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Dual Process Interaction Model of HIV-Risk Behaviors Among Drug Offenders

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Abstract

This study evaluated dual process interaction models of HIV-risk behavior among drug offenders. A dual process approach suggests that decisions to engage in appetitive behaviors result from a dynamic interplay between a relatively automatic associative system and an executive control system. One synergistic type of interplay suggests that executive functions may dampen or block effects of spontaneously activated associations. Consistent with this model, latent variable interaction analyses revealed that drug offenders scoring higher in affective decision making were relatively protected from predictive effects of spontaneous sex associations promoting risky sex. Among drug offenders with lower levels of affective decision making ability, spontaneous sexually-related associations more strongly predicted risky sex (lack of condom use and greater number of sex partners). These findings help elucidate associative and control process effects on appetitive behaviors and are important for explaining why some individuals engage in risky sex, while others are relatively protected.

Keywords

Dual processes; Implicit associations; Decision making; HIV risk; Condom use

Introduction

Although dual-process models of decision making, cognition, and memory have gained substantial momentum in basic behavioral research (e.g., [1, 2]), there has been little application of this approach to HIV-risk behavior. Engaging in risky sexual behaviors such as non-condom use or having multiple sex partners can result in potentially harmful consequences, and being aware of these risks but continuing to engage in these behaviors appears to be prototypical irrational decision making. Such decision making is thought to result from the interplay of consciously and non-consciously mediated processes supported by distinct but interacting neural systems. Recent dual process models that consider these interacting systems have been applied to appetitive behaviors with certain biological parallels to sexual behaviors (see [3, 4]) and describe their etiology as being a dynamic interplay between a relatively implicit or automatic associative system and a reflective/executive control system (e.g., [3, 5–8]). The framework outlined below and underlying the present work with drug offenders at elevated risk for unsafe sexual behaviors and HIV infection is derived from basic research on dual cognitive process models and previous studies on addictions (for reviews, [9–11]).

Spontaneous or Automatic Associative Processes and HIV Risk Behaviors

The effects of spontaneous or automatic associations are now well documented in numerous studies on appetitive behaviors, showing predictive utility in a range of populations and for several drugs of abuse (for reviews and theoretical background, see [9, 11–14]). Fewer studies, however, have addressed more automatic processes or associative memory principles in research on HIV-risk behaviors. A few investigators have studied implicit processes among college students, finding relationships between implicit associations and casual sex without condoms in various comparisons [15, 16] (also see [17]). Additionally, a few studies have evaluated implicit processes in relation to sexual arousal [18, 19], sexual orientation [20], and socio-sexuality [21]. To our knowledge, only a couple of studies have addressed spontaneous processes in HIV-risk behavior in more at-risk populations. In one field study, Stacy et al. [22] used word production association tests to show that spontaneous sexually-related cognitions predicted unprotected sex in an adult, community sample. More recently, in an adult sample of known drug users, Stacy et al. [23] showed that similar association measures of spontaneous cognition independently predicted risky sexual behavior tendencies. The predictive effect of spontaneous cognitions was stronger than drug use and comparable to sensation seeking in magnitude, with similar effects across gender. Other research in drug user samples has revealed cues likely to trigger spontaneous cognitions promoting risky sex [24], as well as important relations between spontaneous associations and drug use in this population [25]. Spontaneous processes related to HIV-risk also have been successfully investigated in an incarcerated population [26].

Spontaneous or automatic associative processes develop over time through experiences with reinforcing events (see [27–31]). Over time, functional changes in the brain occur that include associative learning processes enhanced through the reinforcing effects of a behavior. Neutral stimuli associated with an appetitive behavior come to represent and cue the behavior (see [3, 32, 33]). As associations are strengthened through continued experience, patterns of associations come to signal and drive behavior with less involvement of controlled processes. Cues strongly associated with a behavior (e.g., sexual behaviors) can trigger an “automatic” pattern of activation in memory, which, in turn influences and promotes the behavior. Although associations promoting risky behaviors are often spontaneously activated, it is likely that these activated associations do not always translate into behavior given the potential influence of protective executive control functions. The specific control function addressed in this study is affective decision making mediated by both prefrontal cortical (cognitive) and subcortical (affective) systems, highly relevant to behavioral control ability [5, 34]. It is expected that good affective decision making would be protective or dampen the influence of spontaneously activated associations on risky sexual behaviors.

