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Associations Between Delay Discounting and Risk-Related Behaviors, Traits, Attitudes, and Outcomes

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ABSTRACT

Delay discounting—preference for immediate, smaller rewards over distal, larger rewards—has been argued to be part of the "generality of deviance", which describes the co-occurrence of various forms of impulsive and risky behaviors among individuals. Some studies have linked laboratory-measured delay discounting to behaviors, traits, attitudes, and outcomes associated with risk, but these associations have been inconsistent. Furthermore, many of these studies have been conducted with exclusively undergraduate samples, or in samples offering low statistical power. In a large community sample ($n = 328$) diverse in age and socioeconomic status, we examined associations between two measures of behavioral delay discounting (single-shot and canonical k-parameter estimation) and behavioral risk-taking, personality traits associated with risk, domain-specific risk attitudes, gambling and problem gambling, antisocial behavior, and criminal outcomes. In addition, we explored whether a novel response time latency measure of delay discounting explained variance in these risk-related outcomes. Results indicated that behavioral delay discounting was consistently associated with all variables related to impulse control: high trait impulsivity, low trait self-control, risk-averse attitudes toward financial investment, risk-prone attitudes toward gambling and health/safety risks, gambling and problem gambling, antisocial conduct, and criminal outcomes. Latency-measured delay discounting was inconsistently associated with behavioral delay discounting and risk-related measures. Together, results suggest that delay discounting is associated with poor impulse control consistent with a generality of deviance account. Copyright © 2016 John Wiley & Sons, Ltd.

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KEY WORDS delay discounting; risk; risk attitudes; behavioral risk-taking; gambling; antisocial behavior; crime; impulsivity

The *generality of deviance* framework posits that various forms of impulsive and risky behaviors co-occur among individuals (reviewed in Gottfredson & Hirschi, 1990; Hirschi & Gottfredson, 1994; Jones & Quisenberry, 2004). Much theorizing and empirical evidence suggests that delay discounting —behavioral preference for smaller, immediate rewards over larger, distal rewards—is part of this generality of deviance. The evidence for this link between discounting and other risk-related behaviors, traits, and outcomes has been inconsistent, however.

In the following, we first review theoretical frameworks suggesting that discounting should be associated with measures of impulsivity and risk-propensity consistent with a generality of deviance account. Second, we review previous work that has examined associations between discounting and various risk-related behaviors, traits, attitudes, and outcomes. Third, we provide evidence suggesting that different measures of discounting (specifically, single-shot and response time latency) may be useful in accounting for variance in risk-propensity. Fourth, we provide evidence suggesting that sample characteristics (namely, age and socioeconomic status) may have played some role in the inconsistent prior associations observed between discounting and risk measures in the literature. Finally, we present a large-n study utilizing a diverse community sample examining the link between delay discounting (measured in three different ways) and various risk-related behaviors, traits, attitudes, and outcomes.

Discounting and the generality of deviance

Several theoretical frameworks suggest that various forms of impulsive and risk-taking behaviors should co-occur among individuals. Gottfredson and Hirschi (1990) argued in their influential *general theory of crime* that all antisocial behavior is a product of trait (low) self-control combined with opportunity. *Problem-behavior theory* (Jessor, 1991) suggests that general risk-propensity and antisocial conduct is a product of environmental and developmental instigations (risk factors) and controls (protective factors). Evolutionary theorists have argued that domain-general risk-propensity is a response to competitive pressures (especially among those who are competitively disadvantaged) because of persistent embodied, situational, or environmental factors (e.g., Mishra, Barclay, & Lalumière, 2014; Mishra, Barclay, & Sparks, in press). Despite variability in proposed mechanisms, these theories all advance the idea of shared variance among various forms of risky and impulsive behavior.

Substantial evidence supports the generality of deviance hypothesis. Various forms of impulsive and risky behavior tend to co-occur within individuals, including crime, reckless driving, substance abuse, sexual risk-taking, aggression and violence, and gambling, among many others (reviewed in

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Mishra & Lalumière, 2009; Toneatto & Nguyen, 2007; Zuckerman, 2007). Those who engage in this constellation of behaviors also tend to possess higher levels of personality traits associated with poorer impulse control (e.g., low self-control, high impulsivity) and greater sensation-seeking (reviewed in Zuckerman, 2007). Discounting fits within this generality of deviance given that it is a manifestation of behavioral impulsivity. In the following, we review empirical evidence supporting the hypothesis that discounting is a part of a broader pattern of risky and impulsive behavior consistent with the generality of deviance.

Discounting and impulsive behavior

Impulsivity can be broadly defined as "a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions to the impulsive individual or to others" (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001, p. 1784). Several studies have demonstrated that delay discounting is associated with real-world behaviors considered to be impulsive. Reimers, Maylor, Stewart, and Chater (2009) showed in a large sample that a single-shot delay discounting measure (a choice between £45 in three days or £70 in three months) was associated with earlier age of first sexual activity, recent relationship infidelity, smoking, and higher body mass index. Others have shown that behavioral discounting measures are associated with various substance use problems, as well as problem and pathological gambling tendencies (reviewed in Reynolds, 2006).

Discounting and risk-taking

Risk is most parsimoniously defined as outcome variance. This definition of risk as variance has been broadly used in the behavioral sciences, including biology, economics, and psychology (reviewed in Mishra, 2014; Mishra, Barclay, and Sparks, in press). Impulsive behaviors often involve exposure to relatively greater outcome variance, and thus are typically "riskier" than non-impulsive behaviors. Many of the behaviors that have been linked to delay discounting reviewed above involve high outcome variance. However, few studies have examined whether discounting is associated with risk-taking in a controlled laboratory setting. Furthermore, few studies have examined whether risk-prone (or risk-averse) attitudes (i.e., favorable or unfavorable dispositions toward risk) are associated with greater (or lesser) levels of delay discounting.

Mishra and Lalumière (2011) found no relationship between delay discounting and risk-taking as measured by the Choice Task (which measures variance preference controlling for expected value; Mishra & Lalumière, 2010). They also observed a surprising negative relationship between discounting and risk-taking as measured by the Balloon Analogue Risk Task (an extensively used sequential risk measure; Lejuez et al., 2002). Last, there was no relationship between discounting and measures of risk attitudes aggregated across multiple content domains.

