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Are self-injurers impulsive?: Results from two behavioral laboratory studies

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Abstract

Common clinical wisdom suggests that people who engage in self-injury are impulsive. However, virtually all prior work in this area has relied on individuals' self-report of impulsiveness, despite evidence that people are limited in their ability to accurately report on cognitive processes that occur outside awareness. To address this knowledge gap, we used performance-based measures of several dimensions of impulsiveness to assess whether people engaging in non-suicidal self-injury (NSSI) demonstrate greater impulsiveness than non-injurers. In Study 1, we compared adolescent self-injurers ($n=64$) to age, sex, and race/ethnicity matched, non-injurious controls ($n=30$) on self-report impulsiveness (Schedule for Affective Disorders and Schizophrenia for School Age Children, Present and Lifetime Version, Kaufman et al., 1997), and on performance-based measures of two dimensions of impulsiveness: behavioral disinhibition (Conners' Continuous Performance Test, Conners, 1995) and risky decision-making (Iowa Gambling Task, Bechara et al., 1994). In Study 2, we compared adult female self-injurers ($n=20$) to age and race/ethnicity matched, non-injurious controls ($n=20$) on self-report impulsiveness (Barratt Impulsiveness Scale-11, Patton et al., 1995), and performance-based measures of behavioral disinhibition, risky decision-making, and two measures of delay discounting (Kirby et al., 1999; Richards et al., 1999). In both studies, self-injurers reported greater impulsiveness; however, performance-based measures of impulsiveness failed to detect any between-group differences. We propose several potential explanations for the discrepancies observed between self-report and performance-based measures of impulsiveness and discuss directions for future research on impulsiveness and self-injury.

Keywords

self-injury; self-harm; suicide; impulsiveness; impulsivity

1. Introduction

Non-suicidal self-injury (NSSI), which refers to the direct and deliberate destruction of one's own body tissue without intent to die, is a prevalent, pervasive, and dangerous public health problem (Briere and Gil, 1998; Klonsky et al., 2003). NSSI is estimated to occur in 4% of the adult population and in 21% of adult psychiatric patients (Briere and Gil, 1998; Klonsky et al.,

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2003). Adolescence and young adulthood is a time of heightened risk for NSSI, with 17% of college students (Whitlock et al., 2006) and 14-21% of adolescents in community samples reporting such behavior (Ross and Heath, 2002; Zoroglu et al., 2003). Moreover, approximately 50-75% of those with a history of NSSI make a suicide attempt at some point (Joiner, 2006; Nock et al., 2006), further highlighting the dangerousness of this behavior problem.

Clinical experience and some prior research suggest that impulsiveness is an important correlate of NSSI (Herpertz et al., 1997; Herpertz et al., 1995; Simeon et al., 1992). Self-reported impulsiveness is correlated with the severity and frequency of NSSI (Simeon et al., 1992) and with the absence of forethought before engaging in NSSI (Herpertz et al., 1995). Moreover, the strong link between NSSI and suicide attempts (Joiner, 2006; Nock et al., 2006) combined with research on the role of impulsiveness in suicide attempts (e.g., Dougherty et al., 2004; Jollant et al., 2005) suggest that measures of impulsiveness may provide insight into NSSI. Moreover, knowledge that impulsiveness is linked with NSSI suggests that those developing behavioral and pharmacological treatments for NSSI should aim at decreasing impulsiveness.

However, research on the role of impulsiveness in NSSI has been limited in several important ways. First, prior studies have relied primarily on self-report measures of impulsiveness (Evans et al., 2000; Herpertz et al., 1997; Simeon et al., 1992). Research in cognitive and social psychology has revealed that people have limited understanding of the mental processes involved in evaluation, judgment, problem-solving and the initiation of behavior (Nisbett and Wilson, 1977). In particular, the mental processes involved in thinking about, planning, and enacting NSSI may be outside of conscious awareness. People are much more capable of accurately reporting that they *have engaged* in a specific behavior; however, it is less likely that they can accurately explain the cognitive processes underlying this behavior.

Another limitation of prior work is that often impulsiveness is defined and measured in different ways. Several recent studies have suggested that there are different dimensions of impulsiveness, such as behavioral disinhibition, risky decision-making, and delay discounting (Avila et al., 2004; Dom et al., 2007; Glicksohn et al., 2006; Matthys et al., 1998; Reynolds et al., 2006; White et al., 1994). Behavioral disinhibition refers to acting without thinking or failing to inhibit an initiated response. Risky decision-making involves reward sensitivity, punishment insensitivity, and a tendency to discount risks and make decisions that lead to negative consequences. Delay discounting refers to a preference for smaller immediate rewards over larger later rewards. Studies of normal and pathological behavior, human neurophysiology, psychopharmacology, and animal behavior indicate that there is no unique neurobiological basis for the broad construct of impulsiveness (Evernden, 1999; Matthys et al., 1998; McNaughton and Gray, 2000). Studies of animal models of impulse control further underscore the importance of distinguishing the distinct dimensions of impulsiveness (Monterosso and Ainslie, 1999). Each of these distinct dimensions may be uniquely related to NSSI; however no prior work has examined how self-injurers perform on tasks assessing these multiple dimensions.

