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The Sexual Discounting Task: HIV Risk Behavior and the Discounting of Delayed Sexual Rewards in Cocaine Dependence

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Abstract

Background—Cocaine dependence is associated with high rates of sexual risk behavior and HIV infection. However, little is known about the responsible mechanism(s).

Methods—Cocaine-dependent individuals (N=62) completed a novel Sexual Discounting Task assessing decisions between immediate unprotected sex and delayed sex with a condom across four hypothetical partners: most (and least) likely to have a sexually transmitted infection (STI), and most (and least) sexually desirable; a real rewards money delay-discounting task, and self-reported sexual risk behavior using the HIV Risk-Taking Behavior Scale (HRBS).

Results—Sexual Discounting Task results were largely systematic and showed a strong effect of delay in decreasing condom use. Sexual discounting (preference for immediate unprotected sex) was significantly greater when making responses for partners judged least (compared to most) likely to have an STI, and for partners judged most (compared to least) desirable. Differences in sexual discounting were significant after controlling for differences in condom use (with no delay) between conditions. Greater discounting in 3 or the 4 Sexual Discounting Task conditions, but not in the money discounting task, was associated with greater self-reported sexual risk behavior as measured by the HRBS.

Conclusions—Results suggest that delay is a critical variable strongly affecting HIV sexual risk behavior, and that the Sexual Discounting Task provides a clinically sensitive measure of this phenomenon that may address a variety of questions about HIV risk in future research. The wealth of behavioral and neurobiological data on delay discounting should be brought to bear on HIV education and prevention.

Keywords

delay discounting; impulsivity; cocaine; HIV; sexual risk behavior; condom

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Contributors

Dr. Johnson designed the study and wrote the protocol. Dr. Bruner assisted with conducting experimental sessions. Drs. Johnson and Bruner contributed to interpretation of results, conducted statistical analyses, and wrote the first draft of the manuscript. Both authors contributed to and have approved the final manuscript.

Conflict of interest

Both authors declare that they have no conflicts of interest.

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1. Introduction

Substantial evidence shows cocaine abuse to be associated with increased rates of HIV sexual risk behavior and HIV infection (Booth et al., 1993; Edlin et al., 1994; Bux et al., 1995; Grella et al., 1995; Joe and Simpson, 1995; Hoffman et al., 2000; Edwards et al., 2006). One potential mechanism is that cocaine-abusing individuals may trade sex for drugs or money to buy drugs (Edlin et al., 1994; Edwards et al., 2006). However, this would not explain why other illicit and expensive drugs such as heroin are not associated with the same levels of sexual risk. Another possibility is that dopaminergic stimulants such as cocaine may acutely increase sexual desire, although increased desire does not necessarily entail increased risk (Volkow et al., 2007). Another potential mechanism (that may interact with sexual desire) is that cocaine-dependent individuals may exhibit a systematic bias in a decision-making process involved in sexual risk behavior.

Delay discounting is one candidate decision-making mechanism driving HIV sexual risk behavior. Delay discounting refers to the devaluation of a consequence due to a delay until that consequence (Rachlin and Green, 1972; Ainslie, 1975; Rachlin et al., 1991). Delay discounting may model a choice made on a chronic basis in drug dependence: choosing a smaller sooner reward over a larger later reward (Bickel and Johnson, 2003a; Bickel and Johnson, 2003b). In drug dependence, the choice is between the immediate and brief effects of the drug, and the arguably more valuable but delayed improvements in health and social functioning that come with sustained abstinence. Although these two choices qualitatively differ in the clinical scenario, in human delay discounting studies choice is typically modeled by using differing amounts of the same commodity (e.g., less money now or more money later). Using the same commodity for the immediate and delayed options is methodologically simple and allows for a determination of the discounting rate for a particular commodity. The finding that drug-abusing individuals prefer smaller sooner money rewards more than control participants has now been shown for a variety of drugs, including cocaine (Coffey et al., 2003; Kirby and Petry, 2004; Heil et al., 2006). Studies in both humans and nonhuman subjects show that the discounting of consequences across delay follows a hyperbolic-like function (Mazur, 1987; Rachlin et al., 1991; Myerson and Green, 1995). Hyperbolic discounting indicates that for each additional unit of delay until reward delivery, present value decreases by an increasingly smaller proportion, a form which specifically predicts preference reversal from a larger later reward to a smaller sooner reward as the time until both rewards draws closer (consistent with relapse or “lose of control” in drug dependence) (Green et al., 1994a; Kirby, 1997; Frederick et al., 2002).

In addition to decisions regarding drug abuse, delay discounting may also model the choice between immediate unprotected sex (ultimately less valuable given the increased risk of HIV and other health problems) versus waiting some length of time so that a condom can be obtained to have protected sex (ultimately more valuable given a healthier life). Moreover, hyperbolic discounting may explain why some individuals engage in risky sexual behavior despite previous intentions to practice safer sex, a pattern consistent with empirical findings (Deas-Nesmith et al., 1999; Patinkin et al., 2007). One study in undergraduate students asked participants to make hypothetical choices between an immediate shorter duration of an unspecified preferred sexual activity (e.g., 3 minutes now) versus a delayed but longer duration of the same activity (e.g., 10 minutes in 1 week) (Lawyer et al., 2010). Data from that study, as well as data from another study in undergraduates examining delay discounting for hypothetical erotic stimuli, often conformed to a hyperbolic function (Lawyer, 2008), consistent with the results observed with non-sexual rewards in humans and nonhuman animals described above. This commonality in function shape suggests that decisions regarding delayed sexual rewards follow basic patterns governing how animals make decisions regarding delayed rewards in general, and therefore suggests that delay