Discounting and personality

Some research suggests that delay discounting is associated with stable individual differences in impulse control and sensation-seeking, although these findings are inconsistent. Ostaszewski (1996) and Copping, Campbell, and Muncer (2014) found that discounting was associated with greater trait impulsivity. Romer, Duckworth, Sznitman, and Park (2010) found weak evidence linking discounting and trait sensation-seeking. Others, however, have demonstrated null relationships between delay discounting and individual differences in impulse control and sensation-seeking. For example, Mishra and Lalumière (2011) found no significant associations between discounting and trait impulsivity, self-control, or sensation-seeking. Reynolds, Ortengren, Richards, and de Wit (2006) found that discounting was not associated with trait impulsivity or self-control.

Discounting and antisocial conduct

Few studies have directly examined whether delay discounting is associated with antisocial and criminal outcomes. Ramos, Victor, Seidl-de-Moura, and Daly (2013) showed that disadvantaged youths in Rio de Janeiro engaged in higher levels of discounting compared to university students. Similarly, White et al. (2014) showed that youth with conduct disorder engaged in greater discounting compared to healthy controls. People with substance disorders who also present with antisocial personality disorder exhibited higher levels of discounting (Petry, 2002; Sargeant, Bornovalova, Trotman, Fishman, & Lejuez, 2012). In contrast, Wilson and Daly (2006) found that juvenile offenders did not exhibit higher levels of discounting compared to matched non-offending controls. No studies, to our knowledge, have examined whether discounting is associated with such clear antisocial outcomes as being arrested, charged, convicted, or incarcerated for a crime in a general sample.

Discounting, age, and socioeconomic status

One possible explanation for the inconsistent associations observed between delay discounting, personality traits, antisocial conduct, and risk-taking in the literature is the nature of samples used to examine these associations. Samples used to examine associations between discounting and risk-related outcomes have been varied, with some comprising solely of undergraduate students (e.g., Mishra & Lalumière, 2011). Some of these samples are also quite small and thus limited in power (e.g., Ostaszewski, 1996). These varied samples—especially undergraduate-only samples—are problematic given that there is strong empirical evidence to suggest that there are robust age and socioeconomic effects in discounting and risk-related behaviors.

Substantial evidence indicates that younger people are disproportionately likely to engage in risk-related and discounting behaviors, and that these behaviors decline quickly after adolescence. The well-known "age–crime" curve, for example, documents the robust finding that engagement in crime peaks in the teenage years and rapidly declines thereafter (Farrington, 1986). Recent evidence has

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extended this work to more generally demonstrate an "age–risk" curve: Various forms of risk-taking show the robust pattern of a peak in the teenage years and a decline thereafter (for a meta-analysis, see Mata, Josef, Samanez-Larkin, & Hertwig; for a recent review of cross-national data, see Mata, Josef, Samanez-Larkin, & Hertwig, 2011). This phenomenon of a peak in risk-taking behavior in adolescence extends to patterns of delay discounting. Substantial evidence indicates that those who are younger are significantly more likely to engage in discounting relative to those who are older (Green, Fry, & Myerson, 1994; Green, Myerson, & Ostaszewski, 1999; Harrison, Lau, & Williams, 2002; Read & Read, 2004; Reimers, Maylor, Stewart, & Chater, 2009; Steinberg et al., 2009: Whelan & McHugh, 2009).

In addition to age, socioeconomic status has been implicated as an important correlate of engagement in impulsive, risky, and discounting behaviors. It is well-established that lower socioeconomic status is associated with greater risk-taking, including higher rates of criminal and antisocial conduct (reviewed in Piotrowska, Stride, Croft, & Rowe, 2015). Furthermore, a large body of evidence indicates that those who are poorer have been demonstrated to engage in higher levels of laboratory measured delay discounting (de Wit, Flory, Acheson, McCloskey, & Manuck, 2007; Green, Myerson, Lichtman, Rosen, & Fry, 1996; Harrison et al., 2002; Jaroni, Wright, Lerman, & Epstein, 2004; Reimers et al., 2009). Given the substantial evidence linking younger age and lower socioeconomic status with greater risk-taking, criminal conduct, and discounting, it is therefore possible that inconsistent results in previous research measuring associations between discounting and risk-related behaviors and outcomes are in part caused by sampling from populations that are overly homogenous (i.e., range restricted) in age and socioeconomic status.

Measuring discounting

Another possible explanation for the inconsistent relationships between delay discounting and risk-related outcomes and behaviors is the nature of the instruments used to measure discounting. One of the most common behavioral methods used to measure discounting is a monetary choice questionnaire developed by Kirby and colleagues (Kirby, 1997; Kirby & Maraković, 1995, 1996; Kirby, Petry, & Bickel, 1999). It involves presenting participants with a series of paired options between a small amount of money available immediately and a larger amount of money available later (e.g., "Would you rather have $31 today, or $85 in seven days?"). These choices involve relatively small, medium, and large amounts of money. For example, someone who is particularly present-oriented would likely choose $31 today over $85 in seven days. Someone who is particularly future-oriented would likely choose $80 in 162 days over $78 today. For each series of choices (small, medium, or large), most people exhibit a "switch point" where waiting for a reward is no longer preferable. From this switch point, a discounting parameter (k) can be computed that describes where on a hyperbolic function a particular individual lies regarding present versus future orientation (Kirby & Maraković, 1995, 1996; Kirby et al., 1999). Other studies have utilized single-shot measures of delay discounting, which do not involve computation of a discounting parameter, but rather involve a single choice between a smaller payout now and a larger payout later (e.g., Reimers et al., 2009).

Choice-based behavioral measures of delay discounting necessarily involve conscious, explicit, and deliberative decision-making. However, many decisions are not necessarily products of conscious, explicit, and deliberative processes. Rather, many decisions are in large part products of unconscious processes that reflect varied developmental, social, and environmental inputs and a history of learned behavior-response contingencies. Consequently, a deliberative and explicit measure of delay discounting may not best capture the implicit processes involved in real-world choices between present and future outcomes.

Reaction time offers a glimpse into the unconscious processes involved in decision-making by capturing *processing fluency*. Processing fluency is the ease (or difficulty) of processing information (reviewed in Alter & Oppenheimer, 2009). Someone who makes a quick decision may do so because the choice they faced was simple and easy to process. Conversely, someone who takes a long time to make a decision is likely engaging in a more deliberative process. Some research suggests that reaction time measures of choice capture unique aspects of decision-making that explicit choices do not (Chabris, Laibson, Morris, Schuldt, & Taubinsky, 2009; Geng, 2016; Rubinstein, 2007, 2013; Schotter & Trevino, 2014).

