

BRIEF REPORT

A Comparison of Delay Discounting Among Substance Users With and Without Suicide Attempt History

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Although substance use disorders are associated with overall increased suicide risk, there is considerable variability in suicide risk among substance-dependent individuals (SDIs). Impairment in impulse control is common among SDIs, and it may contribute to vulnerability to suicidal behavior. The present study examined the relation between one specific aspect of impulsivity—delay discounting—and suicide attempt history in a sample of SDIs. An interaction was observed between suicide attempt history and discounting rates across delayed reward size. Specifically, SDIs with no history of attempted suicide, devalued small relative to large delayed rewards. In contrast, SDIs with a history of suicide attempts appeared comparatively indifferent to delayed reward size, discounting both small and large delayed rewards at essentially identical rates. These findings provide evidence that, despite the view that SDIs are characterized by marked difficulties in impulsivity, significant variability exists within this group in delay-discounting tendencies. Furthermore, these differences provide preliminary evidence that specific aspects of impulsivity may help to identify those most at risk for suicidal behavior in this population. The potential implications of our findings for suicide prevention efforts are discussed.

Keywords: delay discounting, impulsivity, substance use disorders, suicide

Substance use disorders (SUDs) are associated with increased risk of suicide (Nock et al., 2008). Moreover, among individuals experiencing suicidal ideation in one cross-national study, the risk for subsequent suicide attempts was highest for those with SUDs (Nock et al., 2008). The majority of substance-dependent individuals (SDIs), however, never attempt suicide, raising the critical question whether more specific predictors of risk for suicidal behavior can be identified within this population.

The construct of impulsivity (Goldstein & Volkow, 2002; Verdejo-García, A., & Pérez-García, 2007) has been broadly defined as an individual's "predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions to the impulsive individual or others" (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001, p. 1784). Impulsivity is considered a critical component of models of addiction and is commonly associated with suicide attempts (Dougherty et al., 2004) and completion (Dervic, Brent,

& Oquendo, 2008; Maser et al., 2002). Despite its intuitive appeal, investigations have not consistently documented an association between impulsivity and suicidal behavior among SDIs.

Recent models have conceptualized impulsivity as a multidimensional rather than a unidimensional construct, encompassing subtypes with distinct cognitive, behavioral, and underlying neural correlates (Barratt & Slaughter, 1998; Dougherty et al., 2003; Klonsky & May, 2010; Nigg, 2000). Few studies have applied this more complex model to investigate suicidal behavior among SDIs, but available data suggest its application has potential utility. Supporting evidence is provided by a recent finding (Klonsky & May, 2010) that a broad and unidimensional operational definition of impulsivity did not distinguish suicide attempters from ideators. In contrast, a multidimensional assessment of impulsivity revealed a selective relation between specific aspects of impulsivity (i.e., poor planning) and suicidal behavior.

Delay discounting (DD, or "impulsive choice") is the tendency to undervalue an anticipated future reward as the time delay prior to obtaining the reward increases (Bickel et al., 2010; Dougherty et al., 2003; Green & Myerson, 2004). In general, people tend to prefer small immediate rewards over larger delayed rewards (Green, Myerson, & McFadden, 1997), and the rate that delayed rewards are discounted provides a behavioral index of impulsivity (Madden & Bickel, 2010). Additionally, the size of the delayed reward has been consistently found to influence temporal discounting behavior. Specifically, people tend to discount smaller delayed rewards at a higher rate than larger ones, a tendency that has been referred to as the magnitude effect (Green, Fry, & Myerson, 1994; Green & Myerson, 2004; Johnson & Bickel, 2002; Stranger et al., 2011).

