

Probability and delay discounting of erotic stimuli

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ABSTRACT

Adult undergraduate men ($n = 38$) and women ($n = 33$) were categorized as erotica “users” ($n = 34$) and “non-users” ($n = 37$) based on their responses to screening questions and completed computerized delay and probability discounting tasks concerning hypothetical money and erotica. Erotica users discounted the value of erotica similarly to money on three of the four erotica tasks; erotica non-users discounted the value of money consistent with erotica users, but not the value of erotica. Erotica users were disproportionately male, scored higher on several psychometric measures of sexuality-related constructs, and exhibited more impulsive choice patterns on the delay discounting for money task than erotica non-users did. These findings suggest that discounting processes generalize to erotic outcomes for some individuals.

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1. Delay and probability discounting

Discounting refers to the extent to which an individual de-values a reinforcer as a function of the delay to or probability of receiving it (Ainslie, 1975; Rachlin, 1989; Green and Myerson, 2004). Delay discounting tasks assess individual decision-making patterns by determining indifference points that represent the current subjective value of a delayed outcome by providing a series of choices between two outcomes: a smaller reinforcer available immediately and a larger reinforcer available after some delay. In a typical *delay discounting* task with human participants, for example, given a choice of receiving “\$1 right now or \$10 in 1 day,” an individual would likely choose the \$10. However, over the course of a series of questions, the smaller immediate amount is increased systematically (\$1, \$2, \$3, \$4, etc.) and at some point, most people switch and choose the immediate outcome (e.g., \$8) over the delayed outcome, which represents the *current subjective value* of the larger outcome at that delay. Similar questions are asked in *probability discounting* tasks, except that the individual chooses between relatively small but certain outcomes and larger but uncertain outcomes (e.g., “Would you prefer \$1 for sure or \$10 with a 25% chance?”). In both tasks, the subjective value of the larger outcome typically decreases as a function of the delay to receiving the outcome (in the delay task) or the odds against receiving the outcome (in the probability discounting task).

Indifference point data across different delays and/or probabilities can be analyzed and described mathematically, and two contrasting models frequently are applied to discounting data. The *exponential model* ($V = A^{-kD}$) for delay discounting assumes that reward value decreases at a constant rate across units of delay to receiving an outcome, while *hyperbolic model* ($V = A/(1 + kD)$) predict that the value of a delayed outcome flattens as time to receiving the larger outcome increases. In each equation, V represents the subjective value of a delayed reward, A represents the amount of the delayed reward, D represents the delay to receipt, and k represents a free parameter that indexes the rate of discounting (higher values indicate more impulsive decision-making).

Probability discounting data also can be described using an exponential ($V = A^{-hO}$) and hyperbolic ($V = A/(1 + hO)$) functions, both of which predict that the value of an uncertain outcome decreases systematically with a decrease in its probability. In each model, V represents the subjective value of a probabilistic reward, A represents the amount of the larger probabilistic reward, O represents odds against receiving the larger outcome ($1/(p - 1)$), h represents a free parameter that indexes the rate of discounting (lower values indicate tendency to choose probabilistic outcomes), and p represents the probability of receiving the larger outcome. Discounting researchers frequently compare the fit of the exponential and hyperbolic discounting functions to their data and research clearly indicates that the hyperbolic function fits discounting data better than the exponential function for both delay and probability discounting (Green and Myerson, 2004). Moreover, research to date suggests that discounting functions apply similarly to hypothetical outcomes by comparison

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with real outcomes (e.g., Madden et al., 2003; Johnson and Bickel, 2002).

1.1. Discounting phenomena and non-monetary outcomes

Researchers frequently examine discounting behaviors using money because it is universally reinforcing and easily quantifiable. Indeed, discounting patterns regarding money provide some understanding regarding fundamental behavioral mechanisms associated with a variety of health behavior problems, including alcohol and illicit drug use (e.g., Bickel et al., 2007), health care utilization (Tucker and Davison, 2000), gambling (Rachlin et al., 1991), and tobacco use (Bickel et al., 1995), among others, since many such health behavior problems are characterized by patterns of impulsive choice. However, some researchers have advocated for research that addresses stimulus-specific decision-making processes (Johnson et al., 2004; Pinkerton and Abramson, 1992) that may differ from general decision-making patterns. In fact, research clearly shows that the discounting paradigm is readily applied to decision-making regarding non-monetary outcomes. Numerous studies document discounting-related phenomena regarding cigarettes (Bickel et al., 1999; Mitchell, 1999), heroin (Madden et al., 1997), health outcomes (Chapman, 1996; Odum et al., 2002), alcohol (Odum and Rainaud, 2003; Petry, 2001), cocaine (Coffey et al., 2003) and food products (Estle et al., 2007; Odum et al., 2006; Odum and Rainaud, 2003).