This paper reports on two studies designed to provide a comprehensive test of the relation between NSSI and the distinct dimensions of impulsiveness described above. In Study 1, we compared adolescents with a lifetime history of NSSI to those with no such history on self-reported impulsiveness and on performance-based measures of behavioral disinhibition and risky decision-making. Study 2 provided a replication and extension of Study 1 with a sample of adults who had engaged in more recent NSSI and were more homogeneous (female only), maximizing the likelihood of detecting any effect if it exists. Study 2 also examined delay discounting in relation to NSSI. We hypothesized that self-injurers would be more impulsive than non-injurers as evidenced by scores on these various performance-based measures. We

sought to assess impulsiveness as a stable trait among self-injurers across various states and situations (e.g., in the laboratory on performance-based measures, in the moment of engagement in NSSI, and on self-report measures). Based on previous research, we hypothesized that self-injurers would demonstrate greater self-reported impulsiveness than non-injurers (Evans et al., 2000; Herpertz et al., 1997; Simeon et al., 1992) on self-report measures of impulsiveness (which ask about both behavioral disinhibition and risky decision-making) as well as on performance-based measures of behavioral disinhibition, risky decision-making, and delay discounting. We did not have any specific hypotheses regarding which performance-based measure would most capture the impulsiveness self-reported by self-injurers.

STUDY 1

2. Method

2.1. Participants—Participants ($N=94$) were 64 adolescents and young adults (aged 12 to 19 years) with a lifetime history of engaging in NSSI and 30 non-injurious controls matched on age, sex, and race/ethnicity (Table 1). Among those participants who had engaged in NSSI, the average age of onset was 13.52 (2.68) years; the mean past year frequency was 62.61 (130.90); 87.5% had engaged in NSSI in the last year; and 70.3% had engaged in NSSI in the last month. In the total sample, 33.0% met the diagnostic criteria for a current mood disorder, 46.8% met the diagnostic criteria for a current anxiety disorder, and 13.8% met the diagnostic criteria for a current substance use disorder (Kaufman et al., 1997). All participants were recruited from local psychiatric clinics and the community via announcements posted in clinics, newspapers, community bulletin boards, and the internet. All procedures were approved by the Harvard University institutional review board. After complete description of the study to the participants, written informed consent was obtained, with parental consent obtained for those less than 18 years. The participants in Study 1 took part in a larger, comprehensive laboratory study of NSSI. All participants in the larger study were included in analyses for the current study. The data presented in the current paper were not included in any earlier papers resulting from this study (Glassman et al., 2007; Najmi et al., 2007; Nock and Banaji, 2007a,b; Nock et al., 2007; Nock and Mendes, 2008; Nock et al., in press; Wedig and Nock, 2007; Weierich and Nock, 2008).

2.2. Assessment

2.2.1. Demographic factors: Participants provided information about demographic characteristics including age, sex, race/ethnicity, and treatment history via face-to-face interviews (See Table 1).

2.2.2. Self-injurious thoughts and behaviors: Self-injurious and suicidal thoughts and behaviors were assessed using the Self-Injurious Thoughts and Behaviors Interview (SITBI), (Nock et al., 2007) a structured clinical interview that assesses suicidal thoughts and behaviors, as well as NSSI. Participants were classified based on their responses to questions from the NSSI module of the SITBI about lifetime engagement in NSSI (i.e., “Have you ever purposely hurt yourself without intending to die?”). If participants endorsed these thoughts and behaviors, they were asked additional questions about specific characteristics of their thoughts and behaviors, including how long they typically think about the behavior before engaging in it (i.e., impulsiveness). The SITBI has strong inter-rater reliability (average $\kappa=.99$), test-retest reliability over a 6-month period (average $\kappa=.70$), and construct validity as demonstrated by strong relations with other measures of self-injurious thoughts and behaviors (average $\kappa=.54$).

2.2.3. Self-reported impulsiveness: Self-reported impulsiveness was assessed using one item from the Schedule for Affective Disorders and Schizophrenia for School Age Children, Present

and Lifetime Version (K-SADS-PL), a semi-structured diagnostic interview (Kaufman et al., 1997). Specifically, participants were asked “Do you act before you think, or think before you act? Has there ever been a time when these kinds of behaviors got you into trouble? Give some examples.” From the answers to these questions, trained interviewers rated each participant as 1=not impulsive, 2=sometimes impulsive, or 3=often impulsive.

2.2.4. Behavioral disinhibition: Behavioral disinhibition was measured using the errors of commission score from the Conners’ Continuous Performance Test (CPT)(Connors, 1995). The CPT is a computerized, visual performance task commonly used to study attention in which the participant presses the spacebar every time a letter appears on the screen, but inhibits their response whenever the letter presented is a “x” (Connors, 1995). Failing to inhibit the bar-pressing response to the letter “x” is considered an error of commission. The errors of commission T-score (scaled based on normative age and gender data), used in this study, is a commonly used measure of behavioral disinhibition (Halperin et al., 1991; Halperin et al., 1988; McGee et al., 2000).

