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Frequency of nonsuicidal self-injury is associated with impulsive decision-making during criticism

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Abstract

Research indicates that nonsuicidal self-injury (NSSI) is associated with impulsive traits, but not impulsive behavior on laboratory tasks, even in the context of negative mood. However, previous studies may not have induced forms of negative affect most relevant to NSSI. For example, evidence implicates both *self-criticism* and *feeling criticized* by others in NSSI engagement. We conducted two studies examining whether negative mood related to criticism increases impulsive decision-making among individuals with NSSI histories, using a gambling task embedded with auditory critical comments; participants imagined loved ones saying these comments to them. Study 1 evaluated community adults with (n = 33) and without (n = 31) NSSI histories. Despite no group differences in task performance, we found an association between past-year NSSI frequency and more impulsive choices during criticism. This was confirmed in Study 2 using a separate sample of adults (n = 69) with more frequent and recent NSSI. In regression models including self-criticism and depressive symptoms, only task performance (i.e., decision-making while receiving critical feedback) predicted NSSI frequency across multiple measurement periods. These studies suggest that more frequent and recent NSSI is associated with neurocognitive impulsivity, specifically in negative emotional contexts involving actual or imagined criticism in close relationships.

Keywords

Self-harm; Impulsivity; Risk-Taking; Self-Criticism; Emotional Stress

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1. Introduction

Nonsuicidal self-injury (NSSI), direct and deliberate self-inflicted bodily harm without lethal intent, is alarmingly prevalent: according to a meta-analysis of community samples, 17.2% of adolescents, 13.4% of young adults, and 5.5% of adults report lifetime NSSI histories (Swannell et al., 2014). Despite occurring without suicidal intent, NSSI is one of the strongest predictors of future attempted suicide, equivalent to previous attempts (Ribeiro et al., 2016). Given that suicide is the 10th leading cause of death in the United States (Centers for Disease Control and Prevention, 2018), determining shared and distinct factors involved in nonsuicidal and suicidal forms of self-injury is critical.

Impulsivity is one construct featured prominently in theories of self-injurious behaviors (Nock, 2010; O'Connor, 2011; van Heeringen and Mann, 2014; Van Orden et al., 2010). Though research supports the role of impulsivity in suicide, the magnitude of this association is small, leading some to suggest that this trait elevates risk through increasing the likelihood of other experiences that influence suicidal behavior, such as NSSI (Anestis et al., 2014). Yet data for this assertion are mixed: whereas meta-analysis suggests a modest cross-sectional relationship between trait impulsivity and NSSI (Hamza et al., 2015), its predictive power in longitudinal studies is relatively weak (Fox et al., 2015).

Notably, impulsivity comprises multiple aspects of personality, cognition, and behavior. NSSI is most strongly associated with self-reported impulsive personality traits, particularly *negative urgency* (Hamza et al., 2015). This is the tendency to act rashly in response to negative emotions (Cyders and Smith, 2008). Prospective research suggests that this trait increases risk for NSSI initiation (Riley et al., 2015), consistent with the idea that people who have difficulty controlling their impulses when distressed may select NSSI as a strategy to reduce negative affect. Indeed, emotion regulation is the most endorsed function of NSSI (Taylor et al., 2018), in line with theoretical models (see Hooley and Franklin, 2018) and empirical evidence (Armey et al., 2011; Fox et al., 2015; Klonsky, 2007).

In contrast to self-report, most studies using behavioral tasks have not found elevated impulsivity among people who engage in NSSI (Liu et al., 2017). There are several potential explanations for this discrepancy. Self-reported personality traits are considered relatively stable compared to task-based impulsivity measures, which may be more state-sensitive, and these methods often show poor concordance (Cyders and Coskunpinar, 2011, 2012; MacKillop et al., 2016; Sharma et al., 2014; Stahl et al., 2014). Relatedly, behavioral impulsivity measured in the absence of negative affect may not capture inhibitory deficits involved in negative urgency. Hamza and colleagues (2015) therefore suggested that researchers manipulate affect prior to assessing impulsive behavior in people engaging in NSSI. However, subsequent work from our laboratory (Allen and Hooley, 2017) and others' (Lengel et al., 2016) found that increased negative mood did not correspond to heightened neurobehavioral impulsivity or impaired response inhibition (c.f. impulsive action; Bari and Robbins, 2013; Hamilton et al., 2015a; Liu et al., 2017) in this population. Schatten et al. (2015) similarly did not observe an association between NSSI and neurocognitive or choice impulsivity (c.f. impulsive decision-making; Hamilton et al., 2015b; Liu et al., 2017) following a distressing social exclusion task.

