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Relationship between impulsivity and decision-making in cocaine dependence

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Abstract

Impulsivity and decision-making are associated on a theoretical level in that impaired planning is a component of both. However, few studies have examined the relationship between measures of decision-making and impulsivity in clinical populations. The purpose of this study was to compare cocaine-dependent subjects to controls on a measure of decision-making (the Iowa Gambling Task or IGT), a questionnaire measure of impulsivity (the Barratt Impulsiveness Scale or BIS-11), and a measure of behavioral inhibition (the immediate memory task or IMT), and to examine the interrelationship among these measures. Results of the study showed that cocaine-dependent subjects made more disadvantageous choices on the IGT, had higher scores on the BIS, and more commission errors on the IMT. Cognitive model analysis showed that choice consistency factors on the IGT differed between cocaine-dependent subjects and controls. However, there was no significant correlation between IGT performance and the BIS total score or subscales or IMT commission errors. These results suggest that in cocaine dependent subjects there is little overlap between decision-making as measured by the IGT and impulsivity/behavioral inhibition as measured by the BIS and IMT.

Keywords

Impulsive Behavior; Decision-making; Cocaine Dependence; Behavioral Measures; Expectancy-valence model

1. Introduction

Impulsivity has been variously defined as swift action without forethought or conscious judgment (Hinslie L, 1940) or behavior without adequate thought (Smith, 1952). In the psychological literature authors have defined impulsivity as "the tendency to act with less forethought than do most individuals of equal ability and knowledge" (Dickman, 1993; Goudriaan et al., 2005), choice of a small, short term gain at the expense of a large, long term loss (Ainslie, 1974), or "a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions to the impulsive individual or to others." (Moeller et al., 2001). Implicit in all definitions of impulsivity are two key features. First, impulsivity involves action. Second, impulsivity involves a lack of planning. The method of determining whether the action was truly

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unplanned in two of the definitions above is to look at the outcome of the action, with poor planning being associated with long term losses in spite of short term gains.

Decision-making involves the outcome of cognitive processes leading to a choice between alternative courses of action. Poor decision-making has been described as "deciding against one's best interests and inability to learn from previous mistakes, with repeated decisions leading to negative consequences" (Bechara, 2005).

A commonly used measure of decision-making is the Iowa Gambling Task (IGT) (Bechara et al., 1994). The IGT was originally developed to measure decision-making in patients with focal brain injury. Patients with prefrontal brain damage were noted to make poor choices, especially in social interactions, leading to negative consequences in spite of having otherwise intact intellectual function. Using the IGT, Bechara et al., have shown that the real life problems with decision-making in patients with ventromedial prefrontal cortical injury are paralleled by their performance on the IGT. Subjects with brain lesions in these areas repeatedly respond disadvantageously, making few changes in their behavior in spite of the losses that accumulate (Bechara et al., 2000). Thus, disadvantageous decision-making as measured by the IGT overlaps conceptually with lack of planning, which is a critical component of impulsivity. The IGT has also been used to study other clinical populations that are known to have problems with decision-making and impulsivity, including subjects with pathological gambling (Goudriaan et al., 2005) and substance abuse (Bechara and Damasio, 2002; Stout et al., 2004; Verdejo-Garcia et al., 2007a, b). Most of these studies find that performance on the IGT parallels problems with real life decision-making.

Since its development, the IGT has looked at decision-making in terms of overall net gain from choices, though its authors acknowledge the role of individual components of the decision-making process such as sensitivity to gains and losses and learning from past mistakes. Like impulsivity, there are many aspects that shape decision-making including expected outcomes, memory, and learning. In order to thoroughly assess the relationship between impulsivity and decision-making, it is necessary to examine the different processes involved in decision-making. One method that has been used to examine these processes in the IGT is the expectancy-valence learning model or EVM (Busemeyer and Stout, 2002). Using this model, each trial block's gains and losses are assigned a valence, with expectancies regarding each valence learned by an adaptive learning mechanism. Probability of choice on trials can then be selected by looking at expectancies based on previous decisions. The EVM has three parameters that represent stages in the decision-making process: valence of gains/losses, expectancies about outcomes, and consistency of choices with regard to valence and expectancy. Each of these components allows for a more specific measure of different aspects of choice by isolating attention and learning rate. These parameters may correspond in different ways to components of impulsivity.

