true' and 'false') varied for every item presentation. The time that elapsed from the presentation of the item until a correct response was recorded (response latency) was used to calculate the IRAP D scores.

Similar to other implicit assessment methods it is hypothesized that the average response latencies should be shorter for the blocks of items that are consistent with an individual's beliefs compared to blocks that are inconsistent with their beliefs. Thus, individuals who relate cocaine use to positive consequences, or not using cocaine to negative consequences, should respond quicker on the IRAP trials that were categorized as "pro-cocaine" and slower on the IRAP trials that were categorized as "anti-cocaine". An overall index, A D-IRAP score, based on differences in response times between the pro-cocaine and anti-cocaine trials

across the six test blocks, was calculated for each of the four trial types and for the overall assessment (22). The D-IRAP score is an adaptation of the D-algorithm scoring for the Implicit Association Test (25) and functions to characterize the difference in performance between the two response sets (pro-cocaine and anti-cocaine) while minimizing the impact of factors such as age, motor skills, and/or cognitive ability on latency data. A positive D-IRAP score reflects relatively stronger pro-cocaine beliefs (i.e. or slower responding during the inconsistent test blocks compared to the consistent test blocks). In contrast, a negative D-IRAP score reflects relatively stronger anti-cocaine beliefs. In accordance with recommended D-IRAP calculation procedures, one participant's data was eliminated because more than 10% of their response latencies were less than 300ms.

To assess the internal consistency of the IRAP, test trials were designated as odd or even depending on their order of presentation. Two D-scores, one based on even trials and one based on odd trials, were calculated for the four individual trial types (With Cocaine Positive; With Cocaine Negative; No Cocaine Positive, and No Cocaine Negative), the two category labels: 'With Cocaine' and 'No Cocaine', and an overall D-score. Split-half correlations between the D-scores calculated from the odd and even trials applying Spearman-Brown corrections were calculated (n=19 for all reliability analyses). Reliabilities for the individual trial types were as follows: With Cocaine Positive, r=.35; With Cocaine Negative, r=−.15; No Cocaine Negative, r=.47; and No Cocaine Positive, r=.34. The poor reliability for the With Cocaine Negative trials was due to two significant outliers on the even trials (the split-half correlation was r=.44 with the participants removed). Reliabilities for the two category labels and overall score were adequate: 'With Cocaine' trials r=.74; 'No Cocaine' trials r=.49; and overall D-score r=.85.

Cocaine Effects Questionnaire (18)—The CEQ is a 33-item self-report instrument assessing a participant's belief in the short term positive and negative consequences of their own cocaine use. Each item is rated along a 7-point Likert scale with the anchors of 1("never") and 7 ("always"). Items load on four positively valenced factors (enhanced well-being, sexual enhancement, social facilitation, and pain reduction) and three negatively valenced factors (social withdrawal, aggression, and increased tension). The global positive (the average of the four positive valence factors; Cronbach's alpha .93 for this sample) and negative effect (the average of the three negatively valenced factors; Cronbach's alpha .81) scales were used for the present study.

Cocaine Craving Questionnaire (CCQ; 26)—The CCQ is a 45-item self-report instrument developed to assess a general level of cocaine craving and urges for cocaine experienced over the preceding week (e.g. "I want cocaine"). Items are rated along a 7-point Likert scale with the anchors of 1 ("Strongly Disagree") and 7 ("Strongly Agree"). The CCQ total score, an averaging of the responses across the 45 items, was used for the present study (Cronbach's alpha .62).

3.0 Results

3.1 Treatment Outcome

Treatment and assessment outcomes for the entire sample are presented in Table 1. Over-half the participants completed the first phase of treatment and approximately a third completed the full 6-month treatment program. On average, participants attended a majority of treatment sessions and demonstrated a little more than a month of continued abstinence during phase-one. The attendance rate and proportion of cocaine negative urines were reduced during phase-two, the point at which the escalating voucher system was removed.

