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Affective differences in Iowa Gambling Task performance associated with sexual risk taking and substance use among HIV-positive and HIV-negative men who have sex with men

Sarit A. Golub^{1,2}, Louisa I. Thompson², and William J. Kowalczyk³

Louisa I. Thompson: Lthompson@gradcenter.cuny.edu; William J. Kowalczyk: bill.kowalczyk@nih.gov

¹Department of Psychology, Hunter College of the City University of New York (CUNY), New York, NY, USA

²Doctoral Program in Psychology, The Graduate Center of the City University of New York (CUNY), New York, NY, USA. Contact: (212)396-6680

³Clinical Pharmacology & Therapeutics Branch, Intramural Research Program, National Institute on Drug Abuse, Baltimore, MD, USA. Contact: (443) 740-223

Abstract

We investigated the relationship between emotional distress and decision-making in sexual risk and substance use behavior among 174 (ages 25 to 50, 53% black) men who have sex with men (MSM), a population at increased risk for HIV. The sample was stratified by HIV status. Measures of affective decision-making (Iowa Gambling Task, IGT, Bechara et al., 1994), depression, anxiety, sex acts, and substance use during the past 60 days were collected at our research center. Negative binomial regression models were used to examine the relationship between age, HIV status, anxiety, depression, and IGT performance in the prediction of number of risky sex acts and substance use days. Among those without anxiety or depression, both number of risky sex acts and drug use days decreased with better performance during risky trials (i.e., last two blocks) of the IGT. For those with higher rates of anxiety, but not depression, IGT risk trial performance and risky sex acts increased *concomitantly*. Anxiety also interacted with IGT performance across all trials to predict substance use, such that anxiety was associated with greater substance use among those with better IGT performance. The opposite was true for those with depression, but only during risk trials. HIV-positive participants reported fewer substance use days than HIV-negative participants, but there was no difference in association between behavior and IGT performance by HIV status. Our findings suggest that anxiety may exacerbate risk-taking behavior when affective decision-making ability is intact. The relationship between affective decision-making and risk taking may be sensitive to different profiles of emotional distress, as well as behavioral context. Investigations of affective decision-making in sexual risk taking and substance use should examine different distress profiles separately, with implications for HIV prevention efforts.

Correspondence regarding this article should be addressed to Sarit A. Golub, Department of Psychology, Hunter College of the City University of New York, 695 Park Avenue, New York, NY 10065. Email: sarit.golub@hunter.cuny.edu.

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Keywords

Decision-Making; Iowa Gambling Task; Anxiety; Sexual Risk Taking; Substance Use

Despite sustained prevention efforts, the overall rate of new HIV infections in the United States has remained stagnant over the past decade, at approximately 50,000 new infections each year (Center for Disease Control [CDC], 2012). Sexual transmission accounts for over 90% of infections, and the virus disproportionately affects men who have sex with men (MSM), who represent 2% of the population, but 56% of U.S. HIV cases (CDC, 2012). Drug use, especially use of stimulants and opiates, is also linked to HIV infection rates both directly, through needle sharing during injection drug use, and indirectly, through the association between substance use and high-risk sexual behavior (Mansergh et al., 2006).

As such, behavioral HIV prevention involves reducing or eliminating behaviors that are often driven by a complex decision-making process of weighting rewards (e.g., pleasure) and costs (e.g., exposure to illness). For better or for worse, these decision-making processes are often not fully conscious or rational (Bargh & Chartrand, 1999; Kihlstrom, 1987). Although most people realize that sex under the influence is riskier than sober sex, many repeat this pattern of behavior, even despite unpleasant consequences and/or intentions to stop. Several theories have proposed that affective experience plays a critical role in guiding the risky decision-making processes involved in these kinds of behaviors (Baumeister, Vohs, DeWall, & Zhang, 2007; Damasio, 1994; Loewenstein, Weber, Hsee, & Welch, 2001; Zajonc, 1980). According to the somatic marker hypothesis, the ventromedial prefrontal cortex (VMPFC) is thought to summate affective cues of reward and punishment to inform decisions (Bechara, Damasio, Damasio, & Anderson, 1994). These cues are associations between stimuli and the rudimentary physiological emotion states they induce, accumulated and adjusted through experience. When decision making is complex or requires a quick choice, affective cues weigh heavily in the process.

The Iowa Gambling Task (IGT) is designed to be sensitive to the integration of affective cues in decision-making (Bechara et al., 1994). Good performance on the IGT is associated with an increased anticipatory autonomic response before making poor decisions on the task, which is thought to reflect the integration of emotional information during the decision-making process (Bechara, Damasio, Damasio, & Lee, 1999; Carter & Pasqualini, 2004). Analogous to many decisions about risky sexual behavior or substance use, good performance on the IGT requires learning to choose smaller short-term rewards in order to minimize larger long-term losses. The IGT distinguishes individuals with VMPFC lesions from controls, but poorer IGT performance has also been demonstrated in individuals with substance use disorders and gambling addiction (Bolla et al., 2003; Linnet, Møller, Peterson, Gjedde, & Doudet, 2011; Buelow & Suhr, 2009).

Additionally, several studies suggest that HIV-positive individuals are more likely to perform poorly on the IGT (Hardy et al., 2006; Martin et al., 2004). HIV can negatively impact cognitive functioning, particularly higher level processes, and further studies confirm that worse IGT performance in HIV-positive individuals may be at least in part due to greater

executive dysfunction (e.g., problem solving and strategy implementation) (Arentoft, Thames, Panos, Patel, & Hinkin, 2013; Thames et al., 2012).