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Higher discount rates have consistently been found among SDIs, including individuals dependent on alcohol (Bickel & Marsch, 2001; Petry, 2001), cocaine (Coffey, Gudleski, Saladin, & Brady, 2003), opioids (Bickel & Marsch, 2001; Kirby, Petry, & Bickel, 1999), and methamphetamine (Monterosso et al., 2007). DD has been relatively understudied in relation to suicide risk among SDIs despite its potential conceptual relevance. Although models of suicidal behavior typically focus on relief or escape from distress rather than appetitive rewards, they resemble DD by emphasizing the overwhelming importance of *immediate* outcome, which takes precedence over any future event (Dombrovski et al., 2011; van Heeringen, Bijttebier, & Godfrin, 2011).

Additionally, two cognitive components of DD—anticipatory time perception and sensitivity to reward—may be especially relevant to suicidal behavior among SDIs. Past studies have linked suicidality with impairments in future-directed thinking and time perception (Krynska, Heller, & De Leo, 2006) and with oversensitivity to immediate reward (van Heeringen et al., 2011), which are also prominent characteristics among SDIs (Dawe & Loxton, 2004; Hogarth, 2011; Wittmann, Leland, Churan, & Paulus, 2007). Indirect support is also provided by functional magnetic resonance imaging studies of suicidal behavior, which have consistently noted abnormal activation in dorsolateral and orbitofrontal cortices, brain regions linked with temporal horizon and reward processing (van Heeringen et al., 2011).

These findings provide converging evidence that a link between DD and suicidal behavior could shed light on neurobiological mechanisms and more specific risk factors for suicide as well as inform the study of suicidality within this particularly high-risk population.

In the current study, we administered a measure of DD to a large sample of SDIs with and without a history of suicide attempts. We hypothesized that (a) SDIs with a history of attempted suicide would discount delayed rewards at a significantly greater rate than would those with no history of suicide attempts, and that (b) SDIs with no suicide attempt history would be less likely to discount large delayed rewards relative to small ones, whereas SDIs with a history of attempted suicide would be relatively unmoved by differences in delayed reward magnitude, given the importance of immediacy over any future event.

Methods

Participants

Participants in the current study included 466 individuals with diagnosed SUDs (primarily cocaine or opioid dependence), as defined by the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)* (American Psychiatric Association, 2000), enrolled in a larger study of neurocognitive effects of HIV and substance dependence. Participants were recruited from Jesse Brown VA Medical Center substance dependence programs, community clinics, and word of mouth. The inclusion criteria were: (a) absence of acute mania or major depression, (b) no documented history of neurologic AIDS-defining or other of neurologic illness or injury, including cerebrovascular accident, open head injury, closed head injury with loss of consciousness exceeding 30 min, neurosyphilis, or seizure disorder, (c) no history of schizophrenia or current neuroleptic treatment, and (e) negative

breathalyzer test using an Intoxilyzer S-D2 (CMI Inc.) and rapid urine toxicology screening for opiates and cocaine using Visualine V (Sun Biomedical Laboratories) at the time of study visit. The study was approved by the institutional review boards for the University of Illinois at Chicago and the Jesse Brown VA Medical Center. All subjects provided informed consent and were compensated for their time.

Measures

Lifetime history of substance use disorders, and unipolar and bipolar mood disorders. All subjects were administered the Structured Clinical Interview for *DSM-IV* (SCID) Substance Use Module and Mood Disorders Module (First, Spitzer, Gibbon, & Williams, 1995) in order to determine lifetime history of SUDs, major depressive disorder, and bipolar disorder.

HIV and hepatitis C serostatus. HIV and hepatitis C serostatus were verified by enzyme-linked immunosorbent assay at the time of study participation.

Suicide attempt history. History of suicide attempts was indexed from the Addiction Severity Index (ASI; McLellan et al., 1985), a semistructured interview that assesses severity of alcohol and drug use, indices of employment, social and psychiatric status, and includes a question that asks whether the participant has attempted suicide at least once at any point in his or her life.