Typical behavioral delay discounting measures involve computation of a discounting parameter based on a switch point from present to future rewards in a series of choices. An alternative method of computing a discounting parameter involves identifying the point where a decision-maker makes the most deliberative choice—that is, the decision that requires the most cognitive effort to process, and thus involves the longest response time latency. In a series of choices between present and distal rewards, the choice that has the longest response time latency likely indicates the most difficult choice a decision-maker was presented with, and may thus serve as an implicit, unconscious indicator of a switch point.

Overview

The present research consists of a study examining whether delay discounting is associated with behavioral risk-taking, personality traits associated with risk, pro-risk attitudes, gambling and problem gambling, antisocial conduct, and criminal outcomes. The present study replicates and extends previous research by (i) utilizing a large community sample diverse in age and socioeconomic status; (ii) utilizing multiple measures of delay discounting, (iii) measuring numerous risk-related behaviors and outcomes in a diverse manner, and (iv) offering relatively high compensation to participants. We expand on the importance of these study characteristics in the following.

Sample characteristics

Many previous studies have involved either small sample sizes and/or homogenous samples, several of which

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comprised young undergraduate students of relatively high socioeconomic status. As reviewed above, a large body of evidence suggests that age and socioeconomic status are important influences on both discounting and risk-related behaviors. Consequently, this study involved the direct replication and examination of previous associations involving delay discounting in a large and diverse community sample specifically targeted to increase variability in age and socioeconomic status compared to other convenience samples.

Small sample sizes are an issue in much of the extant discounting literature (and in psychological science more generally; reviewed in Asendorpf et al., 2013). Schönbrodt and Perugini (2013) provided simulation evidence indicating that for typical correlations in personality and social psychology research (i.e., *r*s of approximately .20), a sample size of $n = 250$ provides a stable estimate of correlation magnitude. Our large sample size thus provides more than enough statistical power to establish reliable estimates of effect sizes. This sample size combined with the diversity of our sample allows us to provide better estimates (with greater generalizability) of the magnitude of associations between delay discounting and risk-related measures. Direct replication of previous research is also particularly important in psychological science, where growing attention has been paid to the issue of generally low replicability of research in the area (reviewed in Pashler & Wagenmakers, 2012).

Diversity of discounting measures

We measured discounting in three different ways. First, we measured discounting using canonical *k*-parameter estimation through a series of paired choices between smaller choices available now and larger distal choices available in the future. Second, we measured discounting using a single-shot measure of discounting. Third, we used an exploratory response time latency measure of discounting—a measure that, to our knowledge, has not been empirically examined in past literature. This study also examined several risk-related measures that have not been extensively investigated in the context of delay discounting in the extant literature: laboratory-based risk-taking, domain-specific risk attitudes, and discrete criminal outcomes (i.e., whether one has been arrested, charged, convicted, or incarcerated for a crime). To our knowledge, no studies have examined whether criminal outcomes are associated with discounting behavior. Hanoch and Gummerum (2010) examined domain-specific risk attitudes among prisoners and non-prisoners; however, as they suggested, further research was (is) necessary to examine the association between discounting and criminal outcomes.

Payment structure

Evidence suggests that varied payment structures have differential effects on responding in behavioral decision-making studies (Ferrey & Mishra, 2014; Göritz, 2004; Schmidt & Hewig, 2015). Generous pay and performance-based payment have both been demonstrated to be associated with improved task performance and higher rates of successful task completion in experimental studies (Brase, 2009; Camerer & Hogarth, 1999; Gneezy & Rustichini, 2000), although some have noted concerns about overly desirable responding (Göritz, 2004). We compensated participants for their participation ($30) and offered additional compensation tied to actual decision-making in each of the behavioral tasks (average earnings from task-based decision-making were $58.38). Typical compensation in delay discounting tasks in other studies has involved some probabilistic process (e.g., rolling "snake eyes"; Schmidt & Hewig, 2015). In our study, all participants received compensation for one of their decisions in the delay discounting task.

Study predictions

Consistent with prior theorizing and (some) empirical evidence suggesting that discounting (along with various manifestations of impulsivity and risk-propensity) are part of the generality of deviance, we expected that delay discounting would be positively associated with greater behavioral risk-taking, higher levels of personality traits associated with risk (especially those involving poor impulse control, namely high impulsivity and low self-control), risk attitudes in domains involving impulsivity, gambling and problem gambling behaviors, and antisocial and criminal outcomes. We also predicted that latency-measured delay discounting would be similarly positively associated with these measures. Finally, we predicted that latency-measured delay discounting would account for unique variance in risk-related variables because it should reflect unique implicit decision processes that may not necessarily be captured in an "end result" behavioral choice.

METHOD

A total of 328 participants (160 women, 165 men, 3 unreported sex; age: $M = 31.0$, $SD = 12.5$, *Range*: 18 to 73) were recruited from a small Canadian city using posters in the general community, the local university and college, homeless shelters, local employment offices, food banks, and the John Howard Society (a non-profit organization dedicated to supporting former prisoners). Participants were recruited from these diverse sources to increase variability in age and socioeconomic status relative to typical student-only convenience samples.

Employment status was as follows: student (21.2%); employed full-time (15.7%); employed part-time (31.7%); homemaker (3.1%); retired (4.9%); unemployed (23.4%). Median reported personal income ($10 001 to $20 000) and household income ($30 001 to $40 000) was relatively low; the median personal income in Canada is $31 400, and the median family income is $76 550 (data obtained from Statistics Canada). Highest educational attainment was as follows: Completed grade eight (1.9%); some high school (13.6%); high school graduate or equivalent (14.5%); vocational or trade school (6.8%), community college (7.1%); some university (49.4%); and graduate/professional school (6.8%).

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Participants completed the measures below, along with other personality and individual differences measures (unrelated to the present study), in random order on a computer. All measures with multiple items had each item presented randomly. The software computed and outputted total scores for all measures as described below. All participants were compensated for their participation ($30), and earned additional money for decisions as described below (total compensation: $M = \$58.38$, $SD = \$21.91$). The same participants were used in Mishra and Carleton (2015) to examine different research questions on relative deprivation and health.

