

The influence of executive functions, sensation seeking, and HIV serostatus on the risky sexual practices of substance-dependent individuals

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Abstract

From a public health standpoint, identifying factors that contribute to risky sexual practices among substance-dependent individuals is critical, particularly in the context of HIV infection. This study examines the respective contributions of executive neurocognitive functions, sensation seeking, and HIV serostatus in predicting risky sexual practices among poly-substance users (with a history of dependence primarily for cocaine or cocaine/heroin). HIV+ ($n = 109$) and HIV- ($n = 154$) substance-dependent individuals were assessed using three neurocognitive tasks of executive functions: Stroop reaction time, delayed non-matching to sample, and the Iowa Gambling Task. Sensation seeking was assessed using the Sensation Seeking Scale-V. Greater sensation seeking was associated with more risky sexual practices among HIV+ participants, particularly among those who performed best on the Iowa Gambling Task. Our findings indicate that continued risk behavior among HIV+ drug users may be driven by sensation seeking (a personality trait common among drug users); however, the impact of executive functions is less clear. (*JINS*, 2005, *11*, 121–131.)

Keywords: Impulsivity, HIV, Substance dependence, Addiction, Executive functions

INTRODUCTION

Both HIV infection and substance dependence have known adverse effects on neurocognition (reviewed in Basso & Bornstein, 2000; Hardy & Hinkin, 2002; Reger et al., 2002; Rogers & Robbins, 2001; Verdejo-Garcia et al., 2004), and in turn affect the capacity to engage adequately in various activities of daily living (Benedict et al., 2000; Heaton et al., 1994, 2004). Recent findings have suggested that HIV infection and substance dependence may interact in complex ways, compounding cognitive and behavioral abnormalities (Basso & Bornstein, 2000; Hinkin et al., 2004; Martin et al., 2004; Nath et al., 2002; Rippeth et al., 2004; Vazquez-

Justo et al., 2003). Investigations on HIV transmission and exposure will most likely be informed by findings from studies examining multiple factors pertinent to drug abusers, such as neurocognitive function, personality, and HIV serostatus. However, few studies have examined how these factors might interact.

Neurocognitive impairments observed in individuals with HIV have been well characterized, and include difficulties in learning and recalling new information, slowed processing speed, and difficulties in executive functions (reviewed in Hardy & Hinkin, 2002; Reger et al., 2002). The pattern of these neurocognitive deficits reflects disruptions in prefrontal-subcortical brain circuits, for which HIV has been shown to demonstrate a predilection (Jernigan et al., 1993; Stout et al., 1998). Similar types of neurocognitive deficits have been reported among seronegative individuals dependent on drugs of abuse, such as cocaine, methamphetamine,

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and heroin (reviewed in Rogers & Robbins, 2001; Verdejo-Garcia et al., 2004). Impairments of executive control among drug users are hypothesized to result from abnormal functioning of systems involving the mesolimbic dopamine pathways, which have been implicated consistently in the study of reward processing and other hypothesized mechanisms of addiction (reviewed in Cami & Farre, 2003; Volkow et al., 2002).

The underlying neuropathology and cognitive deficits in HIV share some common features with those observed among individuals addicted to drugs (reviewed in Basso & Bornstein, 2000; Nath et al., 2002). Studies designed to examine specific aspects of executive functions in substance-dependent individuals, with and without HIV, have demonstrated abnormal executive processing, which include deficits in working memory (Bartok et al., 1997; Farinpour et al., 2000; Martin et al., 2001, 2003; Mintzer & Stitzer, 2002), decision-making (Bechara et al., 2001; Bolla et al., 2003; Grant et al., 2000; Martin et al., in press; Mintzer & Stitzer, 2002), and response inhibition (Martin et al., 2004; Mintzer & Stitzer, 2002).

The executive deficits noted above may result in participants' experiencing difficulties assessing the relationship between their current behavior and future outcomes of such behavior. Decision-making deficits, for example, can cause response choices to be directed primarily by current reward values rather than long-term consequences of the behaviors in question (reviewed in Bechara, 2003). Such impairment could theoretically contribute to engagement in high-risk behaviors such as unprotected sex, multiple sexual partners, indiscriminate sharing of injection drug paraphernalia, and other behaviors that increase the likelihood of contracting and transmitting HIV or other infectious diseases (e.g., the hepatitis C virus). Despite the obvious need for scientific work in this area, to our knowledge, few studies have examined possible relationships between executive deficits and engagement in risky behaviors among substance-dependent individuals with and without HIV.