Understanding stimulus-specific decision-making patterns that are directly relevant to a behavioral problem is potentially important, as individual choice patterns may vary as a function of the commodity. Several studies have shown commodity effects in rates of delay discounting. For example, cigarette smokers, alcohol abusers, cocaine users and heroin users discount the value of their drug of choice more so than money (Coffey et al., 2003; Madden et al., 1997; Odum et al., 2000) suggesting different choice patterns that vary as a function of commodity.

1.2. Purpose of the present study

The current study used the delay and probability discounting paradigms to examine decision-making regarding hypothetical sexual stimuli and answer several fundamental questions. First, among those reporting that they find erotica reinforcing, can choice patterns concerning hypothetical erotic stimuli be described using mathematical parameters described in the discounting paradigm? Second, would different discounting tasks (e.g., those using probabilities and different delay time-frames) be differentially sensitive to capturing individual choice patterns for erotica? Third, among individuals who report finding erotica reinforcing, would rate of erotica discounting be related to sexuality-related behaviors and constructs? Fourth, how would discounting patterns for erotica differ when comparing individuals who do not find erotica reinforcing compared to those who do?

2. Materials and methods

2.1. Participants

Participants were students ($n=71$) recruited from undergraduate psychology courses. A little more than half of the participants was male ($n=38$; 53%) and the average age of all participants was 23.4 years ($S.D.=7.7$; range=18–57). The vast majority of participants reported Caucasian ethnicity ($n=60$; 84.5%), while others reported Hispanic ($n=5$; 7.0%) or other ($n=5$; 7.0%) ethnicities. The majority of participants (93%; $n=66$) reported some form of religious affiliation. The majority of participants (59%;

$n=42$) reported being single/never married, 29.6% ($n=21$) reported being married, 4.2% were divorced, and 7% ($n=5$) reported being unmarried but living with his/her partner. Almost all of the participants reported a heterosexual sexual orientation (95.8%; $n=68$); 4.2% ($n=3$) reported being bisexual. All participants received a small amount of course credit for their participation.

2.2. Demographic and self-report measures

In addition to providing basic demographic information, participants completed several self-report measures concerning sexuality-related constructs. The *Sexual Opinion Survey* (SOS; Fisher et al., 1988) is a well-established 21-item Likert-type measure of dispositional patterns of negative (erotophobia; lower scores) and positive (erotophilia; higher scores) responses to various sexual stimuli. The *Sexual Compulsivity Scale* (SCS; Kalichman and Rompa, 1995) is an established 10-item measure that assesses sexual preoccupation and hypersexuality. The *Sexual Inhibition and Excitation Scales* (SIS/SES; Janssen et al., 2002a,b) includes 45 items that measure factors related to sexual inhibition due to performance failure (SIS1) and to performance consequences (SIS2) and to sexual excitation. There are separate versions of this scale for male and female participants. The *Erotica Consumption Scale* (ECS) was developed for this study to measure the frequency with which subjects view various kinds of erotic material. Participants indicated whether they had ever viewed a sexually explicit adult video before, indicated how much they would enjoy watching a sexually explicit video if given the chance (0 = “not at all” to 10 = “very much”), and indicated the average monthly frequency with which they viewed sexually explicit magazines, books, and adult movies, and how frequently they visited sexually explicit internet web sites over the past year. The five items assessing frequency of erotica use were summed to form an ECS composite score representing frequency of monthly erotica use in the past year.

2.3. Discounting tasks

2.3.1. Delay and probability discounting for money

The discounting tasks concerning money were completed using an established discounting computer program and procedures (see Richards et al., 1999 for details regarding the task). Each participant answered a series of questions that elicited choices between \$10 to be received after each delay period (or with each probability) and a smaller amount of money available immediately (or “for sure”). The program calculated indifference values for each delay or probability for each task by incrementally adjusting the smaller amount of money up or down ($\pm\$50$) depending on participant responses to previous questions. The adjustments were made such that each question narrowed the range of values on successive choice trials until an indifference point was established. Indifference point values were used to calculate discounting curves.