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Such unexpected findings might be related to the use of mood inductions with limited ecological relevance to NSSI. Based on accumulating evidence implicating criticism – both *towards oneself* and *from others* – in NSSI, exposure to actual critical feedback may be a more effective proxy for situations involving elevated risk of self-injury or other impulsive behaviors. For example, evidence suggests that the mood benefits of pain or pain offset appear to be potentially accessible to everyone – regardless of whether they harm themselves intentionally (Hooley and Franklin, 2018) – yet most people do not select NSSI as a mood regulation strategy. Hooley and Franklin propose that this is due to the presence of barriers to NSSI engagement, such as having a positive view of the self. People who view themselves positively are unlikely to intentionally inflict damage on their bodies. In contrast, beliefs about being bad, defective, and therefore deserving of punishment, may lower this barrier. People with such self-views might therefore be more inclined to consider NSSI to regulate mood.

Several lines of evidence converge with this tenet of Hooley and Franklin's model: high levels of self-criticism distinguish NSSI from indirectly self-destructive behavior (St. Germain and Hooley, 2012); and among people who self-injure, self-criticism is associated with willingness to endure pain (Hooley et al., 2010; Hooley and St. Germain, 2014), better mood during pain, and more frequent NSSI (Fox et al., 2017). Self-critical beliefs also mediate the relationship between adverse childhood experiences (e.g., parental abuse and trauma) and NSSI (Glassman et al., 2007), suggesting that these distal social risk factors (Nock, 2010) operate through a specific psychological mechanism, contributing to a negative self-concept. Ecological momentary assessment (EMA) examining the trajectory of affective states as they temporally relate to NSSI episodes also supports the notion that intrapersonal negative emotions directly precipitate self-injury. In particular, self-loathing, guilt, and shame increase prior to an NSSI episode, peak during it, and decrease in the following hours (Armey et al., 2011). Nock et al. (2009) similarly found that self-directed anger and self-hatred were among the strongest contextual predictors of actual engagement in NSSI, in contrast to sadness, which was associated with increased likelihood of NSSI thoughts but *decreased* odds of acting on those thoughts.

Self-critical thoughts may be more likely to occur in specific contexts, such as difficulties in familial, peer, and intimate partner relations, which are established correlates of NSSI (Adrian et al., 2011; Di Pierro et al., 2012; Levesque et al., 2010). Indeed, longitudinal research suggests that interpersonal stressors promote NSSI thoughts and behaviors. For example, relationship conflict is associated with NSSI at the daily level (Turner et al., 2016), often co-occurs with NSSI at the momentary level (Nock et al., 2009), and is also among the most frequent antecedents of self-injury (nonsuicidal and suicidal; Hawton and Harriss, 2006). EMA research indicates elevated overall negative mood during NSSI urges (Armey et al., 2015). However, specific interpersonally-focused negative affective states, such as feeling rejected and angry towards others, predict acting on those urges (Nock et al., 2009), and also rise in the hours preceding NSSI acts and decrease afterwards (Snir et al., 2015). Together, the above literature suggests that "trait" self-criticism (i.e., a relatively stable negative view of the self) might facilitate initial utilization of NSSI as an emotion regulation strategy, whereas negative affective states associated with both *self*-criticism and *feeling* criticized/rejected in close relationships – perhaps through the activation of self-critical

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beliefs – may each contribute to NSSI maintenance. Supporting this latter possibility, self-criticism mediates the relationship between perceived parental criticism and NSSI (Baetens et al., 2013).

The present work thus sought to evaluate the relationship between NSSI and neurocognitive impulsivity using a mood induction designed to elicit feelings related to self-criticism and criticism from others. To this end we modified a standard decision-making task to include standardized critical comments presented at regular intervals. In Study 1, we examined task performance in individuals reporting a lifetime history of NSSI and demographically matched healthy controls. In Study 2, we assessed a larger sample of participants, all with NSSI histories, who reported more recent and frequent episodes. We hypothesized that NSSI would be associated with behavioral impulsivity on this Criticism Gambling Task; specifically, that participants reporting lifetime NSSI histories would make more impulsive choices in the context of critical feedback than controls without NSSI, and that NSSI frequency would be associated with more impulsive decision-making during criticism exposure. We included multiple variables associated with NSSI that might influence risky, reward-seeking behavior in response to critical feedback (i.e., trait impulsivity, trait self-criticism, and depressive symptoms) to include as covariates in regression analyses (to examine potential influences on the predicted relationship between NSSI frequency and neurocognitive impulsivity.