Several previous studies have examined IGT performance and response inhibition in cocaine-dependent subjects. Outcomes in these studies have not conclusively linked IGT performance to response inhibition tasks, though many have reported poor decision-making and increased impulsivity in cocaine dependent subjects, and in substance-dependent individuals more broadly. Stout et al., found that cocaine-dependent subjects showed a preference for the disadvantageous decks relative to control subjects, and that these choices appeared to be related to motivational and choice consistency factors (Stout et al., 2004). Hanson et al., (2008) compared MDMA (3,4 methylenedioxymethamphetamine, also know as ecstasy) users with other drug users and controls on outcomes from BIS-11 and IGT, finding that both study groups tended to have increased impulsivity and fewer advantageous choices on IGT (Hanson et al., 2008). Both groups tended to show dose-related effects, with heavier use correlating with more impulsivity and more decision-making deficits (Hanson et al., 2008). Another study compared outcomes on IGT and various response-inhibition tasks in cocaine and heroin polysubstance abusers. Findings showed that cocaine polysubstance abusers had significant deficits in response inhibition as measured by go no-go and Stroop tasks compared to heroin polysubstance abusers, additionally both groups made less advantageous choices on the IGT than controls (Verdejo-Garcia et al., 2007b) In a recent report, cocaine-, methamphetamine- and alcohol-dependent men and women were compared to controls by performance on the IGT. This study showed fewer advantageous choices on IGT with methamphetamine- and cocaine-dependent individuals, as well as gender differences in performance, with methamphetamine- and cocaine-dependent women making more disadvantageous choices than men (van der Plas et al., 2008). Additionally, this study assessed response inhibition in these groups via stop-signal task, and did not find a correlation between categorical drug dependence and response inhibition, or a correlation between decision-making and response inhibition (van der Plas et al., 2008).

In summary, previous studies in substance abusing individuals have shown higher scores on questionnaire measures of impulsivity, higher rates of impulsive errors on behavioral inhibition tasks, and poorer decision making as measured by the IGT, however few studies have examined the relationship among all these constructs.

The purpose of this study was to measure performance on the IGT, the Immediate Memory Task (IMT) (Dougherty et al., 2002), and a well-validated self-report measure of impulsivity, the Barratt Impulsiveness Scale (BIS-11) (Patton et al., 1995) in treatment seeking cocaine-dependent subjects and healthy controls. We hypothesize that subjects with cocaine dependence would show impairment on all of these measures compared to healthy controls. Unlike previous trials that have assessed impulsivity or decision-making in cocaine dependent populations, this study aimed to measure both via behavioral tests, as well as analyze outcome from the EVM applied to the IGT, to assess the relationship of different decision-making parameters to tests of impulsivity. In summary, this study sought to provide additional information about the relationship between cocaine use, impulsivity and decision making through: a. examination of a laboratory measure of behavioral inhibition, attention, and memory along with a questionnaire measure of impulsivity and a laboratory measure of decision-making (including EVM parameters of IGT) all in the same group of cocaine dependent subjects and controls, b. examination of the relationship between these measures, c. examination of EVM in a larger group of cocaine users than has previously been studied.

2. METHODS

2.1. Sample and Study Procedures

A total of 66 cocaine-dependent subjects and 20 healthy control subjects were included in the current study. Participants were recruited from local newspaper advertisements for a study on behavioral effects of cocaine. Newspaper distribution drew in cocaine and control subjects from similar areas. Subjects underwent a screening consisting of a physical examination and structured psychiatric interview using the SCID (First, 1996). Cocaine-dependent subjects were excluded if they did not meet DSM-IV criteria for current cocaine dependence, had a concomitant Axis I disorder other than substance induced mood disorder or if they had evidence of a general medical condition that could affect the central nervous system (CNS) such as HIV. Though the SCID does not explicitly screen for ADHD, subjects were excluded if they reported a history of past or present treatment for or diagnosis of ADHD. Subjects were excluded if they met criteria for other substance dependence or abuse other than alcohol or marijuana abuse, and were also excluded for active medical conditions requiring medication with central nervous system effects (hypertension or cardiac disease included). Healthy controls were excluded for the same criteria plus current or past substance abuse or dependence. Cocaine-dependent subjects underwent behavioral testing at baseline prior to entry into a treatment study combining medication and cognitive behavioral therapy for cocaine dependence described elsewhere (Moeller et al., 2007). For study inclusion, cocaine-dependent subjects had to report recent cocaine use. Addiction Severity Index was also administered to cocaine dependent subjects, and amount of use was quantified by days of use in the last 30 days, with a mean of 13.8 days for our cocaine dependent subjects. On the day behavioral paradigms were assessed, subjects received urine drug screens. All subjects with positive tests were assessed by a physician to determine cocaine intoxication by DSM-IV criteria. All subjects with intoxication at time of paradigm were excluded.

