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Optimal neurocognitive, personality and behavioral measures for assessing impulsivity in cocaine dependence

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Abstract

Background—Impulsivity may underlie the poor treatment retention and high relapse rates observed in cocaine-dependent persons. However, observed differences in measures of impulsivity between cocaine-dependent and healthy control participants often do not reach clinical significance, suggesting that the clinical relevance of these differences may be limited.

Objectives—To examine which measures of impulsivity (i.e. self-report impulsivity, self-report personality, neurocognitive testing) best distinguish cocaine-dependent and healthy control participants (i.e. showing differences at least 1.5 standard deviations [SD] from controls). Optimal measures were considered to demonstrate sufficient classification accuracy.

Methods—Sixty-five recently abstinent cocaine-dependent and 25 healthy control participants were assessed using select neurocognitive tests and self-report questionnaires including the NEO Personality Inventory-Revised (NEO-PI-R), Temperament and Character Inventory (TCI), Barratt Impulsiveness Scale (BIS-11a), and the Frontal Systems Behavior Scale (FrSBe).

Results—When corrected for years of education and gender, neurocognitive measures did not demonstrate clinically significant differences between cocaine-dependent and control participants. The personality measures TCI Purposefulness and Congruent Second Nature and NEO-PI-R Impulsiveness, and the self-rating measures FrSBe Disinhibition and BIS-11 Motor Impulsivity and Total successfully identified clinically meaningful elevations in impulsivity within cocaine-dependent participants (>1.5 SDs from controls). Furthermore, these measures achieved 84–93% accuracy in discriminating cocaine-dependent from control participants.

Conclusion—Clinically significant neurocognitive impairment in cocaine-dependent participants was not observed in this sample. As the BIS-11 or FrSBe are brief to administer,

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

accurate, and have been shown to predict treatment retention and relapse, these measures appear to be optimal, relative to the personality measures, for examining trait impulsivity in cocaine dependence.

Keywords

BIS-11; cocaine dependence; FrSBe; impulsivity; neurocognitive

Introduction

Poor treatment retention and high relapse rates are two important factors making treatment of cocaine dependence and substance abuse challenging (1–3). Aharonovich and colleagues showed over 50% of cocaine-dependent patients drop out of a cognitive-behavioral treatment program (4,5), similar to the drop-out rate of other treatments (6). Poor retention is problematic since patients who leave treatment early tend to have poorer outcomes (i.e. relapse, unemployment, and incarceration) (7,8). Up to 70% of cocaine-dependent patients relapse following inpatient treatment (9,10) and approximately 80% relapse while receiving outpatient pharmacotherapy and psychotherapy (11). Impulsivity has been identified as a possible determinant of poor treatment retention and high relapse rates. High levels of impulsivity, as assessed by neurocognitive, personality, and self-rating measures, are associated with low treatment retention (4,12–18) and personality and self-rating measures also predict relapse (17,19).

Impulsivity is a multidimensional trait manifested by rapid, unplanned reactions to stimuli before complete processing of information, decreased sensitivity to negative feedback resulting in repetitive mistakes, and a disregard for long-term consequences (20). Many of these processes have been found to be impaired in cocaine-dependent persons. Specifically, cocaine-dependent persons have often shown difficulty inhibiting prepotent responses [e.g. Stroop Color and Word Recognition Test (Stroop), Trail Making Test (TMT)] (21–25) and flexibly alternating demands on tasks of executive function [e.g. Wisconsin Card Sorting Test (WCST)] (26–28). These patients also demonstrate poor decision-making skills on the Iowa Gambling Task (IGT) by repeatedly choosing short-term high monetary rewards with long-term losses rather than low monetary rewards with long-term gains (28,29). On personality inventories such as the NEO Personality Inventory-Revised (NEO-PI-R), (30) cocaine users (31) and cocaine-dependent persons (19) demonstrate low scores on Conscientiousness and high scores on Neuroticism, both of which have been linked to impulsivity (32) and higher rates of relapse (19). Significantly lower scores on the Temperament and Character Inventory's (TCI) (33) Congruent Second Nature, a measure of establishing habits consistent with one's preferred long-term goals, suggest cocaine-dependent persons have poorer response inhibition than controls (34). On the Minnesota Multiphasic Personality Inventory (MMPI), elevations on Psychopathic Deviate and Hypomania scales suggest nonconformity to rules, impulsivity, and sensation seeking are commonly reported in cocaine-dependence (35) and may partly account for poor treatment retention. Additionally, relative to healthy controls, cocaine-abusing persons report elevated impulsive traits on other personality measures including the Eysenck Impulsiveness Questionnaire (36) and the Zuckerman-Kuhlman Personality Questionnaire (ZKPQ) (37);