A significant challenge in examining the relationships between neurocognitive functioning and risk behaviors is the necessity to account for longstanding personality traits that may predate active substance use or HIV disease. Poor decision-making and engagement in risky behaviors might be accounted for in part by dispositional traits. Sensation seeking, defined as a need to "reach and maintain an optimum level of arousal" and a need for "varied, novel, and complex sensations . . . and willingness to take risks for the sake of such experiences" (Zuckerman et al., 1964; Zuckerman, 1994) has been consistently associated with a variety of risky behaviors. These behaviors include dangerous driving (reviewed in Jonah, 1997), sexual risk taking (reviewed in Hoyle et al., 2000), engaging in high-risk sports (Franques et al., 2003), and a propensity for substance abuse (e.g., Crawford et al., 2003). This trait is particularly relevant to the study of risk behavior among substance-dependent individuals given that the proposed neurobiological underpinnings of sensation seeking may overlap with neural path-

ways that underlie the pleasurable and addictive properties of various substances (i.e., mesolimbic and mesocortical dopaminergic pathways). Animal models, genetic studies, and investigations with healthy controls and substance-dependent individuals suggest that sensation seeking traits may be related to the functioning of monoaminergic systems, particularly those involving dopamine (Dellu et al., 1996; Hutchison et al., 1999; Limosin et al., 2003; Netter et al., 1996; Zuckerman, 1994, 1996; Zuckermann & Kuhlman, 2000): neurotransmitter systems that are known to be stimulated by most common drugs of abuse.

Clearly, various factors may be associated with risky sexual practices among substance-dependent individuals (with and without HIV). In the current investigation, we evaluated relationships between the integrity of specific executive functions previously shown to be affected among HIV+ individuals (e.g., response inhibition, working-memory, and decision-making), degree of sensation seeking, and self-reported engagement in risky behaviors among polydrug users with and without HIV. Our aims were to evaluate if executive functions and sensation seeking would independently predict engagement in risky sexual practices. We hypothesized that both aforementioned factors would account for unique and statistically significant variance in reported risky sexual practices. Further, we examined the role of HIV serostatus in predicting the risky sexual practices of substance-dependent individuals, and if HIV served to mediate relationships observed between sensation seeking, executive functions, and engagement in risky sex. Due to the lack of available research on this topic, it was unclear how HIV serostatus would independently relate to or interact with other factors in predicting risky sexual practices.

METHODS

Participants

The subject sample consisted of 263 polydrug users from the Chicago metropolitan area. Participants were recruited from the Jesse Brown Veterans Association Healthcare Division–West Side Division, the HIV Early Intervention Clinic at Mile Square Health Center, community addiction and HIV treatment programs, and through "word-of-mouth." Most of the individuals that seek services from these agencies tend to be economically disadvantaged and our experiences suggest that most of the participants in the current investigation are of low socio-economic status. Participation in our study is voluntary and is not a requirement for any participant that may be undergoing substance use treatment. Participants are substance users who meet DSM-IV criteria for a history of dependence (96%) or abuse (4%) for at least one substance. The vast majority of participants (97%) met dependence and/or abuse criteria for more than one substance in their lifetime, other than nicotine or caffeine. Detailed inclusion and exclusion criteria have been described elsewhere (Martin et al., 2003). Briefly, partici-

pants in our study met the following criteria: (1) no clinical dementia secondary to HIV or substance use; (2) no history of other neurologic disorder, such as stroke or epilepsy; (3) no history of open head injury or closed head injury with loss of consciousness greater than 30 min; (4) no history of schizophrenia; (5) not on neuroleptic treatment; (6) at least nine years of education; (7) able to speak and read in English; (8) no signs of acute intoxication or withdrawal; and (9) no signs of active psychosis. All participants underwent Breathalyzer testing and rapid urine toxicology screening at testing in order to ensure no recent drug or alcohol use.

The sample consisted primarily of high school educated, African-American men in their fourth decade of life. The American National Adult Reading Test (AmNART: Grober & Sliwinski, 1991) and the Wide Range Achievement Test—III Oral Reading subtest (WRAT—III: Wilkinson, 1993) were used to assess literacy and provide estimates of verbal IQ. Current emotional distress and symptoms of depression, anxiety, post-traumatic stress disorder (PTSD), attention-deficit hyperactivity disorder, and antisociality were respectively assessed with the Beck Depression Inventory (BDI; Beck et al., 1961), the State portion of the State-Trait Anxiety inventory (Spielberger et al., 1983), the PTSD Symptom Checklist—Civilian Version (Weathers et al., 1994), the Wender-Utah Rating Scale (Stein et al., 1995; Ward et al., 1993), and the socialization scale of the California Personality Inventory (Gough, 1994).