2.3.2. Delay and probability discounting for erotica

The discounting tasks concerning erotica used the same computer program used for the money tasks. Four different erotica discounting tasks were used. All tasks were completed in the same session, questions were intermixed, and indifferent points were calculated for each of five probability or delay values within each task. One task (erotica probability) was a probability discounting task in which indifference points were calculated for each of five probability values (1.0, .9, .75, .50, and .25). In the other three erotica tasks, indifference points were calculated across three different time-periods. Erotica delays (days) were 1, 2, 30, 180, 365 days; erotica delays (h) were 1 h, 2 h, 1 day, 1 week, 2 weeks; and erotica delays

Table 1
Statistical comparisons of erotica “users” ($n = 34$) and “non-users” ($n = 37$) across psychometric measures

Measure	M (S.D.)		<i>t</i>	<i>p</i>
	Erotica users	Erotica non-users		
SOS	93.3 (22.7)	84.9 (22.1)	1.58	ns
SCS	17.6 (7.8)	12.6 (3.8)	3.42	<.001
SES	57.9 (7.8)	41.7 (11.6)	6.71	<.001
SIS1	27.6 (5.8)	28.7 (3.9)	-.97	ns
SIS2	28.9 (5.6)	32.0 (8.0)	-1.86	ns
ECS composite	23.2 (31.6)	1.4 (2.3)	4.19	<.001

(min) were 1, 2, 10, 25, 60 min. In each task, the smaller amount of minutes was increased and decreased in amount (± 50 min) by the program until an indifference point was determined for each probability and delay period.

Prior to completing the erotica-related task, participants were read the following script:

In the task that follows, you will have the opportunity to choose between different amounts of time to watch your favorite kind of erotic material after different delays or with different probabilities. For this task, answer the questions as if each of the following were true: (1) you would watch your favorite kind of sexual/erotic material, whatever that may be, (2) the only options you have to view erotic material are those given in the question, and (3) you must watch the material you choose given the question. The test consists of about 110 questions, such as the following: (a) Would you rather watch 10 minutes of erotica in 30 days or 2 minutes right now, or (b) would you rather watch 5 minutes of erotica right now or 10 minutes with a 25% chance? You will not actually watch erotic material, but we want you to make your decisions as though you really would watch erotic material.

The qualifications regarding the context for making decisions regarding erotica were added to the erotica task instructions to account for (1) individual differences in preferences for erotic material and (2) the possibility that choices for delayed outcomes might be influenced by the availability of erotica at home or on the internet.

Participants completed delay and probability discounting tasks with regard to money (one delay and one probability task) and erotica (three delay and one probability tasks) as two separate tasks and in a counterbalanced order to control for order effects.

2.4. Procedure

After providing written consent, participants were escorted to a small windowed room containing a desk, chair, and a computer, where they completed all psychometric and behavioral measures. All measures and tasks were completed in total privacy to protect

confidentiality and reduce demand effects. Total time for completing the study was about 40 min.

2.5. Analyses

SPSS 14.0 (2005) statistical software was used for all statistical analyses. Nonlinear regression procedures were used to compare the goodness of fit of the hyperbolic and exponential discounting functions and to calculate h and k parameters derived from the discounting functions for individual and group (median) indifference point data. Rate of discounting also was estimated via area under the curve (Myerson et al., 2001) analyses, which provide a non-theoretical measure of discounting rate and are more appropriate for parametric statistical comparisons than are k and h values, which tend to be skewed. In addition, area under the curve estimates provide an index of preference for erotica outcomes even among participants who did not discount the value of erotica in a way that would provide a meaningful k or h value (e.g., an invariant high or low value for erotica outcomes across delays or probabilities).

3. Results

3.1. Determining erotica users and non-users

Participants were categorized as erotica “users” (i.e., those who find erotica reinforcing) and “non-users” (i.e., those who are averse to erotica) based on their responses to two items on the Erotica Consumption Scale. Participants were categorized as erotica “users” if they answered “yes” to item 1 (having viewed a sexually explicit video in the past) and a six or greater to item 2 (interest in watching sexually explicit video if given the chance). All other participants were categorized as erotica “non-users.” A series of statistical comparisons revealed that erotica “users” were more likely to be male (60.5%) than female (39.5%; $\chi^2 = 5.23$; $p = .02$) and reported more erotica consumption (ECS scores) and higher scores on the Sexual Compulsivity Scale and Sexual Excitability scale of the SIS/SES, but not on the Sexual Opinion Survey (see Table 1).