Several studies have distinguished between earlier versus later trials of the IGT, suggesting that the task engages different aspects of learning, decision-making, and executive functioning as it progresses (Dunn, Dalgleish, & Lawrence, 2006; Brand, Labudda, & Markowitsch, 2006; Noël, Bechara, Dan, Hanak, & Verbanck, 2007). During early trials, the decision-making context may be ambiguous, as the individual has little awareness of gain and loss contingencies to guide their choices. Learning is thus implicit at first, but becomes more explicit as the task progresses and participants begin to develop a hunch about the contingencies associated with each deck (Guillaume et al., 2009; Maia & McClelland, 2004). During the later trials, explicit learning allows for more strategic consideration of the task and decision-making becomes more about taking or avoiding risks. Executive abilities such as cognitive flexibility, planning, and working memory may become more important at this later phase of performance, as the gist of the different outcomes now associated with each deck must be held in mind and updated continuously (Bechara & Martin, 2004). Consistent with this, previous research suggests that other executive function tasks (e.g., the Wisconsin Card Sort Task) predict performance during the last 40 to 20 trials of the IGT, but have little or no association with performance during the first 20 to 60 trials (Brand, Recknor, Grabenhorst, & Bechara, 2007; Noël et al., 2007; Sinz, Zamarian, Benke, Wenning, & Delazer, 2008). Thus, the IGT may also assess other aspects of executive function during late trials, and individual consideration should be given to early versus late trials, as opposed to overall task performance, in order to capture this complexity and possible relationships with real-world risk taking behaviors.

Few studies have examined the role of IGT performance in predicting sexual behavior. The two primary investigations of this association have identified IGT performance as a moderator of the association between affective factors and sexual risk taking. In one study of HIV-positive substance dependent individuals, sensation seeking (defined as a need for arousal through intense experience) was positively associated with greater sexual risk taking only among those who performed well on the IGT (Gonzalez et al., 2005). In another study of HIV-positive substance dependent individuals, emotional distress was positively associated with increased sexual risk, but again only among those with good IGT performance (Wardle, Gonzalez, Bechara, & Martin-Thormeyer, 2010). Both of these studies suggest an unexpected influence of decision-making ability on risk; affective factors that increase vulnerability to risk taking appear relevant only for those with better ability to integrate affective cues into their decision-making process. In other words, affective cues may be less relevant for individual who have difficulty using these cues to influence their decision-making (i.e., those with poor IGT performance). In contrast, individuals who perform well on the IGT have better functional integration of affective cues, but when these cues favor poor choices they may be more likely to bias decision-making toward risk.

This idea is consistent with research showing that bodily responses to reward and loss influence intuitive ability during decision-making to a greater extent among individuals with better interoceptive ability (Dunn et al., 2010). Better interoception does not necessarily lead to better decision-making, as anticipatory bodily cues could favor advantageous or

disadvantageous choices depending on the person and situation. A converging body of evidence lends support for the idea that interoceptive sensitivity is implicated in the development and maintenance of anxiety disorders by increasing the experience of potentially anxiety inducing sensations (for review see Domschke, Stevens, Pfleiderer, & Gerlach, 2010; Paulus & Stein, 2010). Thus, in a physiological arousing and potentially anxiety provoking situation such as a sexual encounter, anxious individuals who are good at sensing and integrating affective cues in decision-making may actually experience greater bias toward choices that reduce anxiety and improve affect in the present moment (e.g., avoiding a conversation about condom use, using drugs or alcohol).

Stress, mood and anxiety disorders, and lab induced changes in state affect have been shown to influence performance on the IGT; however, findings are often inconsistent, with some showing that depression and anxiety are detrimental to decision-making performance, while others suggest that anxiety can be beneficial to performance (Cella, Dymond, & Cooper, 2010; Mather & Lighthall, 2012; McFarland & Klein, 2009; Miu, Heilman, & Houser, 2008; Mueller, Nguyen, Ray, & Borkovec, 2010). Outside the laboratory, emotional distress is associated with greater risk taking, including substance use and sexual risk-taking (Brown et al., 2006; Marmorstein, White, Loeber, & Stouthamer-Loeber, 2010; Shiffman & Waters, 2004; Williams & Latkin, 2005). However, the associations are more consistently found for substance use than they are for sexual risk taking (Crepaz & Marks, 2001; Kalichman & Weinhardt, 2001). Preliminary findings from our research on sexual risk taking among emerging adults suggest that depression and anxiety differ in their degree of impact on sexual risk, with anxiety contributing more to greater risk taking (Thompson, Wells, Parsons, & Golub, 2013). However, more research is needed to distinguish between different profiles of emotional distress and improve our ability to understand how affective cues and reward/punishment contingencies are weighed and integrated during decision-making under risk.

The purpose of this study is to explore the extent to which IGT performance (i.e., the ability to integrate affective cues in decision-making) interacts with emotional distress (i.e., depression or anxiety) to predict reported sexual risk taking and substance use in a sample of HIV-positive and HIV-negative MSM. By examining the interaction of IGT performance and emotional distress, we hope to better understand the decision-making processes involved in sexual risk taking in this population, where associations with increased rates of HIV infection are a continuing concern.

Consistent with the substance use literature, we expect that individuals with anxiety and depression will report a higher number of risky sex acts and higher levels of substance use relative to those without emotional distress. Consistent with the decision-making literature, we expect that individuals without emotional distress will show a negative association between IGT performance and sexual risk or substance use. However, we expect that individuals with anxiety and will demonstrate a unique positive association between IGT performance and risk, such that better ability to integrate affective cues during decision-making will actually result in increased risk taking.