Affective Decision Making: A Distinct Executive Control Process

Affective decision making, assessed with the Iowa Gambling Task (IGT), is an important, specific aspect of higher order executive control functioning. The functional distinction of affective decision making processes from other executive inhibitory/control functions comes from extensive clinical observation and research with patient populations with lesions in areas of the frontal lobe [34] and imaging studies that delineate the neural basis of IGT performance (see [35]). The IGT was developed by Bechara et al. [36] and is one of the most frequently used neuropsychological tests of decision making involving reward processes across a wide range of populations (for review [37]). Adequate affective decision making reflects an integration of both cognitive and affective systems and the ability to more optimally weigh short-term gains against the probability of long-term gains or losses or probable outcomes of an action.

Some executive inhibitory functions can be protective when risky situations are encountered. On the other hand, an imbalance of executive systems can lead to problems in behavioral regulation that may exacerbate risks. For example, substance dependent individuals consistently show impaired decision making when compared to controls on the IGT, and choices made are similar to decisions made by individuals with lesions of the ventral medial prefrontal cortex (e.g., [38, 39]). Numerous studies across a wide range of populations demonstrating poor behavioral decisions (e.g., substance users, psychopathic offenders, pathological gamblers, and adolescents with externalizing behavior) have shown that the IGT detects decreased decision performance in comparison with non-problematic groups (for reviews [37, 40]). In a recent study, Wardle et al. [41] found affective decision making, assessed with the IGT, to interact with emotional distress in the prediction of risky sexual behaviors among HIV positive substance dependent individuals, but affective decision making did not independently predict risky sexual behavior. Interestingly, individuals who scored higher on affective decision making and higher on emotional distress were more likely to engage in risky sexual behaviors. A range of other cognitive effects associated with these behaviors has been uncovered in research on populations relevant to HIV risk. For example, several researchers have examined the impact of cognitive impairment (e.g., deficits in memory, attention, learning and retention of new information, and self-regulation) on continued involvement in risky sexual behaviors among HIV positive and negative substance abusing populations (e.g., [42]; for review [43, 44]; also see [45]). Low functional health literacy among such populations also places them at increased risk for transmission [46]. However, no previous studies have examined the interplay of spontaneous associations and affective decision making on sexual behavior in these populations.

Dual Process Interaction Model

The dual process interaction model evaluated here suggests that some executive functions dampen or block the effects of spontaneously activated associations on unsafe or risky sex. Associative processes reinforced by appetitive behaviors (e.g., sex) result in neurobiological consequences that include the strengthening of motivationally-relevant associations that affect subsequent behavior. Some neural systems support a type of reflective or executive control processing that provides protection from the influence of these automatic associative processes (e.g., [3, 5]). For some individuals, specific executive control functions may affect automatically activated associative processes such that they are less powerful in their effects on behavior—essentially putting the “brakes” on spontaneous associations and reducing their relative influence on behavior. This type of interaction has been supported across diverse areas (e.g., social behavior [47]; dietary behavior [48]; problem solving [49] and in studies on addictive behaviors (e.g., alcohol [50, 51]; alcohol and tobacco [52, 53]). The dual process findings across research areas reveal an important degree of generality for this form of interaction that is evaluated in the present study on HIV-risk behaviors among drug offenders.

Overview

The dual process interaction model evaluated in this study tested the following hypothesis: that good affective decision-making, assessed with the Iowa Gambling Task [36], would make spontaneously activated associations less powerful in their effects on risky sexual behaviors among drug offenders. That is, for the functional moderator, the “free reign” of spontaneously activated harmful associations promoting unsafe or risky sex is likely to be dampened as affective decision making ability increases. It is also expected that if spontaneous risky sex associations are low, there would be less of a need for countervailing influences or protection. Therefore, the affective decision making function is hypothesized to show a buffer (protective) interaction pattern (see Fig. 1).

In addition, a main effect for spontaneous processes was hypothesized consistent with support from previous studies on HIV-risk tendencies [22, 23]. The possible main effect of affective decision making also was explored as a comparison in the prediction of risky sexual behavior. The dual process synergistic and main effects predicted here could be important for explaining why some individuals engage in risky behaviors while others are relatively protected.