Table 1 shows the demographic characteristics of the two groups. Participants evidenced average premorbid verbal intellectual functioning and demonstrated a minimal level of self-reported depressive symptoms. HIV+ and HIV− participants did not differ significantly on any of these demo-

graphic variables (all p values $> .05$), indicating satisfactory group matching.

Of the total sample ($N = 263$), 41% ($n = 109$) were positive for HIV. HIV serostatus in all cases was ELISA-verified with Western Blot confirmation of positive serostatus. The majority of HIV+ participants (82%) were taking some form of antiretroviral medications, and 41% of the total HIV+ sample reported being on highly active antiretroviral therapy (HAART). HIV-infected participants demonstrated evidence of affected immune functions based on \log_{10} of HIV RNA levels in plasma (median = 2.87; IQR [2.60, 3.93]) and CD4 T-lymphocyte counts (median = 454, IQR [266, 639]). Approximately 19% of HIV+ individuals in our sample had an AIDS-defining CD4 count. Plasma viral load was below the threshold for detection (<400 copies/ml) in 33% of the HIV+ sample.

Assessment of Substance Use

History of substance dependence was determined using the Structured Clinical Interview for DSM—IV—Substance Abuse Module (SCID-SAM: First et al., 1996). Participants also completed the Addiction Severity Index (ASI), a standardized measure used to estimate severity of drug and alcohol abuse, as well as associated social, legal, medical, and psychiatric complications (McLellan et al., 1985). Table 2 presents detailed substance use information for participants. Most participants (92%) identified cocaine, heroin, or a combination of both as their substance(s) of choice. The majority met DSM—IV criteria for lifetime dependence for cocaine (77%), alcohol (65%), and heroin (53%). Few participants, however, met DSM—IV criteria for current

Table 1. Demographic characteristics and psychological functioning of participant sample

	HIV− ($n = 154$)	HIV+ ($n = 109$)	Combined group ($n = 263$)
Age	43.7 (7.8)	44.6 (6.1)	44.1 (7.2)
Years of education	12.4 (1.8)	12.3 (1.7)	12.4 (1.8)
AmNART IQ	100.8 (9.2)	102.2 (9.4)	101.4 (9.3)
WRAT—III—Reading (raw score)	41.1 (7.2)	41.7 (7.6)	41.4 (7.4)
BDI	9.0 (9.5)	11.6 (9.2)	10.1 (9.5)
State-Trait Anxiety Inventory—State	36.79 (11.6)	38.28 (10.5)	37.4 (11.2)
Wender-Utah Rating Scale	28.81 (18.5)	31.21 (18.9)	29.8 (18.7)
Socialization Scale	27.38 (6.2)	26.6 (5.8)	27.1 (6.1)
PTSD Checklist—Civilian version	34.63 (13.9)	38.2 (13.9)	36.1 (14.0)
RAB—Sexual Practices	3.84 (3.0)	3.71 (3.3)	3.79 (3.1)
Sensation Seeking Scale—V	15.67 (5.5)	14.92 (6.0)	15.36 (5.7)
Sex (number of men, % of sample)	135 [88%]	94 [86%]	229 [87%]
Ethnicity (number, % of sample)			
African American	138 [90%]	100 [92%]	238 [91%]
Caucasian	7 [4.5%]	4 [3.5%]	11 [4%]
Hispanic	7 [4.5%]	4 [3.5%]	11 [4%]
Other	2 [1%]	1 [1%]	3 [1%]

Note. Means and standard deviations are presented, unless otherwise noted; AmNART, American National Adult Reading Test; WRAT—III, Wide Range Achievement Test—3rd edition; BDI, Beck Depression Inventory; RAB, Risk Assessment Battery.

Table 2. Drug use characteristics of participant sample

	HIV–		HIV+		Combined group	
Years of drug use (mean, SD)	22.1	(8.5)	21.4	(8.6)	21.8	(8.5)
Days since last use (median, IQR)	92.5	[35, 240]	140	[41, 370]	109	[36, 313]
Addiction Severity Index (median, IQR)						
Alcohol	.17	[0, .17]	.12	[0, .17]	.16	[0, .17]
Drug	.08	[.07, .10]	.08	[0, .08]	.08	[0, .10]
Drug of Choice (number, % of sample)						
Cocaine	67	[45%]	49	[47.5%]	116	[46%]
Heroin	47	[31%]	29	[27%]	75	[30%]
Cocaine/Heroin	28	[19%]	13	[12.5%]	41	[16%]
Alcohol	5	[3%]	10	[10%]	15	[6%]
Marijuana	3	[2%]	3	[3%]	6	[2%]
DSM–IV Current Dependence						
Alcohol	13	[8%]	4	[4%]	17	[6%]
Cocaine	13	[8%]	15	[14%]	16	[6%]
Heroin	6	[4%]	5	[5%]	11	[4%]
Marijuana	3	[2%]	1	[1%]	4	[2%]
Other Drug	2	[1%]	3	[3%]	5	[2%]
DSM–IV Past Dependence						
Alcohol	103	[67%]	68	[62%]	171	[65%]
Cocaine	123	[80%]	79	[72%]	202	[77%]
Heroin	82	[53%]	57	[52%]	139	[53%]
Marijuana	76	[49%]	52	[48%]	128	[49%]
Other Drug	57	[37%]	35	[32%]	92	[35%]

Note. IQR, inter-quartile range.