METHOD

Participants

Participants were 175 men who have sex with men (MSM) recruited in New York City using passive recruitment methods (e.g., flyers), active recruitment methods (i.e., outreach at bars, events, and community-based organizations), and incentivized participant referral. Eligible individuals were males between the ages of 25 and 50, who reported three or more instances of cocaine, methamphetamine (meth), or heroin use in the last 60 days. To be eligible, participants also had to be sexually active, operationalized as reporting at least two acts of anal intercourse with casual male partners in the past 60 days. Participant recruitment was stratified to include participants who were either “high-risk” (i.e., participants who reported two or more condomless anal sex acts in the past 60 days) or “low-risk” (i.e., those who reported condom use during 100% of anal sex acts in the past 60 days). This stratification was designed to ensure both quantitative and qualitative variation in behavioral patterns of participants, excluding those whose risk reduction or risk taking might be a random or one-time occurrence and including only participants who either demonstrated ability to engage in consistent condom use or those who demonstrated consistent patterns of risk taking. Participants were required to obtain a score of 25/30 or higher on the Mini-Mental Status Examination (Folstein, Folstein, & McHugh, 1975), an established cut-off to rule out cognitive impairment (Tombaugh & McIntyre 1992). Finally, participants underwent the Structured Clinical Interview Psychotic Screening Module for DSM-IV-TR Axis I Disorders, Research Version (SCID-I/P W/ PSY SCREEN; First, Spitzer, Gibbon, & Williams, 2002) to screen out participants with psychotic disorders (no one was excluded based on these criteria). All procedures were reviewed and approved by the Human Research Protections Program at the City University of New York.

Demographics and HIV status—The sample was diverse in terms of ethnicity (Table 1). Just over half of participants (56%) reported education beyond a high school diploma. Approximately half of participants were between the ages of 39 and 50. HIV-positive status was confirmed through written documentation (e.g., diagnosis letter, HIV services referral form) or presentation of HIV medication bottles bearing the participant’s name. HIV-negative status was confirmed using OraQuick fingerstick rapid testing for HIV antibodies. Sampling was stratified by HIV status (49% positive).

Assessment of Substance Dependence

Substance use disorders were assessed using the SCID Substance Abuse Module (SCID-SAM; First et al., 2002). The SCID-SAM is an interviewer-administered questionnaire that assesses for the presence or absence of substance use disorders based on the diagnostic criteria from the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.; DSM-IV-TR; American Psychiatric Association, 2000). Based on DSM criteria, participants were coded as dependent, abusive, or neither for each drug of interest. Overall, 49% of the sample reported current dependence on one or more drugs, 89% reported lifetime dependence (Table 1).

Iowa Gambling Task

The Iowa Gambling Task (IGT) is a computerized card game test of judgment and decision-making originally designed to identify individuals with lesions of the VMPFC (Bechara et al., 1994). The IGT is also sensitive to neurocognitive deficits among individuals with substance dependence, including methamphetamine and cocaine users (Bechara, Dolan, & Hines, 2002; Bolla et al., 2003; Verdejo-Garcia et al., 2007). In the IGT, participants are told to try to win as much virtual money as possible by selecting cards from four available decks (A, B, C and D). Each selection results in either a gain or a gain and a loss of money. Two of the decks (bad decks) yield high rewards but even greater losses, eventually resulting in a net loss of money. The other two decks (good decks) yield smaller rewards but smaller losses, resulting in a net gain of money. The decks are set up so that participants are generally unable to consciously predict reward/loss schedules; however, most individuals gradually learn to select from the good decks and perform well over the course of the task's 100 trials. In order to examine possible differences in the type of decision-making assessed during early versus later trials of the IGT, we examined performance on the first 60 trials (i.e., first 3 blocks; hereinafter referred to as decisions under ambiguity) separate from performance on the last 40 trials (i.e., last 2 blocks; hereinafter referred to as decisions under risk). Previous studies have noted that the point at which the different reward/loss contingencies of the task become more apparent is subject to individual variability; however, most indicate that in normal adults this learning process typically takes at least 40 trials, and can be expected to have occurred by the last 40 trials (Brand et al., 2007; Noël et al., 2007). This study used the IGT software licensed by Psychological Assessment Resources (PAR™, 2007). The program calculates total scores by subtracting the number of cards selected from bad decks from the number of cards selected from good decks, such that higher scores indicate better performance. Raw scores are adjusted to standard scores (T scores) based on norms for age and education ($M = 44.3$, $SD = 9.1$).

Sexual Behavior and Substance Use

The timeline followback (TLFB) semi-structured interview (Sobell & Sobell, 1992), modified for the assessment of sexual risk behavior and substance use (Carey, Carey, Maisto, Gordon, & Weinhardt, 2001; Irwin, Morgenstern, Parsons, Wainberg, & Labouvie, 2006), was used to collect data for the previous 60 days. The TLFB has demonstrated good test-retest reliability, convergent validity, and agreement with collateral reports for sexual behavior and substance use (Weinhardt, Carey et al., 1998; Fals-Stewart, O'Farrell, Freitas, McFarlin, & Rutigliano, 2000). Using a calendar, interviewers asked participants to identify each instance of sexual behavior and/or substance use on each of the preceding 60 days. For each instance of anal sexual intercourse, participants were asked to report both the type of partner (main or casual) and whether or not they used a condom. A main partner was defined as anyone with whom the participant considered their relationship to be romantic in addition to sexual. A casual partner was characterized as any one-time partner (e.g., hook-up) or other non-main partner. For this analysis, we created two behavioral measures. First, total *number of risky sex acts* was defined as the number of condomless anal sex acts with casual partners in the past 60 days ($M = 16$; $SD = 36.1$). Inspection of this variable indicated one extreme outlier who reported 610 condomless sex acts (9.5 SDs above the mean, while no other participants reported values more than three SDs above the mean); this outlier was

excluded from subsequent analysis. Second, *total number of drug use days* was defined as the number of days in the past 60 in which a participant used methamphetamine, heroin, or cocaine/crack. These three drugs were chosen as our primary drugs of interest because of their established association with HIV risk behavior, especially among MSM (Campsmith, Nakashima, & Jones, 2000; Kral, et al., 2005; Ostrow et al., 2009; Plankey, et al., 2007).