2.2. Measures

2.2.1. Iowa Gambling Task (IGT)—A computerized version of the original gambling task was used (Bechara et al., 1994) in which subjects are asked to choose between four decks of cards that result in theoretical monetary rewards at different rates. Each deck (labeled A, B, C, and D) contains 60 cards. Subjects must make 100 choices over the testing session. Healthy controls typically determine that two decks of cards (A, B) on the short-term lead to small immediate monetary rewards but over the long-term are more advantageous due to large losses in the other two decks of cards (C, D). The task takes about 15 minutes to complete. Scoring for the IGT is based on the total number of cards selected from the advantageous minus the disadvantageous decks (e.g. net score) across five blocks of 20 cards each. The net score of cards selected ((C+D)−(A+B)) in each of the five blocks was used as a measure of overall performance to compare groups on the task, and for correlation analyses.

2.2.2. Barratt Impulsiveness Scale. (BIS-11) (Patton et al., 1995)—This instrument is a 30-item questionnaire that has been used in several previous studies of impulsivity and aggression (Allen et al., 1998; Cherek et al., 1997). The BIS-11 provides a total score as well as three subscale scores labeled non-planning, attentional, and motor impulsivity based on a principal component analysis (Patton et al., 1995).

2.2.3. Immediate Memory Task (IMT)—This task is part of the Immediate and Delayed Memory Task (Dougherty et al., 2002) which is a version of the continuous performance test (CPT) designed to measure brief attentional capacity, memory, and behavioral inhibition. Correct detections are believed to be a measure of sustained attention, commission errors are attributed to response inhibition (Nuechterlein, 1984, Koch M., 1985, Shapiro SK, 1986, Beale et al., 1987, Halperin et al., 1988, O'Toole et al., 1997, Dougherty et al., 1999, Dougherty et al, 2000). A series of 5-digit numbers (e.g., 73021) are displayed on the monitor for 0.5 s and separated by a 0.5 s blackout period. There are several distinct types of stimuli presented and three types of responses that can be made. Subjects are instructed to respond when a 5-digit number (the target stimulus) appears that is identical to the preceding stimulus. The probability of a target stimulus is set at 33%. A response made while a target stimulus appears on the monitor, or made before the next stimulus appears (1.0 s total), is recorded as a correct detection (or "hit"). A failure to respond to a target stimulus is recorded as an omission error (or "miss"). In addition to target stimuli, there is a 33% probability that a catch stimulus will appear. A catch stimulus is a number that differs from the preceding number by only one of the five digits (its position and value is determined randomly). Responses (errors) made to catch stimuli are considered commission errors (or "false alarms"). Novel stimuli (numbers) that are not either target or catch trials (34% of the stimuli) are called filler stimuli and responses made to these stimuli are called random errors. Correct detections are often used as a measure of attentional capacity, and commission errors are often used as a laboratory measure of behavioral inhibition (Dougherty, et al., 2002).