Delay discounting

Single-shot discounting (SSD)

At the conclusion of the data collection session, participants were presented with a choice of receiving earnings from participation ($30 plus earnings from tasks) immediately, or to receive their total earnings plus an additional $10 in two weeks (in the form of a post-dated cheque). Participants who chose the immediate option (i.e., those who discounted the future) were coded as 1 and those who delayed gratification were coded as 0 (such that higher scores indicated greater discounting). Similar single-shot measures have been associated with hyperbolic delay discounting measures, as well as various measures of real-world impulsive behavior (Reimers et al., 2009; Sparks, Isen, & Iacono, 2014; Wulfert, Block, Santa Ana, Rodriguez, & Colsman, 2002).

Behavioral discounting (BD)

Participants were presented with 27 choices between an amount of money available today and an amount of money available in the future (Kirby et al., 1999). Choices were for small, medium, and large amounts of money (nine in each category; Kirby et al., 1999). Instructions for the task indicated that participants would receive the amount of one of their 27 choices. At the end of the task, the software randomly chose one of their 27 choices, and participants were compensated in the form of a cheque (either immediately cashable, or post-dated to the relevant date in the future). The dependent measure consisted of a discounting parameter (k) computed for each of the small, medium, and large reward series, calculated as described in Kirby et al. (1999) (i.e., assigned based on participants' switch points from distal to immediate rewards). Higher discounting parameters indicated a greater preference for immediate over later rewards.

Latency-based discounting (LD)

Response time latency for each delay discounting choice was also measured. The response latency timer recorded how long it took participants to make each choice (in milliseconds, as measured from the time participants saw the choice, to the moment they clicked on their preferred choice). For each of the small, medium, and large reward sets, a k-parameter was assigned based on the choice that involved the longest response time latency. Consequently, this latency measure of delay discounting serves as an implicit or unconscious indicator of the most difficult choice that the participant faced (i.e., the choice that required the most processing time). As reported later in the manuscript, participants' most deliberative choice took significantly longer time to process compared to all other choices.

Risk-taking

Choice Task (CT)

Participants made six decisions, each between two monetary options presented on a computer screen (Mishra & Lalumière, 2010). Both options had equal expected values but differed in variance (e.g., "Would you rather choose [A] $3 guaranteed, or [B] a 30% chance of earning $10?"). At the conclusion of the experimental session, the software randomly selected one of the six choices participants made, and then simulated the outcome (i.e., if a probabilistic choice was made—e.g., a 10% chance of $30—a computer simulation determined the outcome) and the participant received the value of the choice they made in cash. A total score of number of risky choices was computed.

Balloon Analogue Risk Task (BART)

Participants saw a computer screen with a deflated balloon and a "PUMP" button. Each pump of the balloon increased participants' earnings by one cent, and increased the degree to which the balloon was inflated. The balloon was set to pop randomly, with 65 pumps required on average before popping. If the balloon popped, participants lost all money gained for that trial. Participants could end a trial at any time by clicking on a "COLLECT" button. Thirty trials were presented. Following Lejuez et al. (2002), the average number of pumps for all trials where the balloon did not pop was computed. Participants received the amount of their earnings from the BART following completion of the task.

Individual differences

Eysenck's Impulsivity Scale (EIS)

The EIS (Eysenck, Pearson, Easting, & Allsopp, 1985) consists of 19 yes/no statements about impulsive behaviors (e.g., "Do you often buy things on impulse?"). A total score was obtained by summing the number of "yes" answers.

Zuckerman's Sensation-Seeking Scale (SSS-V)

The SSS-V consists of 40 choices between paired statements regarding preferences for varied, stimulating experiences and disinhibited behavior (e.g., "A sensible person avoids activities that are dangerous" versus, "I sometimes like to do things that are a little frightening"; Zuckerman, 1994). A total score was obtained by summing the number of high sensation-seeking choices.

Retrospective Behavioral Self-Control Scale (RBS)

The RBS consists of 67 items measuring the frequency of behaviors associated with low self-control in childhood

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(e.g., "I copied homework from classmates"), adolescence ("I have been late for school or work because I stayed out too late the night before"), and adulthood (e.g., "I have been caught in a speed trap"; Marcus, 2003). Behaviors were rated on a scale from 1 (*never*) to 7 (*always*). Scores were reversed so that higher scores indicated lower self-control.

Risk attitudes

Risk attitudes were measured using the Domain-Specific Risk-Taking Scale (DOSPERT; Blais & Weber, 2006), which measures likelihood of engagement in 30 risky behaviors in six domains of life: ethics, (financial) investment, health/safety, social, gambling, and (physical) recreation. Prospective likelihood of engaging in these behaviors were rated on a scale from 1 (*extremely unlikely*) to 7 (*extremely likely*).

Gambling and antisocial behavior

Gambling

Problem and pathological gambling tendencies were assessed using the nine-item Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001), which measures frequency of nine outcomes and behaviors associated with disordered gambling (e.g., "Have you bet more than you could really afford to lose?"). Items were rated on a scale from 0 (*never*) to 3 (*almost always*). The PGSI is widely considered to be the best available non-clinical problem gambling screening instrument (reviewed in Stinchfield, Govoni, & Frisch, 2007).

General gambling tendencies were assessed using self-reports of frequency of engagement in various gambling behaviors, as well as the number of different gambling behaviors engaged in (Mishra, Lalumière, & Williams, 2010). A total score of what we call *general gambling involvement* was computed by summing the *z*-scores of the two general gambling measures.

Antisocial behavior

Antisocial behavior was assessed using the Self-Report Early Delinquency Instrument (SRED; modified from Moffitt & Silva, 1988), which measures frequency of engagement in 36 minor, moderate, and severe antisocial behaviors (e.g., "Carried a weapon"; 0 = *never*; 1 = *once*; 2 = *more than once*). The instrument was modified to assess engagement in antisocial behaviors both in the past year and over the lifetime.

Criminal outcomes

Participants self-reported if they were ever arrested, charged, convicted, or incarcerated for a crime.