Methods

Subjects

Participants in this study were drug offenders sampled from among the pool of available drug diversion programs in the Los Angeles metropolitan area. The analytic sample evaluated in the present work consisted of 166 adult drug offenders who had been randomly assigned to take the Iowa Gambling Task to evaluate their affective decision making ability. Individuals in drug diversion programs are first and second time drug offenders referred to drug education classes by the courts in California in lieu of prosecution for various drug-related offenses. These individuals vary in the degree to which they are involved in illegal activities related to the use of and/or sale of substances as well as risky behaviors associated with drug-related behaviors. Program attendees ranged in age from 18 to 66, with a mean age of 30. Participants were of mixed gender (26% female) and ethnicity (53% Hispanic). Ninety-seven percent of subjects reported having used alcohol in their lifetime, with 81% reporting past 4 month use. Eighty percent of subjects reported having used (meth)amphetamine in their lifetime, with 42% reporting having used amphetamines in the past 4 months. Nineteen percent of the population reported having injected drugs in their lifetime.

Of the analytic population, 90% reported having had sex in the past 12 months, with 3% of males reporting having engaged in sex with only males, and 2% of males reporting having engaged in sex with both males and females. The majority of males and females reported engaging in heterosexual activity. None of the analytic population reported being HIV positive. Most (76%) of the program attendees engaged in casual sex with 1 or more partners in the past 4 months. Most (79%) reported having had 2 or more sex partners in the past 4 months, with 62% of the sample reporting having had 5 or more partners in the past 4 months. Thirty percent reported rarely or never having used a condom with casual partners in the past 4 months (also, see [54]). The reported average number of casual sex partners in the past 12 months was 3.05 (SD = 7.63; range 0–60 partners). Individuals in this population clearly engage in behaviors that place them at increased risk of contracting and spreading HIV.

Procedure

To schedule specific data collections, a coordinator from Claremont Graduate University (CGU) contacted the drug diversion program directors and scheduled a time to recruit participants. Drug diversion education classes were randomly chosen from a list of classes provided by program administrators who agreed to provide recruitment access. All participants attending the selected classes on the day of data collection were invited to participate. On the day of a scheduled data collection, a CGU data collector read aloud an information sheet, which constituted a verbal consent for potential participants. Participants were asked to participate in a completely anonymous and voluntary study, and told that their responses were protected by a Certificate of Confidentiality obtained from the National Institutes of Health. Participants were informed that the study was related to health behaviors that may be considered sensitive, personal, and possibly unlawful.

The study used an intensive mobile computer laboratory in the field, found effective in previous field research in diverse at-risk populations. Up to 15 participants were randomly selected and assigned to one of the computer stations during a data collection session. Individuals wore headphones in order to listen to prerecorded task instructions and were able to complete the tasks at their own pace. To prevent priming of sex and drug-related concepts, items were ordered such that scales containing direct questioning about sex and drug use appeared later in the assessment, with measures of more indirect tests of association administered early on in the assessment process. The types of computerized assessments used in this study have been used successfully in problematic, convicted adult participants in previous research (e.g., [55–57]), as well as our own research on implicit associative processes and executive function across a variety of populations (e.g., [58–61]). All participants were assessed at a single time of measurement and had up to 90 minutes to complete all tasks. Participants were paid \$15 each for their participation.

Measures

Indirect Assessments of Spontaneous Associative Processes: WATs

Word Association Tests (WAT): WAT provide an indirect assessment of associations in memory. These tests assess whether content promoting risky behaviors is spontaneously generated in response to a variety of cues associated with behavior. Consistent evidence across diverse paradigms from basic research shows that word association tests are capable of detecting implicit conceptual memory in both Amnesic and non-Amnesic populations [62–65], and associations uncovered in these tests predict the implicit activation of cognitions across a wide range of experimental procedures (e.g., [66–68]; for review [69]). Further, neural imaging findings reveal marked differences in activation patterns depending on whether stimuli are strongly or weakly associated in these tests [70], and these differences in regional activation are consistent with neural theories of differences between automatic and controlled processes [71, 72]. Finally, these tests are among the best predictors of risk behaviors such as drug use across a range of populations (see [12, 14, 69]). In a major meta-analysis of substance use, Rooke et al. [14] found that these tests had by far the best effect sizes among all other indirect tests of association. Since interaction effects involving individual differences are especially difficult to detect, it would not make sense to use indirect assessments with lower effect sizes in the present study focusing on moderator effects.