Affective Factors

Depression was assessed using the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977), a 20-item self-report scale for research in the general population (Hann, Winter, & Jacobson, 1999; Orme, Reis, & Herz, 1986). Among HIV-positive samples, inflated depression rates may in part occur due to HIV symptom overlap. The CES-D's sensitivity to clinically significant depression in this population has been previously demonstrated (Eller et al., 2010; Simoni et al., 2010; Kalichman, 2000). The CES-D is often used as a screening instrument, with total scores of 16 and 26 indicative of mild and moderate to severe depression, respectively (Radloff, 1977). Dichotomous variables using both cutoffs were tested in our main models. In our sample, 59% of participants ($n = 103$) met the 16 cut-off. This rate was higher than would be expected, even despite evidence of increased rates of depression in MSM, substance users, and HIV-positive individuals. The cut-off of 26 characterized 30.5% of participants ($n = 53$) as depressed, a number more consistent with previously reported clinically significant rates, and therefore less likely to include false positives due to inflated somatic symptom endorsement or generic psychological distress. For these reasons, we decided to use the cutoff of 26 for our final analyses.

Anxiety was assessed using the Brief Symptom Inventory (BSI) Anxiety Subscale, a widely utilized and extensively validated instrument (Derogatis & Melisaratos, 1983; Derogatis, 1993) that has been used in research with MSM populations (Rosario, Schrimshaw, & Hunter, 2006; Kecojevic, Wong, Corliss, & Lankenau, 2015). The BSI anxiety subscale was chosen because it includes fewer somatically oriented questions (e.g., sweaty palms) relative to scales such as the Beck Anxiety Inventory (Beck, Epstein, Brown, & Steer, 1988), while still focusing on anxious arousal as opposed to worry – a dimension more likely to overlap with the assessment of rumination in depression. It was again important to avoid potential inflation of somatic symptom endorsement in this sample, given that stimulant drug use can cause many of the same physiological side effects as anxiety. Although there is no official cut-off score for the BSI Anxiety Subscale, the use of a dichotomized score is more relevant to clinical practice and more statistically manageable relative to continuous raw scores, which are commonly skewed. We placed our cutoff at the sample mean of 0.81, based on comparisons with the normative samples available in the BSI Administration, Scoring, and Procedures Manual (Derogatis, 1993). A mean split, which is a common method for dichotomization, was further deemed appropriate for these data, because our sample mean value of 0.81 fell approximately halfway between the adult male outpatient mean of 1.5 ($SD = .98$), and the male non-patient mean of 0.26 ($SD = .31$). A total of 41.4% ($n = 72$) of participants were categorized as anxious based on this criteria.

Data Analyses

Spearman's nonparametric correlations were conducted to examine relationships between anxiety and depression, IGT performance, sexual risk taking, and substance use variables. Nonparametric correlations were examined due to the large number of variables that were not normally distributed.

Next we created regression models to test our hypotheses regarding the interaction between IGT performance and anxiety and depression in the prediction of sexual risk taking and substance use. IGT performance was treated as a continuous covariate and the dichotomous depression and anxiety variables were entered as independent factors. Two manual interaction terms were also entered to examine the relationship between IGT performance and depression and IGT performance and anxiety. Separate models were run for condomless sex acts with casual partners and number of substance use days as dependent variables. For each of these dependent variables, two series of analyses, with two models each, were run to examine IGT ambiguity and IGT risk trials separately. The first model contained only main effects of HIV status, age, anxiety, depression, and IGT performance. The second model added IGT by anxiety and depression interaction terms. IGT variables consisted of age and education normed T scores centered on our sample mean of 43.3.

Because number of risky sex acts and drug use days are both count variables, we used negative binomial regression models for our analyses. Unlike classic regression models, negative binomial regression models are able to produce the most accurate estimates using positively skewed count data (Long, 1997, p.217; Cox, West, & Aiken, 2009). For negative binomial regression, the dependent variable is log transformed using the canonical link function. This allows the assumption that the independent variables will have a linear relationship with the log-transformed dependent variable. All analyses were conducted using SPSS 20.

RESULTS

Descriptives and Spearman Correlations

Descriptive statistics for sample demographics and nonparametric correlations between variables of interest are presented in Tables 1 and 2, respectively. Number of risky sex acts was positively associated with anxiety and drug use (i.e., number of marijuana use days, as well as combined number of methamphetamine, cocaine, and heroin use days). Number of heavy drinking days was also positively associated with drug use days. Total IGT T score was negatively associated with both heavy drinking days and drug use days. HIV status did not predict IGT performance across ambiguity, risk, or total T score measures ($t(172) = 0.57$, $p = 0.6$).

Regression Models

Associations with risky sex acts—We first tested exploratory main effects models examining demographic variables (i.e., age, ethnicity, education), HIV status, and our primary variables of interest (i.e., dichotomous anxiety and depression, and continuous covariates (i.e., IGT risk and ambiguity average T scores) to determine which factors might

account for significant variance in risky sex acts. The model containing IGT risk revealed main effects for age (mean split .39) and anxiety (mean split .81), whereby older and more anxious participants engaged in a greater number of risky sex acts ($p < .05$). Only the main effect of age was significant in the model containing IGT ambiguity ($p < .05$). These results are shown, excluding non-significant demographic variables, in model 1a (IGT risk) and model 2a (IGT ambiguity) (Table 3).

Next we added interaction terms for anxiety and depression by IGT performance scores (Table 3, models 1b and 2b). The addition of the interaction terms improved overall fit for the IGT risk model (Table 3, model 1b), as indicated by a significant improvement in the likelihood ratio determined via a chi-square test ($\chi^2(2) = 11.3, p < .01$). There was no significant improvement in the ambiguity model by adding these same interaction terms (Table 3, model 2b).

In the full IGT risk model (1b), the main effect of anxiety persisted, while the main effect of age dropped out. A main effect of IGT risk performance also emerged, indicating that for non-anxious, non-depressed participants, better IGT performance on risk trials predicted fewer reported sexual risk acts. The significant parameter estimate for the interaction between IGT risk performance and anxiety indicates that the slope of this relationship differs significantly from the relationships between IGT risk performance and non-anxious, non-depressed emotional health status (i.e., the main effect of IGT risk performance), as well as the relationship between IGT risk performance and depression. Specifically, this relationship suggests that, for anxious participants, number of risky sex acts increased with *increasing* IGT performance, while the relationship between IGT risk performance and depression was non-significant (Figure 1).