discounting is relevant to sexual decision making. However, those studies (Lawyer, 2008; Lawyer et al., 2010) did not assess participants' sexual risk behavior. To determine if delay discounting is relevant to HIV sexual risk behavior, we examined the relationship between delay discounting for sexual rewards in cocaine-dependent participants, a population with high rates of HIV sexual risk behavior, and self-reported sexual risk behavior using the valid and reliable HIV Risk-Taking Behavior Scale (HRBS) (Darke et al., 1991; Petry, 2001). Delay discounting for sex was assessed with the novel Sexual Discounting Task, which framed delay discounting questions with clinical relevance to HIV sexual risk behavior (i.e., hypothetical decisions involving immediate sex without a condom vs. delayed sex with a condom with the same person), and in reference to specific photographed individuals deemed sexually desirable by participants. The Sexual Discounting task was completed in reference to multiple individual sexual partners in order to examine whether discounting of sex differed depending on the sexual desirability of the partner, and the participant's judgment that the partner may have a sexual transmitted infection (STI). Delay discounting for money was also examined to determine if any relationship between sexual risk behavior and delay discounting was domain specific, as empirical relationships involving delay discounting can depend on the nature of the commodity being discounted (e.g., Ostaszewski et al., 1998; Rasmussen et al., 2009).

2. Methods

2.1 Participants

Sixty-two cocaine dependent individuals (43 male, 19 female) volunteered to participate in this study, and were compensated \$130. Fifty-four of these participants self-identified as African-American, six as Caucasian, one as Asian American, and one as biracial without further specification. Inclusion criteria included being aged 18–65 years and reporting having engaged in sexual intercourse in the last 30 days. Participants met Diagnostic and Statistical Manual of Mental Disorders (4th edition, DSM-IV) criteria for current cocaine dependence but no other drug (excluding caffeine and nicotine) as assessed by a DSM checklist (Hudziak et al., 1993) updated for DSM-IV. Urinalysis results were positive for cocaine on at least one of two lab visits. Psychiatric treatment in the past six months was an exclusion criterion. Fifty-three participants identified themselves as heterosexual, three as gay men, five as bisexual men, and one as a bisexual woman. Other relevant demographics for these participants are listed in Table 1.

2.2 Procedure

Participants were initially interviewed over the telephone to collect demographic information and screen out psychiatric disorders or abstinence from intercourse in the last 30 days. If they initially qualified for the study, they were invited to participate in an in-person screening, where they provided informed consent, gave a urine sample to test for drugs of abuse, completed the Quick Test, a test of verbal intelligence (Ammons and Ammons, 1962), and provided demographic and drug use history information. All procedures were approved by a Johns Hopkins Medicine Institutional Review Board.

If participants qualified, they were invited to take part in the two-session study. Immediately after screening, participants began the first session. Approximately one week later (mean=7.2 days, SD=1.3 days), the second session took place. Cigarette smokers were given a 10-min break every two hours (between tasks) during screening and sessions to smoke, to minimize the effects of nicotine withdrawal on outcome measures. Tasks were not completed until at least 20 min after smoking to avoid peak nicotine plasma concentrations (Benowitz et al., 1988). Participants completed several tasks, including the Sexual Discounting Task, a money delay-discounting task (Johnson and Bickel, 2002; Baker et al.,

2003; Johnson et al., 2007), and the HRBS, as described below. Participants also completed other tasks not immediately relevant to the current analyses, and are therefore not described here. Different tasks were administered across the two sessions, and task order was randomized for individual participants. The HRBS was administered as the final task in the second session to maximize honesty by assuring participants that staff would not view their answers until participation was complete.

2.2.1 Sexual Discounting Task—In this task, delay discounting for sexual rewards was assessed in reference to specific photographed hypothetical sexual partners. The use of photographed individuals was intended to increase the salience and visceral nature of the hypothetical sexual outcomes. Participants were initially trained to make ratings using visual analog scales (VAS). A research assistant then spread out 60 color photographs of clothed people (30 male, 30 female), each printed on a 21.59 × 27.94 cm sheet of paper, on the floor in front of the participant. Photographs were selected to provide a diverse sample within each gender in terms of race/ethnicity, age, weight, body shape, clothing style, and attractiveness. The participant was asked to select the photographs of all people with whom he or she would be willing to have casual sex based on physical appearance, using the following verbal instructions:

For this task, we will ask you hypothetical or pretend questions about your willingness to have sex in various situations. For the purpose of this task, please pretend that you are not currently in a committed sexual relationship if you are. In other words, please pretend that you are single and available, and that you are not cheating on anybody if you indicate you would have sex with somebody in this task. As you can see, I have laid out a lot of pictures of people. For each person, I would like you to think about how attractive that person is. Based on physical appearance alone, please think about whether each person is someone that you would consider having sex with in the right environment and if you liked the person's personality. Please pick up the pictures of the people you would have sex with.

Of all photographs that were selected, the participant was asked to identify, based on appearance alone, the person: (1) most likely to have an STI, (2) least likely to have an STI, (3) he or she most wants to have sex with, and (4) he or she least wants to have sex with. One photograph was allowed to serve for multiple categories. For each of the four categories (presented in randomized order), participants were presented with a paper questionnaire with eight VAS (100-mm lines), with the photograph corresponding with that category in sight immediately next to the questionnaire. The first VAS was a 0-delay trial to rate the likelihood (0–100%) of using an immediately available condom. The VAS ranged from “I will definitely have sex with this person now without a condom” to “I will definitely have sex with this person now with a condom.” Participants were asked to imagine that there was no chance of pregnancy.

For the next seven VAS (delay trials), the participant was asked to rate his or her likelihood of waiting a specified period of time for protected sex when no condom was immediately available. The VAS ranged from “I will definitely have sex with this person now without a condom” to “I will definitely wait [delay] to have sex with his person with a condom.” This question was repeated with the delay changed to assess seven total delays in ascending order: 1 hour, 3 hours, 6 hours, 1 day, 1 week, 1 month, and 3 months. The delays utilized in the task were somewhat arbitrary, but were generally selected to increase by progressively larger durations, and to have relevance for decisions regarding condom use at both the shortest and longest delays. If one photograph served for multiple categories, the eight VAS were completed only once for that photograph.