RESULTS

Of the data from 328 participants, missing values were observed for age ($n = 2$), sex ($n = 3$), small *k*-parameter ($n = 24$), medium *k*-parameter ($n = 23$), large *k*-parameter ($n = 21$), single-shot discounting ($n = 26$), small *k*-latency parameter ($n = 2$), medium k-latency parameter ($n = 2$), large *k*-latency parameter ($n = 2$), BART ($n = 1$), impulsivity ($n = 1$), arrest record ($n = 4$), charge record ($n = 3$), conviction record ($n = 3$), incarceration record ($n = 3$), and the DOSPERT ($n = 1$ for all subscales and total except for health/safety). Shapiro–Wilk tests were used to examine the normality of all variables. Only sensation-seeking ($W = .995$, $p = .42$) was normally distributed (all other Ws $< .990$, ps $< .04$). Consequently, we use non-parametric statistics where possible for all analyses. The relatively large number of missing values on the behavioral and latency measures of discounting is because of the fact that some participants made inconsistent choices (i.e., they exhibited multiple inconsistent switch points between immediate and distal rewards), perhaps because of the fact that we fully randomized presentation of all 27 decision options. The relatively large number of missing values for single-shot discounting was because of responses not being appropriately recorded in some cases.

Participants exhibited significant variation in important risk-related outcomes. Based on PGSI scores, 50.0% of participants were non-problem gamblers, 27.1% were low-risk gamblers, 13.1% were moderate gamblers, and 9.8% were problem/pathological gamblers. Participants also exhibited varied antisocial and criminal histories. Twenty-nine percent of participants indicated that they had been arrested once, 27.1% were charged with a crime, 25.9% were convicted of a crime, and 17.4% had been incarcerated at least once. Descriptive statistics for all non-discounting measures are provided in Table 1.

Table 1. Descriptive statistics for non-discounting measures

Measure	*M*	*SD*
Behavioral risk-taking		
CT	2.5	1.8
BART	41.1	16.4
Individual differences		
SSS	21.0	6.8
EIS	8.3	4.9
RBS	368.4	62.2
Risk attitudes		
DOS-I	11.2	4.0
DOS-E	16.3	6.1
DOS-G	6.1	3.3
DOS-S	27.7	5.0
DOS-R	23.9	7.6
DOS-H	22.1	6.8
Gambling		
GGI	.00	1.7
PGSI	2.3	4.4
Antisocial behavior		
A-Y	4.0	3.7
A-L	22.4	14.7

Note: CT = Choice Task; BART = Balloon Analogue Risk Task; SSS = sensation-seeking; EIS = impulsivity; RBS = self-control; DOS = DOSPERT (risk attitudes); I = investment; E = ethical; G = gambling; S = social; R = recreational; H = health/safety; GGI = general gambling involvement; PGSI = problem gambling tendencies; A-Y = antisocial behavior in the last year; A-L = antisocial behavior over the lifetime.

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Discounting associations

Descriptive statistics for the behavioral and latency discounting measures are provided in Table 2. The mean latency for participants' most deliberative decision was substantially higher than the mean latency for all eight other choices, for small ($t = 23.86$, $p < .001$), medium ($t = 14.73$, $p < .001$), and large magnitudes ($t = 22.53$, $p < .001$). For the single-shot discounting (SSD) measure, 53.6% of participants chose the immediate payout, and 46.4% of participants chose the distal payout.

All three conventional *k*-parameters were highly correlated (all *rhos* > .80, *ps* < .001). To simplify subsequent analyses, all values were *z*-scored and summed to create a variable we call *behavioral discounting* (BD). Of the three latency-measured discounting (LD) parameters, the small and medium parameters were significantly associated, *rho* = .27, $p < .001$, as were the medium and large parameters, *rho* = .16, $p = .005$. The small and large parameters were not significantly associated, *rho* = .099, $p = .07$. Because of these inconsistent and relatively small associations, we examine each of the LD parameters separately in subsequent analyses. BD was significantly associated with all three LD measures (all *rhos* > .25, *ps* < .001), suggesting some shared variance. SSD was significantly associated with both BD, *rho* = .45, $p < .001$, and all three LD parameters (all *rhos* > .12, *ps* < .037), although these latter associations were much smaller.

Behavioral risk-taking

Associations between discounting measures and behavioral risk-taking are summarized in Table 3. After Bonferroni correction for 10 comparisons ($p < .005$), the only remaining significant association was a negative correlation between SSD and BART scores.

Table 2. Descriptive statistics for behavioral and latency-measured discounting (*k*-parameters, and latencies in milliseconds)

Measure	*M*	*SD*
Behavioral k-parameter		
BD-S (*k*)	.059	.076
BD-M (*k*)	.050	.077
BD-L (*k*)	.045	.076
Latency k-parameter		
LD-S (*k*)	.045	.071
LD-M (*k*)	.042	.073
LD-L (*k*)	.040	.068
Largest latency		
LL-S (ms)	8655	5902
LL-M (ms)	9388	10 046
LL-L (ms)	9506	7119
Latency of other choices		
L-S (ms)	3016	1094
L-M (ms)	3064	1191
L-L (ms)	3069	1166

Note: BD = behavioral discounting; LD = latency-measured discounting; L = latency of all choices excluding the largest latency (raw value, in milliseconds); LL = largest latency (raw value, in milliseconds); S = small; M = medium; L = large.

Table 3. Correlations between discounting and behavioral risk-taking

	CT	BART
SSD	.055 (.34)	**−.17** (.003)**
BD	.062 (.29)	−.12* (.035)
LD-S	.035 (.53)	−.061 (.27)
LD-M	−.010 (.86)	−.045 (.42)
LD-L	.039 (.49)	.062 (.27)

Note:
$^{+}p < .10$;
$^{*}p < .05$;
$^{**}p < .01$;
$^{***}p < .001$. SSD = single-shot discounting; BD = behavioral discounting; LD = latency-measured discounting; S = small; M = medium; L = large; CT = Choice Task; BART = Balloon Analogue Risk Task. Significant correlations after Bonferroni correction ($p < .005$) are bolded. All *ns* ≥ 289.

We conducted partial correlations to examine whether latency-measured discounting measures explained variance in risk-taking above and beyond conventional delay discounting measures with partial correlations controlling for the three BD measures. In this set of analyses (and in all other partial correlation analyses conducted to examine whether LD explains additional variance above and beyond BD for all risk measures), LD did not consistently account for significant additional variance in risk-related traits, attitudes, and outcomes. We thus report all of these partial correlation analyses in detail in Supporting Information (Tables S1–S5) and not in the main manuscript. We do so because in spite of not providing "positive" results, these analyses were planned *a priori* and address questions of interest as outlined in the introduction. Given that psychological science suffers from biased selective reporting of positive results (Ferguson & Brannick, 2012), we considered it important to report these findings in the context of the present investigation.