The present study used a well-researched form of WAT classified as verb generation [63, 70], in which participants produce the first action or behavior that pops to mind in response to various cues. Participants were instructed: “For the next set of items, please type the very 1st behavior or action that comes to mind when you read a phrase on the screen. Behaviors, activities, or actions are ‘things to do’.” The assessments were presented as a series of word association trials using the same verb generation instructions and format for all association items (e.g., [28, 70]).

Multiple indicators of spontaneous sex-related cognitions assessed with word association tests have been found to form common factors with sufficient internal consistency and good predictive utility in research on drug use and HIV-risk [28, 58, 73], and good test–retest reliabilities [74, 75]. The indicators used in this study are classified as various types of behavior-related associations (explained below) and are supported in many field studies in high-risk populations (for review [12]).

Outcome-Behavior Association Test (OBAT): Participants responded to ambiguous anticipated affective outcome phrases used to implicitly activate responses associated in

memory (e.g., *feeling good*:_____). All cues presented on this task were outcomes generated by at-risk populations in our previous studies [76–78].

Cue-Association Test (CAT): Using the same verb generation instructions, participants also responded to ambiguous situation or word cues (e.g., *Friday night*:_____). The cues for this task were generated in our previous work among at-risk populations (e.g., [77]).

Compound Cues: These association items combined different types of associations (OBAT, CAT). Participants responded to pairs of combined outcome associations and cue associations (e.g., *Friday night, feeling good*:_____). This approach has shown utility in research on drug use and can yield additional variability in association responses [58].

Neutral Associations: Neutral cues were intermixed with the affective outcomes (*OBAT*), situations (*CAT*), and compound cues and consisted of words and phrases that were not expected to yield risk-related associates but were used to reduce response chaining and priming effects (e.g., *Thursday morning*:_____).

All association items were presented in randomized order to each respondent, with at least one neutral cue for each three risk-related cues. Actual stimuli came from our previous research that has obtained norms (frequencies) on cues from the participants themselves. Participants self-coded their responses on the computer after completing all of the word association tests. Fourteen categories were provided. The procedure resulted in a code (1 = related to a category; 0 = not related to a category). The present study focused on codes for sex-related association scores that were summed responses yielding indexes of associative strength in memory [28].

Neurocognitive Assessment of Affective Decision Making

Iowa Gambling Task: IGT [36] was used to assess affective decision making, a specific executive inhibitory/control function with distinct neural activity (e.g., [79, 80]). The computerized format of the IGT simulates real world decisions by using a card task. Participants choose cards from “good” and “bad” decks, making choices about future consequences based on reward/punishment contingencies. The “bad” decks yield high immediate rewards with occasional, high penalties that result in an overall loss of money, while the “good decks” provide more moderate immediate rewards with milder penalties, resulting in a net profit. The IGT detects whether people learn from experiences with negative outcomes, and make appropriate choices. In the present study, scoring of the IGT consisted of summing trials of good card deck selections (C or D) and then subtracting the sum of bad card deck selections (A or B), yielding a score across trials.

Assessment of Drug Use

Alcohol and Methamphetamine Use: Alcohol and meth-amphetamine use were assessed with previously evaluated measures of frequency of use [28, 81]. Frequency measures included previous lifetime use, as assessed in previous studies in the drug offender population (e.g., [73, 82]). Although some underreporting of drug use can occur, the types of self-report drug use measures used in this study have shown good reliability (e.g., 10-year retest for hard drugs, $r = 0.63$ for daily use to 0.71 for abstinence) and validity when compared with independent methods of assessment (e.g., 70–94% concordance with urinalysis for a variety of drugs) among drug using populations (for review [83]).

Measures of Risky Sexual Behavior

Multiple Sexual Partners: Participants were asked “Within the past four months, how many (1) Sexual partners have you had? (2) Casual sexual partners have you had? (3) People

have you had sex with on the same day you first met them? and (4) One-night stands have you had?” (Cronbach's alpha = 0.86).

Response options ranged from 0 to 6 or more [23].

Condom Use: Participants were asked (1) “How often did you use a condom when you had vaginal sex in the past 4 months? (2) How often did you use a condom when you had oral sex in the past 4 months? and (3) How often did you use a condom when you had anal sex in the past 4 months?” (Cronbach's alpha = 0.70). Response options ranged from 0 to 4 as follows: 0 = Did not have vaginal sex in the last 4 months, 1 = Used a condom all the time, 2 = Used a condom most of the time (about 75% of the time), 3 = Used a condom half the time, 4 = Used a condom sometimes (about 25% of the time), 5 = Never used a condom. Higher scores equal less use of condoms.