2.2.2 Money delay discounting—Delay discounting for a potentially real \$10 reward was assessed using a task previously used and described in greater detail (Johnson and Bickel, 2002; Baker et al., 2003; Johnson et al., 2007). Participants made choices between receiving a \$10 reward at a particular delay (e.g., 1 day), or a smaller, immediate reward that adjusted in amount across trials until indifference between the two rewards was detected. Participants were instructed to treat all choices as if they were real because the consequence to one randomly selected trial would actually be provided. Four delays were examined in ascending order: 1 day, 1 week, 1 month, and 6 months. Upon task completion, one trial was randomly selected and if the delayed reward was chosen, the participant was given a choice between picking up the \$10 at the laboratory after the specified delay, or to have the money mailed after the delay. If the immediate option was chosen, the participant received the money in cash at the end of the session. The potentially real rewards task used in the present study is identical to a hypothetical money delay-discounting procedure used previously (Johnson and Bickel, 2002; Baker et al., 2003; Yi et al., 2005; Heil et al., 2006; Johnson et al., 2007; Yoon et al., 2007; Johnson et al., 2010) with the exceptions that in the hypothetical procedure the reward contingency was absent, and 3 additional delays were examined (1, 5, and 25 years).

2.2.3 HIV Risk-Taking Behavior Scale (HRBS)—Participants completed the psychometrically reliable and valid 11-item self-report HRBS, which assessed specific risk taking behaviors during the last month (Darke et al., 1991; Petry, 2001). Each item was assessed on a 6-point scale (scores of 0–5). The HRBS includes two subscales: one related to sexual drug use risk behaviors (5 items), and one related to injection risk behaviors (6 items). Possible scores on the sexual risk subscale ranged from 0–25. The injection risk subscale was not examined in the present analysis.

2.3 Data analysis

Raw delay-discounting data consisted of 5 sets of indifference points (4 Sexual Discounting Task conditions and the single money condition) for each participant. Indifference points were defined as a proportion of the larger, later reward for money discounting, and as proportion of the VAS line marked for the Sexual Discounting Task. Area under the curve (AUC) was determined for each set of indifference points using a previously described method (Myerson et al., 2001). Lower AUC values indicate greater delay discounting, or relative preference for smaller, sooner rewards.

2.3.1 Orderliness of data—A previously published algorithm (Johnson and Bickel, 2008) was used to assess the orderliness of data from the novel Sexual Discounting Task and the money discounting task. The Johnson and Bickel (2008) algorithm has been successfully employed in a variety of delay-discounting studies to provide an objective metric of discounting data orderliness (Beck and Triplett, 2009; Bobova et al., 2009; Melanko et al., 2009; Herting et al., 2010; Johnson et al., 2010; Lawyer et al., 2010; Mitchell and Wilson, 2010; Rasmussen et al., 2010; Saville et al., 2010; Sellitto et al., 2010; Wilson et al., 2011). Specifically, discounting functions were identified as nonsystematic if any delay's rating was at least 0.2 greater than the delay preceding it, starting with the second shortest delay.

2.3.2 Comparisons across the Sexual Discounting Task partner conditions—Paired t-tests were conducted to compare group mean AUC of sexual discounting between the “most want to have sex with” and “least want to have sex with” conditions, and between the “most likely to have an STI” and “least likely to have an STI” conditions. Paired t-tests were also used to compare the relative value of condom use when one was immediately available (0-delay trial) between the two pairs of conditions, as an index of the reinforcing value of condom use when no delay was involved.

The analysis of Sexual Discounting Task data described above possibly allows for differences in condom use regardless of delay (i.e., relative reinforcing efficacy of condom use) across individuals to drive results, rather than the effects of delay on condom use (delay discounting) *per se*. To address this concern, Sexual Discounting Task data were also analyzed after indifference points were normalized relative to the reported likelihood of using a condom when one was immediately available (i.e., VAS values were divided by the VAS value in the 0-delay trial). Although AUC for discounting data typically results in normally distributed values, the normalization caused the distribution to be positively skewed. Therefore, non-parametric Wilcoxon signed-rank tests compared AUC of sexual discounting between the two pairs of conditions when using normalized data.

2.3.3 Relationships among measures—Pearson correlations were conducted to examine the relationship between AUC for each Sexual Discounting Task partner condition and the number of photographs selected in the Sexual Discounting Task, and money discounting AUC. Pearson correlations were also conducted between the HRBS sexual risk subscale and the delay-discounting measures. To determine if photograph selection in the Sexual Discounting task was related to number of sexual partners in the real world, Pearson correlations were also conducted between number of photographs selected and the individual item on the HRBS assessing number of sexual partners in the last month (item 7). The correlations involving the Sexual Discounting Task were replicated using AUC values based on normalized indifference points (Spearman rank correlations were used due to skewed data).

3. Results

3.1 Orderliness of data

Overall, 31 (12.5%) of all sexual discounting functions were found to be nonsystematic. Of these functions, most were cases in which only a single data point of the 8 appeared to be aberrant. Four (6.5%) of the money delay-discounting functions were found to be nonsystematic.