2.2.5. Risky decision-making: The Iowa Gambling Task (IGT) is a performance-based computerized test of risky decision-making (Bechara et al., 1994). The procedure used followed standard administration and scoring procedures for this task (Bechara et al., 1999). In the IGT the participant is required to repeatedly select cards from one of four decks, each associated with a different reward-to-punishment ratio (the participant wins or loses play money after each card draw). The goal is to win as much money as possible, and the participant does not know that there are two advantageous decks (relatively small immediate rewards but even smaller immediate losses, resulting in a good long-term outcome) and two disadvantageous decks (relatively large immediate rewards but even larger immediate losses, resulting in a poor long-term outcome). The IGT has been used to demonstrate impaired decision-making among suicide attempters, individuals with substance addictions, psychopathic prison inmates and patients with prefrontal brain damage (Bechara et al., 1994; Bechara and Martin, 2004; Jollant et al., 2005; Losel and Schmucker, 2004).

IGT card choices were categorized as advantageous (selected from one of the two advantageous decks) or disadvantageous (selected from one of the two disadvantageous decks), and an individual’s summary score on the IGT was calculated by subtracting the total number of disadvantageous cards selected from the total number of advantageous cards selected, yielding a value that represents net number of advantageous cards selected. Five intermediate scores were calculated for each participant to indicate choice patterns during the task (i.e., score for cards 1-20, 21-40, 41-60, 61-80, and 81-100). These data were not normally distributed so they were logarithmically transformed to more closely approximate a normal distribution (Tabachnick and Fidell, 2001).

2.2.6. Psychiatric diagnoses: Psychiatric diagnoses reported in the description of participants were assessed using the K-SADS-PL (Kaufman et al., 1997). The K-SADS-PL has demonstrated excellent concurrent validity, interrater reliability, and test-retest reliability (Kaufman et al., 1997).

2.3. Data analysis—Five self-injurious participants were excluded from analysis of the IGT and two from analysis of the CPT because of failure to complete the task. Preliminary analyses (independent samples *t*-tests for sex differences and Pearson correlations for age differences) were conducted to test whether performance on the various measures of impulsiveness (self-report impulsiveness, CPT, IGT overall performance) differed by age, sex, or treatment status. In the main study analyses, we examined group differences on self-reported impulsiveness and on the CPT using independent samples *t*-tests. To test the role of risky decision-making in NSSI, IGT performance across blocks was evaluated using a two-way within-subjects

ANOVA, and group comparisons were conducted using independent samples *t*-tests. For instances in which demographic factors (age and sex) were correlated with primary study variables (measures of impulsiveness), we also examined the relation between self-injury status and the primary study variables after statistically controlling for the demographic correlates to ensure that any effects were not due to these confounding factors. This was done using partial correlations and hierarchical linear regression analyses with the demographic factors entered in the first step. All tests were two-tailed with alpha set at 0.05.

3. Results

3.1. Preliminary analyses—We first tested whether performance on the various measures of impulsiveness differed by age or sex. There were no age differences on self-reported impulsiveness. However, males self-reported more impulsiveness ($M=1.86$, $SD=0.85$) than did females ($M=1.42$, $SD=0.64$), $t(26.88)=2.15$, $p<.05$, $d=0.83$. Variance was unequal for this *t*-test so we adjusted the degrees of freedom and resulting *t* statistic accordingly. In addition, age was significantly correlated with impulsiveness on the CPT ($r=.31$, $p<.01$) with greater impulsiveness on the CPT associated with older age. Males demonstrated less impulsiveness on the CPT ($M=47.21$, $SD=13.53$) than did females ($M=54.09$, $SD=12.58$), $t(90)=-2.17$, $p<.05$, $d=0.46$. In addition, age was significantly correlated with impulsiveness on the IGT overall performance ($r=.22$, $p<.05$) with greater impulsiveness on the IGT associated with younger age. There were no gender differences on IGT overall performance.

Among self-injurers, we examined the impact of current receipt of psychotherapy or psychotropic medication among self-injurers on the various measures of impulsiveness (self-report impulsiveness, CPT, IGT). There were no significant differences between self-injurers currently receiving psychotherapy and self-injurers not currently receiving psychotherapy on self-report impulsiveness $t(54)=-0.03$, $p=0.98$, $d=0.01$, CPT performance $t(53)=-0.30$, $p=0.77$, $d=0.08$, or IGT performance $t(50)=1.48$, $p=0.15$, $d=0.42$. In addition, there were no significant differences between self-injurers currently receiving psychotropic medication and self-injurers not currently receiving psychotropic medication on self-report impulsiveness $t(52)=0.10$, $p=0.92$, $d=0.03$, CPT performance $t(51)=-1.64$, $p=0.11$, $d=0.46$, or IGT performance $t(48)=2.28$, $p=0.21$, $d=0.66$.

3.2. Relations among dimensions of impulsiveness—As expected, performance on the IGT and CPT were uncorrelated ($r=-0.03$, $p=0.81$), as were the CPT and self-reported impulsiveness ($r=0.09$, $p=0.39$). However, performance on the IGT and self-reported impulsiveness were significantly negatively correlated ($r=-0.32$, $p<0.005$). The results of these correlations do not change if age and sex are not statistically controlled, i.e., IGT and CPT remain uncorrelated ($r_{\text{partial}}=-0.08$, $p=0.47$), CPT and self-reported impulsiveness remain uncorrelated ($r_{\text{partial}}=0.11$, $p=0.32$), and IGT and self-reported impulsiveness remain significantly negatively correlated ($r_{\text{partial}}=-0.31$, $p<0.005$). This indicates that there is a relation between performance-based risky decision-making and self-reported impulsiveness.