3.2 Self-Report Assessments

On average, participants' endorsement of negative and positive consequences of cocaine use were of similar magnitude (i.e. the 95% CI's overlap) prior to beginning treatment. Further, ratings for the cocaine-craving questionnaire during the first week of treatment indicated a moderate level of craving at the start of treatment.

3.3 Task Performance

On average, participants demonstrated a positive interference score on the Drug Stroop task. However, there was considerable variability around the group mean and the confidence interval included zero, which suggested that an attentional bias towards cocaine related words was not demonstrated in this sample. On the IRAP task, an overall significant negative IRAP D-score was demonstrated. Negative D- scores were also demonstrated across all four trial types. The negative D score indicates participants responded quicker to the items presented during inconsistent blocks (anti-cocaine) compared to items presented in the consistent blocks (pro-cocaine). This pattern suggests stronger "anti-cocaine" beliefs relative to "pro-cocaine" beliefs. It should be noted that there was considerable variability in both the IRAP and Drug Stroop performances. Approximately 50% of the participants demonstrated relatively stronger "pro-cocaine beliefs" (i.e. a positive IRAP D-score) and an attentional bias to cocaine stimuli (i.e. a positive interference score; slower responding to cocaine words).

3.4 Relationship between Explicit (self-report) and Implicit (performance-based) Measures and Treatment Outcome

The correlations assessing the prospective relationship between the explicit and the implicit measures with treatment outcome are presented in Table 2. D-IRAP scores were inversely and moderately correlated with treatment outcomes during the first 12 weeks of treatment. This relationship was strongest for the 'with cocaine positive' and the 'with cocaine negative' trial types. These results indicate participants who exhibited relatively faster reaction times to trials reinforcing a relationship between cocaine use and positive consequences (e.g. 'with cocaine' – 'I am sexier' – 'true') and trials denying a relationship between cocaine use and negative consequences ('with cocaine' – 'I am tense' - '*false*') demonstrated lower treatment attendance rates and proportions of cocaine-free urines. Stroop Interference, CEQ, and CCQ scores were not correlated with treatment outcome during phase-one of treatment.

Stroop Interference scores were positively and moderately correlated with the three treatment outcome measures for the second phase of treatment. This indicates that participants who exhibited a relatively stronger attentional bias to cocaine stimuli subsequently were more likely to enter phase two of the treatment and demonstrated higher treatment attendance rates and a greater proportion of cocaine-free urines. In addition, greater cocaine use in phase two of treatment was associated with a stronger pro-cocaine belief on the 'with cocaine positive' IRAP trial types. Similar trends were noted for the 'with cocaine negative' trials indicating participant responses more consistent with an absence of negative consequences were associated with worse treatment outcome during phase two of treatment. The overall IRAP, CEQ, and CCQ, scores were not correlated with treatment outcome during the second treatment phase.

3.5 Relationship between the Explicit and implicit Measures

Table 3 presents the correlations among the explicit (CEQ and CCQ) and implicit measures (Drug Stroop and IRAP). There was a significant negative association between IRAP D-scores for the 'with cocaine positive' trial type and Stroop interference scores. This

relationship indicates that relatively stronger anti-cocaine' beliefs, (slower responding on items that reinforce positive consequences of cocaine use), was associated with a greater attentional bias towards cocaine-related stimuli. The explicit measures were not associated with either the Stroop or IRAP performances. Additional analyses (not shown) controlling for the frequency of cocaine use in the month before treatment did not alter either the magnitude or the direction of the reported findings.

4.0 Discussion

This study found that cocaine dependent treatment seekers, as a group, derived stronger relations between cocaine use and negative outcomes then cocaine use and positive outcomes when assessed with the IRAP, an implicit assessment procedure. Further, as a group, cocaine dependent participants did not demonstrate an attentional bias for cocaine related stimuli. However, individual differences on the IRAP and Drug Stroop measures were prospectively related to treatment outcome while differences on the self-report, or explicit, measures were not. Derived relations between cocaine use and positive consequences and cocaine use and the absence of negative consequences were associated with poorer retention and worse treatment outcome when an escalating voucher-incentive program for cocaine abstinence was in place. Furthermore, a similar pattern of associations were noted when a non-escalating contingency management protocol was in place. A relatively stronger attentional bias to cocaine stimuli was also associated with longer treatment retention and better treatment outcome when a non-escalating contingency management protocol was in place.