higher elevations on ZKPQ Impulsive Sensation Seeking scale have shown associations with increased drug use, poor treatment retention, and early relapse (38). Furthermore, cocaine dependence is associated with significantly higher levels of self-rated impulsivity on the Barratt Impulsiveness Scale Version 11 (BIS-11) (39–42) and Disinhibition on the Frontal Systems Behavior Scale (FrSBe) (28,43).

From a clinical perspective, each of the three assessment approaches (objective neurocognitive, self-rated personality, and self-rated impulsivity) have advantages and disadvantages that could be meaningful when deciding which measures to use. The neurocognitive approach allows clinicians to assess inefficient and intact cognitive processes in cocaine-dependent persons that could indicate potential problems in activities of daily living or employment and subsequently prompt the development of compensatory strategies. However, the literature is mixed concerning the pattern of neurocognitive impairment in cocaine-dependent persons, as some studies report performance on TMT Part B (23,24,26,44), Stroop (22,25), and WCST (26–28) to be worse than healthy controls, whereas others do not (44–48). Even when cocaine-dependent patients score statistically lower than controls, it is questionable whether the deficits are severe enough to be clinically meaningful, as some studies report differences <1 SD from controls (22,24,45,49). Personality inventories allow clinicians to assess a large number of characterological traits including coping styles, interpersonal patterns, and impulsivity (50), but are typically time intensive, requiring at least 45 min to administer. Self-rating scales of impulsivity, such as the BIS-11 and FrSBe, are brief measures (3–15 min); however, relative to the other assessment approaches, the results are rather limited to one or a few characterological traits. The degree to which each of these measures might be most meaningful in assessing impulsivity within cocaine dependence is poorly understood as no empirical support has been provided to endorse use of some of these measures over others.

In this study, we examine which measures of impulsivity are optimal for discriminating cocaine-dependent persons from controls. An optimal measure should reflect clinically significant differences from controls to denote elevations in impulsivity in cocaine-dependent persons, and demonstrate adequate sensitivity and specificity. Identifying an optimal measure of impulsivity may provide a method of predicting who is at risk of poor treatment retention or early relapse following treatment.

Materials and methods

Sixty-five cocaine-dependent participants (six females) in early remission (i.e. 1–3 weeks abstinence) were recruited from residential treatment programs at the VA North Texas Health Care System in Dallas, Homeward Bound, Inc., and Nexus Recovery Center, Inc., while 25 healthy controls (eight females) were recruited through local advertisements in newspapers, the Internet, and bulletin boards. Subjects were recruited for participation in a study exploring neural predictors (as assessed by functional magnetic resonance imaging) of cocaine relapse (51). All cocaine-dependent participants endorsed cocaine as their primary drug of choice, were diagnosed with current cocaine dependence using the DSM-IV Structured Clinical Interview (SCID-1) (52), and remained in a structured, residential unit until study completion. Due to the extensive use of nicotine and other substances within

cocaine-dependent populations, patients using other substances were included. Patient exclusion criteria included current use of any central nervous system active medications (including psychotropics); history of traumatic brain injury with persisting symptoms; the presence of major medical or affective, anxiety, and psychotic disorders; women experiencing perimenopause or postmenopause; and an estimated IQ score <70 on the Wechsler Test of Adult Reading (WTAR) (53). The WTAR was used to eliminate subjects with low cognitive ability and/or limited reading proficiency. Exclusion criteria for healthy controls were the same as for cocaine-dependent participants; however a lifetime history of any psychiatric disorder (except nicotine dependence) was not allowed.