Delayed reward discounting task. All participants completed the Monetary Choice Questionnaire (MCQ; Kirby et al., 1999), a paper-and-pencil measure commonly used to index DD in SDIs. The measure consists of 27 two-choice items that pair a small immediate reward and a larger delayed reward (e.g., Would you prefer to have \$5 now or \$10 one week from now?), and subjects were instructed to select the more desirable reward. Subjects were instructed to respond in the same manner as they would with real money. To increase motivation, we informed participants that they had a one-in-six chance of obtaining an actual monetary reward, a commonly used procedure when administering the MCQ (for details, see Kirby et al., 1999). After completing the questionnaire, participants rolled a die to determine if they would win a \$10 reward. A preference for smaller immediate rewards over larger later ones is taken as being reflective of greater impulsivity (Ainslie, 1975).

Procedures

Prospective participants were administered an initial in-clinic or phone screen of medical and substance abuse history to determine their eligibility for study participation. Participants were instructed to abstain from all drug use for at least one week prior to their participation. To verify abstinence at each of their two study visits, participants completed a breathalyzer test and rapid urine toxicology screen for opiates and cocaine. If a participant tested positive, the visit was terminated without payment and the testing was rescheduled. The SCID and ASI were administered during the initial visit, whereas the DD task was completed during the second visit. The interval between first and second visits ranged from 5–21 days.

Data Analysis

For the DD task, each participant's discount-rate parameter, k , was determined using Mazur's (1987) hyperbolic discount func-

tion (i.e., $V = A/[1 + kD]$, where V is a future reward's discounted value, A is its immediate value, and D is the delay interval) based on their choices across the 27 MCQ items and in a manner consistent with previous research (e.g., Businelle, McVay, Kendzor, & Copeland, 2010; Lempert & Pizzagalli, 2010). Larger k values are indicative of a higher discounting rate (i.e., greater impulsivity as defined by a preference for a small immediate reward over a larger delayed reward). Because previous research has demonstrated an inverse relation between discount rates and magnitude of delayed reward (Kirby, 1997), we estimated discount rates separately for small (\$25–35) and large (\$75–85) delayed rewards as well as an overall discount rate across all delayed reward magnitudes. To satisfy assumptions of normality, and in a manner consistent with past research (e.g., Businelle et al., 2010; Lempert & Pizzagalli, 2010), we analyzed the log-transformed k values in analyses of covariance (ANCOVAs) with suicide attempt history as the between-subjects variable and delayed reward size as the within-subjects variable. Given previous research associating DD performance with sex (Kirby & Maraković, 1996), HIV risk (Chesson et al., 2006; Odum, Madden, Badger, & Bickel, 2000), hepatitis C–seropositive status (Huckans et al., 2011), anhedonia (Lempert & Pizzagalli, 2010), and bipolar disorder (Strakowski et al., 2009; Swann, Lijffijt, Lane, Steinberg, & Moeller, 2009), we covaried sex, HIV serostatus, hepatitis C serostatus, and lifetime history of major depression and bipolar disorder.

Results

Participants' Characteristics

The study sample was 30.3% women, 82.8% African American, 12.7% White, and 3.4% Hispanic, with a mean age of 42.2 years ($SD = 8.2$) and mean years of education of 11.6 years ($SD = 1.8$).

A total of 88 (18.9%) of participants endorsed a history of attempted suicide.

Table 1 shows demographic, HIV and hepatitis C serostatus, substance use, and mood disorder characteristics, as well as overall discounting rates for participants with and without a history of suicide attempts. We compared the groups on these characteristics using independent sample t tests for parametric data and chi-square tests for categorical data. Participants with a history of attempted suicide were more likely to be female, $\chi^2 = 8.587, p < .01$, and to have a positive history of major depression, $\chi^2 = 12.873, p < .001$, or bipolar disorder, $\chi^2 = 16.108, p < .001$. We also found that history of suicide attempts was more strongly associated with positive HIV serostatus, $\chi^2 = 14.384, p < .001$. No group differences were observed in age, education, ethnicity, hepatitis C serostatus, or prevalence of lifetime alcohol, cocaine, or opioid dependence.