Individual differences

Associations between discounting measures and individual differences are summarized in Table 4. After Bonferroni

Table 4. Correlations between discounting and risk-related personality traits

	SSS	EIS	RBS
SSD	.090 (.12)	**.31*** (<.001)**	**.35*** (<.001)**
BD	.058 (.33)	**.24*** (<.001)**	**.23*** (<.001)**
LD-S	.065 (.24)	.13* (.016)	.092^{+} (.096)
LD-M	−.039 (.48)	.088 (.11)	.13* (.017)
LD-L	.023 (.69)	.113* (.041)	.140* (.011)

Note:
$^{+}p < .10$;
$^{*}p < .05$;
$^{**}p < .01$;
$^{***}p < .001$. SSD = single-shot discounting; BD = behavioral discounting; LD = latency-measured discounting; S = small; M = medium; L = large; SSS = sensation-seeking; EIS = impulsivity; RBS = self-control. Significant correlations after Bonferroni correction ($p < .004$) are bolded. All *ns* ≥ 290.

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Table 5. Correlations between discounting and risk attitudes in six content domains

	DOS-I	DOS-E	DOS-G	DOS-S	DOS-R	DOS-H
SSD	**−.20** (.001)**	.15* (.012)	**.21*** (<.001)**	−.045 (.44)	−.13* (.03)	**.28*** (<.001)**
BD	**−.20** (.001)**	.11^{+} (.074)	**.22*** (<.001)**	−.16** (.006)	−.11^{+} (.051)	**.19** (.001)**
LD-S	−.15** (.007)	.089 (.11)	.065 (.24)	−.033 (.55)	−.056 (.32)	.012 (.82)
LD-M	−.065 (.24)	.005 (.92)	.046 (.40)	−.099^{+} (.074)	−.16** (.004)	.034 (.54)
LD-L	−.13* (.02)	.076 (.17)	.092^{+} (.097)	−.009 (.88)	−.073 (.19)	.11*(.04)

Note:
$^{+}p < .10$;
$^{*}p < .05$;
$^{**}p < .01$;
$^{***}p < .001$. SSD = single-shot discounting; BD = behavioral discounting; LD = latency-measured discounting; S = small; M = medium; L = large; DOS = DOSPERT (risk attitudes); I = investment; E = ethical; G = gambling; S = social; R = recreational; H = health/safety. Significant correlations after Bonferroni correction ($p < .0017$) are bolded. All $ns \geq 290$.

correction for 15 comparisons ($p < .004$), the associations between SSD, BD, impulsivity, and low self-control remained significant. Partial correlations between latency-measured discounting and personality controlling for BD revealed no significant associations (Table S2, Supporting Information).

Risk attitudes

Associations between discounting and risk attitudes are summarized in Table 5. After Bonferroni correction for 30 comparisons ($p < .0017$), the associations between SSD and greater risk attitudes in the gambling and health/safety domains remained significant, as well as the association between SSD and lower risk attitudes in the investment domain. The same pattern of results was observed for associations between BD and risk attitudes. None of the associations with latency-based discounting remained significant. None of the partial correlations between latency-measured discounting and risk attitudes remained significant after controlling for behavioral discounting (Table S3).

Gambling and problem gambling

Associations between discounting measures and general gambling involvement and problem gambling tendencies are summarized in Table 6. After Bonferroni correction for ten comparisons ($p < .005$), both associations between problem and pathological gambling and single-shot and behavioral discounting remained significant, as well as the associations between single-shot discounting and general gambling involvement, and between medium LD and general gambling involvement. These results indicate that behavioral delay discounting is robustly associated with greater gambling behaviors and tendencies. Partial correlations between latency-measured discounting and gambling controlling for BD revealed no significant associations with general gambling involvement or problem gambling tendencies after correction (Table S4).

Antisocial behavior

Associations between discounting measures and antisocial behavior are summarized in Table 7. After Bonferroni correction for 10 comparisons ($p = .005$), the associations between single-shot discounting and both measures of antisocial behavior remained significant.

Criminal outcomes

Participants who had reported that they had been arrested ($\chi^2 = 31.54$, $p < .001$), charged ($\chi^2 = 32.65$, $p < .001$), convicted ($\chi^2 = 28.28$, $p < .001$), or incarcerated ($\chi^2 = 30.48$, $p < .001$) for a crime were significantly more likely to have chosen the immediate payout in the single-shot discounting task (Figure 1). Mann–Whitney tests demonstrated that those who were arrested ($z = 3.70$, $p < .001$), charged ($z = 3.92$,

Table 6. Correlations between discounting, general gambling involvement, and problem gambling tendencies

	GGI	PGSI
SSD	**.21*** (<.001)**	**.34*** (<.001)**
BD	.13* (.022)	**.25*** (<.001)**
LD-S	.037 (.50)	.082 (.14)
LD-M	**.17** (.003)**	.07 (.20)
LD-L	.13* (.023)	.12* (.025)

Note:
$^{+}p < .10$;
$^{*}p < .05$;
$^{**}p < .01$;
$^{***}p < .001$. SSD = single-shot discounting; BD = behavioral discounting; LD = latency-measured discounting; S = small; M = medium; L = large; GGI = general gambling involvement; PGSI = problem gambling tendencies. Significant correlations after Bonferroni correction ($p < .005$) are bolded. All $ns \geq 290$.

Table 7. Correlations between discounting and antisocial outcomes

	A-Y	A-L
SSD	**.18** (.001)**	**.22*** (<.001)**
BD	.09 (.11)	.16** (.008)
LD-S	.038 (.49)	.071 (.20)
LD-M	−.018 (.74)	.041 (.46)
LD-L	−.028 (.61)	.12* (.029)

Note:
$^{+}p < .10$;
$^{*}p < .05$;
$^{**}p < .01$;
$^{***}p < .001$. SSD = single-shot discounting; BD = behavioral discounting; LD = latency-measured discounting; S = small; M = medium; L = large; A-Y = antisocial behavior in the last year; A-L = antisocial behavior over the lifetime. Significant correlations after Bonferroni correction ($p < .005$) are bolded. All $ns \geq 290$.