Table 2
Mean (S.E.) R^2 accounted for by hyperbolic and exponential discounting functions for money- and erotica-related tasks when fit to individual indifference point data among erotica users ($n = 34$) and non-users ($n = 37$)

Commodity/task	Hyperbolic		Exponential	
	Erotica users	Erotica non-users	Erotica users	Erotica non-users
Money				
Probability	.806 (.04)	.771 (.05)	.714 (.05)	.715 (.05)
Delay	.683 (.06)	.702 (.05)	.633 (.06)	.646 (.05)
Erotica				
Probability	.704 (.06)**	.187 (.06)	.646 (.06)**	.169 (.05)
Delay (days)	.423 (.07)**	.102 (.04)	.362 (.07)*	.094 (.04)
Delay (h)	.280 (.06)*	.103 (.04)	.254 (.06)*	.094 (.04)
Delay (min)	.394 (.06)**	.088 (.04)	.381 (.06)**	.080 (.04)

* $p < .05$; ** $p < .01$.

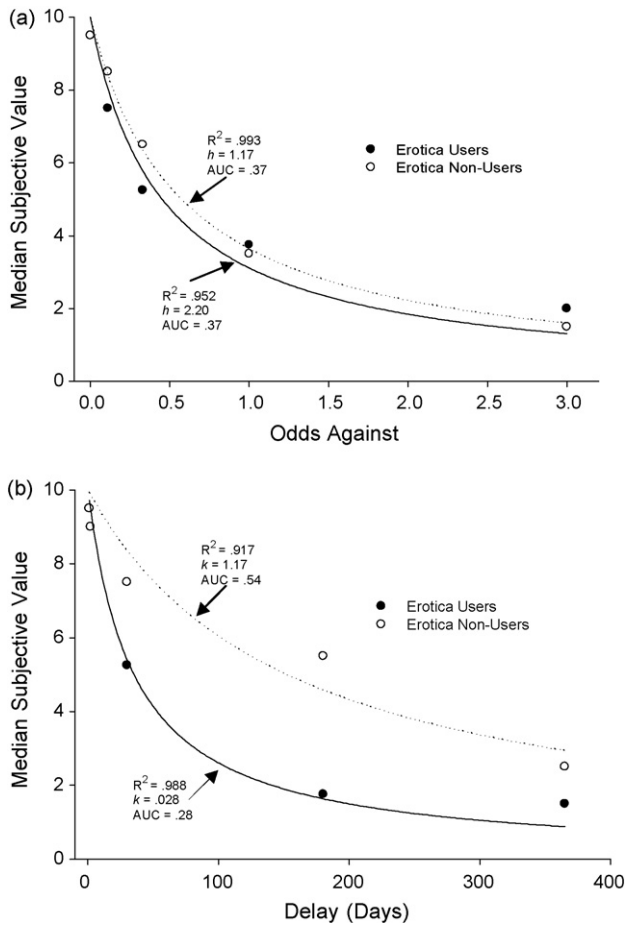


Fig. 1. Median subjective values for receiving \$10 (a) odds against and (b) days delay to receiving the outcome among erotica users ($n = 34$) and non-users ($n = 37$). Fit lines represent fit to hyperbolic discounting function for erotica users (solid line) and non-users (dotted line).

In order to be sure that the assignment to the counterbalance orders did not introduce a bias, a series of comparisons were conducted between individuals in each counterbalance condition. Counterbalance condition was not associated with disproportionate numbers of erotica users or non-users, with gender, or with scores on any psychometric measures.

3.2. Delay and probability discounting for money

Table 2 shows the mean R^2 values indicating proportion of variance accounted for by the hyperbolic and exponential functions when fit to individual indifference point data among erotica users and non-users. Consistent with previous research, the hyperbolic function tended to fit the data better than did the exponential function in both discounting tasks. Therefore, only data relating the hyperbolic function are presented in the subsequent figures.

Fig. 1 shows the median indifference points regarding \$10 in the delay and probability discounting tasks among erotica users and non-users. Erotica users discounted the value of money more steeply than did erotica non-users on the delay discounting (but not the probability discounting) task as indicated both visually and by a statistical comparison of mean area under the curve estimates (see Table 3).