(<1 month) dependence for any substance. HIV+ and HIV– participants did not demonstrate statistically significant differences on prevalence of current or past substance dependence history, reported drug of choice, years of substance use, or scores on the Addiction Severity Index (all *p*-values > .05).

Assessment of Sensation Seeking

The Sensation Seeking Scale–Version V (SSS–V) was used to assess sensation seeking among participants (Zuckerman, 1996). This self-report questionnaire consists of 40 forced-choice items reflecting a propensity to engage in novel, risky, or arousing types of behaviors. For example, “I like ‘wild’ uninhibited parties” or “I prefer quiet parties with good conversation.” Ample research attests to its reliability and validity (Loas et al., 2001; Roberti et al., 2003; Zuckerman, 1994). For the current investigation, we employed the overall score on this questionnaire to assess the degree of sensation seeking among our participants.

Assessment of Risk Behavior

All participants completed an extended version of the Risk Assessment Battery (RAB). The RAB is a self-report questionnaire containing various questions regarding risky behaviors associated with injection drug use and sexual practices that shows good agreement (kappas = .76 to .88) with “one-

to-one clinical interviews” of these behaviors (Metzger, 1993; Metzger et al., 1991, 1992; Navaline et al., 1994). The RAB has been used successfully in several investigations that assess HIV-related risk behaviors (Avants et al., 2000; Sees et al., 2000; Woody et al., 2003). Responses on the RAB can be tabulated to generate a total score, which can be subdivided into two subscales: “Needle Use” (RAB-NU) and “Sexual Practices” (RAB-SP). Questions for both of these subscales are based on multiple-choice items reflecting frequency or quantity (0–4 points) of specific behaviors that a participant may have engaged in during the past 6 months. Total scores on the RAB may range from zero to 40 points—participants can obtain a maximum of 22 points on the NU section and 18 points on the SP section. Sample questions from the SP subscale of the questionnaire include: “With how many men have you had sex in the past 6 months?; In the past 6 months, how often have you had sex so you could get drugs?; In the past 6 months, how often were you paid money to have sex with someone?; In the past 6 months, how often did you use condoms when you had sex?” Most participants in our sample were not actively using injection drugs during the 6 months prior to their assessment; therefore, the variability of scores on the RAB-NU subscale was extremely restricted, median = 0, IQR [0, 0]. For the RAB-SP subscale, ample variability in scores was evidenced in our sample (range = [0, 18], median = 3, IQR [1, 5]). Essentially all of the variance in the RAB total scores was the result of responses on the RAB-SP subscale.

As a result, only risky sexual behaviors (during the previous 6 months), as assessed by the RAB-SP subscale, was used as the dependent variable in statistical analyses.

Neurocognitive Tasks of Executive Functions

Iowa gambling task (GT)

Bechara et al. (1994) developed the GT as a probe of deficits in *judgment and decision-making* typically shown by patients with lesions of the ventromedial (VM) prefrontal cortex. This task has been previously described in detail and has been repeatedly shown to be sensitive to the neurocognitive deficits of various substance-dependent individuals (Bartzokis et al., 2000; Bechara et al., 2001; Bechara & Martin 2004; Bolla et al., 2003; Ernst et al., 2003; Grant et al., 2000; Martin et al., in press; Petry et al., 1998). The task requires the participant to make a series of choices from a computerized display of four card decks, and each card selection results in a win or a loss of some money (as indicated on the computer screen). Participants are to choose cards to obtain the overall highest “winnings” possible by the end of the task. Each deck is associated with a certain amount of reward (two decks with \$50, two with \$100). Choices from the high-reward (“bad”) decks also occasionally result in a large penalty (large loss of reward), whereas choices from the low-reward (“good”) decks occasionally result in a small penalty. The participant is unable to predict when the penalties will appear. Choices from the “bad” decks (high reward/high penalty) ultimately results in lower net “winnings” at the end of the task and are ultimately disadvantageous. In the current investigation, performance on the GT was quantified as the overall number of choices from “bad” decks.