All participants underwent a medical history and physical examination, clinical laboratory tests, and a urine drug screen. The SCID-1 and all assessment instruments were administered by trained bachelor's or master's level research assistants who were instructed and supervised by a psychologist during practice administrations until mastery. Lifetime and previous ninety days cocaine use was obtained from cocaine-dependent participants using the TimeLine Follow Back interview (TLFB) (54). The Inventory of Drug Use Consequences (INDUC) (55) was also administered to assess drug dependence severity. After a complete description of the study by research assistants aforementioned, informed consent was obtained. Approval for the study was obtained from the Institutional Review Board of the University of Texas Southwestern Medical Center at Dallas and the VA North Texas Health Care System. Participants received $100 in gift cards as financial compensation for their participation in the neurocognitive tasks.

Materials

Neurocognitive assessment—Neurocognitive measures were selected based on their ability to assess the multiple components of impulsivity previously established by Moeller et al. (2001) as outlined earlier. Inhibition of automatic reactions to stimuli was assessed with the Trail Making Test (TMT) Part B (56), Color-Word trial of the Stroop Color and Word Recognition Task (Stroop) (57), and Conners' Continuous Performance Test Second Edition (CPT-II) (58) Commission Errors. Repetitive errors from decreased sensitivity to negative feedback was assessed with The Wisconsin Card Sorting Test (WCST) Perseverative Errors (59). Decreased sensitivity to long-term consequences and risk taking was assessed with the Iowa Gambling Task (IGT) total score (60) and the Balloon Analogue Risk Task (BART) adjusted average number of pumps (61).

Self-rating scales—Four TCI facets [Impulsiveness (NS2), Purposefulness (SD2), Congruent Second Nature (SD5) and Persistence (P)] and four NEO-PI-R scales [Impulsiveness (N5), Self-discipline (C5), Deliberation (C6), and Order (C2)] were chosen based on their relevance to impulsive behaviors and addiction. The BIS-11a (62) was used to assess impulsivity related to non-planning, motor impulsivity, and attention (39). Scores were prorated to BIS-11 scores according to procedures previously developed (63). Disinhibition and Executive Dysfunction were examined on the FrSBe as these scales pertain to difficulty with behavioral/emotional constraint and making repeated errors respectively (64). Derivation and validation of the neurocognitive and self-rating measures are described in the Supplementary Material section, available online.

Procedures

Neurocognitive measures were completed by cocaine-dependent participants between two and four weeks in the treatment program. Both cocaine-dependent and control participants completed measures in the following order as determined by a neuropsychologist: TMT, Stroop, FrSBe, CPT-II, WCST, BART, and IGT. Participants were allowed to take brief breaks in between measures to avoid fatigue and required approximately 75 min to complete.

Statistical analysis

Demographic characteristics were examined using chi-square analyses for gender and ethnicity and independent *t*-tests for age, IQ, and years of education. Raw scores were used for all primary analyses due to the need to adjust for demographic characteristics in our sample (i.e. education and gender) and also due to the differences in the nature of some normative samples used to derive standardized scores in our measures. Three multivariate analyses of variance (MANOVA) were conducted with years of education and gender as covariates on each measure (i.e. neurocognitive, personality, and impulsive ratings) to examine differences between the two groups. A significance rate of $p<0.05$ was used for all analyses. While there is no consensus on the cut-off for determining clinically meaningful scores (65), a range of 1–1.5 SDs from the mean is generally considered to be clinically significant (66). For the present study, we defined a difference of at least 1.5 SDs from controls as being clinically significant for all measures. Measures that met criteria for clinical significance were examined using receiver operating characteristic (ROC) analysis to determine scale sensitivity and specificity and the optimal cut-off for cocaine dependence. Pearson correlation analyses were performed to evaluate the convergent and discriminant validity of the measures using a Bonferroni correction of 0.0025 (0.05/20) to maintain a 5% Type I error rate.

Frequency analysis was used to determine the percentage of cognitive impairment (scores > 1.5 SD or a T<35) within cocaine dependence for each measure that T-scores were available (TMT, Stroop, WCST, and CPT-II). An overall frequency of cognitive impairment was calculated based on the percentage of participants in each condition who were impaired on at least two neurocognitive measures. Post-hoc MANOVAs examined demographic and self-report measures between cognitively impaired and unimpaired cocaine-dependent participants. Chi-square analysis was used to examine if cognitive impairment classification was associated with a history of alcohol use disorder (DxETOH).