Table 3

Comparisons of mean (S.E.) area under the curve estimates between erotica “users” ($n = 34$) and “non-users” ($n = 37$) across all discounting tasks

Commodity	Task	Erotica users	Erotica non-users
Money	Probability	.36 (.03)	.39 (.02)
	Delay	.39 (.04)	.54 (.04)*
Erotica	Probability	.36 (.04)	.60 (.05)**
	Delay (days)	.21 (.03)	.40 (.06)*
	Delay (h)	.07 (.06)	.07 (.05)
	Delay (min)	.11 (.05)	.07 (.06)*

* $p < .05$; ** $p < .01$.

3.3. Delay and probability discounting for erotica

Consistent with the money-related data, the hyperbolic discounting function provided the best overall fit to individual indifference point data concerning erotica among erotica users and non-users (see Table 2), though there was significant variability in the fit of the models across groups and tasks. A comparison of the R^2 values calculated for hyperbolic and exponential discounting functions among erotica users and non-users revealed that erotica users had higher R^2 values than did erotica non-users on all of the erotica tasks, but not on the money tasks. Among erotica users, the hyperbolic discounting function provided a good fit for probability discounting data when fit to individual indifference points. By contrast, the mean R^2 values for the three delay tasks were relatively low (e.g., R^2 values ranged .280–.423).

Fig. 2 shows the median indifference point values across tasks and groups with lines representing fit to the hyperbolic function among erotica users only. Visual inspection of the figure corresponds with the data in Table 2 such that, among erotica users, the probability and delay (min) tasks elicited data that were well-described by the hyperbolic discounting function while the other two tasks were less so. Among erotica non-users, median indifference values did not follow a typically discounting pattern in the tasks. In fact, three of the four tasks (excluding the delay [min] task) elicited median response patterns that appeared opposite those among the erotica users. Specifically, these tasks generated data indicating that many participants tended to value lower probability and larger delayed outcomes more than higher probability and more immediate outcomes, suggesting that erotica outcomes were aversive to a significant number of these participants.

3.4. Relationships between discounting and sexuality variables

To determine whether rate of discounting for erotica or money was statistically related to sexuality-related constructs, a series of Pearson’s r correlations between area under the curve estimations for each discounting task and the SES, SOS, SCS, and the ECS composite score among erotica users. These analyses yielded two significant correlations; area under the curve for erotica task E3 was significantly correlated with scores on the SCS ($r = -.41$; $p < .05$) and area under the curve for erotica task E4 was significantly correlated with scores on the SOS ($r = .38$; $p < .05$). There were no other significant relationships.

4. Discussion

The purpose of the present study was to determine whether decision-making concerning erotica stimuli could be elicited and characterized using the discounting paradigm, whether different discounting tasks would more differentially elicit decision-making patterns for erotica that could be described using mathematical dis-