2.3. Cognitive Modeling (Expectancy-Valence Model) of the IGT

Use of the EVM in this study was based on its utility in previous reports showing differences between controls and substance abusing and cocaine-dependent subjects (Busemeyer et al., 2002; Stout et al., 2004; Stout et al., 2005). Parameters assessed are theoretical estimates of psychological factors that influence choices on the IGT (Busemeyer et al., 2002). As a subject begins the process of choosing decks in the IGT, these choices are initially almost random. As information regarding the decks accumulates, choices become more strongly influenced by expectancies regarding the decks (Busemeyer et al., 2002). The EVM's choice predictions are influenced by three separate parameters: attention weight or valence, learning/memory or updating, and choice consistency. Attention weight is a function of wins and losses as well as the magnitude of wins and losses experienced with each trial. Update rate is a measure of the influence of past experiences, and whether or not recent or remote experiences influence current choices. This parameter is updated with each trial, as outcomes influence future expectancies. Choice-consistency measures the reliability of the selection, given previous selections and experiences. Consistency that is low is independent of expectancy, and may indicate impulsive lack of planning and/or attention to the task. Lower values on the consistency parameter reflect decision-making patterns that do not correspond to the expectancy and valence parameter values, and therefore can be interpreted as more random, less organized, not well-planned, and perhaps more impulsive. For further information on the expectancy-valence model and computation, please see Appendix 1 in the online appendix.

2.4. Statistical Analyses

Demographic differences between groups were assessed with independent sample t-tests and chi-square tests. An Analysis of Covariance (ANCOVA) was used to compare group means on variables that were normally distributed. Covariates were included in the analysis if they differed between groups and were correlated with dependent variables. For the IGT, a repeated measure ANCOVA was performed using each of the five blocks of 20 trials for the task. Due to the non-normal distribution of the EVM data, Mann-Whitney U test was used to determine group differences on the three parameters. Spearman's correlation analysis was used to examine the relationship between the different parameters on the IGT resulting from the EVM analysis and the IMT, BIS-11 and education data.

3. RESULTS

A total of 20 healthy controls and 66 cocaine-dependent subjects met the inclusion criteria for the study. For technical reasons 5 of the 20 controls did not complete the IMT. Demographic variables and means for the BIS and IMT are listed in Table 1. There was a significant difference in education level between groups, with a higher percentage of controls having a college education compared to the cocaine-dependent group (X^2 (1, n = 81) = 14.4, $p < 0.001$). Education level correlated with IMT commission errors (Spearman r = −0.471, p = <0.001), BIS-11 scores (Total: Spearman r = −0.308, p = 0.004; Nonplanning: Spearman r = −0.219, p = 0.043; Motor: Spearman r = −0.322, p = 0.002; Attentional: Spearman r = −0.339, p = 0.001), and IGT total score (Spearman r = 0.289, p = 0.007). Education level did not correlate with IGT EVM parameters (Update Spearman r = 0.106, p = 0.333; Valence Spearman r = −0.147, p = 0.176; Consistency Spearman r = 0.086, p = 0.429). Since education differed between groups and correlated with task performance, it was included as a covariate in subsequent analyses.

As shown in Table 1, cocaine dependent subjects had significantly higher BIS total scores as well as higher scores on each of the BIS subscales compared to controls. In addition, cocaine-dependent subjects had significantly higher commission errors on the IMT. The repeated measures ANCOVA for the IGT total score showed a significant between subjects-group effect (F =6.21, df = 1, 83, p = 0.015), but no significant effect of Block (F = 0.528, df = 4, 332, p = 0.715) and no block by group interaction (F = 0.561, df = 4, 332, p = 0.691). The overall pattern of responding showed that control subjects showed a greater preference for the advantageous decks compared to cocaine-dependent subjects (See Figure 1). On EVM analysis, the consistency parameter was significantly lower on cocaine subjects than controls on Mann-Whitney U test (z = −2.31, p = 0.021). Parameters of valence and update were not significantly different in the cocaine-dependent population(z = −0.540, p = 0.589, and z = −1.128, p = 0.259, respectively). For complete results of the EVM parameter values please see Table 3 in the online appendix.

Examination of the correlations between behavioral measures across all subjects showed that there was significant correlation between commission errors on the IMT and BIS Nonplanning, Motor, and Total Scores. There was no significant correlation between the IGT net score summed across all blocks or the EVM consistency parameter and any of the other measures (See Table 2).

4. DISCUSSION

Cocaine-dependent subjects showed higher scores on the BIS, more commission errors on the IMT, and a preference for disadvantageous decks on the IGT compared to non-drug using controls. There also was a significant correlation between commission errors on the IMT and BIS scores. There was no significant correlation between IGT net scores or EVM parameters and the impulsivity measures.