3.3. Self-reported impulsiveness—Consistent with our hypotheses, self-injurious adolescents reported significantly greater impulsiveness ($M=1.63$, $SD=0.77$) than did non-injurious adolescents ($M=1.30$, $SD=0.53$), $t(78.28)=-2.38$, $p=0.02$, $d=0.54$. Variance was unequal for this *t*-test so we adjusted the degrees of freedom and resulting *t* statistic accordingly. This difference remains significant even after taking into account sex differences using a hierarchical linear regression with sex entered in the first step, $\Delta R^2=0.05$, $\Delta F(1, 91)=5.55$, $p<.05$, $\beta=0.23$. This suggests that differences between male and female adolescents are not affecting group differences.

Among self-injurious adolescents, when asked about time spent thinking about NSSI before engaging in it, responses were somewhat variable (Table 2). This indicates that the degree of impulsiveness associated with the act of NSSI varies among this sample.

3.4. Behavioral disinhibition—In contrast to our hypotheses, CPT errors of commission T-scores did not differ significantly between the NSSI group ($M=53.60$, $SD=12.35$) and the comparison group ($M=50.30$, $SD=14.35$), $t(90)=1.14$, $p=0.26$, $d=0.24$. This difference remains non-significant even after taking into account age and sex differences in a hierarchical linear regression with demographic variables entered in the first step, $\Delta R^2=0.003$, $\Delta F(1, 88)=0.32$, $p=.57$, $\beta=0.06$. This suggests that differences based on age and sex are not obscuring group differences. These findings indicate that adolescents who have engaged in NSSI do not demonstrate greater behavioral disinhibition on a laboratory task than do non-injurious adolescents.

3.5. Risky decision-making—As expected on the IGT, a two-way within-subjects ANOVA revealed that for both groups performance on the IGT significantly improved during the course of the task, $F(4,84)=112.31$, $p<0.001$, *partial* $\eta^2=0.84$. However, in contrast to our hypotheses, no significant time by group interaction was observed, $F(4,84)=0.73$, $p=0.576$, *partial* $\eta^2=0.03$. In addition, the main effect of group was non-significant, $F(1,87)=2.67$, $p=0.106$, *partial* $\eta^2=0.03$. In fact, more focused analyses revealed that groups did not differ significantly on IGT performance overall, $t(87)=1.79$, $p=0.09$, $d=0.19$, or at any of the five blocks. However, after taking into account age differences in a hierarchical linear regression with age entered in the first step, self-injurers and non-injurers differed significantly on IGT performance, $\Delta R^2=0.06$, $\Delta F(1, 86)=5.50$, $p<.05$, $\beta=-0.25$. This suggests that differences based on age may be obscuring group differences.

4. Discussion

Although self-injurers report being more impulsive than non-injurers, they do not show any differences on commonly used measures of impulsiveness, in this case, measures of behavioral disinhibition or risky-decision-making. In addition, not all self-injurers report engaging in this behavior impulsively, as there is some variability in the amount of time spent thinking about NSSI before engaging in it.

The group differences on self-report measures of impulsiveness fit with most previous research, but the behavioral findings are surprising. Behavioral disinhibition on the CPT has been associated with impulsive behavior in the context of attention deficit hyperactivity disorder (e.g., Halperin et al., 1988). In addition, risky decision-making on the IGT has been demonstrated among suicide attempters, individuals with substance addictions, psychopathic prison inmates and patients with prefrontal brain damage (Bechara et al., 1994; Bechara and Martin, 2004; Jollant et al., 2005; Losel and Schmucker, 2004). It was hypothesized that self-injurious adolescents would have patterns of behavioral disinhibition and risky decision-making similar to these other populations which would contribute to engagement in NSSI. In particular, given the overlap between NSSI and suicidal self-injury and the research linking impulsiveness to suicide (e.g., Corruble et al., 1999; Dougherty et al., 2004; Jollant et al., 2005; Mann et al., 1999), these findings were quite surprising. Previous research took into account medication status in recruitment procedures by excluding those on medication from the entire study (Jollant et al., 2005) or from the comparison group (Dougherty et al., 2004). Although we did not exclude participants based on psychotherapy or psychopharmacological treatment status, we examined differences among self-injurers based on these treatment variables. However, no differences among self-injurers were found on any measure of impulsiveness based on treatment status.

Study 1 had several important limitations that could have obscured group differences on behavioral measures of impulsiveness. First, the sample was limited to self-injurious adolescents who self-referred to a laboratory study. Adolescents may in general be more impulsive and therefore the absence of group differences may be due to most adolescents (even those in the control group) being relatively impulsive on performance-based measures. In addition, for these adolescents to participate, they needed parental consent. Adolescents who are willing to talk to their parents about their NSSI may represent a unique sample of self-injurers. Second, this study did not assess the third commonly studied dimension of impulsiveness: delay discounting. Self-injurers may be uniquely impulsive on this dimension and therefore likely even in the laboratory to demonstrate greater discounting of future rewards. Lastly, the self-injurers in this study had engaged in NSSI any time in their lifetime. A more precise assessment of the role of impulsiveness in NSSI would use a sample currently engaging in NSSI. We were surprised by the null findings in Study 1 and designed a follow-up study to address the aforementioned limitations and to provide a replication and extension of this study.