Results

Demographics (Table 1)

Ethnicity and age did not statistically differ between the two groups. Control participants had more years of education, higher IQ estimates, and a greater percentage of females than

Supplementary Material Available Online
Derivation and validation of the neurocognitive and self-rating measures.

cocaine-dependent participants. Since IQ is highly correlated with years of education, all comparisons utilized years of education and gender as covariates.

Neurocognitive measures (Table 2)—The IGT was the only neurocognitive measure found to be statistically different ($p<0.05$) between cocaine-dependent and control participants. Nonetheless, all neurocognitive measures failed to reach our cut-off for clinical significance.

Personality measures—Cocaine-dependent participants scored significantly higher than controls on TCI Impulsiveness (NS2) and lower on Purposefulness (SD2) and Congruent Second Nature (SD5). Similarly, cocaine-dependent participants scored higher on NEO PI-R Impulsiveness (N5) and lower on Self-Discipline (C5) and Deliberation (C6). TCI Persistence (P) and NEO-PI-R Order (C2) scores did not statistically differ between the two groups. TCI Purposefulness (SD2) and Congruent Second Nature (SD5) and NEO-PI-R Impulsiveness (N5) were the only scales to differ >1.5 SDs, denoting clinical significance.

Impulsivity scales (BIS-11 and FrSBe)—Cocaine-dependent participants reported significantly higher scores than controls on all prorated BIS-11 scores (Nonplanning, Motor Impulsivity, Attentional and Total) and FrSBe Disinhibition and Executive Dysfunction scores. Cocaine-dependent participants' scores on FrSBe Disinhibition and BIS-11 Motor Impulsivity and Total achieved a clinically significant difference from controls.

ROC analysis—ROC analyses revealed significant discrimination ($p<0.0001$) between cocaine-dependent and control participants for all clinically significant measures [i.e. TCI (SD2) and (SD5), NEO-PI-R (N5), FrSBe Disinhibition, BIS-11 Motor Impulsivity, and BIS-11 Total]. Classification accuracy was similar among these measures and ranged from 0.89–0.93, with the exception of TCI Purposefulness which was 0.84. Optimal cut-off points were identified for discriminating cocaine-dependent from healthy control participants for each measure: Impulsiveness (N5): 16.5 (sensitivity 73%, specificity 95%); Congruent Second Nature (SD5): 8.5 (sensitivity 74%, specificity 96%); Purposefulness (SD2): 6.5 (sensitivity 66%, specificity 84%); BIS-11 Motor Impulsivity: 21.4 (sensitivity 80%, specificity 91%); BIS-11 Total score: 56.9 (sensitivity 71%, specificity 91%); FrSBe Disinhibition: 36.5 (sensitivity 75%, specificity 91%).

Correlation analysis—Correlations between self-rating measures of personality and impulsivity with neurocognitive tests were universally non-significant ($p>0.0025$). With the exception of FrSBe Disininhibition and BIS-11 Nonplanning, all BIS-11 and FrSBe scores were significantly correlated ($r=0.36–0.47$). BIS-11 Motor Impulsivity and Total scores and FrSBe Disinhibition were also significantly correlated ($r=0.40–0.62$) with all personality scales except for TCI Persistence (P) and NEO-PI-R Order (C2) and FrSBe Disinhibition with NEO-PI-R Self Discipline (C5).

Frequency of cognitive impairment—Frequency estimates revealed 5–19% of cocaine-dependent participants showed impairment >1.5 SD on neurocognitive tests, with the WCST showing the highest percentage of impairment. Overall frequency of cognitive impairment in cocaine dependence was 6% compared to 0% for controls. Using a less

conservative definition of impairment, i.e. >1 SD, this resulted in a frequency of just 20% for cocaine dependence and 12% for controls. Due to the lack of participants showing impairment >1.5 SD, post-hoc tests were completed using performances >1 SD for classification of cognitive impairment. Results from MANOVA revealed no significant differences in terms of age, IQ, years of education, and lifetime and recent cocaine use between cognitively impaired and unimpaired cocaine-dependent participants. Only TCI Persistence statistically differed between these two groups (p=0.004), where cognitively impaired cocaine-dependent participants reported lower scores than non-impaired participants. No significant relationship was found between cognitive impairment and a history of alcohol use disorder (DxETOH n=9; p=0.32).