2. Study 1

2.1. Methods and participants

We recruited community participants using printed and online advertisements directing interested individuals to a screening website that collected demographic information and psychiatric history, including lifetime presence of self-injury (NSSI and suicide attempts) and past-year NSSI frequency. We invited two groups of English-speaking adults (18+) to complete a laboratory session: those reporting lifetime NSSI histories (n = 33), and controls reporting no history of nonsuicidal or suicidal self-injury, psychiatric illness, or treatment (n = 31). Following consent procedures, participants completed an IRB-approved protocol including the Criticism Gambling Task and a battery of self-report and behavioral measures, some results of which have been reported in previous publications (Allen and Hooley, 2015, 2017). The primary analyses in this report have not been described elsewhere.

Within the NSSI group, 17 participants (51.5%) reported episodes within the last year (M = 5.42, SD = 8.73, Mdn = 1). Eight (24.2%) additionally reported suicide attempt histories. The majority reported psychiatric diagnoses (n = 22; 66.7%), most commonly depression (n = 20; 60.6%), followed by generalized anxiety disorder (n = 9; 27.3%), eating disorders (n = 6; 18.2%), bipolar disorder, (n = 3; 9.1%), and obsessive-compulsive disorder, panic disorder, post-traumatic stress disorder, and developmental disorders/learning disabilities (each n = 2; 6.1%). Nearly half (n = 15; 45.5%) reported current psychiatric medication use.

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2.2 Measures

2.2.1. Beck Depression Inventory-II (BDI-II)—The BDI-II (Beck et al., 1996b) is a 21-item self-report questionnaire that measures severity of depressive symptoms over the past two-weeks on a four-point Likert-type scale (0 = *not at all* to 3 = *most severe*). It shows high test-retest reliability (r = 0.93) and internal consistency in clinical and community samples (α = 0.98 in this study; Beck et al., 1996a).

2.2.2. Self-Rating Scale (SRS)—The SRS (Hooley et al., 2010) is an eight-item measure that evaluates self-critical beliefs on a seven-point Likert-type scale (1 = *strongly disagree* to 7 = *strongly agree*). Previous work indicates that the SRS has good internal consistency (Glassman et al., 2007; Hooley et al., 2010), which was also observed in this study (α = 0.92). Its validity is supported by data indicating that it discriminates between individuals with and without NSSI histories (Hooley et al., 2010) and is also modestly correlated with NSSI frequency (Fox et al., 2017).

2.2.3. Schedule for Nonadaptive & Adaptive Personality-2 (SNAP-2) Impulsivity subscale—The SNAP-2 (Clark et al., 2009) was used to assess self-reported impulsive personality. This 390-item true/false inventory is designed to measure normal and disordered personality (based on DSM-IV criteria). Research supports this measure's overall psychometric properties (Calabrese et al., 2012). The SNAP-2 Impulsivity subscale contains 19 items corresponding to disinhibited and reckless behavior, which demonstrated adequate internal consistency (α = 0.82) in the present sample.

2.2.4. Positive and Negative Affect Schedule (PANAS)—The PANAS (Watson et al., 1988) is a 20-item measure of state mood, comprised of two 10-item scales assessing levels of affect associated with positive and negative mood. Participants rate the degree they feel each item "right now" on a five-point scale (1 = *very slightly or not at all* to 5 = *extremely*). We administered the PANAS at baseline, i.e., prior to criticism exposure in the CGT, and after participants finished the task. Consistent with the aims of the present report, the analyses focus on changes in the negative affect (NA) scale, which includes emotions such as "hostile", "ashamed", and "guilty". Internal consistency in this sample was good both before (α = 0.83) and after (α = 0.87) the task.

2.2.5. Criticism Gambling Task (CGT)—The CGT is a modified version of the Iowa Gambling Task (IGT; Bechara et al., 1994), a widely used paradigm to assess decision-making. In this computerized task, participants receive $2000 in virtual currency and are instructed to maximize profit over 100 trials by selecting from four decks of cards. These decks offer different schedules of monetary gains (occurring on every trial) and occasional losses. Participants are told that "some decks are worse than others" and to "avoid these decks" in order to succeed on the task, but given no specific information regarding payoff distributions. Decks A and B are "disadvantageous," offering higher immediate gains ($100) but also occasional large losses (Deck A: 0.5 probability of a $250 loss; Deck B: 0.1 probability of $1250 loss). Selections from these decks result in a net decrease in currency. The other two "advantageous" decks offer smaller short-term gains ($50), but also incur smaller losses (Deck C: 0.5 probability of a $50 loss; Deck D: 0.1 probability of a $250