3.2 Comparisons across Sexual Discounting Task partner conditions

Figure 1 shows Sexual Discounting Task group median data for the four partner conditions with 2-parameter hyperboloid functions (Rachlin, 1989; Green et al., 1994b) fit to the median data. This hyperboloid function typically provides a close fit to delay-discounting data (Green et al., 1994b; Myerson and Green, 1995). Individual sexual discounting functions were typically monotonically decreasing or flat (i.e., little or no change across delays), and generally well described by the hyperboloid discounting equation. The “most likely to have an STI” condition had greater AUC ($M = .750$, $SD = .362$) (i.e., had a greater likelihood of waiting until a condom was available) than the “least likely to have an STI” condition ($M = .443$, $SD = .445$), $t(61) = 6.09$, $p < .0001$. The “least want to have sex with” condition had greater AUC ($M = .610$, $SD = .437$) than the “most want to have sex with” condition ($M = .420$, $SD = .435$), $t(61) = 3.20$, $p < .01$.

There were significant differences found between conditions for condom use when delay was not involved (in the 0-delay trial). On average, participants rated that they would more likely use a condom if one was readily available in the “least want to have sex with” condition ($M = .856$, $SD = .300$), than in the “most want to have sex with” condition ($M = .754$, $SD = .385$), $t(61) = 2.32$, $p = .02$. Participants also rated that they would be much more likely to use a condom for the person they deemed “most likely to have an STI” ($M = .969$, $SD = .088$) than the person they rated “least likely to have an STI” ($M = .717$, $SD = .409$), $t(61) = 5.02$, $p < .0001$.

Figure 2 shows 2-parameter hyperboloid functions fit to the Sexual Discounting Task group median data that were normalized relative to likelihood of using a condom in the 0-delay trial. Participants had significantly greater AUC in the “least want to have sex with” condition (median=.955) than the “most want to have sex with” condition (median=.430) ($Z=2.70$, $n=62$, $p < .01$). Participants also had significantly greater AUC in the “most likely to have an STI” condition (median=1.00) than the “least likely to have an STI” condition (median=.529) ($Z=4.31$, $n=62$, $p < .0001$).

3.3 Relationships among measures

Table 2 shows various Pearson correlation results among AUC (non-normalized) for the Sexual Discounting Task partner conditions, HRBS sexual risk subscale score, number of photographs selected, and money discounting. The average score on the HRBS sexual risk subscale was 8.4 (SD = 4.7, range: 0–19). The correlation coefficients for the HRBS scores and each sexual discounting condition were negative and significant (greater sexual risk was associated with greater delay discounting), with the exception of the “most want to have sex with” condition, which was negative but not significant. A mean of 9.7 (SD = 6.3, range: 1–27) photographs were selected. The number of photographs selected was significantly negatively correlated with AUC in all four conditions (i.e., a greater number of photographs selected was associated with a greater preference for immediate unprotected sex). Delay discounting AUC for money ($M = .414$, $SD = .242$) was positively correlated with AUC in all Sexual Discounting Task conditions, but was significant for only the “most likely to have an STI” condition. Money discounting was not significantly correlated with HRBS score. Number of photographs selected was significantly and positively correlated with self-reported number of sexual partners in the last month (HRBS item 7) ($r = .259$, $n = 62$, $p = .04$). Re-analyzing the Sexual Discounting Task correlations using AUC values based on normalized indifference points (using Spearman’s rank correlations) did not alter the correlation direction in any case, and altered whether significance was reached in only three of 12 cases: 1) the correlations between “least likely to have an STI” AUC and the HRBS sexual risk subscale changed from $p = .05$ to $.16$; 2) the correlation between “most likely to have an STI” AUC and the HRBS changed from $p = .04$ to $.14$; 3) the correlation between “most likely to have an STI” AUC and number of photographs selected changed from $p = .003$ to $.06$.

4. Discussion

Several categories of results from this study suggest that delay discounting is an important variable for understanding HIV sexual risk behavior, and that the Sexual Discounting Task provides a clinically meaningful assessment of this phenomenon. First, the algorithm by Johnson and Bickel (2008) for detecting nonsystematic discounting data indicated that the Sexual Discounting Task data were largely systematic, (87.5% of individual functions). That is, delayed reward value decreased from shorter to longer delays or was unaffected by delay, conforming to most basic patterns expected in delay discounting (Johnson and Bickel, 2008). The percent of nonsystematic functions was lower with money discounting, although the percent would be expected to be somewhat lower in the money task because fewer delays were examined. The percent of systematic discounting functions for the Sexual Discounting task was similar to a previous study showing that 81.4% of functions were systematic (using the same single-criterion algorithm utilized in the present study) for another procedure assessing the delay discounting of sexual rewards (Lawyer et al., 2010). The percent was also similar to another study showing that 86.7% of functions were systematic (using the same single-criterion algorithm utilized in the present study) when assessing discounting for marijuana (Johnson et al., 2010).

The second category of results showed that the Sexual Discounting Task was sensitive to factors that may influence real world decisions to use condoms. That is, participants showed significantly greater discounting (relative preference for immediate unprotected sex) for partners they found most sexually desirable compared to those they found least desirable (but with whom they were nonetheless willing to have sex). The increased discounting of sex when viewing and responding in regard to the most sexually desirable photographed individual bears similarity to the finding that men discount delayed money to a greater extent when they are exposed to photographs of attractive women (Wilson and Daly, 2004). Participants also showed significantly greater discounting for partners they judged least likely to have an STI compared to those they judged most likely to have an STI. As can be seen with median data in Fig.1 and Fig. 2, the Sexual Discounting Task was sensitive to differential rates of discounting across conditions, but showed the systematic hyperboloid shape in each condition. The re-analysis after normalizing data relative to condom use in the 0-delay trial provided further evidence that differences across conditions reflected differences in delay discounting, above and beyond differences in condom use.