STUDY 2

5.1. Participants—Participants ($N=40$) were 20 female adults (aged 18 to 30 years) with a history of NSSI in the last three months and 20 non-injurious female controls matched on age and race/ethnicity (Table 3). Among those participants who had engaged in NSSI, the average age of onset was 12.85 (5.2) years; the mean past year frequency was 68.30 (98.46); the mean frequency in the past three months was 18.00 (27.25) and 70% had engaged in NSSI in the last month. In the total sample, 20.0% met the diagnostic criteria for a current mood disorder, 50.0% met the diagnostic criteria for a current anxiety disorder, and 15.0% met the diagnostic criteria for a current substance use disorder (Sheehan et al., 1998). As in Study 1, all participants were recruited from local psychiatric clinics and the community via announcements posted in clinics, community bulletin boards, and the internet. All procedures were approved by the Harvard University institutional review board. After complete description of the study to the participants, written informed consent was obtained.

5.2 Assessment

5.2.1. Demographic factors: Participants provided information about demographic characteristics including age, sex, and race/ethnicity via telephone screening interviews (See Table 3).

5.2.2. Self-injurious thoughts and behaviors: Self-injurious and suicidal thoughts and behaviors were assessed using the SITBI (Nock et al., 2007) and the identical procedure as in Study 1.

5.2.3. Psychiatric disorders: Participants were administered the Mini International Neuropsychiatric Interview (MINI)(Sheehan et al., 1998) to assess for the presence of psychiatric disorders. The MINI is a brief (approximately 15-minute) structured interview which assesses the presence of 18 common axis I disorders. The MINI has demonstrated reliability and validity (Sheehan et al., 1997, 1998).

5.2.4. Self-reported impulsiveness: The Barratt Impulsiveness Scale-11 (BIS-11) was used to measure self-reported impulsiveness (Patton et al., 1995). The BIS-11 is among the most commonly used and well-validated self-report assessments of impulsiveness. The BIS-11 consists of 30 statements from six different components of impulsiveness: attention, motor impulsiveness, self-control, cognitive complexity, perseverance, and cognitive instability. From these statements, a total impulsiveness score is computed.

5.2.5. Behavioral disinhibition: Identical to Study 1, the CPT was used to assess behavioral disinhibition.

5.2.6. Risky decision-making: Identical to Study 1, the IGT was used to assess risky decision-making.

5.2.7. Delay discounting: Participants completed two tasks assessing delay-discounting (i.e., the tendency to choose an immediate smaller reward over a larger delayed reward). The first was Kirby and colleagues' (1999) questionnaire-based measure of delay-discounting. On this task, participants are presented a fixed set of 27 choices between smaller, immediate rewards (SIRs) and larger, delayed rewards (LDRs). For example, on the first trial participants are asked "Would you prefer \$54 today, or \$55 in 117 days?" The participant indicates which alternative he or she would prefer to receive by circling that alternative on the questionnaire.

The second measure of delay discounting was a computer-based task developed by Richards, Zhang, Mitchell and de Wit (1999). In this task, participants are asked a series of questions regarding preference for an immediate smaller reward or a larger delayed reward, and this computer-based adjusting-amount (AA) procedure adjusts the amount of the immediate alternative to determine indifference points. The computer generates the questions on the basis of the participant's answers to the preceding questions about preference of immediate versus delayed rewards, which allows the AA procedure to rapidly determine indifference points.

Participants were informed prior to beginning the tasks that they would have a chance to win money based on their choice on one of the trials in one of the two tasks. After study completion, participants drew a card from a bag which contained the number of every question on the paper questionnaire and the computer task and won the amount they chose for that question (i.e., either the smaller immediate reward or the larger delayed reward). Participants were paid either at the end of the study or by mail after the specified delay.

5.3. Data analysis—Data were lost for the last two blocks of the IGT for two control participants due to a computer error. In addition, three self-injurers and five control participants were excluded from analyses of the computerized delay-discounting measure because the discounting parameter could not be computed as choices implied a parameter outside the range of the choice set.

For the questionnaire-based measure of delay discounting, choices on the choice pairs with small, medium, and large sums were used to compute three hyperbolic discounting parameters (i.e., k values) for each participant following the method of Kirby et al. (1999). Then an overall discounting parameter or k value equal to the geometric mean of the three intermediate parameters was computed for each participant. Following Kirby et al. (1999), these k values were logarithmically transformed to more closely approximate a normal distribution (Tabachnick and Fidell, 2001).

For the computer-based measure of delay discounting, using the computer-determined indifference points, a k value was computed for each participant. These k values were not normally distributed and therefore were logarithmically transformed to more closely approximate a normal distribution (Tabachnick and Fidell, 2001).