Delayed non-matching to sample (DNM)

Based on the traditional delayed non-matching to sample paradigm used to assess *working memory* in comparative studies, Bechara and colleagues (1998) developed and described this computerized task to assess working memory performance in human adults. Recent findings suggest that working memory performance, as assessed by this task, also influences decision-making (Bechara & Martin, 2004) and appears to be adversely affected in substance-dependent individuals (Martin et al., 2003). Participants are shown a red or a black card on a computer screen for 2 s, followed by an array of four cards (two red and two black). Participants are to select two of the four cards using the initial card as a guide. After an initial training period, 45 trials are administered, with a 10-, 30-, or 60-s delay between presentation of the sample card and the four-card array. During the delay, participants must read aloud from a written narrative in order to minimize rehearsal of the correct response. Delay times vary randomly across trials, ensuring that 15 trials are administered at each time delay. For the current study, performance on the DNM was quantified as the per-

centage of correct responses averaged across the 30-s and 60-s delay trials.

Stroop task—reaction time version (Stroop-RT)

The Stroop paradigm has a lengthy history of use in the psychological literature as a tool to assess *automatic and controlled attentional processes* or *response inhibition* (Stroop, 1935). A computer-administered version of this measure has been employed and described previously in neurocognitive studies of substance-dependent individuals with and without HIV infection (Martin et al., 1992, 1998, 2004). Participants are shown a colored word on a computer monitor, and instructed to name the display color and ignore the word. Participants respond verbally, and reaction time measurements are automatically recorded by the computer. Twenty-five percent of trials are color-congruent (e.g., “GREEN” in green), 50% are neutral (animal names in color), and 25% are color-incongruent (e.g., “BLUE” in red). Performance on this task was quantified by calculating separately the median reaction time for each of the three conditions. Stroop RT data for eight individuals (HIV–, $n = 6$; HIV+, $n = 2$) were excluded because they were identified as outliers based on their overall error rate ($> 10\%$).

Data Analyses

Multiple linear regressions were used to examine relationships among sensation seeking, neurocognitive executive functioning, serostatus, and their interaction effects on self-reported risky sexual practices (RAB-SP scores). All regression models employed RAB-SP scores as the dependent variable and included total scores on the SSS–V and serostatus as an independent variable. In addition, each regression model included performance on only one of the executive functioning measures. Independent variables with $p < .05$ were deemed statistically significant predictors of RAB-SP scores. When necessary, variables were transformed to ensure that assumptions of normality and homogeneity of variance were met. Analyses for outliers and leverage points were conducted by visually examining scatterplots associated with each of the analyses conducted, as well as by examining Cook’s D statistic for each participant contributing data to analyses.

Multiple linear regression was employed to examine the following variables as potential covariates: age, years of education, sex (male or female), ethnicity, history of injection drug use, methadone treatment, hepatitis C serostatus, and BDI scores. Results revealed that age, methadone treatment, history of injection drug use, and BDI scores accounted for significant unique variance in RAB-SP scores ($R^2 = .12, p < .0001$). To control for possible confounding effects of these variables, the residuals of RAB-SP scores obtained in this multivariable regression were used as the dependent variable for analyses.

We also examined if degree of sensation seeking and risky sexual practices differed between HIV+ and HIV–

Table 3A. Main effects from three multiple regressions examining sensation seeking, HIV serostatus, and cognitive performance on self-reported risky sexual behaviors (RAB-SP)

	Standardized Beta	<i>p</i> value
Working Memory (<i>n</i> = 252)		
DNM: average percent correct, 30-s and 60-s delays	.024	.70
HIV: positive [1] or negative [0] serostatus	-.044	.49
SSS-V: total score	.23	<.001
Decision Making (<i>n</i> = 253)		
GT: choices from "bad" decks	.073	.24
HIV: positive [1] or negative [0] serostatus	-.068	.27
SSS-V: total score	.22	<.001
Response Inhibition (<i>n</i> = 209)		
Stroop: median reaction time on interference condition	-.10	.13
HIV: positive [1] or negative [0] serostatus	-.049	.47
SSS-V: total score	.25	<.001

Note. DNM, Delayed Non-matching to Sample; SSS-V, Sensation Seeking Scale-Version V; GT, Iowa Gambling Task; Stroop, Stroop Task-Reaction Time Version.

individuals. A one-way ANOVA comparing SSS-V scores between HIV+ and HIV- individuals revealed no statistically significant differences, $R^2 < .01$, $F(1, 261) = 1.54$, $p = .23$. Similarly, no statistically significant differences were observed between HIV+ and HIV- individuals on RAP-SP scores, $R^2 < .01$, $F(1, 251) = 1.18$, $p = .28$.