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loss), ultimately yielding an increase in currency. Subtracting the number of advantageous deck selections from disadvantageous deck selections provides an index of neurocognitive/choice impulsivity or risky decision-making, which we used as the primary outcome in CGT analyses. Healthy individuals generally improve (i.e., make fewer selections from risky decks) in a quadratic manner over each block of the task (Bechara, 2007). IGT impairment is associated with suicide attempt history (Jollant et al., 2005), in addition to various psychiatric and neurological conditions (Bechara, 2007). Past studies using the IGT have not observed neurocognitive impulsivity in NSSI (Janis and Nock, 2009; McCloskey et al., 2012; Schatten et al., 2015).

The CGT differs from the IGT by including criticism at regular intervals. Participants are first asked to identify an individual with whom they have an important, intimate relationship; most chose their mother (n = 42; 65.6%), 13 chose a close friend (20.3%), and nine chose a romantic partner (14.1%). They were then informed that they would occasionally hear comments while performing a task, which they were asked to imagine being said to them by the identified person. These standardized critical comments were pre-recorded in a female voice and lasted approximately 20 seconds each, during which participants could not proceed to the next trial. Four criticism stimuli were presented in the same order, with one comment after each 20-trial block of the CGT. The following provides an illustrative example: “One thing that really bothers me about you is that you always have to get your own way. You have a hard time taking ‘no’ for an answer and you really get resentful when you don’t get what you want. You don’t seem to realize that there needs to be some ‘give and take’ if you’re going to get along with people. You have a lot of trouble with relationships, and this is one of the reasons why.” Our colleagues and our past investigations have used similar stimuli to induce self-referential negative affect; these types of comments significantly increase negative mood in a variety of diagnostic groups and healthy participants (e.g., Baeken et al., 2018; Dedoncker et al., 2018; De Raedt et al., 2017; Hooley et al., 2009; Nook et al., 2018).

2.3. Data analysis

We first conducted χ^2 and independent t-tests to compare groups on demographic and self-report measures. Then we performed a 2 (Group: lifetime NSSI history vs. control) X 2 (Time: Pre vs. post) repeated-measures analysis of variance (ANOVA) on the PANAS-NA scale as a mood manipulation check. To assess our first hypothesis, we conducted a 2 (Group) X 5 (CGT Block) repeated-measures analysis of covariance (ANCOVA) on CGT impulsivity, controlling for suicide attempt history, given its association with impulsive decision-making. We used linear correlations to evaluate our second hypothesis, examining relationships among task performance, past-year NSSI frequency, presence of suicide attempt history (coded as 0 or 1), self-criticism, self-reported impulsivity, and depression symptoms. Finally, we performed a zero-inflated negative binomial (ZINB) multiple regression[1] predicting NSSI frequency from CGT impulsivity, while accounting for other correlated variables. All tests were two-tailed using $p < .05$ as the significance threshold.

[1]ZINB is suitable for over-dispersed count data such as NSSI episodes with “excess” unobserved cases and was thus appropriate for our model, which included controls whose data were theoretically restricted to zero values, as well as a majority of NSSI participants who reported no past-year episodes.

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One control participant had missing PANAS/CGT data and was excluded from relevant analyses.

3. Results

Although groups were demographically comparable, participants with NSSI histories reported more depressive symptoms and self-criticism, but not higher impulsivity on the SNAP-2, relative to controls (Table 1). Time had an effect on PANAS-NA, $F(1, 61) = 39.76$, $p < 0.001$, partial $\eta^2 = 0.40$, suggesting that criticism increased negative mood, with no between-group differences [$F(1, 61) = 2.19$, $p = 0.14$, partial $\eta^2 = 0.04$; interaction $F(1, 61) = 0.00$, $p = 1.00$, partial $\eta^2 = 0.00$]. ANCOVA indicated an effect of CGT Block, $F(4, 240) = 5.18$, $p = 0.001$, partial $\eta^2 = 0.08$, such that participants made fewer impulsive choices over the course of the task [linear contrast $F(1, 60) = 11.74$, $p < 0.001$, partial $\eta^2 = 0.16$]. Again, we found no Group effects [between-subjects $F(1, 60) = 0.02$, $p = 0.89$, partial $\eta^2 = 0.00$; interaction $F(4, 240) = 1.75$, $p = 0.14$, partial $\eta^2 = 0.03$].