The finding that a cocaine-associated attentional bias was associated with better treatment outcome was inconsistent with studies that suggest attentional biases may be prognostic of a poor treatment response (7,8). The present results suggests individuals who are more reactive to cocaine related stimuli may be more likely to benefit from counseling strategies that aim to identify triggers and develop alternative coping responses. However, few studies have directly investigated the clinical implications of attentional biases, thus continued research in this area is needed to more fully delineate how attentional biases may influence behavior change. Moreover, parameters of the present study may have contributed to the inconsistent findings. Participants in this study were assessed after 14-days of abstinence. Previous studies have included treatment seekers who were actively using at the time of treatment enrollment, which may have selected participants with more severe cocaine dependence. This study also employed an escalating voucher incentive protocol for cocaine-free urines at the beginning of treatment. Voucher incentives can exert a strong effect on drug use behavior and may have counteracted the deleterious effect of having a strong attentional bias towards cocaine stimuli in the beginning of treatment. Also, the non-escalating voucher protocol was implemented in the second half of the treatment program, thus the effects of the escalating voucher system and participant attrition may have influenced the demonstrated relationship between stroop performance and treatment outcome during phase two of treatment. Further research is needed to highlight how specific elements of a treatment protocol alter the prognostic significance of different cognitive processes, such as an attentional bias to cocaine stimul.

Responding more quickly to IRAP items relating cocaine use to both the presence of positive consequences and the absence of negative consequences (i.e. "pro-cocaine" beliefs) was associated with poorer treatment outcome in the context of an escalating voucher incentive program that reinforced abstinence from cocaine. Further, self-report assessments of craving and the beliefs about the negative and positive consequences of cocaine use did not correlate with treatment outcome in either phase of treatment. These findings are consistent with other investigations demonstrating a link between substance use outcome

beliefs and treatment response (17,18). However, unlike previous studies, the relationship was only demonstrated with an indirect measure of an individual's belief about the effects cocaine use. Evidence suggests direct and indirect assessment procedures do not always covary (27) and each may have a different relation with drug use (15). Implicit measures may offer a platform for assessing the strength of beliefs about drug use that reduces the influence of demand characteristics. Moreover, implicit assessment procedures may highlight the role of psychological processes (e.g. motivation) that are not accessible by more explicit assessment methods. Thus, as the current findings suggest, the use of implicit assessment procedures can provide important prognostic information. Future studies are needed to better understand the processes captured by different measurement procedures, how they may influence treatment outcome in the context of different therapy platforms, and the malleability of these processes in response to specific intervention techniques.

It is interesting to note that there was an inverse association between the IRAP and Drug Stroop performances. A stronger attentional bias was associated with IRAP responding that was more consistent with an "anti-cocaine" perspective on the 'with cocaine positive' trials. Specifically, a stronger attentional bias was associated with IRAP responding relating cocaine use to the absence of positive consequences. This demonstrated relationship is more consistent with the view that threat – or distress - based processes may drive an attentional bias among treatment seekers (13). In contrast, the incentive-motivational theory would predict a positive relationship between an attentional bias towards cocaine stimuli and IRAP responding indicative of "a pro-cocaine" beliefs (the presence of positive consequences, the absence of negative consequences). However these are preliminary findings and further studies investigating the motivational and cognitive processes driving the stroop interference effects among treatment seekers are needed.