As in Study 1, preliminary analyses (Pearson correlations) were conducted to test whether performance on the various measures of impulsiveness differed by age, and relations were tested among measures of impulsiveness using Pearson correlations and partial correlations to take into account differences based on age. We tested group differences on self-reported impulsiveness and performance on the CPT using t -tests. As in Study 1, IGT performance

across blocks was evaluated using a two-way within-subjects ANOVA, and group comparisons on the IGT were conducted using *t*-tests. To test the role of delay discounting in NSSI, group differences on the *k* parameters for the two measures of delay discounting were evaluated using *t*-tests. In addition, to measure the relation between these two measures of the same construct, Pearson correlations were computed between these measures. Lastly, on the questionnaire-based measure of delay discounting, choices across sum size were evaluated using a two-way within-subjects ANOVA. For variables that did differ based on age, hierarchical linear regression analyses also were conducted with age entered in the first step to examine whether taking into account age differences influenced group differences on the variables of interest. All tests were two-tailed with alpha set at 0.05.

6. Results

6.1. Preliminary analyses—We tested whether performance on the various measures of impulsiveness differed by age. Age did not significantly correlate with, BIS-11 score, IGT performance or delay discounting on either measure. However, age was significantly negatively correlated with CPT impulsiveness ($r=-.33, p<.05$) with greater impulsiveness on the CPT associated with younger age. This is the opposite finding from the age differences found in preliminary analyses for Study 1.

6.2. Relations among dimensions of impulsiveness—As in Study 1, the different dimensions of impulsiveness were uncorrelated. The two measures of delay discounting (presumably measuring the same dimension) were highly correlated; however no other measures were significantly correlated. Correlation coefficients are presented in Table 4. Partial correlations taking into account age differences are reported for correlations with CPT performance. These findings support previous research indicating that the behavioral and self-report dimensions of impulsiveness are distinct and uncorrelated (Avila et al., 2004; Dom et al., 2007; Glicksohn et al., 2006; Matthys et al., 1998; Reynolds et al., 2006; White et al., 1994).

6.3. Self-reported impulsiveness—Consistent with our hypotheses, the self-injurious participants exhibited greater impulsiveness ($M=69.00, SD=11.80$) on the BIS-11 than did the comparison participants ($M=60.40, SD=9.83$), $t(38)=-2.50, p<.02, d=0.81$. As in Study 1, among self-injurious adults, when asked about time spent thinking about NSSI before engaging in it, responses were quite variable (Table 2). This indicates that the degree of impulsiveness associated with the act of NSSI is variable among this sample.

6.4. Behavioral disinhibition—Replicating Study 1, CPT errors of commission T-scores did not differ between the NSSI group ($M=52.33, SD=12.02$) and the comparison group ($M=50.56, SD=11.92$), $t(38)=-0.47, p=.64, d=0.15$. This difference remains non-significant even after taking into account age differences in a hierarchical linear regression with age entered in the first step, $\Delta R^2=0.001, \Delta F(1, 37)=0.05, p=.83, \beta=0.03$. This suggests that differences based on age are not obscuring group differences. These findings replicate the findings of Study 1 and indicate that adults who have engaged in recent NSSI do not demonstrate greater behavioral disinhibition on a laboratory task than do non-injurious adults.

6.5. Risky decision-making—A two-way within-subjects ANOVA revealed that for both groups performance on the IGT significantly improved during the course of the task, $F(4, 33)=20.80, p<0.001, partial \eta^2=0.72$. However, in contrast to our hypotheses, no significant time by group interaction was observed, $F(4,33)=0.305, p=0.873, partial \eta^2=0.04$. In addition, the main effect of group was non-significant, $F(1,36)=0.617, p=0.437, partial \eta^2=0.02$. In fact, more focused analyses revealed that groups did not differ on IGT performance overall, $t(36)=-1.07, p=.29, d=0.36$, or at any of the five blocks. These findings suggest that adults who have

engaged in recent NSSI do not demonstrate greater risky decision-making on a laboratory-based behavioral task than do non-injurious adults.

6.6. Delay Discounting—Contrary to our hypothesis that self-injurers would be more likely to discount future rewards, the groups did not differ significantly on either the questionnaire measure of delay discounting [NSSI group $M=0.005$ (0.005), Comparison group $M=0.005$ (0.008), $t(38)=0.28$, $p=.79$, $d=0.0$] or the computer-based measure of delay discounting [NSSI group $M=0.006$ (0.008), Comparison group $M=0.015$ (0.024), $t(30)=1.49$, $p=.15$, $d=0.54$].

Although the absence of group differences is difficult to interpret, two additional findings speak to the credibility of these findings and suggest that participants did understand the task and take it seriously. First, the discounting parameters derived from the two measures of delay discounting were highly correlated ($r=0.81$, $p=0.001$) suggesting that these measures are indeed accessing a representative discounting parameter. Second, on the questionnaire task, there were significant differences between the k parameters for the small vs. medium vs. large sums, replicating results from Kirby and Marakovic (1996) and Wilson and Daly (2006). For both groups, mean k values were significantly higher for small (\$25, \$30, \$35), vs. medium (\$50, \$55, \$60) vs. large (\$75, \$80, \$85) sums, $F(2, 37)=13.28$, $p<.001$, *partial* $\eta^2=0.42$. However, there was no significant interaction between sum size and study group. The consistency of these findings suggests that the absence of group differences on these two measures indicates a true absence of differences between self-injurers and non-injurers.