Delay Discounting

Table 1 shows the log-transformed k values for each group. We first examined whether SDIs with and without a history of attempted suicide differed on overall DD rates in a univariate ANCOVA, controlling for sex, HIV and hepatitis C serostatus, and lifetime major depression and bipolar disorder. No main effect was observed for suicide attempt history. $F(1, 436) = 2.530, p = .11$, with only hepatitis C serostatus yielding a significant main effect among the covariates. $F(1, 436) = 5.200, p = .023$.

Next we conducted a 2×2 (suicide attempt history vs. no attempt history \times small vs. large delayed reward) mixed-design ANCOVA with suicide attempt history as the between factor and reward size as the within factor, controlling for sex, HIV and hepatitis C serostatus, and lifetime major depression and bipolar disorder (see Figure 1). We found a significant interaction between

Table 1
Demographic, Descriptive Characteristics of the Sample, and Log-Transformed k by Group

Variable	Negative suicide attempt history ^a ($n = 378$)	Positive suicide attempt history ^a ($n = 88$)	Statistic	p
Sex (female)	27.25	43.18	$\chi^2 = 8.587$	.003
Race/ethnicity				
White	12.70	12.50	$\chi^2 = 0.003$	.960
African American	82.80	81.81	$\chi^2 = 0.048$	.826
Hispanic	3.44	3.41	$\chi^2 < 0.001$	.989
Other	0.79	2.27	$\chi^2 = 1.471$	.225
Age (years)	42.19 (8.24)	42.16 (8.08)	$t = -0.027$	.979
Education (years)	11.62 (1.80)	11.72 (2.04)	$t = 0.387$	.699
HIV seropositive	26.98	47.73	$\chi^2 = 14.38$	<.001
Hepatitis C–seropositive	17.46	22.99	$\chi^2 = 1.434$	.231
Substance dependence				
Alcohol	74.54	76.14	$\chi^2 = 0.097$	.755
Cocaine	80.00	84.09	$\chi^2 = 0.768$	.381
Opioid	50.53	42.05	$\chi^2 = 2.05$	.152
Mood disorders				
Bipolar disorder	2.65	12.50	$\chi^2 = 16.11$	<.001
Major depression	15.34	31.81	$\chi^2 = 12.87$	<.001
DD log-transformed k				
Small reward	−1.395 (0.035)	−1.362 (0.077)		
Large reward	−1.630 (0.041)	−1.406 (0.090)		

Note. DD = delay discounting.

^a Values are percent or M (SD).

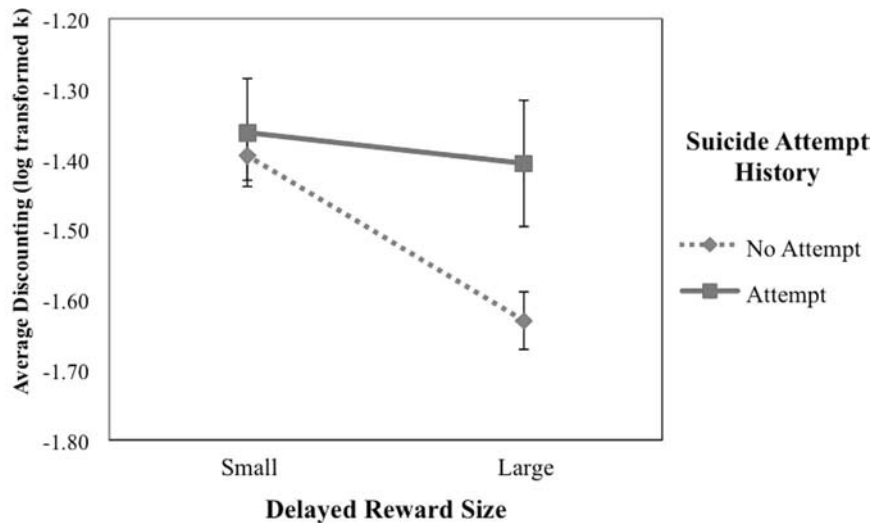


Figure 1. Lifetime history of attempted suicide moderates the relation between delayed reward size and discounting rates.