This study had several limitations. The small sample size prohibited multivariate modeling of the relationship between treatment outcome and Drug Stroop and IRAP performances and may have also increased the chances of not detecting associations that did exist (i.e. Type II error). For example, the correlations between the IRAP trial types and phase two treatment outcome measures were of a notable magnitude but failed to reach statistical significance. The relatively low reliabilities on the IRAP trial types may have mitigated against finding stronger relationships between these measures and treatment response. However, the overall D-score did demonstrate a stronger reliability and demonstrated a similar pattern of relationships with treatment outcome and explicit measures. The primary objective of the parent study (21) was to investigate the neurobiological correlates of behavior change during a treatment episode. As such long term post-treatment assessments were not completed. Thus, the present study cannot address the relationship between implicit cognition and long-term post treatment outcomes. Further investigation of this relationship would be an important addition to the literature. Moreover, while the IRAP effect has been replicated (24) and compares well with other indirect measures (e.g. IAT), it is a fairly new procedure that continues to be researched. Despite these limitations this preliminary investigation indicates that: 1). Performance based measures of derived relations and an attentional bias may identify important relationships between specific cognitive and verbal processes and treatment outcome and 2). The parameters of the treatment platform employed may influence which psychological factors relate to behavior change.

Acknowledgments

The authors acknowledge the support of NIDA R01-DA20855 and K23-DA021850 and thank Krysten Williams for her data management assistance.

References

1. Prendergast ML, Podus D, Chang E, Urada D. The effectiveness of drug abuse treatment: a meta-analysis of comparison group studies. Drug Alcohol Depend. 2002; 67:53–72. [PubMed: 12062779]
2. Morgernstern J, McKay JR. Rethinking the paradigms that inform behavioral treatment research for substance use disorders. Addiction. 2007; 102:1377–1389. [PubMed: 17610541]
3. Williams JMG, Mathews A, MacLeod C. The emotional Stroop Task and psychopathology. Psychol Bull. 1996; 120:3–24. [PubMed: 8711015]
4. Woods, DW.; Kanter, JW.; Landes, SJ.; Adcock, AC. Introduction to understanding behavior disorders: A contemporary behavioral perspective. In: Woods, DW.; Kanter, JW., editors. Understanding Behavior Disorders: A Contemporary Behavioral Perspective. Reno, NV: Context Press; 2007. p. 11-19.
5. Field M, Cox WM. Attentional bias in addictive behaviors: A review of its development, causes, and consequences. Drug Alcohol Depend. 2008; 97:1–20. [PubMed: 18479844]
6. Wilson KG, Hayes SC. Why it is crucial to understand thinking and feeling: An analysis and application to drug abuse. Behav Analyst. 2000; 23:25–43.
7. Carpenter KM, Schreiber E, Church S, McDowell D. Drug stroop performance: relationships with primary substance of abuse and treatment outcome in a drug-dependent outpatient sample. Addict Behav. 2006; 31:174–181. [PubMed: 15913898]
8. Marissen MAE, Franken IHA, Waters AJ, Blanken P, van den Brink W, Hendriks VM. Attentional bias predicts heroin relapse following treatment. Addiction. 2006; 101:1306–1312. [PubMed: 16911730]
9. Franken IHA. Drug craving and addiction: integrating psychological and neuropsychopharmacological approaches. Prog Neuro-Psychoph. 2003; 27:563–579.
10. Carroll, KM. A cognitive-behavioral approach: Treating cocaine addiction (NIH Publication No 98-4308). Rockville, MD: National Institute on Drug Abuse; 1998.
11. Mercer, DE.; Woody, GE. NIH Publication No 00-4380. Rockville, MD: National Institute on Drug Abuse; 1999. An individual drug counseling approach to treat cocaine addiction: The collaborative cocaine treatment study model.
12. Schoenmakers T, Wiers RW, Jones BT, Bruce G, Jansen ATM. Attentional re-training decreases attentional bias in heavy drinkers without generalization. Addiction. 2007; 102:399–405. [PubMed: 17298647]
13. Vadhan NP, Carpenter KM, Copersino ML, Hart CL, Foltin RW, Nunes EV. Attentional bias towards cocaine-related stimuli: relationship to treatment-seeking for cocaine dependence. Am J Drug Alcohol Ab 2007. 2007; 33:727–736.
14. Waters AJ, Carter BL, Robinson JD, Wetter DW, Lam CY, Kerst W, Cinciripini PM. Attentional bias is associated with incentive-related physiological and subjective measures. Exp Clin Psychopharm. 2009; 17:247–257.
15. Stacy AW. Memory activation and expectancy as prospective predictors of alcohol and marijuana use. J Abnorm Psychol. 1997; 106:61–73. [PubMed: 9103718]
16. Rohsenow DJ, Martin RA, Monti PM. Urge-specific and lifestyle coping strategies of cocaine abusers: Relationships to treatment outcomes. Drug and Alcohol Depend. 2005; 78:211–219.
17. Jones BT, McMahon J. Negative and positive alcohol expectancies as predictors of abstinence after discharge from a residential treatment program: a one-month and three-month follow-up study in men. J Stud Alcohol. 1994; 55:543–548. [PubMed: 7990464]
18. Rohsenow DJ, Sirota AD, Martin RA, Monti PM. The Cocaine Effects Questionnaire for patient populations: Development and psychometric properties. Addict Behav. 2004; 29:537–553. [PubMed: 15050672]
19. Field, M.; Mogg, K.; Bradley, BP. Attention to Drug-related Cues in Drug Abuse and Addiction: Component Processes. In: Weirs, RW.; Stacy, AW., editors. Handbook of Implicit Cognition and Addiction. Thousand Oaks, CA: Sage; 2006. p. 151-163.
20. Ames, SL.; Franken, IHA.; Coronges, K. Implicit Cognition and Drugs of Abuse. In: Weirs, RW.; Stacy, AW., editors. Handbook of Implicit Cognition and Addiction. Thousand Oaks, CA: Sage; 2006. p. 363-378.