Analytical Procedure

In all models evaluated, the main effects predictors were: (1) spontaneous sex-related associations assessed with various word production association tests, and (2) affective decision making assessed with the Iowa Gambling Task. A number of covariates were also included in the models. All analyses adjust for alcohol and methamphetamine use, gender, and ethnicity. Our primary risk behavior outcome variables evaluated in separate models were condom use and multiple partner behaviors.

First, a confirmatory factor analysis (CFA) was conducted to evaluate the hypothesized relationships among the various indicators of spontaneous sex-related associations, affective decision making, and HIV-risk behaviors (condom use and multiple sex partners), and factor intercorrelations were estimated. Next, latent variable interaction models were estimated. An “unconstrained” latent interaction approach of Marsh et al. [84, 85] was used in the present analyses. This approach provides one of the most consistently validated tests of latent interaction [84, 86]. The CFA and latent variable interaction models were evaluated using the Mplus software [87] and recommended model evaluation procedures. The overall goodness of fit of the models were evaluated with the use of the Chi-square goodness-of-fit test, Tucker–Lewis index [88], comparative fit index (CFI), and root mean square error of approximation (RMSEA) and its confidence interval [89].

Results

CFA Models for Condom Use Behavior and Multiple Partner Behavior

Initial confirmatory factor analysis (CFA) models were evaluated to determine whether the hypothesized indicators adequately reflect the proposed latent factors. Factor inter-correlations were estimated and the overall fit of the measurement model evaluated. The latent factors assessed were: spontaneous sex associations, affective decision making, and multiple partners or condom use. The multiple partners and condom use behavior factors consisted of multiple indicators consisting of scale items. The affective decision making factor indicators were created from parcels consisting of trials of the IGT. Each trial of the IGT is a selection of a good card deck (C or D) or a bad card deck (A or B). The overall score is the sum of the good card selections minus the sum of the bad card selections which results in a score across trials. Three indicators or parcels were composed of 33 trials randomly selected and scored in the manner described above.

The Spontaneous Sex Association factor indicators were 3 parcels comprised of various compound cue, cue-behavior association, and outcome-behavior association items. Parcels were created for use as indicators due to the large number of items in each measure and

associated concerns about model stability [90]. First, cues were selected that formed a reliable scale on a single dimension using non-parametric item response theory [91] and then items were randomly assigned to 1 of 3 parcels (sum of 3 randomly selected items formed each parcel).

Correlations between factors were estimated between all factors; however, in the final CFA model, non-significant correlations between factors were excluded. The hypothesized indicators in the model adequately reflected the latent factors. The conventional standard for adequate fit in covariance structure analysis is a CFI of 0.9; however, Hu & Bentler [92], recommend a cutoff criterion for adequate fit that is slightly greater (i.e., CFI > 0.96 and RMSEA < 0.06). The fit of the CFA model for multiple partners reached statistical nonsignificance, $\chi^2(70, N = 166) = 87.069, p > 0.05$, CFI = 0.976, TLI = 0.969, RMSEA = 0.038, (95% CI: 0.000, 0.062). The fit of the CFA model for condom use also reached statistical nonsignificance, $\chi^2(48, N = 166) = 60.856, p > 0.05$, CFI = 0.971, TLI = 0.961, RMSEA = 0.040, (95% CI: 0.000, 0.068).

Latent Variable Interaction Analysis

With a latent interaction procedure (see [84]) main effects and interaction terms are each represented by latent factors (using multiple indicators). The main effect predictors in the present study (X and Z) were formed as follows: (a) multiple indicators from tests of word associations coded as sex related associations loaded on a factor (loadings ranged from 0.62 to 0.77) of spontaneous sex associations (X), and multiple indicators from the Iowa Gambling Task loaded on a factor (loadings ranged from 0.79 to 0.90) of affective decision making (Z). For the interaction term, product indicators were formed by multiplying indicators X1, X2, X3 and Z1, Z2, Z3 from the latent factors affective decision making and spontaneous sex associations, in accord with Marsh et al. [84]. Multiplication terms: X1Z1, X2Z2, and X3Z3, were created to serve as the product indicators of the interaction latent factor: (XZ). Factor loadings for the interaction factor ranged from 0.38 to 0.98. The outcome variable (Y) was condom use in the first model and multiple partners in the second model. Multiple indicators of measured condom use loaded on a Condom Use behavior factor (loadings ranged from 0.48 to 0.82). Similarly, multiple indicators of measured multiple partners loaded on a factor of Multiple Partner behavior (loadings ranged from 0.59 to 0.85).