RESULTS

Omnibus models of all three multiple regressions were statistically significant ($p < .01$), accounting for 8–11% of the variance in RAB-SP scores (i.e., self-reported risky sexual behavior during the last 6 months). Tables 3A and 3B present standardized beta coefficients and *p* values for all independent variables employed in each of the three multiple regression analyses.

Main Effects

Table 3A presents statistics associated with the main effects examined across the three multiple regression models. Across all multiple regressions, scores on the SSS-V (i.e., self-reported sensation seeking) consistently accounted for statistically significant variance in RAB-SP scores (p values < .0001), regardless of the neurocognitive measure included in the regression. Significant simple main effects of HIV serostatus were not observed in any instance. Similarly, none of the neurocognitive measures were found to account for unique variance in RAB-SP scores. Thus, analyses of main effects revealed that higher self-reported sensation seeking (SSS-V) was associated with higher levels of risky sexual behaviors during the previous 6 months (RAB-SP). However, two interaction effects demonstrated a trend toward statistical significance, suggesting that the relationship between sensation seeking and risky sexual practices may be mediated by additional factors.

Interaction Effects

Table 3B summarizes pertinent statistics for the interaction effects included in the three multivariable regressions that were conducted. Across analyses, a trend toward a statistically significant two-way interaction between HIV serostatus and SSS-V scores was observed (p values = .04 to .08). A follow-up examination of this interaction effect revealed that, overall, SSS-V scores were only correlated with RAB-SP scores among HIV+ individuals, $R^2 = .16$,

Table 3B. Interaction effects from three multiple regressions examining sensation seeking, HIV serostatus, and cognitive performance on self-reported risky sexual behaviors (RAB-SP)

	Standardize Beta	<i>p</i> value
Working Memory (<i>n</i> = 252)		
DNM × HIV	-.062	.32
DNM × SSS-V	-.029	.64
HIV × SSS-V	.13	.04
HIV × SSS-V × DNM	-.035	.57
Decision-Making (<i>n</i> = 253)		
GT × HIV	-.016	.80
GT × SSS-V	-.026	.68
HIV × SSS-V	.11	.07
HIV × SSS-V × GT	-.12	.06
Response Inhibition (<i>n</i> = 209)		
Stroop × HIV	-.060	.37
Stroop × SSS-V	.033	.63
HIV × SSS-V	.12	.08
HIV × SSS-V × Stroop	-.088	.20

Note. HIV-negative participants coded [0], HIV-positive participants coded [1]; DNM, Delayed Non-matching to Sample; SSS-V, Sensation Seeking Scale-Version V; GT, Iowa Gambling Task; Stroop, Stroop Task-Reaction Time Version.

$F(1,107) = 19.54, p < .001$, but not among HIV- individuals, $R^2 = .012, F(1,153) = 1.82, p = .18$ (i.e., higher self-reported sensation seeking was associated with greater sexual risk behavior only for the HIV+ sample).

Other statistically significant two-way interactions were not observed. However, we observed a trend toward a statistically significant three-way interaction (SSS-V \times HIV \times GT) in the multiple regression employing GT performance as the neurocognitive measure ($p = .06$), suggesting that the relationship between SSS-V and RAB-SP scores among HIV+ individuals appeared to be influenced by GT performance.

Follow-up statistical analyses were conducted to examine the trend for a three-way interaction observed among SSS-V scores, HIV serostatus, and GT performance. To illustrate and more readily understand the interaction, GT scores were dichotomized using a median split of the distribution. Those obtaining ≥ 54 choices from “bad” decks were classified as showing a “poorer” performance, whereas those with < 54 choices from “bad” decks were deemed to exhibit a “better” performance. Follow-up analyses revealed that, among HIV+ individuals, SSS-V scores were associated significantly with RAB-SP scores for individuals with a “better” performance on the GT, $R^2 = .27, F(1, 50) = 17.97, p < .001$, but not among those with “poorer” performance on the GT, $R^2 = .04, F(1, 53) = 2.26, p = .14$.