Discussion

This study is the first, to our knowledge, to examine the utility of multiple measures of impulsivity in cocaine-dependent participants compared to healthy controls. Self-rating measures of personality and impulsivity identified clinically relevant elevations in impulsivity, but neurocognitive measures did not show systematic differences between groups. Scores on TCI Purposefulness (SD2) and Congruent Second Nature (SD5), NEO-PI-R Impulsiveness (N5), BIS-11 Motor Impulsivity and Total, and FrSBe Disinhibition significantly differed (>1.5 SDs) between cocaine-dependent and control participants.

The personality findings were largely consistent with prior results showing large differences (i.e. two SDs) between cocaine users (31) and cocaine-dependent individuals (34) relative to healthy controls. Differences observed on the BIS-11 Motor Impulsiveness (42,67,68) and Total scale (42,68,69) were also supported by other research findings. In respect to the FrSBe Disinhibition scale, some studies provide support for our findings [i.e. similar samples with nearly equivalent raw scores (70) and T-scores (17) to our samples], while others do not (28). However, since higher FrSBe Disinhibition scores have been linked to early treatment dropout (i.e. 31.6% within 8 weeks of treatment) (17), it is possible that persons with higher Disinhibition scores did not stay in the extended treatment from which that sample was derived (28).

We found that none of the neurocognitive measures examined, with the exception of the IGT, significantly differed between cocaine-dependent participants and controls. Whereas several studies report statistically significant differences between these groups [TMT (23,24,26,44), Stroop (22,25), WCST (26–28), and IGT (25,42)], others do not [TMT (45–48), Stroop (44–46,48), WCST (45–47) and IGT (45)]. A review by Jovanovski et al. (2005) reported that the sensitivity of several of the neurocognitive measures used in assessing cocaine-dependent participants (e.g. Stroop, TMT, and WCST) was between 0.61 and 0.52 (21), suggesting that cognitive impairment in these samples is lower than in many other neuropsychiatric conditions (45). Similarly, we found a low frequency of neurocognitive impairment, ranging from 6–20% across tests. Such findings may underlie the mixed reports of neurocognitive differences between cocaine-dependent and control participants and the lower sensitivity of neurocognitive measures within this population.

There are several possible reasons why cocaine-dependent persons' scores on self-rating measures of personality and impulsivity achieved clinical significance while the neurocognitive measures did not. First, cocaine-dependent participants may over report symptoms/behaviors on the self-rating measures. However, this did not seem likely, as some scales, such as TCI Persistence and NEO-PI-R Order (C2), did not differ between the two groups. Furthermore, Verdejo-Garcia et al. (2008) found that substance abusers' self-report on the FrSBe while abstinent were not significantly different from an informant's rating (71). Second, the wording of items in these measures may be confounded with addictive behaviors (e.g. "I buy things on impulse"), possibly allowing cocaine-dependent persons to relate the statements to their addiction when responding and, thus, result in elevated scores. Even so, it is important to note that not all questions on these measures can be seen as directly related to addiction, e.g. "I change jobs" and "I plan for the future." Finally, it should be noted that congruence of neurobehavioral performance and self-reported symptoms is not expected, since neurocognitive and self-report measures of mood, personality, and behavior assess different constructs and there are often differences in reported versus measured cognitive functioning (18,26,28,42).

The self-rating measures of personality and impulsivity had good accuracy and similar sensitivity and specificity. In addition, these measures showed clinically meaningful differences between cocaine-dependent and control participants and were found to be highly correlated, indicating similar constructs. The self-rating impulsivity measures, such as the BIS-11 and FrSBe, may be the most useful in clinical practice, relative to the personality inventories, as the BIS-11 and FrSBe take just 3–15 min to complete vs. the 45 min for personality inventories. Besides these measures' brevity, both the BIS-11 and FrSBe appear to be good predictors of treatment retention (12,17,18) and the FrSBe has been shown to be a predictor of cocaine relapse (17).