The third category of findings concerns the relationships among measures. The HRBS sexual subscale was negatively and significantly correlated with three of the four Sexual Discounting Task partner conditions, and a non-significant negative correlation was found in the remaining “most want to have sex with” condition. The finding that self-reported sexual risk on a validated and reliable scale correlates in the predicted direction with the Sexual Discounting Task provides evidence that the task relates to real world behavior. These correlations were significant with the exception of the “most want to have sex with” condition, which was associated with the greatest preference for immediate unprotected sex. One possible reason for that exception is that the photographed individuals selected for the “most want to have sex with” condition may have been judged substantially more sexually desirable than the sexual partners the participant actually had sex with during the preceding month (the basis for HRBS questions). Because the correlation was in the predicted direction but the correlation coefficient was smaller than in the other conditions, the lack of significance could also reflect a smaller effect but insufficient power to detect it. In contrast to sexual discounting, money discounting was not significantly correlated with scores on the HRBS sexual subscale or the number of photographs selected, suggesting domain specificity, and that the Sexual Discounting Task is more sensitive than money discounting at reflecting differences in real world sexual risk behavior. Consistent with domain specificity, the Sexual Discounting Task showed generally weak positive correlations with money discounting (preference for immediate money was associated with preference for immediate unprotected sex), with only the correlation in the “most likely to have STI” condition reaching statistical significance. Also consistent with domain specificity, selecting a greater number of photographs (individuals to have sex with) was significantly associated with greater sexual discounting in all four partner conditions (i.e., variables within the sexual domain). Number of photographs selected may be considered a model of promiscuity within this task because it was significantly correlated with the HRBS item assessing the number of people the participant has had sex with in the last month. Correlations involving the Sexual Discounting Task were largely unchanged when replicated using data that were normalized relative to condom use in the 0-delay trial, suggesting that delay discounting for sex, above and beyond difference in condom use, was responsible for the reported associations.

The domain specificity observed in the present study is consistent with previous studies showing that delay discounting can depend on the nature of the commodity being discounted. For example, one study showed participant body fat to be more strongly related to delay discounting for food than to delay discounting for money (Rasmussen et al., 2010). Another study showed that delay discounting for Polish currency, but not US currency, was

affected by inflation within the Polish economy (Ostaszewski et al., 1998). Delay discounting studies have showed significant positive correlations between one's discounting rate for one commodity (e.g., money) and another commodity (e.g., drug, food) (e.g., Charlton and Fantino, 2008; Johnson et al., 2010; Odum, 2011), suggesting the lack of absolute domain specificity. However, those same studies show that despite these significant correlations between commodities, the different commodities are discounted at significantly different rates (e.g., drug or food discounted more rapidly than money), suggesting some degree of domain specificity. Collectively, the present results and previous findings suggest that domain specificity may be an important focus for future delay discounting research.

Limitations should be kept in mind when reviewing these results. First, the Sexual Discounting Task involves hypothetical consequences rather than real consequences. Therefore, it is possible that participants' responses regarding immediate unprotected sex versus waiting for a condom do not reflect the actual behavior that participants would show if the consequences had been real. Although it would be ethically problematic to test whether Sexual Discounting Task results would differ when using hypothetical versus real consequences, numerous studies with money delay discounting suggest similar results when using real and hypothetical money (Johnson and Bickel, 2002; Baker et al., 2003; Madden et al., 2003; Madden et al., 2004; Lagorio and Madden, 2005; Johnson et al., 2007), including research showing similar neurobiological response to real and hypothetical rewards (Bickel et al., 2009). These results showing the validity of using hypothetical choices in money delay discounting suggest that the same may be true for the Sexual Discounting Task.

Another potential limitation is that the Sexual Discounting Task relies on subject-rated likelihood of engaging in immediate unprotected sex or delayed sex with a condom. Most delay-discounting research in human and nonhuman subjects has used discrete trial choice procedures to determine the value of a delayed reward, with choices between a smaller and larger amount of the same commodity (e.g., money, food, water). We considered using a choice procedure manipulating some aspect of sexual reward, such as the duration of sexual activity, such as the method of Lawyer et al. (2010) (e.g., 3 min now versus 10 min later). However, we judged that manipulating duration of sex might be problematic because of individual differences in preferred duration of sexual activity. Ultimately, the orderliness of the data and the differences across conditions suggest that the methods in the present study were successful in modeling the delay discounting of sexual outcomes.

Another possible limitation is that the Sexual Discounting Task pitted outcomes against each other that differed by an aspect other than delay. That is, immediate sex was always without a condom, and delayed sex was always with a condom. It was judged that isolating the pure effect of delay was less important than the increased face validity and relevance regarding HIV risk afforded by manipulating condom use. Such cross-commodity delay-discounting procedures have been previously used successfully to address clinically relevant issues in delay discounting and drug dependence (Yoon et al., 2009; Bickel et al., 2011).

Another potential limitation of the Sexual Discounting Task was that participants were not presented with an option to *not have sex* with the target person during VAS completion (i.e., choice ranged from unprotected sex now vs. protected sex later). However, an option not to have sex was implicit in the initial component of the task which asked the participant to select all photographs of persons with whom he/she was willing to have casual sex. Participants could select as few or as many photographs as they wished (e.g., they could choose 0 photographs). However, all participants indicated they were willing to have sex with at least one person during the task. Therefore, participants only completed the VAS component of the Sexual Discounting Task in reference to photographs of individuals with whom the participant indicated willingness to have sex. If a participant had chosen zero

photographs in the present study, that observation itself would have been reported, and that participant would not have been included in other analyses. Future studies with the task make take a similar approach, or may modify the procedure to increase the likelihood that the participant would select photographs (e.g., modify the hypothetical narrative, or increase the number and/ or variety of photographs). Because no sex is ultimately less risky than sex with a condom, the selection of zero photographs itself can be coded as the lowest level of risk when using rank ordered non-parametric analyses (i.e., participants who select zero photographs would be coded as the lowest level of risk, even below the participants who select photographs but show low rates of sexual discounting).