Associations with drug use days

The same analytic approach was used to examine the association between IGT performance and number of cocaine/crack, methamphetamine, and heroin drug use days. Exploratory main effects models containing demographics, HIV status, and our main variables of interest were again conducted to determine which variables could account for variance in drug use days. We found significant main effects of HIV status and age for both the IGT risk and IGT ambiguity models, such that HIV negative participants and older participants reported a greater number of drug use days ($p < .05$). There were no main effects of anxiety, depression, or IGT performance variables. Results are shown in model 3a (IGT risk) and model 4a (IGT ambiguity) (Table 4).

Next we added interaction terms for both depression and anxiety with IGT performance variables. The addition of the interaction terms significantly improved overall fit for the IGT risk model ($\chi^2(2) = 11.8, p < .01$) (Table 4, model 3b), but not the IGT ambiguity model (Table 4, model 4b); however, the likelihood ratio did increase from model 4a to model 4b, and a significant interaction between IGT ambiguity and anxiety emerged (discussed below). The effects of HIV status and age remained significant in both IGT risk and ambiguity models. Main effects of IGT risk and ambiguity performance also emerged in both models, indicating that for non-anxious, non-depressed participants, better performance on both early and late trials of the task predicted fewer drug use days.

Significant parameter estimates for the interactions between IGT performance and anxiety and depression were found in the IGT risk model, indicating that the slopes of these relationships differed significantly from each other, as well as those found for non-anxious and non-depressed participants (Figure 2). The directionality of these relationships differed between anxiety and depression, and this was true in both the IGT risk and ambiguity models, although the ambiguity performance by depression interaction was not significant. Specifically, a positive predictive relationship was observed between IGT risk performance and drug use for those with depression, such that reported drug use decreased with increasing IGT performance (Figure 2). In contrast, the opposite was true of the relationship between anxiety and IGT risk and ambiguity performance, where reported drug use increased with *increasing* performance.

Supplementary analyses

There were no significant interactions between HIV status or age and IGT performance, anxiety, or depression in the prediction of risky sex acts or drug use days. The significant parameter estimates for HIV status appeared to be a function of an overall difference in drug use days, such that HIV-negative participants reported significantly more drug use days ($M = 33$, $SD = 27$) compared to HIV-positive participants ($M = 22$, $SD = 16$, $p < .01$). Similarly, both continuous and dichotomous age variables were found to predict drug use, with older participants ($M = 31.6$, $SD = 23.1$) reporting greater use compared to younger participants ($M = 22.6$, $SD = 21.8$; $p < .01$).

We ran additional negative binomial analyses in the same manner as described above in order to examine marijuana use days and heavy drinking days, given their prevalence in this sample, and in the case of marijuana, significant association with IGT performance (Table 2). The overall fit of these models was not robust; full models containing IGT and emotional distress variable interactions predicting marijuana use days (likelihood ratio, $\chi^2 = 11.6$, $p > .05$) and heavy drinking days (likelihood ratio, $\chi^2 = 9.5$, $p > .05$) were both non-significant.

DISCUSSION

Following previous research suggesting that emotional distress is linked to risk only for those who are sensitive to emotional factors in judgment of risk (Wardle et al., 2010), the present study sought to build on past findings in three ways. First, we distinguished between anxiety and depression in order to examine their differential interactions with IGT performance. Second, we examined two types of real world behavior with important implications for HIV transmission: sexual risk behavior and substance use. And third, we explored the extent to which these associations were consistent across both HIV-positive and HIV-negative individuals.

Our findings support both the literature and our hypotheses, indicating that affective decision-making ability (i.e., IGT performance) and emotional distress interact to predict variability in self-report measures of two different types of risk taking. For sexual risk, participants who were not emotionally distressed reported increased risk behavior as IGT performance on risk trials worsened, while participants with anxiety reported increased risk behavior as IGT performance on risk trials *improved*. This effect was not found for

performance on ambiguity trials of the task. There were no associations between IGT performance and sexual risk taking among depressed participants.

For substance use, participants who were not emotionally distressed again reported increased risk behavior as IGT performance on risk trials worsened. In contrast to our findings for sexual risk, depressed participants also demonstrated a negative association between IGT performance and number of drug use days, but only on risk trials of the task. Participants with anxiety again demonstrated a positive association, such that number of drug use days increased as IGT performance improved, and this was true of performance on both risk and ambiguity trials of the task.

Our findings suggest that the relationship between affective decision-making and risk behavior is sensitive both to different profiles of emotional distress, as well as to the context, or type, of risk behavior. Our findings are consistent with the hypothesis that individuals with better ability to integrate affective cues into decision-making may be more vulnerable to the impact of emotional distress on risk taking, with negative consequences (i.e., increased risk taking) uniquely associated with anxiety as opposed to depression. A previous study by Wardle and colleagues (2010) examined emotional distress using a composite score from measures of depression, anxiety, and post-traumatic stress disorder (PTSD). Based on our present findings, it is plausible that the relationship they observed between greater risk taking and improved IGT performance may have similarly been driven by the degree of anxiety reported in their sample.

With some exceptions (Miu et al., 2008), previous research suggests that anxiety is associated with greater risk aversion in decision-making and subsequently better performance on decision-making tasks in the lab (Maner et al., 2007; Mueller et al., 2010). We posit that this association may not hold true in anxiety provoking situations in real-life. In such contexts, high levels of emotional arousal may overwhelm the affective decision-making process and other cognitive resources, resulting in decisions that reflect priority for quick rewards that can reduce anxiety. For example, during sex concomitant with substance use, an anxious individual's need for emotion regulation (e.g., through drug use, or pleasing a partner) may compete with impulse control (e.g., using a condom) (Robinson, Sareen, Cox, & Bolton, 2011). Indeed, in the broader sexual risk taking literature, there is evidence that anxiety may indirectly predict greater sexual risk taking through higher rates of substance abuse (Rosario et al., 2006). This association could be particularly problematic for those who abuse stimulant drugs, which may increase feelings of confidence and invincibility in the short-term, but ultimately exacerbate anxiety symptoms, thereby facilitating a cyclical process of greater abuse and emotional distress.