7. Discussion

The results of Study 2 largely replicated those from Study 1. Self-injurers again reported greater impulsiveness than did non-injurers, but did not differ from non-injurers on behavioral disinhibition or risky decision-making. In Study 2, an additional set of performance-based measures of impulsiveness, the delay discounting tasks, also showed no differences between self-injurers and non-injurers. That the null findings from Study 1 were replicated in Study 2 indicates that the absence of significant group differences on these measures may accurately reflect an absence of group differences. When we designed Study 2, we considered several possible explanations for the absence of group differences in Study 1. Unlike Study 1, Study 2 involved an adult sample, enrolled only self-injurers who reported engagement in NSSI in the last three months, and employed measures of delay discounting. Despite these changes, again no differences were found between self-injurers and non-injurers on performance-based measures of impulsiveness. One important limitation of Study 2 is that we did not collect information on current engagement in psychotherapy or current receipt of psychotropic medications. However as there were no differences among self-injurers on measures of impulsiveness based on treatment status in Study 1, medication status is not likely to account for the absence of group differences in Study 2. A second important limitation of Study 2 is that three self-injurers and five control participants were excluded from analyses of the computerized delay-discounting measure. This was an unfortunate limitation of the computerized measure and may have limited its usefulness for detecting differences between the groups. Fortunately, we had an additional measure of delay discounting (the questionnaire-based measure).

8. General discussion

Taken together, the results of these two studies indicate that although self-injurers report greater global impulsiveness, they do not demonstrate greater impulsiveness than non-injurers on laboratory-based behavioral measures of impulsiveness. The absence of group differences on behavioral tasks was consistent across both studies. Although the findings in these two studies are consistent, they are inconsistent with previous research indicating that suicidal self-injury

is associated with increased impulsiveness on laboratory-based behavioral tasks (Dougherty et al., 2004; Jollant et al., 2005). However, some recent work by Keilp et al. (2006) indicates that among depressed people, self-report measures of aggressiveness, but not measures of impulsiveness, distinguish those with and without suicide attempt histories. Taken together, these findings indicate that impulsiveness alone may not reveal the nature of the decision-making involved in NSSI.

These findings must be interpreted in the context of several important limitations. First, that these behavioral measures did not detect group differences between self-injurers and non-injurers cannot be interpreted as a clear indication that no such group differences exist. The findings are strengthened by the replication in a second study with an older population and by the examination of multiple behavioral measures of impulsiveness. However, null findings are of course very difficult to interpret conclusively. A second limitation of these findings is the clear difference between the results of these studies and the results of previous studies which have found differences between suicidal and non-suicidal individuals on behavioral measures of impulsiveness (Dougherty et al., 2004; Jollant et al., 2005). The absence of group differences in the two studies presented here considered in addition to previous studies suggest that further investigation may be needed to determine the role of impulsiveness in self-injury. A third limitation is our self-report measures of impulsiveness. Our measure of time spent thinking about NSSI before engaging in it (i.e., asking participants to retrospectively recall) is a particularly limited measure. Participants may have trouble recalling this kind of information and therefore may be biased in their reporting. In addition, the use of one question on the K-SADS to measure impulsiveness in Study 1 is an important limitation. Fourth, the predominantly female sample in Study 1 and the all female sample in Study 2 limit the generality of these results. Lastly, the sample size of Study 2 was particularly small. We had initially anticipated recruiting more participants for Study 2, but stopped recruitment when it was clear that no differences between the groups were emerging on performance-based measures of impulsiveness.

There are several potential explanations for the discrepancy between self-report and performance-based measures of impulsiveness in the context of NSSI demonstrated in these two studies. First, NSSI is associated with suicidal thoughts and behaviors, and with various psychiatric disorders and symptoms including substance abuse and dependence, depression, eating disorders, and borderline personality disorder (Zlotnick et al., 1999). The various psychological and diagnostic correlates of NSSI complicate any study of NSSI. The absence of differences on behavioral measures of impulsiveness in this study may be due in part to the heterogeneity of the self-injurious sample. In addition, the control samples were heterogeneous. The heterogeneity of the control samples increases the likelihood that any differences between groups are due to the variable of interest (i.e., engagement in NSSI); however the psychopathology in the control group decreases our ability to detect differences between groups. A second explanation for these findings is that self-report of impulsiveness among a self-injurious sample may reflect self-report of engagement in NSSI. Self-injurers may in fact be using self-injury as an index of impulsiveness. Questions on self-report measures such as "I act 'on impulse'" or "I am more interested in the present than the future" may lead self-injurers to reflect on their self-injurious behavior and report that they are impulsiveness because they engage in NSSI. This confound of self-report measures which would not affect performance-based measures may explain the disparity between self-report and laboratory-based measures of impulsiveness in this population. A third potential explanation is that self-injurers are impulsive only in certain contexts. People who engage in self-injury typically report doing so in response to extreme emotional distress. They may behave impulsively only when under extreme stress or in distress. Therefore laboratory-based behavioral measures may fail to capture the impulsiveness that self-injurers demonstrate in other contexts. A fourth potential explanation for these findings is that the specific performance-based tasks we used may not be

the best performance-based measures of impulsiveness among self-injurers. It is possible that a different set of tasks would successfully detect differences between self-injurers and non-injurers.