The conclusion that delay discounting contributes to HIV sexual risk behavior suggests several important directions to be investigated in future research. Because HIV risk decisions may stem from biases in not only delayed consequences, but also probabilistic consequences, the Sexual Discounting Task could be modified to assess probability discounting (extent to which uncertainty of consequence delivery decreases the value of a reward). The Sexual Discounting Task may be modified to address other clinically relevant aspects of HIV risk other than condom use, and in other drug-abusing populations (e.g., alcohol). The task may also be modified to study unwanted pregnancy rather than, or in addition to, STI risk. Future studies assessing the test-retest reliability of the Sexual Discounting Task will be important for determining its role in longitudinal and within-subject research designs.

Collectively, these findings indicate that delay discounting is a critical variable for understanding HIV sexual risk behavior, and that the Sexual Discounting Task provides a clinically meaningful assessment of this phenomenon. Public health policies and the treatment of high risk populations would benefit by bringing the wealth of behavioral and neurobiological data on delay discounting to bear on HIV education and prevention efforts. The results of this study indicate that people may make decisions regarding delayed sex in a manner fundamentally similar to that in which humans and other animals make decisions regarding delayed reinforcement in general, with a likely common neurobiological basis (McClure et al., 2007). Hyperbolic discounting may specifically account for why individuals sometimes engage in risky sexual behavior despite knowledge of consequences or previous intentions not to do so, which is a pattern observed in HIV research (Deas-Nesmith et al., 1999; Patinkin et al., 2007).

The present results suggest a fundamentally new approach for understanding HIV risk behavior. Notice that even among cocaine-dependent individuals, a population at exceptionally high risk for sexually transmitted HIV, most participants reported a very high likelihood of using a condom when one was immediately available. However, depending on condition, even a few hours of delay were able to drastically decrease reported likelihood of using a condom. Most research on HIV risk focuses on personality or demographic variables correlated with HIV risk, and thus treats HIV risk propensity as a trait variable that is best examined in between-subject analyses. However, the present data strongly indicate that HIV sexual risk can be understood as a within-subject variable, with relatively minor manipulations of delay showing drastic effects on participant behavior.

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References

- Ainslie G. Specious reward: a behavioral theory of impulsiveness and impulse control. *Psychol Bull.* 1975; 82:463–496. [PubMed: 1099599]
- Ammons RB, Ammons CH. The Quick Test (QT): provisional manual. *Psychol Rep.* 1962; 11:111–161.
- Baker F, Johnson MW, Bickel WK. Delay discounting in current and never-before cigarette smokers: similarities and differences across commodity, sign, and magnitude. *J Abnorm Psychol.* 2003; 112:382–392. [PubMed: 12943017]
- Beck RC, Triplett MF. Test-retest reliability of a group-administered paper-pencil measure of delay discounting. *Exp Clin Psychopharmacol.* 2009; 17:345–355. [PubMed: 19803634]
- Benowitz NL, Porchet H, Sheiner L, Jacob P 3rd. Nicotine absorption and cardiovascular effects with smokeless tobacco use: comparison with cigarettes and nicotine gum. *Clin Pharmacol Ther.* 1988; 44:23–28. [PubMed: 3391001]
- Bickel, WK.; Johnson, MW. Delay discounting: a fundamental behavioral process of drug dependence. In: Loewenstein, G.; Read, D.; Baumeister, RF., editors. *Time and Decision*. Russel Sage Foundation; New York: 2003a.
- Bickel, WK.; Johnson, MW. Junk time: pathological behavior as the interaction of evolutionary and cultural forces. In: Vuchinich, RE.; Heather, N., editors. *Choice, Behavioral Economics and Addiction*. Pergamon/Elsevier Science Inc; Amsterdam, Netherlands: 2003b. p. 249–271.
- Bickel WK, Landes RD, Christensen DR, Jackson L, Jones BA, Kurth-Nelson Z, Redish AD. Single- and cross-commodity discounting among cocaine addicts: the commodity and its temporal location determine discounting rate. *Psychopharmacology (Berl).* 2011; 217:177–187. [PubMed: 21487658]
- Bickel WK, Pitcock JA, Yi R, Angtuaco EJ. Congruence of BOLD response across intertemporal choice conditions: fictive and real money gains and losses. *J Neurosci.* 2009; 29:8839–8846. [PubMed: 19587291]
- Bobova L, Finn PR, Rickert ME, Lucas J. Disinhibitory psychopathology and delay discounting in alcohol dependence: personality and cognitive correlates. *Exp Clin Psychopharmacol.* 2009; 17:51–61. [PubMed: 19186934]
- Booth RE, Watters JK, Chitwood DD. HIV risk-related sex behaviors among injection drug users, crack smokers, and injection drug users who smoke crack. *Am J Public Health.* 1993; 83:1144–1148. [PubMed: 8342724]
- Bux DA, Lamb RJ, Iguchi MY. Cocaine use and HIV risk behavior in methadone maintenance patients. *Drug Alcohol Depend.* 1995; 37:29–35. [PubMed: 7882871]
- Charlton SR, Fantino E. Commodity specific rates of temporal discounting: does metabolic function underlie differences in rates of discounting? *Behav. Processes.* 2008; 77:334–342.
- Coffey SF, Gudleski GD, Saladin ME, Brady KT. Impulsivity and rapid discounting of delayed hypothetical rewards in cocaine-dependent individuals. *Exp Clin Psychopharmacol.* 2003; 11:18–25. [PubMed: 12622340]
- Darke S, Hall W, Heather N, Ward J, Wodak A. The reliability and validity of a scale to measure HIV risk-taking behaviour among intravenous drug users. *AIDS.* 1991; 5:181–5. [PubMed: 2031690]
- Deas-Nesmith D, Brady KT, White R, Campbell S. HIV-risk behaviors in adolescent substance abusers. *J Subst Abuse Treat.* 1999; 16:169–72. [PubMed: 10023616]
- Edlin BR, Irwin KL, Faruque S, McCoy CB, Word C, Serrano Y, Inciardi JA, Bowser BP, Schilling RF, Holmberg SD. Intersecting epidemics--crack cocaine use and HIV infection among inner-city young adults. Multicenter Crack Cocaine and HIV Infection Study Team. *N Engl J Med.* 1994; 331:1422–1427. [PubMed: 7969281]
- Edwards JM, Halpern CT, Wechsberg WM. Correlates of exchanging sex for drugs or money among women who use crack cocaine. *AIDS Educ Prev.* 2006; 18:420–429. [PubMed: 17067253]
- Frederick S, Loewenstein G, O'Donoghue T. Time discounting and time preference: a critical review. *J Econ Lit.* 2002; 40(2):351–401.
- Green L, Fristoe N, Myerson J. Temporal discounting and preference reversals in choice between delayed outcomes. *Psychonomic Bull Rev.* 1994a; 1:383–389.