21. Martinez D, Carpenter KM, Liu F, Slifstein M, Broft A, Friedman AC, Kumar D, Van Heertum R, Kleber HD, Nunes E. Imaging dopamine transmission in cocaine dependence: neurochemistry predicts recovery from addiction. Am Journal Psychiat. 2011; 168:634–641. [PubMed: 21406463]

22. Budney, AJ.; Higgins, ST. NIH Publication No 98-4309. Rockville, MD: National Institute on Drug Abuse; 1998. A community reinforcement plus vouchers approach: Treating Cocaine Addiction.

23. Barnes-Holmes D, Hayden E, Barnes-Holmes Y, Stewart I. The Implicit Relational Assessment Procedure (IRAP) as a response-time and event-related potentials methodology for testing natural verbal relations: A preliminary study. Psychol Rec. 2008; 58:497–516.

24. Barnes-Holmes D, Murtagh L, Barnes-Holmes Y, Stewart I. Using the Implicit Association Test and the Implicit Relational Assessment Procedure to measure attitudes toward meat and vegetables in vegetarians and meat-eaters. Psychol Rec. 2010; 60:287–306.

25. Greenwald AG, Nosek BA, Banaji MR. Understanding and using the Implicit Association Test: An improved Scoring algorithm. J Pers Social Psychol 2003. 2003; 74:1464–1480.

26. Tiffany ST, Singleton E, Haertzen CA, Henningfield JE. The development of a cocaine craving questionnaire. Drug and Alcohol Depend. 1993; 34:19–28.

27. Power PM, Barnes-Holmes D, Barnes-Holmes Y, Stewart I. The Implicit Relational Assessment Procedure (IRAP) as a measure of implicit relative preferences: A first study. Psychol Rec. 2009; 59:621–640.