On the IGT, cocaine-dependent subjects shifted to advantageous decks more slowly and to a lesser degree than controls. This is compatible with previous findings for the IGT in cocaine users (Verdejo-Garcia et al., 2007a). In the EVM analysis, the consistency parameter was lower in cocaine-dependent subjects. Valence (motivation) and updating (learning) were not significantly different in cocaine-dependent subjects. These findings are partially consistent with those from Stout et al. 2005, which found consistency (choice) and valence (motivation) to be significantly different between cocaine users and controls. There were no significant correlations between EVM model parameters and BIS or IMT/DMT.

As seen in previous studies examining outcomes of behavioral paradigms assessing attention, impulsivity, and response inhibition in cocaine dependent subjects, cocaine dependent individuals showed deficits related to increased impulsivity, decreased response inhibition and decreased attention (Moeller et al., 2005, Garavan et al., 2008, Colzato et al., 2007, Lane et al., 2007). Previous studies have also shown that decision-making as assessed through various paradigms is influenced by cocaine use and dependence (van der Plas et al., 2008, Green et al., 2009, Verdejo-Garcia et al., 2007a & b, Strickland et al., 1993). However, previous studies have not assessed correlations between these various measures of impulsivity, response inhibition and decision-making in this specific population. Previous studies have looked at “substance dependent populations” (multiple substance types) or cocaine users as a subset of other populations, with fewer looking at cocaine dependent populations specifically. Previous studies by Stout et al. employing EVM analysis of IGT performance in cocaine dependent subjects have shown similar outcomes on EVM parameters, but had smaller samples of cocaine dependent subjects (Stout et al., 2004a).

Analyzing our findings in light of previous EVM analysis in cocaine dependent subjects (Stout et al., 2004a), our findings partially replicate the previous findings, which showed consistency and valence to be lower in cocaine dependent individuals compared to controls. Our findings are also similar to findings in patients with bilateral ventromedial prefrontal cortex (vmPFC) lesions, who had decreased degree of consistency and update rate on EVM analysis (Yechiam et al., 2005). This may represent prefrontal gray matter volume loss observed in substance dependent people (Tanabe et al., 2009).

The results of examination of correlations between questionnaire measures of attentional, motor, and nonplanning impulsivity and response inhibition as well as decision-making joins a group of previous studies examining the relationship between different components of impulsivity and decision making in different subject groups. Previous studies have also described a non-correlating or partially correlating relationship between measures of impulsivity and decision-making. Examining the relationship between similar decision-making tasks (Delay Discounting Procedure or DDP, Gambling Task or GT, and Rogers Decision-Making Task or RDMT) in substance abusers, Monterosso et al. found GT performance correlated with DDP performance, response time on RDMT correlated with GT and DDP performance, and no task was observed to correlate with measures of impulsivity (Monterosso et al., 2001). They attribute these findings to the similarity of the constructs they were measuring; risk, delay, and impulsivity, which overlapped with one another, but may require more refinement in their assessment. A correlation between measures of trait impulsivity and commission errors on a behavioral measure of motor impulsivity (go/no-go task) and lack of correlation between trait impulsivity and decision-making, delayed discounting, reflection impulsivity and self-regulation was also observed in a sample of high and low trait impulsivity women (Perales et al., 2009). There have been other studies that have described a relationship between measures of impulsivity and decision-making. In a study comparing 50 adults with ADHD with 51 controls, there was a negative correlation with BIS-11 nonplanning and net scores on IGT second, third, fourth and fifth blocks, a negative correlation between IGT total net score and BIS-11 nonplanning subscale, and BIS-11 total score negatively correlated with the difference between advantageous and disadvantageous choices in the second and third block of the IGT (Malloy-Diniz et al., 2007). The difference in correlation between IGT and BIS-11 in this population compared with our cocaine-dependent sample may result from differences in the presentation of impulsivity, nonplanning and decision-making in these two populations, as well as inclusion of combined- type ADHD in that study. To compare the findings of the current paper to those of Malloy-Diniz, exploratory correlation analyses were performed on all 5 blocks of the IGT with the other measures (BIS-11, IMT). After correction for multiple comparisons, this analysis revealed no statistically significant correlations. The relatively small size of the control group (N=20) may have contributed to the null findings. Future studies would benefit from larger control sample sizes.