These findings suggest several important future directions for research on NSSI. First, prospective studies are sorely needed to determine whether self-reported impulsiveness among self-injurers is in fact a reflection of their using self-injury as an index of impulsiveness. Such studies would assess both self-report impulsiveness and engagement in self-injury among a large sample of adolescents and young adults at multiple assessment points over time to determine the temporal relation between self-report impulsiveness and self-injury. Only such a study could determine whether self-reported impulsiveness is a risk factor for self-injury or consequence of engagement in self-injury. Second, it is possible that people who engage in self-injury show greater impulsiveness only during times of distress. To test this, behavioral measures of impulsiveness could be administered after a laboratory manipulation to induce emotional distress, or better yet, in a psychiatric emergency department setting. Third, future research on the role of impulsiveness in self-injury could use different performance-based measures of impulsiveness to determine if the absence of group differences in these two studies reflects the specific tasks we used. Other performance-based measures of impulsiveness include: the Trail Making Task, behavioral ratings of motor restlessness and impatience, the Immediate and Delayed Memory Tasks, and various Go/NoGo Tasks (Dom et al., 2007; Dougherty et al., 2004; White et al., 1994). These potential avenues for studying impulsiveness in the context of self-injury are important next steps for improving our understanding of NSSI.

Overall, these findings provide some evidence that although self-injurers self-report greater impulsiveness than non-injurers, they do not demonstrate heightened impulsiveness on laboratory-based behavioral tasks. Understanding what situational and trait-like psychological factors relate to NSSI can improve theory on why people engage in self-injury and ultimately improve our ability to predict, prevent, and treat suicidal and non-suicidal self-injurious thoughts and behaviors.

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Table 1

Characteristics of Study 1 Participant Groups

Variable	Range	NSSI (<i>n</i> =64)	Control (<i>n</i> =30)	Statistic
Age in years, <i>M</i> (<i>SD</i>)	12 – 19	17.4 (1.8)	16.7 (2.0)	$t_{97}=1.66$
Sex (% female)		79.7	73.3	$\chi_1^2=0.48$
Race/Ethnicity (%)				$\chi_5^2=3.30$
European American		75.0	70.0	
African American		3.1	3.3	
Hispanic		7.8	3.3	
Asian		4.7	6.7	
Biracial		9.4	13.3	
Other		0.0	3.3	
Lifetime suicide thoughts (%)		93.8	20	$\chi_1^2=53.12^{**}$
Lifetime history of suicide plans (%)		53.1	3.3	$\chi_1^2=21.67^{**}$
Lifetime history of suicide attempts (%)		42.2	0	$\chi_1^2=17.76^{**}$
At least 1 current mental disorder (%)		76.6	30	$\chi_1^2=18.84^{**}$
Currently receiving psychotherapy (%)		48.2%	10%	$\chi_1^2=12.56^{**}$
Currently receiving psychotropic medication (%)		46.3%	13.8%	$\chi_1^2=8.77^*$

Note.

* $p < 0.01$,

** $p < 0.001$

NSSI = Non-suicidal self-injury.

Table 2

Time Thinking about NSSI Before Engaging in NSSI

Response (% endorsing)	Study 1	Study 2
0 seconds	3.2	0
1-60 seconds	25.8	20
2-15 minutes	41.9	20
16-60 minutes	11.3	30
Less than one day	8.1	25
1-2 days	1.6	0
More than 2 days	3.2	0
Multiple responses	4.9	5

NSSI =Non-suicidal self-injury.

Table 3

Characteristics of Study 2 Participant Groups

Variable	Range	NSSI (n=20)	Control (n=20)	Statistic
Age in years, <i>M</i> (<i>SD</i>)	18 – 30	22.6 (3.2)	23.5 (3.9)	$t_{38}=0.80$
Race/Ethnicity (%)				
European American		80.0	45.0	$\chi^2_3=6.90$
Hispanic		0.0	15.0	
Asian		10.0	30.0	
Biracial		10.0	10.0	
Lifetime suicide thoughts (%)		90	20	$\chi^2_1=19.80^*$
Lifetime history of suicide plans (%)		80	0	$\chi^2_1=26.67^*$
Lifetime history of suicide attempts (%)		50	0	$\chi^2_1=13.33^*$
At least 1 current mental disorder (%)		80	30	$\chi^2_1=10.10^*$

Note.

* $p < 0.001$

NSSI = Non-suicidal self-injury.

Table 4

Study 2: Correlations Among Measures of Impulsiveness

	1.	2.	3.	4.	5.
1. CPT commissions	-				
2. IGT total score	0.18	-			
3. <i>k</i> , computer task	-0.12	0.02	-		
4. <i>k</i> , questionnaire	0.11	0.02	0.81*	-	
5. BIS	-0.12	0.11	0.02	0.15	-

Note.

* $p < 0.001$

NSSI = Non-suicidal self-injury.