DISCUSSION

Sensation seeking has been defined as a personality trait reflecting a need for “varied, novel, and complex sensations . . . and willingness to take risks for the sake of such experiences” (Zuckerman et al., 1964; Zuckerman, 1994). To our knowledge, sensation seeking has not been well studied in the context of neurocognitive functioning among substance-dependent individuals. Examining how sensation seeking and neurocognitive functions affect an individual’s propensity to engage in risky sexual practices may elucidate ways to tailor interventions that prevent the spread of HIV. The primary goal of the current study was to examine if sensation seeking and executive neurocognitive functions accounted for unique variance in risky sexual practices among HIV+ and HIV- substance-dependent individuals. We observed that greater reported sensation seeking correlated directly with more risky sexual practices. However, we observed no direct relationships between performance on each specific neurocognitive measure and self-reported risky sexual practices for the overall subject sample. However, our results suggested that sensation seeking and risky sexual practices were mediated by HIV serostatus and performance on the Iowa Gambling Task (GT). Specifically, sensation seeking and risky sexual practices correlated significantly only for HIV+ individuals with “better” performance on the Iowa Gambling Task (GT). This effect could not be attributed to group differences between HIV+ and HIV- groups on demographic factors, depression, substance use, and history of injection drug use, since groups

were well-matched on these characteristics. Furthermore, self-reported frequency of risky sexual practices (RAB-SP scores) and self-reported sensation seeking did not differ between HIV+ and HIV- participants, suggesting that between-group differences in overall rates of reported risky sexual practices and sensation seeking did not affect our results.

Sensation Seeking and Risky Sexual Practices Among HIV+ Individuals

Other studies have reported that sensation seeking is related to risky sexual practices among individuals with HIV (Kalichman et al., 1994, 1996; Parsons & Halkitis, 2002). Only the HIV+ participants in our sample evidenced a significant relationship between sensation seeking and risky sexual practices. It is likely that engaging in risky sexual practices may be associated with different levels of excitement or salience for HIV+ relative to HIV- individuals. By definition, one can presuppose that a risky behavior can only be associated with an individual’s propensity for sensation seeking if the risky behavior is found to be enjoyable, reinforcing, and exciting. The degree of excitement associated with risky sexual behavior may differ between HIV+ and HIV- individuals, and may influence behavior in different ways. Other investigators have reported that the degree of pleasure obtained from risky sex is important in determining sexual practices among men at risk for (or with) HIV (Bancroft et al., 2003). For example, Kelly and Kalichman (1998) reported that the reinforcement value (i.e., degree of pleasure) that an individual derived from unprotected sex accounted for more variance than several other cognitive and skill factors thought to affect risky sexual practices. The possibility of increased “excitement” associated with risky sex among HIV+ individuals may be one explanation for the relationship that we observed between sensation seeking and risky sexual practices.

Sensation Seeking and Risky Sexual Practices: The Impact of “Decision-Making” Capacity

Our investigation showed tentative evidence suggesting that the relationship observed between sensation seeking and risky sexual practices among substance-dependent individuals with HIV might be mediated by performance on the Iowa Gambling Task (GT). It is important to keep in mind that this is speculative evidence based on exploratory analyses of a higher-order interaction with a marginally significant trend ($p = .06$). Below we consider possible *post-hoc* explanations for these findings. Counterintuitively, we found that those participants performing “better” on the GT (i.e., those that made fewer choices from the bad decks) evidenced stronger positive correlations between sensation seeking and risky sexual practices than those that evidenced “poorer” performance on the GT. These findings may be

explained by considering the various factors thought to affect performance on the GT: one of which is the role of emotional information in guiding behavior (as described by the “somatic marker” hypothesis). Simply stated, the somatic marker hypothesis posits that emotions (somatic states) guide decision-making processes (Bechara, 2004; Bechara et al., 2000; Damasio, 1996).

The GT has been established as a neurocognitive measure of decision-making capacity that is sensitive to disruptions in brain circuits involving the ventromedial prefrontal cortex. Damage to this brain region is generally characterized by disruptions in processing of emotional signals that may lead to behavioral disinhibition and lack of consideration of future outcomes (reviewed in Bechara et al., 2000; Bechara, 2004) on the GT. These impairments are reflected by individuals choosing more cards from “bad decks.” We do not intend to suggest that substance users and/or individuals with HIV show “poorer” performance on the GT because of dysfunctional ventromedial circuits, as their “poorer” performance may be the result of varied factors. However, their pattern of performance on the GT (i.e., making more choices from “bad” decks) does resemble that of individuals with ventromedial lesions, who are thought to have difficulties incorporating emotional information (somatic states) in their decision-making. One way to interpret our findings is to propose that emotional factors related to sensation seeking only influenced risky sexual behaviors among those HIV+ individuals with “better” decision-making abilities; that is, those whose GT performance less resembled that of patients with documented ventromedial dysfunction. We suggest that sensation seeking may only be associated with risky sexual practices when a risky sexual behavior per se is “felt” to be exciting, enjoyable, reinforcing, and have substantial valence/salience. Among individuals with “poorer” performance on the GT, several factors may obfuscate the relationship between sensation seeking and engaging in risky sexual behaviors. To elaborate, consider two individuals that engage in the same risky behavior, but for two different reasons: (1) the first individual feels that a specific behavior is risky, exciting, and enjoyable, so she or he decides to engage in this behavior because they are a sensation seeker (i.e., they enjoy the actual risk), not because they have impaired decision making abilities; (2) the second individual engages in the same risky behavior, but they do not engage in the behavior simply because they find the risk exciting or enjoyable, but rather because of other reasons, such as having impaired decision-making. As assessed by performance on the GT, impaired decision-making may be the result of various factors, such as indifference to negative consequences, hypersensitivity to reward, or impairments in other cognitive abilities that may subserve decision-making. Disruptions in an ability to incorporate somatic states in the decision-making process is thought to contribute to many of these difficulties. Conceivably, for the first individual, we would be able to detect a relationship between their sensation seeking and their engagement in risky behaviors, as it is their desire to engage