Evaluation of substance abuse and pathological gambling via different measures of impulsivity, decision making, sensation seeking and time orientation revealed that substance abusing subjects did poorly on the IGT, but scores did not correlate with performance on impulsivity measures such as BIS-11 (Petry, 2001). Comparisons of performance across the IGT, the Wisconsin Card Sorting Task (a measure of set-shifting), a delayed discounting procedure, and the BIS-11 revealed that higher impulsivity was associated with poorer performance on the IGT, but was not related to card sorting performance in nicotine dependent individuals. (Sweitzer et al., 2008). In a college student sample, self-reported impulsivity and decision making on the IGT were examined. Only lack of premeditation was correlated with performance on the IGT (Zermatten et al., 2005).

Limitations of this study include differences in education level in our cocaine dependent and control groups, noting that education was a covariate in the analyses. In regards to the difference in education between the groups, ANCOVA scoring was based on SCID-I education rating (1 = grade 6 or less, 2 = grade 7–12, 3 = high school graduate, 4 = education beyond high school). On further analysis, the level of education with most frequency in the cocaine dependent group was 3, or high school graduate (50%). For controls, it was 4, or partial college (35%). This signifies that even though there was some difference in level of education, education levels of completion were not highly discrepant (e.g., only a minority of cocaine-users or controls were college graduates). Importantly, this study used a control group closely matched in age and recruited from identical zip codes, thereby approximating a match to the cocaine dependent group in sociodemographics. Notably, IGT performance in the control group may appear inconsistent with performances of control subjects in prior studies (specifically, inconsistent performance across IGT blocks and a large standard deviation even in blocks 4 and 5). This may be due to our control group being recruited from the same zip codes as the cocaine-dependent group, and therefore more comparable in regards to socioeconomic status to our cocaine group than to control groups in previous studies comprised of middle-class adults or college students. Using multinomial logistic model, Fuentes et al. (2006) distinguished pathological gamblers from controls with regression models that included both Go No-Go and BIS-11 scores. With larger datasets, similar approaches may be useful in future studies to examine combinations of factors (e.g., IGT EVM parameters, BIS-11 parameters, IMT outcomes) that may be revealing with regards to differences in cocaine dependent and control populations.

We found no significant correlation between EVM parameters of the IGT (meant to distinguish the underlying processes of decisions made on the IGT) with either measures of response inhibition and attention (IMT), or self-reports of impulsivity (BIS-11). One possible reason is that while similar, the IMT and IGT are measuring behavioral processes with unique features and sources of variance. Additionally, to more completely examine the relationship between decision-making, impulsivity, and behavioral inhibition, future studies might benefit from measures such as reflection impulsivity (the ability to gather information prior to making decisions) to further elucidate the processes of nonplanning and decision-making (Clark et al., 2006). The concept of reversal learning, or the inability to terminate repetitive responses in the presence of previous learning or environmental cues may also play a role in decision-making (Fillmore and Rush, 2006). One study found that in a population of polydrug users (cocaine and heavy alcohol use), subjects displayed acquisition of learning, but impaired discrimination-reversal learning of inhibitory and activational responses compared to controls (Fillmore and Rush, 2006). It is possible that reinforcement contingencies may also play a role in the inability to reverse responses to stimuli in cocaine dependent subjects (Ersche et al., 2008). Further examination of measures of decision-making with reversal learning in cocaine-dependent populations may be worthwhile to better elucidate cognitive deficits in this population.