- Green L, Fry AF, Myerson J. Discounting of delayed rewards: a life-span comparison. *Psychol Sci.* 1994b; 5:33–36.
- Grella CE, Anglin MD, Wugalter SE. Cocaine and crack use and HIV risk behaviors among high-risk methadone maintenance clients. *Drug Alcohol Depend.* 1995; 37:15–21. [PubMed: 7882869]
- Heil SH, Johnson MW, Higgins ST, Bickel WK. Delay discounting in currently using and currently abstinent cocaine-dependent outpatients and non-drug-using matched controls. *Addict Behav.* 2006; 31:1290–1294. [PubMed: 16236455]
- Herting MM, Schwartz D, Mitchell SH, Nagel BJ. Delay discounting behavior and white matter microstructure abnormalities in youth with a family history of alcoholism. *Alcohol Clin Exp Res.* 2010; 34:1590–1602. [PubMed: 20586754]
- Hoffman JA, Klein H, Eber M, Crosby H. Frequency and intensity of crack use as predictors of women's involvement in HIV-related sexual risk behaviors. *Drug Alcohol Depend.* 2000; 58:227–236. [PubMed: 10759033]
- Hudziak J, Helzer JE, Wetzel MW, Kessel KB, McBee B, Janca A, Przybeck P. The use of the DSM-III-R Checklist for initial diagnostic assessments. *Comp Psychiatry.* 1993; 34:375–383.
- Joe GW, Simpson DD. HIV risks, gender, and cocaine use among opiate users. *Drug Alcohol Depend.* 1995; 37:23–28. [PubMed: 7882870]
- Johnson MW, Bickel WK. An algorithm for identifying nonsystematic delay-discounting data. *Exp Clin Psychopharmacol.* 2008; 16:264–274. [PubMed: 18540786]
- Johnson MW, Bickel WK. Within-subject comparison of real and hypothetical money rewards in delay discounting. *J Exp Anal Behav.* 2002; 77:129–146. [PubMed: 11936247]
- Johnson MW, Bickel WK, Baker F. Moderate drug use and delay discounting: a comparison of heavy, light, and never smokers. *Exp Clin Psychopharmacol.* 2007; 15:187–194. [PubMed: 17469942]
- Johnson MW, Bickel WK, Baker F, Moore BA, Badger GJ, Budney AJ. Delay discounting in current and former marijuana-dependent individuals. *Exp Clin Psychopharmacol.* 2010; 18:99–107. [PubMed: 20158299]
- Kirby KN, Petry NM. Heroin and cocaine abusers have higher discount rates for delayed rewards than alcoholics or non-drug-using controls. *Addiction.* 2004; 99:461–471. [PubMed: 15049746]
- Kirby KN. Bidding on the future: evidence against normative discounting of delayed rewards. *J Exp Psychology Gen.* 1997; 126:54–70.
- Lagorio CH, Madden GJ. Delay discounting of real and hypothetical rewards III: steady-state assessments, forced-choice trials, and all real rewards. *Behav Processes.* 2005; 69:173–187. [PubMed: 15845306]
- Lawyer SR. Probability and delay discounting of erotic stimuli. *Behav Processes.* 2008; 79:36–42. [PubMed: 18556145]
- Lawyer SR, Williams SA, Prihodova T, Rollins JD, Lester AC. Probability and delay discounting of hypothetical sexual outcomes. *Behav Processes.* 2010; 84:687–692. [PubMed: 20385215]
- Madden GJ, Begotka AM, Raiff BR, Kastern LL. Delay discounting of real and hypothetical rewards. *Exp Clin Psychopharmacol.* 2003; 11:139–145. [PubMed: 12755458]
- Madden GJ, Raiff BR, Lagorio CH, Begotka AM, Mueller AM, Hehli DJ, Wegener AA. Delay discounting of potentially real and hypothetical rewards: II.. between- and within-subject comparisons. *Exp Clin Psychopharmacol.* 2004; 12:251–261. [PubMed: 15571442]
- Mazur, JE. An adjusting procedure for studying delayed reinforcement. In: Commons, ML.; Mazur, JE.; Nevin, JA.; Rachlin, H., editors. *The Effect of Delay and of Intervening Events on Reinforcement Value.* Lawrence Erlbaum Associates Inc; Hillsdale, NJ: 1987. p. 55-73.
- McClure SM, Ericson KM, Laibson DI, Loewenstein G, Cohen JD. Time discounting for primary rewards. *J Neurosci.* 2007; 27:5796–5804. [PubMed: 17522323]
- Melanko S, Leraas K, Collins C, Fields S, Reynolds B. Characteristics of psychopathy in adolescent nonsmokers and smokers: relations to delay discounting and self reported impulsivity. *Exp Clin Psychopharmacol.* 2009; 17:258–265. [PubMed: 19653791]
- Mitchell SH, Wilson VB. The subjective value of delayed and probabilistic outcomes: outcome size matters for gains but not for losses. *Behav Processes.* 2010; 83:36–40. [PubMed: 19766702]