Our findings lend further support that trait impulsivity is an important factor in cocaine dependence and addressing this would likely benefit treatment. Cognitive-behavioral relapse prevention (CBRP) is a common intervention with substance abusing populations, and as designed by Marlatt and Gordon (72), this treatment seemingly addresses aspects of trait impulsivity. CBRP aims to reduce unplanned drug relapse by increasing coping behaviors in high risk situations. CBRP also includes strategies (e.g. decision matrix on reasons for and against drug use) to increase consideration of long-term consequences from drug use. Use of the BIS-11 and FrSBe would potentially guide clinicians in determining which interventions to emphasize to address elevations in trait impulsivity. For example, elevated BIS-11 Motor Impulsivity or FrSBe Disinhibition scores could indicate that interventions addressing difficulty in acting without thinking or deficits in behavioral restraint may be most useful in reducing poor retention or early relapse. However, the degree to which interventions modify trait impulsivity is not known and should be addressed in future research. Additionally, since CBRP facilitates the development of coping skills after several sessions, more immediate strategies are likely needed in order to reduce early departures that impede the acquisition of such skills; contingency management has shown effectiveness in increasing treatment retention and reducing relapse during treatment (73) and may be an effective adjunct in targeting the impulsive traits that facilitate early departure and relapse. Significant elevations on the BIS-11 or FrSBe scales may suggest that the addition of contingency

management could improve treatment outcomes for cocaine-dependent persons and warrants further research.

Elevated trait impulsivity has not only been demonstrated in cocaine-dependent persons but also in siblings of addicted persons without a history of dependence (74). In addition, neurobehavioral disinhibition in early childhood has shown to be a risk factor for later development of substance use disorders (75–78). These findings suggest that elevated trait impulsivity could be a predisposition to drug addiction, which would support the notion of "addictive personality" as described by Alan Lang (51). Although the present study could not determine whether elevated impulsivity preceded cocaine dependence or developed as a product, our robust findings of elevated trait impulsivity suggests that cocaine-dependent persons are impaired on an integrative level of functioning, specifically personality and its dimensions. Determining the temporal sequence of elevated trait impulsivity could have implications on drug addiction treatment and should be addressed in future studies.

The present study has several strengths and limitations. One strength is that the patient sample came from multiple sites, including federal and non-federal not-for-profit treatment centers, thereby potentially increasing the generalizability of our results. However, the samples recruited from each inpatient program may have differed on self-reported levels of impulsivity, history of drug use, or attrition rates that could reflect a selection bias that may limit the generalization of the results. Many factors that could affect neurocognition were excluded (i.e. other psychiatric and medical disorders, use of psychotropic medications, history of traumatic brain injury with persisting symptoms), although participants with other substance use disorders and possibly attention-deficit/hyperactivity disorder were included. Thus, the effects of cocaine abuse cannot be definitively disentangled from other substances of abuse or neurodevelopmental disorders. Other limitations of the study included the relatively small number of healthy controls who participated and the lack of matching these controls to our cocaine-dependent participants on IQ, education, and gender, although these demographic differences were statistically adjusted. In addition, the BIS-11a was used, and scores were prorated to the BIS-11. The reliability of the prorated scores and its concurrent validity with the BIS-11 is unknown.

In summary, our findings suggest that both the BIS-11 and FrSBe may provide clinically useful information in assessing trait impulsivity in a cocaine-dependent population and, based upon previous studies, may assist in predicting participants at risk of poor treatment retention or early relapse following treatment. Trait impulsivity as measured by the BIS-11 and FrSBe appears to be relatively distinct from neurocognition, thus indicating self-report and neurocognitive measures assess different impulsive constructs. Future studies should assess whether interventions targeting cocaine-dependent patients with high BIS-11 or FrSBe scores successfully lessen early treatment departure or extend time to cocaine relapse. Also, future research should attempt to improve the validity of the BIS-11 and FrSBe by eliminating items confounded by addictive behaviors and determine if changes to internal and concurrent validity is non-significant or significantly improved.

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Table 1

Demographic characteristics and cocaine-dependent subjects' drug use information.