According to (Barratt, 1993), the best way to gather information about the clinical construct of impulsivity may be through the use of a battery of tasks with the overall information summed into an “impulsivity index.” More recently, the different cognitive processes measured for under the definition of “impulsivity” may be of importance in the treatment of substance abuse, and necessitate honing the definition of impulsivity, attention, and decision-making (de Wit, 2009). The findings of the current study support this assertion. A battery of measures may provide the most comprehensive description of impulsivity and decision processes in a clinical population. These findings further support the hypothesis that the clinical construct of impulsivity is multi-factorial, and individual measures in isolation do not capture all its dimensions. The results also suggest that decision-making as measured by the IGT, though closely linked to impulsivity in clinical populations, may represent an independent - though likely not orthogonal - construct.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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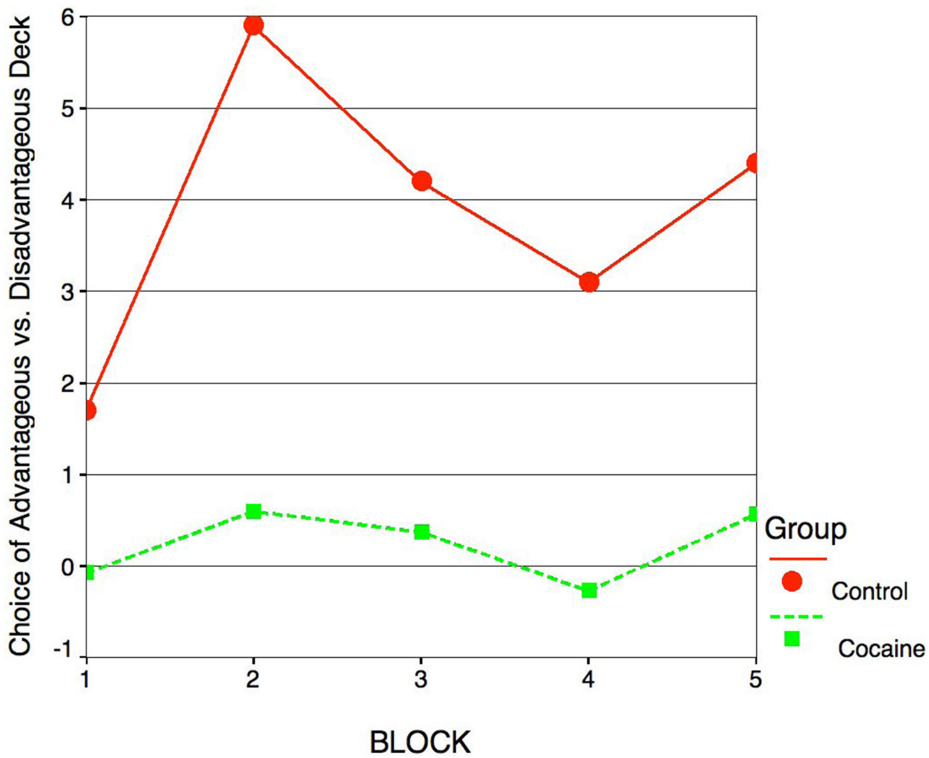

Figure 1.

Iowa Gambling Task Results by Group. Zero line on Y-axis denotes no preference for advantageous vs. disadvantageous decks.

Table 1

Demographic and behavioral results by group.

	Cocaine Dependent	Control	P**
N	66	20	
Age	36.7 ± 7.5	33.9 ± 11.2	0.295
Male N (%)	56 (84.8)	14 (70)	0.135
Female N (%)	10 (15.2)	6 (30)	
Education (% College or Above)	15 (23.4)	13 (76.5)	<.001
BIS Non-Planning	27.5 ± 5.3	21.8 ± 4.0	<0.001
BIS Attentional	16.5 ± 3.8	13.4 ± 3.2	0.024
BIS Motor	26.4 ± 5.2	21.0 ± 3.1	<0.001
BIS Total Score	70.3 ± 10.9	56.1 ± 8.7	<0.001
IMT Correct Detections %	77.2 ± 16.2	88.3 ± 7.7*	0.106
IMT Commission Errors %	30.2 ± 14.9	16.9 ± 9.3*	0.014
IGT Net Score	0.09 ± 22.5	19.3 ± 26.5	0.015

Unless otherwise stated all results are means ± standard deviations

* IMT results n=15

** Significance based on ANCOVA using education as covariate

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Table 2

Correlation between measures across all groups.

		IMT Commission Errors	IMT Correct Detections	BIS Nonplanning Score	BIS Motor Score	BIS Attentional Score	BIS Total Score
IGT Total Score	Spearman r	−0.127	0.004	−0.177	−0.105	−0.193	−0.148
	Sig. (2-tailed)	0.280	0.975	0.104	0.336	0.075	0.174
	N	74	74	86	86	86	86
IGT Consistency	Spearman r	−0.139	−0.058	0.073	0.094	0.000	0.027
	Sig. (2-tailed)	0.237	0.625	0.504	0.391	0.993	0.803
	N	74	74	86	86	86	86
IMT Commission Errors	Spearman r		−0.096	0.387	0.372	0.264	0.411
	Sig. (2-tailed)		0.416	<0.001	<0.001	0.023	<0.001
			74	74	74	74	74