- Myerson J, Green L. Discounting of delayed rewards: models of individual choice. *J Exp Anal Behav.* 1995; 64:263–276. [PubMed: 16812772]
- Myerson J, Green L, Warusawitharana M. Area under the curve as a measure of discounting. *J Exp Anal Behav.* 2001; 76:235–243. [PubMed: 11599641]
- Odum AL. Delay discounting: trait variable? *Behav. Processes.* 2011; 87:1–9.
- Ostaszewski P, Green L, Myerson J. Effects of inflation on the subjective value of delayed and probabilistic rewards. *Psychon Bull Rev.* 1998; 5:324–333.
- Patinkin N, Werner B, Yust I, Yagil Y, Drory M, Burke M. An investigation of the practice of unsafe sex yet repeated HIV testing. *Soc Work Health Care.* 2007; 44:73–90. [PubMed: 17521985]
- Petry NM. Reliability of drug users' self-reported HIV risk behaviors using a brief, 11-item scale. *Subst Use Misuse.* 2001; 36:1731–1747. [PubMed: 11758820]
- Rachlin, H. *Judgment, Decision, and Choice.* Freeman; New York: 1989.
- Rachlin H, Green L. Commitment, choice and self-control. *J Exp Anal Behav.* 1972; 17:15–22. [PubMed: 16811561]
- Rachlin H, Raineri A, Cross D. Subjective probability and delay. *J Exp Anal Behav.* 1991; 55:233–244. [PubMed: 2037827]
- Rasmussen EB, Lawyer SR, Reilly W. Percent body fat is related to delay and probability discounting for food in humans. *Behav Processes.* 2010; 83:23–30. [PubMed: 19744547]
- Saville BK, Gisbert A, Kopp J, Telesco C. Internet addiction and delay discounting in college students. *Psychol Rec.* 2010; 60:273–286.
- Sellitto M, Ciaramelli E, di Pellegrino G. Myopic discounting of future rewards after medial orbitofrontal damage in humans. *J Neurosci.* 2010; 30:16429–16436. [PubMed: 21147982]
- Volkow ND, Wang GJ, Fowler JS, Telang F, Jayne M, Wong C. Stimulant-induced enhanced sexual desire as a potential contributing factor in HIV transmission. *Am J Psychiatry.* 2007; 164:157–160. [PubMed: 17202559]
- Wilson M, Daly M. Do pretty women inspire men to discount the future? *Proc Biol Sci.* 2004; 271(Suppl 4):S177–9. [PubMed: 15252976]
- Wilson VB, Mitchell SH, Musser ED, Schmitt CF, Nigg JT. Delay discounting of reward in ADHD: application in young children. *J Child Psychol Psychiatry.* 2011; 52:256–264. [PubMed: 21083561]
- Yi R, Johnson MW, Bickel WK. Relationship between cooperation in an iterated prisoner's dilemma game and the discounting of hypothetical outcomes. *Learn Behav.* 2005; 33:324–336. [PubMed: 16396079]
- Yoon JH, Higgins ST, Bradstreet MP, Badger GJ, Thomas CS. Changes in the relative reinforcing effects of cigarette smoking as a function of initial abstinence. *Psychopharmacology (Berl).* 2009; 205:305–318. [PubMed: 19390842]
- Yoon JH, Higgins ST, Heil SH, Sugarbaker RJ, Thomas CS, Badger GJ. Delay discounting predicts postpartum relapse to cigarette smoking among pregnant women. *Exp Clin Psychopharmacol.* 2007; 15:176–186. [PubMed: 17469941]

Figure 1. Sexual discounting group median data with best-fit hyperboloid functions for the four conditions. The top panel shows data from the “most likely to have an STI” and “least likely to have an STI” conditions. The bottom panel shows data from the “most want to have sex with” and “least want to have sex with” conditions.

Figure 2.

Sexual discounting group median data with best-fit hyperboloid functions for the four conditions. Data have been normalized relative to likelihood of using a condom at no delay, so that delay discounting differences across groups are not confounded by differences in condom use regardless of delay. The top panel shows data from the “most likely to have an STI” and “least likely to have an STI” conditions. The bottom panel shows data from the “most want to have sex with” and “least want to have sex with” conditions.

Table 1

Demographic and drug use characteristics of cocaine-dependent participants

Demographic	Mean (SD) ^a
Age (years)	48.7 years (8.3)
Education (years)	12.4 years (1.7)
Monthly income (US \$)	\$699 (632)
Quick Test intelligence score ^b	39.0 points (4.4)
Cigarettes smoked per day	7.4 cigarettes (8.2)
Days since last cocaine use	1.6 days (1.4)
Money spent on cocaine per week (US \$)	\$194 (165)
Number married (%)	7 (11%)

^aExcept for number married, for which count and percent are shown

^bmax=50; adult norms: M=41.4, SD=6.0 (Ammons & Ammons, 1962)

Table 2

Pearson's r (p values) for various correlations among AUC (non-normalized) for the Sexual Discounting Task partner condition, HRBS sexual risk subscale score, number of photographs selected, and money discounting AUC. All $n=62$.

Sexual Discounting Task partner condition AUC	HRBS sexual risk score	Number of photographs selected	Money discounting AUC
Least want to have sex with	-.273 (.03) *	-.404 (.001) *	.080 (.54)
Most want to have sex with	-.127 (.33)	-.275 (.03) *	.125 (.34)
Least likely to have STI	-.249 (.05) *	-.263 (.04) *	.146 (.26)
Most likely to have STI	-.268 (.04) *	-.369 (.003) *	.326 (.01) *
Money delay discounting	-.162 (.21)	-.014 (.91)	--

* significant at $p .05$