In the latent variable main effects models of HIV-risk behaviors (condom use and multiple partner behaviors), spontaneous sex associations had a significant main effect ($B = 0.175$ in multiple partners model; $B = -0.181$ in condom use model, $p < 0.05$). Affective decision making trended toward significance in the prediction of multiple partners ($p < 0.10$) but was not significant in the prediction of condom use ($p > 0.10$; models not shown).

In both latent interaction models, the hypothesized interaction was found to be significant in the prediction of risky sexual behaviors. The affective decision making X spontaneous sex associations interaction term was significant in the condom use latent interaction model ($B = 0.160, p < 0.05$; see Fig. 2). The number (or accessibility) of spontaneous sex-related associations was more predictive of lack of condom use for those with lower affective decision making capacity than for those with higher capacity, consistent with a “buffer” (protection) hypothesis (see Fig. 3). The overall moderated latent variable model fit was good, although it did not reach non-significance: $\chi^2 = 112.419, df = 80, p = 0.010$; CFI = 0.938, TLI = 0.908, RMSEA = 0.050 (95% CI: 0.025, 0.070; see Fig. 2).

Additionally, the affective decision making X spontaneous sex associations interaction term was significant in the multiple partners moderated latent variable model ($B = -0.258, p < 0.01$; see Fig. 4). The number of spontaneous sex-related associations was more predictive

of having multiple partners for those with lower affective decision making capacity than for those with higher capacity, also consistent with a “buffer” (protection) hypothesis (see Fig. 5). The overall moderated latent variable model fit was very good: $\chi^2 = 72.158$, $df = 72$, $p = 0.472$; CFI = 1.000, TLI = 1.000, RMSEA = 0.004 (95% CI: 0.000, 0.045; see Fig. 4).

Discussion

The present study extends current theories of appetitive behaviors by addressing the influence of spontaneous associations strongly linked to behavior and by integrating control processes and different types of associations known to predict risky behaviors. To our knowledge, this is the first study to evaluate the interaction between spontaneous associative processes and control processes in predicting any HIV-related behaviors. It is also the first study to investigate the interaction between spontaneous associations and affective decision making predicting any form of appetitive or social behavior. The findings are consistent with previous support for this dual process approach to appetitive behavior (e.g., [52, 53, 93]). The most novel and central finding in this evaluation of dual processes in HIV-risk behavior was that higher affective decision making ability dampened the effect of more spontaneous sex associations with respect to HIV-risk behaviors. Spontaneous sex associations more strongly predicted lack of condom use and increased multiple sex partner behavior among drug offenders with lower levels of affective decision making ability. The latent variable interaction analyses revealed a protective, moderating influence of this specific executive function on spontaneous associative processes implicated in appetitive behavior.

The strength of behavior-specific associations have reliably been found to be important predictors of other appetitive behaviors (for reviews [11–14]). Consistent with these previous findings, spontaneous sex associations were found to be significant independent predictors of risky sexual behavior in main effects models evaluated in this study. The types of association tests used allow for free competition among any possible associate to be generated in response to a range of ambiguous cues. The target behavior—risky sex—was never mentioned in the assessment, minimizing effects of self-reflective confounders [69]. Any alternative (e.g., healthy) memories had a full chance of competing with a risky response in the assessment, providing one of the few approaches capable of assessing *relative* cognition. And, although the cues are limited in set, many of the particular items used in this study were high frequency cues elicited from the population being studied and included a variety of contexts (e.g., ambiguous affective outcomes, social and physical cues). These association tasks do not impose constraints on the respondent, thereby increasing the likelihood of tapping into individual differences in salient sex-related associative structures based on various motivational and contextual stimuli.