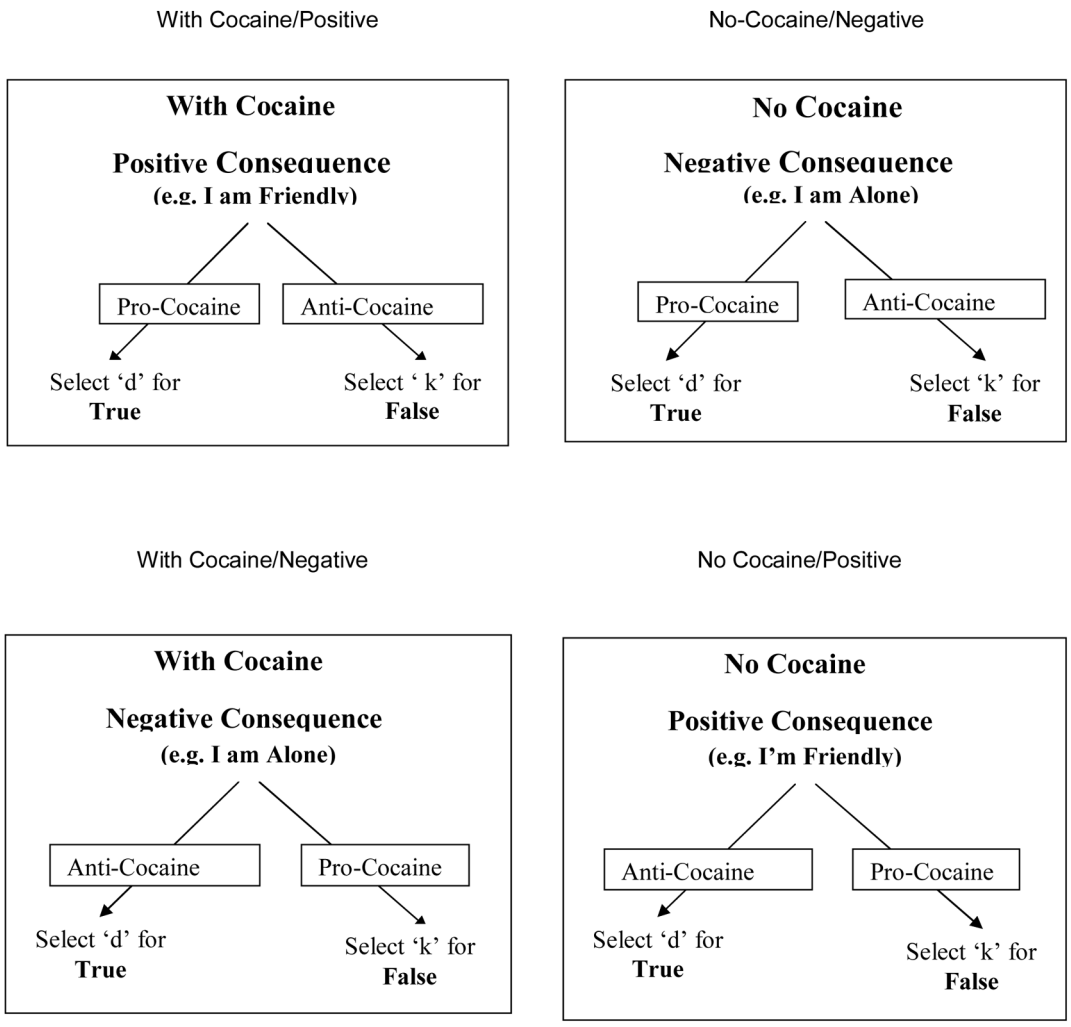

FIGURE 1. The four IRAP trial-types

The category label ('With Cocaine' or 'No Cocaine'), target phrase (either positive effects (e.g. I am friendly) or negative effects (e.g. I am alone)), and response options (True and False) appeared simultaneously on each trial. Arrows with the superimposed text boxes indicate which responses were deemed pro-cocaine or anti-cocaine (boxes and arrows did not appear on the screen).

TABLE 1

Treatment outcome, explicit, and implicit measures and associated 95% Confidence Intervals for cocaine dependent participants beginning the outpatient treatment program.