Our findings have implications for intervention development, as we have identified a subset of individuals for whom risk reduction approaches that focus on improving mental health may prove particularly promising. Cognitive behavioral therapies that can utilize the strength of intact decision-making ability in such individuals could be useful for improving emotion regulation and changing behavioral patterns that lead to sexual risk taking.

The overall strength of both IGT risk and ambiguity models was robust in predicting substance use, while only the IGT risk model was significant in the prediction of risky sex acts. This finding may be reflective of broader differences in the relationship between cognitive function and these two types of risk behavior. Substance abuse, but not sexual risk taking, may cause cognitive dysfunction. Thus, the aspects of cognition that predict sexual risk taking behavior may be fairly specific to those necessary for good performance during risk trials of the IGT (e.g., complex executive functions), while more generalized cognitive dysfunction (e.g., impairments in attention and working memory) associated with substance abuse may predict worse performance on both early and later trials of the IGT. This is an important distinction, as working memory deficits have been associated with poor IGT performance in individuals with substance abuse disorders (Bechara & Martin, 2004; Duarte, Woods, Rooney, Atkinson, & Grant, 2012), and may be a productive target for interventions to treat addiction (Bickel, Yi, Landes, Hill, & Baxter, 2011).

Our finding that an association between IGT performance and risk among depressed participants emerged only for drug use days suggests that sexual risk taking and substance use may be differentially influenced by emotional distress and affective decision-making interactions. This is consistent with the potential contextual differences between these two risk behaviors. Substance use may or may not be a social behavior, while sexual risk taking inherently involves interaction to some degree. For depression specifically, withdrawal, anhedonia, lethargy, and other associated symptoms can contribute to reduced social interaction and increased vulnerability for substance use disorders (Brook, Brook, Zhang, Cohen, & Whiteman, 2002; Gilman & Abraham, 2001). Therefore, while depression may increase substance use and vice versa, its effect on sexual behavior, as result of social withdrawal or changes in libido, may actually be somewhat antagonistic (Bancroft et al., 2003; Lykins, Janssen, & Graham, 2006).

In our sample, there were significant differences between HIV-positive and HIV-negative participants in overall rates of drug use, such that HIV-negative participants reported a higher number of drug use days. We also found a robust age difference in the number of reported substance use days, such that not only HIV-negative, but also older participants engaged in more substance use. This finding is somewhat atypical, although there have been reports of higher rates of injection drug use (e.g., heroin, steroids) among older MSM (Salomon et al., 2008). Research on substance use and sexual risk-taking behavior among older MSM is relatively limited (for a recent review see Heath, Lanoye, & Maisto, 2012), but suggests that this population faces a unique set of psychosocial challenges that contribute to risk behaviors (Jacobs, Kane, & Ownby, 2013). Some research suggests that older MSM are more likely to have concerns about body image and erectile dysfunction that may motivate drug use (Murray & Adam, 2001).

In contrast to prior studies implicating HIV status in neuropsychological changes, including disruptions in decision-making ability (Martin et al., 2013; Thames et al., 2012), there were no significant differences in IGT performance by HIV status among participants in our sample. Furthermore, it is important to note that the patterns of *interaction* between IGT performance and emotional distress and their association with risk behavior did not differ by HIV status (i.e., HIV status did not interact with IGT performance or emotional distress

variables) in the prediction of drug use or risky sex. Our findings suggest that, while HIV status inevitably changes the nature of sexual risk (i.e., risk of transmission versus risk of exposure), the emotional aspects of the behavior, including search for pleasure, intimacy, arousal, and their contribution to decision-making may not differ by HIV status. If this is true, then integrated interventions targeting MSM regardless of HIV status should be equally effective at addressing the role of emotional factors in decision-making around sexual risk. These interventions would have the added benefit of addressing the needs of MSM with diverse experience without perpetuating stigmatization and segregation by HIV status.

It should be highlighted that relative to previous research that conceptualized IGT as a moderator (Wardle et al., 2010), our analyses conceptualized emotional distress as a moderator. Although the overall analysis and interpretation of IGT by emotional distress interactions is similar in the 2010 publication from Wardle and colleagues and the present study, the difference changes how the findings are portrayed. We chose to consider decision-making ability as a relatively stable factor in risk taking compared to emotion distress, which may be more likely to fluctuate over time. The use of IGT performance as a moderator suggests that the role of emotion in decision-making is relevant only for people with good IGT performance, whereas we suggest that people with good IGT performance may be using affective cues to motivate behavior in different ways. However, we acknowledge that for our sample of individuals with high rates of lifetime drug dependence and current abuse, decision-making performance stability may be relatively reduced as compared to the general population. Furthermore, additional research is needed into the difference between emotional distress as an underlying condition and emotional distress as a particular cue to decision-making. Future research should consider trying to elicit feedback from participants regarding the cues to which they are attending when making these different decisions.

The absence of data on the recency of drug use at the time of our assessment is a significant limitation in this research. All participants were required to abstain from drug or alcohol use on the day of their appointment; however, given the high rate of current drug dependence in our sample, it is likely that some participants engaged in substance use in close enough proximity to their appointment that this could have impacted IGT performance. This variability may have had an impact on our findings in ways in which we were unable to account. However, in turn, variable recency of drug use in our sample may have improved the ecological validity of our findings by more accurately reflecting normal variability in the day-to-day decision-making ability of frequent substance users.

Our sample was selected to better understand risk by recruiting participants who were either high risk takers or low risk takers, but engaging in similar amounts of substance use and sexual behavior. This design gave us the advantage of adequate sampling of high risk individuals, who are a minority, in order to make more controlled comparisons between these groups. Although there were no differences between the high and low risk groups in terms of emotional distress and IGT performance, the forced variability in our sample could have improved the power in our models, and thus is an important consideration for the generalizability of our results.