The present work helps us to understand the influence of spontaneous associative processes and control processes involved in HIV-risk behavior. The individuals in this study engage in risky behaviors that place them at increased risk for contracting and spreading HIV as well as other sexually transmitted infections. Given the present findings in this population and the knowledge that individuals vary in differing neural systems that regulate control function abilities, a reasonable goal for interventions would be to tailor program components to train individuals with lower affective decision making ability to regulate impulses when cues activate strong associations related to habit-type behaviors. Cognitive impairment is problematic in chronic drug using populations, whether one is HIV positive or negative, affecting decision making processes and engagement in various risky behaviors with implications for treatment (see [42–44, 94]). Adequate decision making is a key goal of most prevention programs (e.g., [95, 96]), and is clearly linked to variation in specific executive functions. Future studies should consider a broad range of cognitive and

circumstantial factors that reduce decision making ability in these populations. In addition to affective decision making ability, other cognitive abilities and deficits in self-regulation, attention, memory and learning of new materials [42–44, 94], as well as low health literacy [46] should be considered in future intervention research.

An alternative and complementary approach and goal for interventions might be to intervene on spontaneous associative processes [3, 10] by working toward creating strong safer-sex associations in long-term memory between intervention materials and contexts associated with unsafe sexual behaviors. The ultimate goal is to have program materials be spontaneously activated in memory when an individual is confronted with strong risky cues [9]. Competing safer-sex associations could help interfere with or regulate risky automatic or impulsive behaviors. Given a newer generation of dual process models of appetitive behaviors, interventions are unlikely to be highly effective if they fail to tap into both executive control processes and spontaneous associative processes thought by some to represent the “default” system guiding behavior (see [1]). A focus on spontaneous associative processes and effects that can be modified by specific functions emphasizes the dynamic, cue-dependent nature of memory and cognition, not previously addressed in HIV-prevention education [3].

Limitations

The generalizability of the findings reported here are limited by the at-risk drug offender sample; however, it also may be argued that these individuals are a primary target population for HIV-prevention education since this population clearly engages in behaviors that place them at increased risk of contracting and spreading HIV. Another key limitation is the cross-sectional nature of the study, which limits causal inference regarding directional aspects of the latent interaction evaluated. Because of the population sampled and the nature of the study, it is unclear whether strong associative processes resulting from habitual unsafe sex behaviors override decision making ability or whether deficits in affective decision making affect unsafe sexual practices. Nevertheless, the present findings revealed a protective or “buffer” effect for higher affective decision making ability when individuals have strong risky sex associations and either causal inference results in an increase in risky sexual behaviors with potentially harmful consequences among those with lower decision abilities.

Conclusions

Findings in this study help to explain the processes underlying associative and control process effects on appetitive behaviors. The dual process synergistic and main effects evaluated here are important for explaining why some individuals engage in risky behaviors, like unsafe sexual practices, while others are relatively protected. Overall, a focus on spontaneous associations, specific executive control functions, and their interaction in dual process models has much potential for increasing our understanding of appetitive behaviors, which may ultimately lead to new intervention strategies.

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Fig. 1. Specific form of the interaction in the dual process model with affective decision making scores as moderator (Z) and spontaneous sex associations (X) scored continuously from low to high

Fig. 2.

Latent factor interaction model with condom use regressed on spontaneous sex associations (assessed with word association production tests) and affective decision making (assessed with the IGT). Model fit: $\chi^2 = 112.419$, $df = 80$, $p = 0.010$; CFI = 0.938, TLI = 0.908, RMSEA = 0.050 (95% CI: 0.025, 0.070), SRMR = 0.052. Estimates for non-significant covariates are not shown for clarity. Standardized estimates; one-tailed p -values on regression coefficient estimates: $^{\dagger}p < 0.10$; $*p < 0.05$; $**p < 0.01$; $***p < 0.001$

Fig. 3.
Nature of the interaction found when condom use was regressed on affective decision making and spontaneous sex associations scored continuously from low to high

Fig. 4.

Latent factor interaction model with multiple partners regressed on spontaneous sex associations and affective decision making. Model fit: $\chi^2 = 140.157$, $df = 113$, $p = 0.042$; CFI = 0.965, TLI = 0.953, RMSEA = 0.038 (95% CI: 0.008, 0.057), SRMR = 0.051.

Estimates for non-significant covariates are not shown for clarity. Standardized estimates, one-tailed p -values for regression coefficient estimates: [†] $p < 0.10$; * $p < 0.05$; ** $p < 0.01$;

*** $p < 0.001$

Fig. 5.
Nature of the interaction found when multiple partners was regressed on affective decision making and spontaneous sex associations scored continuously from low to high