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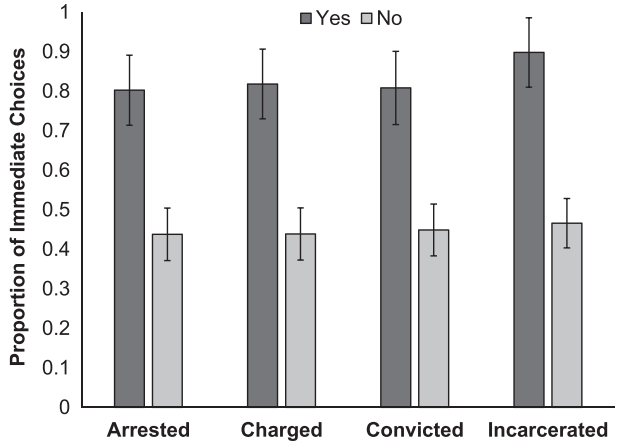

Figure 1. Proportion of immediate choices made in a single-shot delay discounting task as a function of criminal outcomes

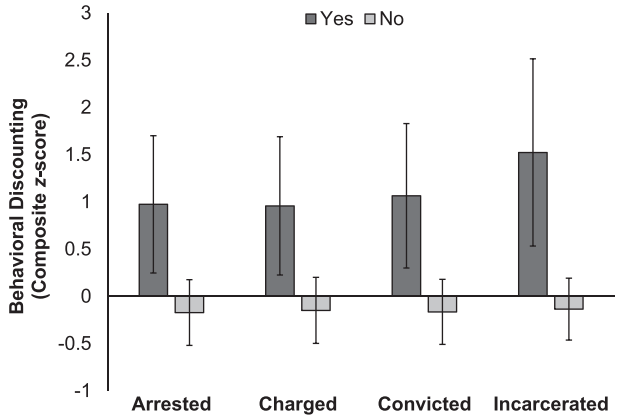

Figure 2. Behavioral discounting as a function of criminal outcomes

$p < .001$), convicted ($z = 4.03$, $p < .001$), or incarcerated ($z = 4.31$, $p < .001$) for a crime also showed significantly higher behavioral discounting rates (Figure 2).

DISCUSSION

In a large community sample diverse in age and socioeconomic status, we examined whether delay discounting was associated was risk-related behaviors, personality traits, attitudes, antisocial tendencies, and criminal outcomes. We quantified delay discounting in three ways: using a single-shot measure, through elicitation of a behavioral discounting parameter, and through measurement of a discounting parameter constructed from response time latencies. Across all analyses, single-shot discounting and behavioral discounting were consistently associated with behaviors, attitudes, traits, and outcomes involving poor impulse control. There was little consistent evidence for associations between discounting and behavioral risk-taking on laboratory tasks, or for a link between discounting and trait sensation-seeking. Furthermore, latency-measured discounting was not robustly or consistently associated with any risk-related measures. Together, our results provide further support for the "generality of deviance" inclusive of behavioral discounting and risk-related traits, attitudes, and behavioral outcomes that reflect impulsivity.

Behavioral risk-taking

Discounting was not associated with behavioral risk-taking measured through canonical variance preference. However, there were unexpected negative associations between discounting and risk-taking in the Balloon Analogue Risk Task (BART), although these results did not remain significant after correction. The negative association between delay discounting and BART scores replicates results from previous research (Mishra & Lalumière, 2011). One explanation for this finding is that people who value immediate rewards also value certainty in probabilistic rewards (e.g., Green & Myerson, 2004). That is, people who are high in intolerance of uncertainty may prefer immediate rewards and more certain or immediate probabilistic outcomes (e.g., Carleton et al., 2016). In the BART, collecting money before the balloon pops can be seen as an immediate, smaller, certain reward as opposed to a delayed, potentially larger, but uncertain reward. More generally, future rewards may be seen as higher in outcome variance (and thus "riskier") because of their inherent uncertainty. In support of this hypothesis, Hardisty and Pfeffer (in press) showed that people prefer immediate rewards when the future is uncertain, and prefer distal rewards when the present is uncertain. Further research is necessary to explore links between uncertainty, outcome variance, and intertemporal choice.

Personality traits associated with risk

Some research has associated delay discounting with personality traits associated with risk, especially those that involve impulse control (e.g., Copping et al., 2014; Ostaszewski, 1996). However, these results have been mixed, with some studies suggesting null relationships (e.g., Mishra & Lalumière, 2011; Reynolds et al., 2006). One possible reason for these mixed results is that many studies have involved small student samples (thus offering lower statistical power and lower variability in measures of interest). In our diverse community sample, we found consistent and robust associations between behavioral delay discounting and traits involving poor impulse control (high impulsivity and low self-control). These findings suggest that delay discounting is associated with stable individual differences in impulse control when measured in an appropriate sample that is well-powered.

Risk attitudes

Risk attitudes are people's evaluations of the favorability of various risky behaviors. We measured risk attitudes in six content domains: social, investment, recreation, gambling, health/safety, and ethics. We found that behavioral delay discounting was associated with risk-prone attitudes in the gambling and health/safety domains, and with risk-averse attitudes in the investment domain. The positive association between discounting and gambling attitudes is not surprising given the large body of evidence linking discounting and

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gambling-related behaviors and outcomes (reviewed in Reynolds et al., 2006). The health/safety related items in the DOSPERT scale largely involve impulsive and shortsighted behaviors (e.g., "Drinking heavily at a social function"; "Riding a motorcycle without a helmet"; "Engaging in unprotected sex"). Thus, the association between present-orientation and greater risk attitudes in this domain is consistent with the broader literature linking discounting and poor impulse control.

The negative associations between discounting and investment-related risk attitudes are somewhat puzzling at first glance. However, items in this domain involve behaviors with significant planning components (and thus, should not be associated with a behavioral measure of poor impulse control). For example, one item evaluates attitudes regarding "Investing 10% of your annual income in a moderate growth mutual fund". Investing necessarily involves risk, but this risk-taking is typically calculated and deliberate, with the expectation of long-term payoffs. It is thus not surprising that delay discounting is negatively associated with such future-oriented risk attitudes. Consequently, our findings regarding delay discounting and risk attitudes are consistent with an account of discounting as a behavioral manifestation of impulsivity. The three strongest associations between discounting and risk attitudes that withstood corrections for multiple comparisons (investment, health/safety, and gambling attitudes) are some of clearest indicators of impulse control in the risk attitudes measure.