history of attempted suicide and delayed reward size, $F(1, 441) = 5.674, p = .018$. Follow-up pairwise comparisons with Bonferroni corrections revealed that SDIs with no suicide attempt history discounted small delayed rewards more than large ones, $F(1, 441) = 50.257, p < .001$, whereas those with a history of attempted suicide showed no difference in discounting rates for small compared with large delayed rewards, $F(1, 441) = .358, p = .550$. Additionally, SDIs with and without a history of attempted suicide did not differ in discounting rates for small delayed rewards, $F(1, 441) = .147, p = .702$, but those with a history of attempted suicide showed a significantly higher discounting rate for large delayed rewards than did those with no suicide attempt history, $F(1, 441) = 5.043, p = .025$.

Discussion

The aim of the current study was to investigate DD in a large sample of SDIs with and without a history of attempted suicide. We provided a particularly conservative test of this association, controlling for the potential effects of sex, HIV and hepatitis C serostatus, as well as lifetime history of major depression and bipolar disorder on DD rates. Overall DD rates did not differ between the two groups. Instead, we found a significant interaction between suicide attempt history and size of the delayed reward. SDIs who previously attempted suicide appeared relatively indifferent to the magnitude of the delayed reward, exhibiting virtually identical discounting rates for both small and large delayed rewards. In contrast, SDIs without a history of attempted suicide displayed the more typical response pattern observed in studies of DD, reflecting a tendency to discount small delayed rewards more than large ones. Additionally, the two groups did not differ in discounting rate for small rewards, but SDIs with a history of suicide attempts discounted large delayed rewards at a higher rate than those with no history of suicide attempts.

These findings also lend weight to the view that, although deficits in impulse control are common among SDIs, there is nevertheless substantial variability in impulsivity within this pop-

ulation (Vassileva, Gonzalez, Bechara, & Martin, 2007). In the current study, individual differences in DD appear to differentiate significantly between SDIs with and without a history of attempted suicide. Our conclusions are necessarily limited by the cross-sectional nature of the study, and although the current findings are consistent with the possibility that suicidal behavior in SDIs reflects impaired sensitivity to significant future rewards, no causal inferences can be made. Therefore, future research is required to replicate and to build on current findings by assessing the potential predictive validity of DD performance for future suicide attempts in SDIs. Additionally, and given increasing recognition of the complex relation between impulsivity and suicidal behavior (Klonsky & May, 2010), future studies should include measures of other types of impulsivity in the assessment of suicidality so to ascertain which specific components of this multidimensional construct relate to suicidal behaviors in SDIs.

The current study compared discounting rates at fixed low and high delayed reward size. Future studies using a continuous measure of DD (e.g., response-based computerized programs; see Christakou, Brammer, & Rubia, 2011), especially with larger delayed rewards, will be important to determine whether SDI suicide attempters are responsive to larger delayed rewards or are truly insensitive to delayed reward magnitude. This is a particularly important consideration, given the preliminary nature of the present findings, which contrast with the robust finding of a magnitude effect in the general delay discounting literature.

It should also be noted that suicide attempt history was indexed by a dichotomous response to an item from the ASI, which did not permit more specific characterization of previous suicide attempts (e.g., distinguishing between planned and nonplanned attempts). Inasmuch as impulsivity is more strongly characteristic of nonplanned suicide attempts (Conner, 2004), DD rates might at least in part contribute to this distinction. In this regard, a recent study of elderly non-SDIs who had attempted suicide found that those individuals reporting high lethality and better planned suicide

attempts were less likely to discount large delayed rewards than were low-lethality counterparts (Dombrovski et al., 2011).

Conclusion

Given the preliminary nature of our findings, further research is required and important insofar as it may eventually inform suicide prevention strategies (Brent, 1987; Conner, 2004). It is worth noting, however, that Bickel, Yi, Landes, Hill, and Baxter (2011) recently reported that substance-dependent individuals who received computerized working memory training also showed improvement in delay discounting compared with a control group. The finding that delay discounting can be directly or indirectly modified suggests that cognitive interventions could potentially be associated with more effective suicide prevention.

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