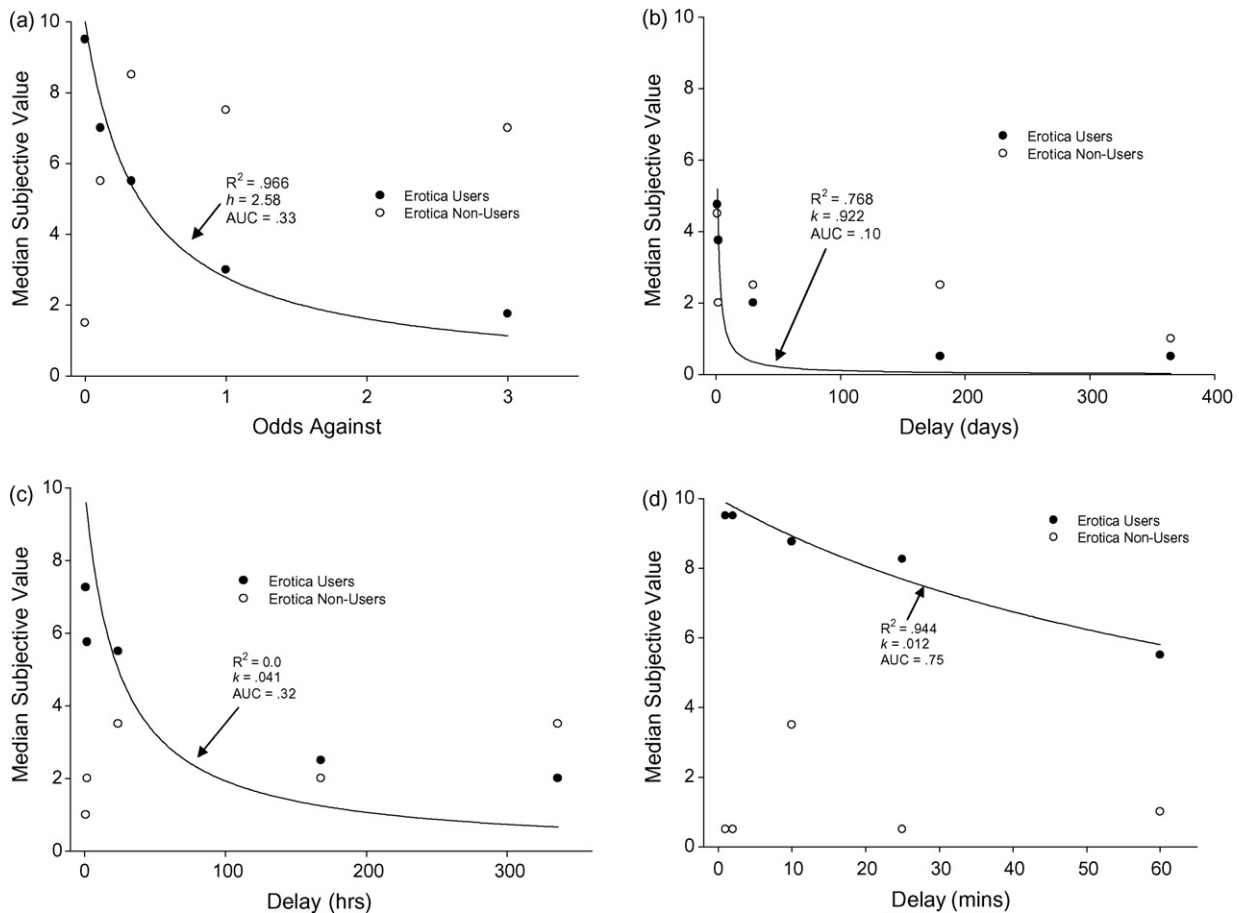


Fig. 2. Median indifference values for receiving 10 min of erotica among erotica users ($n = 34$) and non-users ($n = 37$) as a function of (a) odds against, (b) delay (days) to, (c) delay (h) to, and (d) delay (min) to receiving the outcome. Fit lines represent fit to hyperbolic discounting function for erotica users.

counting functions, whether decision-making for erotic material would be statistically related to relevant sexuality-related constructs, and whether those who report interest in viewing erotica would respond differently to erotica discounting tasks than would those who do not.

4.1. Application of the discounting paradigm to choices concerning hypothetical erotic stimuli

Among “erotica users,” three of the four erotica discounting tasks elicited orderly patterns of responding using the discounting paradigm. These findings extend a growing experimental literature indicating that decision-making for non-monetary stimuli can be characterized using the discounting paradigm (e.g., [Estle et al., 2007](#)). Also consistent with extant research was the superior fit of the hyperbolic discounting function to individual and group-median discounting data concerning erotica than the exponential function (see [Green and Myerson, 2004](#)). Therefore, these data buttress [Bickel and Johnson’s \(2003\)](#) view that discounting is a fundamental mechanism that underlies decision-making behavior and suggest that the same discounting phenomena that underlie decision-making for monetary and non-monetary outcomes also underlie decision-making for erotica.

4.2. Sensitivity of discounting tasks to capturing choice patterns for erotica

It is clear that not all of the tasks were equally efficient at eliciting discounting-related choice patterns for erotica. The probability

discounting task elicited choice patterns that were described using the hyperbolic discounting function more consistently than did the other tasks, as indicated by the fit of the hyperbolic function to individual and group-median data. By contrast, the other erotica tasks yielded data that was much more variable at the individual level (according to R^2 group means), but also at the group-median level where group medians yielded from the delay (h) task were not described well using the discounting paradigm.

Although the probability discounting task for erotica yielded data that were more orderly and better described by the discounting function than the delay tasks, the delay discounting task across minutes may provide some more meaningful data in the future if a longer delay period is used (e.g., 1–120 min) to capture more variability in responding than did the 1–60 min time-frame. This may be useful also for future research if real, as opposed to hypothetical outcomes are used, since the delay period would be more conducive to actually delivering erotic outcomes in a laboratory environment. Research to date suggests that, at least with regard to monetary outcomes, real and hypothetical outcomes yield similar data ([Johnson and Bickel, 2002](#); [Madden et al., 2003](#)), though such generalizations to erotic outcomes await empirical investigation.