Gambling

Our results demonstrating robust and positive associations between delay discounting, gambling behavior, and problem gambling tendencies are consistent with previous findings. A large body of literature indicates that both behavioral and trait measures of impulse control are consistently associated with both general gambling involvement and problem gambling (e.g., Mishra, Lalumière and Williams, in press; Mishra, Lalumière, Morgan, & Williams, 2011; reviewed in Reynolds et al., 2006; Toneatto & Nguyen, 2007).

Antisocial behavior and criminal outcomes

Some evidence suggests that behavioral delay discounting is associated with antisocial and criminal outcomes (Petry, 2002; Ramos et al., 2013; Sargeant et al., 2012, but see Wilson & Daly, 2006). Consistent with some past research, we observed a small relationship between behavioral delay discounting and antisocial behavior in the last year. However, we observed robust and strong relationships between delay discounting and self-reported criminal outcomes (having ever been arrested, charged, convicted, or incarcerated for a crime). To our knowledge, these are the first findings to link categorical criminal outcomes to discounting tendencies.

Latency-measured delay discounting

Latency-measured discounting was consistently associated with behavioral discounting, suggesting some shared variance, but these associations were small. Latency-measured discounting also showed inconsistent and largely non-significant relationships with our risk-related measures. Furthermore, latency-measured discounting did not consistently account for additional variance in our risk-related outcome measures above and beyond behavioral discounting (as reported in detail in Supporting Information). Together, these findings suggest that latency-measured discounting is not a particularly robust measure.

Why was latency-measured discounting not particularly effective in accounting for variance in risk-related measures? Latency-measured discounting may capture a behavioral aspect of time orientation that is largely independent from behavioral delay discounting. Another possibility is that latency-measured discounting is simply a noisy, low validity measure. Correlations among the three latency-measured discounting parameters were small and often non-significant, whereas correlations among the three behavioral discounting parameters were high. However, we do note that the standard deviations of latency-measured discounting parameters were very similar to those of the behavioral discounting parameters. Furthermore, because the largest latency among a series of choices was used to compute *k*-parameters, there is a clear control for individual differences in baseline decision processing time. Regardless, the evidence from our study suggests that quantifying latency-measured discounting is not a particularly valid implicit measure of intertemporal choice.

Strengths and limitations

Many previous studies of delay discounting and risk-related outcomes have involved student samples, many of which offered low statistical power. Schönbrodt and Perugini (2013) demonstrated that for correlations typical to individual differences research, a sample size of 250 or greater is required to obtain a stable correlation estimate. Very few extant studies of discounting involve samples of this size. Consequently, a key strength of the present study is its use of a large sample size of community members recruited to enhance variance in age and socioeconomic status. We also paid participants generously for their involvement in this study, and all behavioral measures involved a payout directly related to the decisions participants made. As reviewed in the introduction, previous research has shown that payment structures have important influence on participants' actual behaviors in decision-making tasks (e.g., Ferrey & Mishra, 2014; Johnson & Bickel, 2002).

Many of our results were (unexpectedly) non-significant (e.g., associations between discounting and behavioral risk-taking), and some associations that were significant were not of particularly large magnitude. We report all of our findings related to questions of interest in this manuscript, including non-significant null results, because we did not want to fall prey to the common problem of selective reporting of only positive results in psychological science (Ferguson & Brannick, 2012). The relatively low effect sizes in our study suggest that the link between discounting and some risk-related behaviors simply is not all that strong (although they remain meaningful, and are still consistent with

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a generality of deviance account). Because of the characteristics of our sample (diversity, heterogeneity, incentive structure, and size), we have fairly high confidence in our effect size estimates (and consequently, confidence in the reliability and likely replicability of our results). It is important to note, however, that myriad other factors may have influenced our observed results (e.g., time of day, mood). Further research involving diverse and large samples (with resultant meta-analyses inclusive of "file-drawered" studies) is necessary to derive truly accurate effect size estimates.

Another key strength of this study is its measurement of diverse risk-related behaviors, attitudes, personality traits, and outcomes. Previous studies have often only included self-report measures or quasi-experimental categories (e.g., drug addicts vs. healthy controls). We measured subjective perceptions (risk attitudes), self-reported individual differences (personality), retrospective reports of behavior (antisocial conduct) and actual behavior (laboratory-based risk-taking). We also assessed discrete, non-subjective outcomes (criminal outcomes). Consequently, our study does not suffer from the problem of shared method variance across discounting and risk measures.

Many different measures of delay discounting have been used in past research, and these various measures have been conceptualized in very different ways. Some consider monetary delay discounting measures to be a behavioral measure of impulsivity, whereas others argue that such measures can be more parsimoniously considered assess time orientation and sensitivity to time horizons. Copping et al. (2014) provide evidence suggesting that constructs that should highly overlap—namely, delay discounting, impulsivity, and future orientation—instead may represent discrete behavioral constructs. The delay discounting literature is populated with such diverse and inconsistent associations and interpretations (e.g., Mishra & Lalumière, 2011; Odum, 2011; Reynolds et al., 2006; Wilson & Daly, 2006; reviewed in Copping et al., 2014; Madden & Johnson, 2010; Odum, 2011). Further research is required to examine whether various measures, constructs, and conceptualizations of discounting are similarly associated with risk-related variables.

Our study (and many others) provide evidence for the "generality of deviance". This framework, however, has a key limitation in that it suggests that various forms of risky behavior are part of a domain-general "taste for risk". Growing evidence suggests that if non-antisocial forms of risk-taking are considered, patterns of risk-taking are demonstrably domain-specific. That is, some individuals tend to engage in high levels of risk-acceptance in some domains (e.g., criminal behavior), but not in others (e.g., financial speculation). In a recent review, Mishra, Barclay, and Sparks (in press) provide evidence suggesting that the "generality of deviance" appears to be inclusive only of antisocial forms of risk-taking, and not asocial or prosocial forms of risk-taking. The evidence from the present study suggests that various forms of risk-acceptance that involve poor impulse control tend to co-occur (and that antisocial forms of risk-taking reflect this lack of impulse control). Other forms of risk-taking, however, contain a significant planning component (e.g., investment risk-taking requires knowledge of markets; recreational risk-taking requires an existing physical skillset and substantial training) that is clearly not impulsive. Further research is necessary to disentangle the etiology of the domain-specificity of risk, and to specifically examine whether impulse control is a key factor that discriminates risk-propensity in different domains. Regardless, the results of this and other studies suggest that various forms of impulsive risk-taking, inclusive of delay discounting, share common variance.

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