While our results have important implications for risk behaviors in mixed serostatus, substance using MSM, they may not be generalizable to other types of risk taking and other populations that engage in above average rates of risk behavior (e.g., adolescents and college students). Furthermore, our findings do not address relationships between affect, decision-making, and risk taking in women with HIV and/or substance use disorders, who may have unique profiles of cognitive dysfunction (Maki et al., 2015; Martin et al., 2015). It is also important to acknowledge that substance use and sexual risk taking are, by design, intertwined in this sample. As such, further research will be necessary to clarify emotional distress and decision-making interactions in groups of sexual risk takers and substance users individually.

Also, caution should thus be taken in the process of comparing and interpreting findings across past and future studies on neurocognitive factors in sexual risk taking as this body of literature grows. The Wardle et al. (2010) and Gonzalez et al. (2005) participant samples differed from ours in several key ways. All participants were HIV-positive and had a prior history of dependence, primarily on cocaine, heroin, or both, but were also required to be abstinent for one week prior to assessment. More importantly, these studies did not recruit participants based on sexual orientation or report the percentage of self-reported sexual risk taking that took place with same sex partners.

Future studies may benefit from the use of daily diary strategies or ecological momentary assessment for recording mood and sexual behavior patterns as an alternative to retrospective reports. Because we relied on self-reports of emotional distress and sexual activity it is possible that our results reflect reduced risk taking behavior *awareness* among certain individuals. However, the TLFB methodology we used for collecting participant reports of behavior has several advantages over traditional self-report measures, such as the Risk Assessment Battery Sexual Practices (RAB-SP) subscale used in previous research (Wardle et al., 2010), and its accuracy has been demonstrated to be comparable with daily diary methods (Carney, Tennen, Affleck, del Boca, & Kranzler et, 1998; Weinhardt et al., 1998). However, this method creates count data, which limits the types of statistical analyses for which it can be used.

Finally, our anxiety and depression measures were somewhat limited in their specificity, as participants were not clinically diagnosed with mood or anxiety disorders, and the experimental self-report measures (i.e., BSI Anxiety subscale and CES-D), although extensively validated, needed to be dichotomized for use in our models. In addition, our measures of anxiety and depression were highly correlated, and we did not have a control measure of stress or state affect, such as the positive and negative affect scale (PANAS). Future research should involve a more fine grained quantification of anxiety and depression through the examination of continuous variables and/or more extensive clinical interviewing approaches (e.g., SCID diagnostic interviews). Ultimately, however, the finding that anxiety and depression differentially predict sexual risk and substance use is important and interesting, as it suggests that, despite shared variance, there may be specific qualities (e.g., depressive withdrawal, anxious arousal) that uniquely relate to specific risk behaviors. While this idea needs to be investigated further with more thorough measures, we believe this approach provides a more nuanced understanding of the relationship between emotion and

risk taking behaviors that may be useful for the development of improved intervention and prevention approaches.

Although our hypotheses were formulated based on the principles of the somatic marker hypothesis and we interpret our results in the context of this model, there are some alternative explanations for our findings. One possibility is that individuals with intact affective decision-making ability and heightened anxiety were more aware of their risk taking behaviors and/or more likely to recall and report these behaviors during our assessment. Specifically, given that worry is an important feature of anxiety, individuals who find their risk taking distressing may have been more likely to have perseverative thoughts about risk-taking episodes, which could have then increased the salience of these episodes during self-reports. Future research should consider including measures to assess participants' feelings about their risk taking behavior in order to address this possibility. An additional factor that could be contributing to our results is the possibility that individuals with poor affective decision-making ability, and particularly those with broader cognitive impairment (e.g., poor episodic memory), may be less likely to recall and report episodes of risk taking. Furthermore, anxiety may be more likely to cause difficulties with memory in individuals with limited cognitive resources (Eysenck, Derakshan, Santos, & Calvo, 2007). These possibilities could be clarified in future research by assessing multiple aspects of cognitive functioning in order to build a more complete picture of any dysfunction that could impact IGT performance and reliable reporting.

Research on how physiological states play an important role in decision-making and risk taking behaviors has been ongoing for some time; however, the extension of this investigation into the domain of sexual risk taking only began more recently. The present study provides further support for recent findings that anxiety may exacerbate sexual risk taking in individuals who demonstrate good affective decision-making ability on the IGT and extends this line of inquiry. Our results lend credence to the notion that some forms of emotional distress may be more problematic for risk taking than others. Furthermore, we provide preliminary evidence that interactions between decision-making, anxiety and depression, and behavior may be unique across different forms of risk taking. Our findings have significant implications for sexual risk taking prevention and intervention efforts. We have identified a subset of individuals for whom approaches that focus on improving mental health, and thereby reduce risk behaviors, may prove particularly promising. Future efforts to extend this line of inquiry may provide further insight by including more thoroughly defined clinical measures of emotional distress and incorporating physiological measures of emotional responding.

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Figure 1. Anxiety and depression interactions with IGT risk trial performance predicting differences in expected number of risky sex acts. IGT = Iowa Gambling Task.

Figure 2. Anxiety and depression interactions with IGT risk trial performance predicting differences in expected number of drug use days. IGT = Iowa Gambling Task.

TABLE 1

Sample demographic characteristics

Variable name		<i>n</i>	%
Race:	Black	92	53
	Latino	41	24
	White	28	16
	Other	13	7
HIV:	Positive	86	49
Risk category:	High risk	111	64
Education:	high school or equivalent	76	44
Lifetime dependence:	Met criteria any drug	154	89
Met criteria for abuse or dependence:	Cocaine/crack	55	32
	Marijuana	21	12
	Methamphetamine	16	9
	Heroin	14	8
Any use in the last 60 days:	Cocaine/crack	160	92
	Heavy drinking	129	74
	Marijuana	120	69
	Methamphetamine	61	35
	Heroin	48	28

Note. Heavy drinking was defined as 5 or more standard drinks in one 24 hour period.