	Controls	Cocaine-dependent
Gender:*		
Males	68.0%	90.8%
Females	32.0%	9.2%
Race:		
Black	52.0%	72.3%
White	40.0%	23.1%
Hispanic	4.0%	4.6%
Other	4.0%	–
Mean age	41.5 ± 8.4	43.8 ± 7.3
Education (years)**	14.0 ± 1.6	12.5 ± 1.8
Estimated IQ**	97.2 ± 10.5	89.0 ± 8.6
# Subjects with Alcohol use disorder	0	42
INDUC 2 Lifetime:		
Physical**	1.4 ± 1.7	6.2 ± 1.7
Interpersonal**	0.96 ± 1.7	9.1 ± 1.9
Intrapersonal**	1.0 ± 2.2	7.5 ± 1.3
Impulse control**	1.9 ± 2.5	8.6 ± 2.4
Social responsibilities**	0.56 ± 1.2	6.3 ± 1.3
TLFB:		
Lifetime # of days used		3208 ± 2191
Lifetime $ spent on cocaine		345,695 ± 393 688
# Days used in last 90 days		66.0 ± 26.4
$ spent in last 90 days on cocaine		6247 ± 5453

* $p < 0.05$;

** $p < 0.0001$ between cocaine-dependent patients and controls on measured variables. INDUC, Inventory of Drug Use Consequences; TLFB, TimeLine Follow Back.

Table 2

Neurocognitive and self-report measures of impulsivity in healthy control and cocaine-dependent participants. Years of education and gender controlled.

Scale	*n* Controls	*n* Patients	Controls Mean ± SD	Cocaine-dep Mean ± SD	SD difference	F	*p* Values
Neurocognitive tests							
TMT Part B	25	54	69.2 ± 30.4	87.7 ± 48.3	0.6	0.64	0.43
Stroop Color Word	25	54	42.8 ± 10.4	39.4 ± 8.2	0.3	1.2	0.27
BART average adjusted pumps	25	54	33.9 ± 17.4	32.1 ± 13.0	0.1	1.1	0.31
GT total score	25	54	1.8 ± 26.8	−6.3 ± 13.4	0.3	5.0	0.03
CPT Commissions	25	54	10.0 ± 5.6	12.2 ± 7.2	0.4	0.16	0.69
WCST Perseveration score	25	54	13.4 ± 12.8	20.3 ± 14.7	0.5	2.0	0.16
Personality inventories							
TCI-R:							
Impulsiveness (NS2)	24	61	2.7 ± 1.7	5.2 ± 2.3	1.47	18.0	<0.0001
Purposefulness (SD2)*	24	61	7.3 ± 0.9	5.3 ± 1.9	2.2	19.2	<0.0001
Congruent Second Nature (SD5)*	24	61	10.9 ± 1.3	6.9 ± 2.5	3.1	53.2	<0.0001
Persistence (P)	24	61	6.0 ± 1.3	5.4 ± 1.9	0.5	1.1	0.31
NEO-PI-R:							
Impulsiveness (N5)*	24	61	12.5 ± 3.3	19.4 ± 4.0	2.1	58.1	<0.0001
Order (C2)	24	61	19.6 ± 3.7	18.6 ± 3.5	0.3	3.4	0.07
Self-discipline (C5)	24	61	23.0 ± 4.4	18.9 ± 5.1	0.9	12.8	0.001
Deliberation (C6)	24	61	20.5 ± 4.5	14.4 ± 4.4	1.4	30.0	<0.0001
Self-rating scales							
BIS-11:							
Non-planning	23	61	17.7 ± 2.8	20.1 ± 2.3	0.9	8.6	0.004
Motor impulsivity*	23	61	17.8 ± 2.9	25.0 ± 4.4	2.5	38.2	<0.0001
Attentional	23	61	12.9 ± 3.1	16.8 ± 3.5	1.3	15.6	<0.0001
Total*	23	61	48.5 ± 6.6	61.5 ± 7.5	2.0	37.0	<0.0001
FrSBe:							
Disinhibition*	23	61	30.8 ± 4.0	40.4 ± 7.0	2.4	23.9	<0.0001
Executive dysfunction	23	61	40.8 ± 4.5	47.3 ± 6.5	1.4	11.9	0.001

* Group differences are significant at <0.05 and a standard deviations difference >1.5. SD, standard deviation; SD difference = (Control Mean − Patient Mean)/Control SD.