Variable	Mean (SD)	(95% CI)
Treatment Outcomes		
CRA + Vouchers (wks 1–12)		
Voucher Earnings	$351.80 (385.49)	($200.7; $502.0)
Proportion of Therapy Sessions Attended	0.64 (0.33)	(0.51; 0.77)
Proportion of Urines Negative for cocaine (missing coded as positive).	0.55 (0.36)	(0.41; 0.69)
No. of consecutive Urines testing negative	14.4 (13.2)	(9.2; 19.6)
% Completing Voucher Segment	56.0 (n=14)	
CRA + Lottery (wks 13–24)		
Proportion of Therapy Sessions Attended	0.30 (0.34)	(0.17; 0.43)
Proportion of Urines Negative for cocaine(with missing coded as positive).	0.24 (0.35)	(0.10; 0.38)
No. of consecutive Urines testing negative	3.2 (5.3)	(1.2; 5.3)
% Completing 6-month Trial	32.0 (n=8)	
Performance Measures (Implicit)		
Drug Stroop (Cocaine Interference)	19.77ms (120.0ms)	(−28.2ms; 67.8ms)
Overall D-IRAP (Test Response Times)	−0.16 (0.34)	(−0.31; −0.01)
IRAP Trial Type (D-scores)		
With Cocaine Positive	−0.19 (0.41)	(−0.37; −0.01)
With Cocaine Negative	−0.23 (0.46)	(−0.44; −0.02)
No Cocaine Positive	−0.16 (0.47)	(−0.37; 0.05)
No Cocaine Negative	−0.07 (0.46)	(−0.28; 0.14)
Self-report Measures (Explicit)		
Negative Cocaine Effects	4.10 (1.10)	(3.64; 4.56)
Positive Cocaine Effects	3.83 (1.32)	(3.27; 4.39)
CCQ Total	3.49 (1.34)	(3.23; 3.75)

TABLE 2

Pearson Correlation Coefficients testing the relationship between treatment outcome and self-report (explicit) and performance (implicit) based measures among cocaine dependent participants beginning outpatient treatment.

	Treatment Weeks 1–12			Treatment Weeks 13–24			
Measures	**Voucher Earnings**	**% Visits Attended**	**% UA Neg for Cocaine**	**Entered Phase II[c]**	**Number of Lotter y Tix**	**% Visits Attended**	**% UA Cocaine Negative**
Self–report							
Negative Cocaine Effects[b]	.06	.03	.12	−.20	−.21	−.27	−.27
Positive Cocaine Effects[b]	.03	−.01	.04	.09	.09	.09	.09
CCQ Total	.25	.16	.21	.24	.21	.11	.18
Performance Measures							
IRAP D-scores by Trial Type[a]							
WITH Cocaine Positive	−.46*	−.58**	−.56*	−.42	−.45	−.37	−.46*
WITH Cocaine Negative	−.38	−.48*	−.48*	−.37	−.37	−.24	−.36
NO Cocaine Positive	−.03	−.19	−.18	−.13	−.13	−.08	−.13
NO Cocaine Negative	−.47*	−.23	−.40	−.01	−.01	.18	−.01
Overall Scores							
D-IRAP[a]	−.43	−.47*	−.52*	−.29	−.30	−.16	−.30
Drug Stroop (Interference)	.11	.28	.18	.46*	.48*	.51*	.49*

Note:

** p < .01,

* p < .05.

N sizes vary due to missing data,

[a](n=19),

[b](n=21) all other comparisons (n=24).

[c]= point-biserial coefficient.

TABLE 3

Pearson Correlation Coefficients testing the relationships among the explicit assessments (cocaine effects and craving) and implicit (Drug Stroop and IRAP) measures.

	Self Report Measures			
	Negative Cocaine Effects	**Positive Cocaine Effects**	**CCQ**	**Drug Stroop**
IRAP Trials[a]				
With Cocaine Positive	−.07	.00	.11	−.55**
With Cocaine Negative	−.26	.07	−.22	−.35
No Cocaine Positive	−.11	.13	.15	−.04
No Cocaine Negative	.02	.19	−.11	.03
Overall IRAP-D	−.14	.14	−.02	−.28
Drug Stroop[b]	.25	.02	−.14	--

Note:

** p <.01;

[a](n=19);

[b](n=21)