in a risky and exciting activity that contributes to them engaging in the act. In contrast, the second individual engages in the same behavior regardless of whether they are a sensation seeker or not, as they engage in the risky behavior due to other factors, as specified above. As such, the first individual would evidence a correlation between sensation seeking and risky behavior, whereas the second individual would not.

It is important to note that engagement in risky sexual practices did not differ between HIV+ individuals in our sample with “better” GT performance (i.e., fewer choices from “bad” decks) relative to those with “poorer” performance (i.e., many choices from “bad” decks) ($p = .22$); that is, both groups were equally likely to report risky sexual behavior during the previous 6 months. Similarly, among the HIV+ individuals in our sample, those with “better” GT performance did not differ on overall reported sensation seeking compared to those with “poorer” GT performance ($p = .56$). Further, scores on the SSS-V did not correlate with GT performance for either HIV+ ($p = .24$) or HIV- ($p = .43$) participants in our sample. Our limited evidence suggests that the relationship between sensation seeking and risky sexual practices may be mediated by GT performance among HIV+ substance-dependent individuals.

Limitations and Further Considerations

Several possible limitations and confounds must be considered in interpreting the findings of the current investigation and generalizing to other contexts. All participants in the current investigation had a history of substance dependence, and most were African-American men. As a result, the generalization of our findings to different populations may not be appropriate. For example, it is possible that sex (male or female) may mediate or moderate the relationships among executive functions, sensation seeking, and risky sexual behaviors. In our sample, however, we found that the correlations between sensation seeking scores and RAB-SP scores did not differ ($z = .34, p = .37$) when examined separately for men ($r = .25, n = 226, p < .01$) and women ($r = .31, n = 34, p = .07$). Moreover, men and women did not differ on the amount of self-reported risky sexual practices, $t(260) = .23, p = .82$. Investigations designed to specifically address the issue of a possible sex effect (female or male) would need to be conducted with a much larger and balanced sample of women. Future studies may also examine results separately for the four well-established factors of the SSS-V (i.e., experience seeking, disinhibition, thrill and adventure seeking, and boredom susceptibility). Refined hypotheses regarding specific subscales on the SSS-V were not examined in the current study due to the lack of previous research examining sensation seeking and executive functions together in relation to risky sexual practices. Future studies that specifically examine the role of sensation seeking in the risky sexual behaviors of drug users (with and without HIV) may benefit from examining how each specific component of the SSS-V con-

tributes to these risky behaviors. It is also important to note that certain aspects of our findings were primarily based on an interaction effect that showed only a marginally significant trend toward statistical significance. As in all preliminary investigations, this finding may have been the result of Type-I error. Additional research is required to determine if our findings are indeed generalizable and replicable. Despite these limitations, our preliminary findings are of particular interest due to the relative paucity of research in this area, but demand replication in an independent sample of subjects. As the factors that may be pertinent in predicting risky behaviors are better understood, more sophisticated statistical approaches, such as path analysis, may be conducted to more clearly specify the relationships among the numerous variables that may contribute to risky behavior.

Conclusions

In summary, preliminary findings from the current investigation emphasize that “real-world” behaviors (e.g., engaging in risky sexual practices) among substance-dependent individuals are the result of multiple and complex factors such as a personality trait (i.e., sensation seeking), an executive neurocognitive function (i.e., GT performance), and HIV serostatus. Our findings suggest that psychological treatments to reduce risky sexual practices among substance-dependent individuals may benefit from identifying those “at risk” by measuring their propensity for sensation seeking and designing appropriate interventions. The role of executive functions in such behaviors remains less clear. Most investigations to date have examined these factors in isolation and have not attempted to understand how they might interact in predicting behavior. The findings from this investigation suggest that personality traits may merit examination in studies that correlate neuropsychological functions with “real-world” behavior.

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