4.3. Relationship between rate of erotica discounting and sexuality-related constructs

Results from this study suggest that choice behavior for hypothetical erotica in the laboratory is not strongly associated with sexuality-related constructs assessed with self-report measures.

On the erotica delay (h) task, more impulsive choice patterns (indicated by lower AUC estimates) were associated with more self-reported sexual compulsivity. Interestingly, AUC estimates on the erotica delay (min) task were positively associated with higher scores on the Sexual Opinion Survey, which indicate an affinity for sexual stimuli in general. This relationship is a bit perplexing, since stronger affinities for erotica should reasonably be associated with more impulsive choice patterns indicated by smaller AUC estimates. However, it is possible that the 1-h delay used as the larger delay may have been sufficiently small that many “erotophilic” participants would be willing to wait to receive the larger (10 min) outcome.

The inconsistent relationships between discounting behavior regarding erotica and psychometric measures of sexuality-related constructs should be considered in light of the small sample size ($n=34$) used to calculate them. However, it is also possible that the self-report and behavioral measures used here assess different constructs. Indeed, Reynolds et al. (2006) reached such a conclusion after finding no correlations between self-report and behavioral measures of putative measures of impulsiveness, including the same money discounting task used here. Taken together, these findings suggest that more research is needed concerning the relationships between self-report and behavioral measures of impulsiveness-related constructs.

4.4. Erotica discounting patterns among erotica users vs. non-users

When erotica users were compared to erotica non-users, there were clear differences in responding on the erotica tasks. While erotica users discounted the value of erotica in a pattern similar to that seen with money, erotica non-users exhibited more varied decision-making patterns that suggested a pattern of valuing low-probability and delayed outcomes over higher probability and immediate outcomes. These patterns resemble those reported by some researchers (e.g., Murphy et al., 2001) reporting that discounting patterns in relation to aversive outcomes (e.g., losing money) mirror those for rewarding outcomes such that the value of an aversive outcome varies as a function of its delay, though a higher value is placed on delayed aversive outcomes than immediate ones. Although the data reported here are less orderly than those reported by Murphy et al., the similarities do deserve some notice.

Interestingly, erotica users discounted the value of delayed (but not probabilistic) money significantly more so than did erotica non-users, suggesting that individuals who reported enjoying watching erotica are generally more impulsive than those who do not. In light of the parallel findings that erotica users scored higher on the Sexual Compulsivity Scale than did non-users, these findings may be relevant to ongoing theoretical and empirical efforts to understand behavioral mechanisms (e.g., an insensitivity to risks associated with unsafe sex) that underlie some problematic sexual behaviors (e.g., Bancroft and Vukadinovic, 2004). Moreover, the fact that these differences in rate of discounting were found in the delay, but not the probability discounting task are consistent with the view that delay and probability discounting tasks measure related, but distinct constructs rather than one underlying construct (see Green and Myerson, 2004 for a substantive discussion of this issue).

4.5. General conclusions and future directions

The present study supports the use of the discounting paradigm to characterize decision-making for hypothetical erotica and help address concerns raised by some researchers (Johnson et al., 2004) that assessment of general decision-making patterns (e.g.,

impulsiveness as a personality disposition) may not adequately capture decision-making patterns for specific stimuli that have functional relevance to specific outcomes. There is clear theoretical and empirical value in generalizing discounting-related processes to various types of stimuli in an effort to identify fundamental decision-making processes, but there also is practical and theoretical relevance to understanding the fundamental processes that underlie sexual decisions. For example, Loewenstein (1996) has argued that certain “visceral factors” (e.g., sexual arousal, hunger, drug cravings) may increase impulsive decision-making with regard to stimuli associated with gratification of those visceral states, but not other stimuli. Although Loewenstein’s (1996) hypotheses have received relatively little empirical attention in recent years, the discounting procedures described here provide one avenue for testing his assertions using an established and theoretically meaningful paradigm. Researchers have yet to apply the discounting paradigm to the study of sexual decision-making, though Logue (2000) highlighted unsafe sexual behavior as being directly related to a tendency to choose short-term rewards (sexual gratification) in spite of potential long-term consequences (disease, unwanted pregnancy) and such efforts would complement existing efforts to apply the discounting paradigm to socially relevant matters (Critchfield and Kollins, 2001).

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