TABLE 2

Spearman correlations between main variables of interest

	1	2	3	4	5	6	7	8	9	10	11
1. CES-D depression	--										
2. BSI anxiety	0.73**										
3. Heavy drinking days ^a	-0.01	0.04									
4. Marijuana use days ^a	-0.04	0.14	0.19*								
5. Cocaine, meth, or heroin use days ^a	0.10	0.16*	0.16*	0.07							
6. Number of risky sex acts ^b	0.06	0.18*	0.05	0.17*	0.29**						
7. IGT total T score	0.07	0.07	0.05	-0.16*	-0.16*	-0.11					
8. IGT ambiguity T score	0.16*	0.14	0.05	-0.11	-0.09	-0.05	0.82*				
9. IGT risk T score	0.05	0.02	0.05	-0.14	-0.14	-0.12	0.83*	0.46**			
10. IGT deck A selections	0.07	-0.01	0.02	0.11	0.06	0.11	-0.37**	-0.28**	-0.28**		
11. IGT deck B selections	-0.10	-0.02	-0.04	0.14	0.21	0.09	-0.77**	-0.62**	-0.68**	-0.14	--
M	20.1	0.81	1.5	20.2	27.2	16.0	44.3	45	43.3	19.2	30.8
SD	12.8	0.82	16.7	23.9	22.9	36.1	9.1	7.3	9.2	8.1	12

Note. IGT decks A and B are the bad decks.

^aTotal use days out of 60 days.^bTotal acts in 60 days.* *p* .05.** *p* .01.

TABLE 3

Negative binomial regression predictors of risky sex acts

IGT Risk Trials	Model 1a		Model 1b	
	<i>Exp(B)</i>	<i>95% CI</i>	<i>Exp(B)</i>	<i>95% CI</i>
Age 39	1.85 *	[1.02, 3.34]	1.46	[0.82, 2.60]
Anxiety 0.81	2.46 *	[1.06, 5.77]	2.54 *	[1.18, 5.47]
Depression 26	0.71	[0.29, 1.74]	0.66	[0.29, 1.50]
IGT Risk average T Score	0.97	[0.94, 1.01]	0.91 **	[0.87, 0.96]
Anxiety * IGT Risk			1.12 **	[1.04, 1.22]
Depression * IGT Risk			1.02	[0.94, 1.11]
Likelihood Ratio $\chi^2_{\text{model}}(1a) = 11.52 *$				
Likelihood Ratio $\chi^2_{\text{model}}(1b) = 22.86 **$				
IGT Ambiguity Trials	Model 2a		Model 2b	
	<i>Exp(B)</i>	<i>95% CI</i>	<i>Exp(B)</i>	<i>95% CI</i>
Age 39	1.86 *	[1.01, 3.41]	1.72	[0.94, 3.15]
Anxiety	2.13	[0.94, 4.87]	2.30	[0.97, 5.44]
Depression	0.77	[0.31, 1.93]	0.64	[0.25, 1.65]
IGT Ambiguity average T score	0.98	[0.93, 1.03]	0.95	[0.89, 1.01]
Anxiety * IGT Ambiguity			1.07	[0.94, 1.22]
Depression * IGT Ambiguity			1.02	[0.88, 1.18]
Likelihood Ratio $\chi^2_{\text{model}}(2a) = 9.63 *$				
Likelihood Ratio $\chi^2_{\text{model}}(2b) = 11.77$				

Note. Age was dichotomized at the mean of 39 years. BSI anxiety scores were dichotomized at the mean value of 0.81. CES-D total scores were dichotomized at 26, the established cutoff for moderate to severe depression. Overall model fit was significantly improved from model 1a to model 1b, but not from model 2a to 2b.

* = $p .05$,

** = $p .01$.

TABLE 4

Negative binomial regression predictors of drug use days

IGT Risk Trials	Model 3a		Model 3b	
	<i>Exp(B)</i>	<i>95% CI</i>	<i>Exp(B)</i>	<i>95% CI</i>
HIV status	0.61 **	[0.53, 0.87]	0.61 **	[0.48, 0.77]
Age 39	1.65 **	[1.29, 2.10]	1.61 **	[1.27, 2.04]
Anxiety .81	1.18	[0.91, 1.68]	1.22	[0.91, 1.64]
Depression 26	0.95	[0.73, 1.41]	1.05	[0.77, 1.44]
IGT Risk average T score	0.99	[0.98, 1.01]	0.98 *	[0.96, 1.00]
Anxiety * IGT Risk			1.05 **	[1.02, 1.08]
Depression * IGT Risk			0.96 *	[0.93, 0.99]
Likelihood Ratio $\chi^2_{\text{model}}(3a) = 30.93^{**}$				
Likelihood Ratio $\chi^2_{\text{model}}(3b) = 41.73^{**}$				
IGT Ambiguity Trials	Model 4a		Model 4b	
	<i>Exp(B)</i>	<i>95% CI</i>	<i>Exp(B)</i>	<i>95% CI</i>
HIV status	0.60 **	[0.48, 0.77]	0.60 **	[0.47, 0.76]
Age 39	1.59 **	[1.25, 2.03]	1.54 **	[1.21, 1.96]
Anxiety .81	1.19	[0.88, 1.60]	1.27	[0.93, 1.73]
Depression	1.15	[0.83, 1.58]	1.04	[0.75, 1.45]
IGT Ambiguity average T score	0.98	[0.97, 1.00]	0.97 **	[0.95, 0.99]
Anxiety * IGT Ambiguity			1.05 *	[1.01, 1.10]
Depression * IGT Ambiguity			0.98	[0.93, 1.03]
Likelihood Ratio $\chi^2_{\text{model}}(4a) = 31.04^{**}$				
Likelihood Ratio $\chi^2_{\text{model}}(4b) = 35.99^{**}$				

Note. Mean BSI anxiety scores were dichotomized at the mean value of 0.81. CES-D total scores were dichotomized at 26. Overall model fit was significantly improved from model 3a to model 3b, but not from model 4a to 4b.

* = $p < .05$,

** = $p < .01$.