Despite no differences between participants with and without lifetime NSSI histories, CGT impulsivity was associated with more frequent past-year NSSI (Table 2). NSSI frequency was also associated with self-criticism, self-reported impulsivity, and depressive symptoms. However, CGT impulsivity was the only correlated variable to predict number of past-year NSSI episodes in multivariate ZINB regression (Table 3).

4. Discussion

As expected, participants with NSSI histories reported more self-criticism and depressive symptoms than controls without lifetime NSSI. Even though NSSI is generally associated with impulsive personality (Hamza et al., 2015), we did not observe self-reported impulsivity differences between these groups of community adults. This is possibly due to low prevalence of recent NSSI (only half reported past-year episodes), which may have also contributed to the absence of predicted group differences on the CGT. Analyses supported our second hypothesis, however: impulsive decision-making during criticism was associated with more past-year NSSI episodes, even after accounting for other correlates of NSSI frequency. Results also confirmed increased negative mood from baseline.

These findings suggest that adults engaging in frequent NSSI may behave impulsively (i.e., make riskier choices) under certain conditions of increased negative affect, e.g., when receiving challenging feedback in close relationships. The association between past-year NSSI frequency and impulsive choices, in the absence of decision-making deficits among individuals with lifetime NSSI histories, accords with the idea that laboratory tasks may be best characterized as state measures of neurocognitive impulsivity that are sensitive to changes in behavior (Liu et al., 2017). Individuals with more recent and frequent NSSI may be more vulnerable to the effects of criticism on decision-making, whereas those with distant NSSI histories might be better able to regulate their emotional and behavioral responses to criticism, mitigating its impact on decision-making. Future research is needed to determine whether this is a result of “recovery” from NSSI (either due to intervention or naturalistic

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processes) or if making safer choices during negative mood and/or in response to interpersonal stressors precedes reductions in NSSI.

Study 1 had several limitations, including a small sample of participants reporting NSSI, especially recently and with limited frequency overall. We therefore lacked statistical power to assess differences among participants in the NSSI group with and without past-year episodes. Additionally, we used a single item to determine group membership (based on presence or absence of lifetime NSSI) and we did not collect information about self-injurious behaviors beyond past-year NSSI frequency. The extent to which participants found the critical comments personally relevant was also unclear. We consequently sought to replicate the above findings while addressing some of these limitations, using a larger sample of participants reporting more recent and frequent NSSI.

5. Study 2

5.1. Methods and participants

Participants (n = 69; female n = 55; 79.7%) were English-speaking adults (age M =24.25, SD = 5.63) recruited online as part of a larger IRB-approved web-based study. To derive a sample with more recent and frequent NSSI, initial inclusion criteria included at least one past-year NSSI episode and at least 10 lifetime episodes. Most participants identified as White/Caucasian (n = 61; 88.4%), followed by Hispanic (n = 5; 7.2%), Multiracial (n = 4; 5.8%), Asian (n = 3; 4.3%), and Native American (n = 1; 1.4%). Most had completed some college (n = 36; 52.2%), over a third had an associate's (n = 4; 5.8%) or bachelor's degree or higher (n = 24; 34.7%), and five had a high school diploma (5.8%) or less (1.4%).

After providing digital consent, participants completed demographic, clinical, and personality questionnaires (including the SRS and BDI-II) hosted online. They then completed CGT procedures identical to those described in Study 1, with the additional step of downloading the stimulus presentation program. Before and after the CGT, participants' mood was measured using Visual Analogue Scales (see below).

As in Study 1, a plurality of participants imagined their mother delivering the CGT's critical comments (n = 28; 41.8%); approximately one-fifth identified another family member (n = 13; 19.4%), nine participants chose a romantic partner (13.4%), another nine (13.4%) chose "other" (e.g., boss, professor)[2], and six chose a friend (9.0%). One participant did not disclose their selection. Following the CGT, participants were asked how likely they were to receive those types of comments in their specified relationship (on a scale of 1 "not at all likely" to 10 "extremely likely"; mean = 6.00, SD = 3.02). Most indicated that their identified person was at least moderately likely (i.e., 5 or above) to give them similar feedback (n = 45; 67.2%), and over half (n = 35; 52.2%) rated them as very likely (i.e., 7 or above).

[2]This included three participants who imagined criticizing themselves. We excluded these individuals in follow-up analyses (available upon request) to confirm that primary results were unaffected.

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5.2. Additional measures

5.2.1. Self-Injurious Thoughts and Behaviors Interview (SITBI)—Participants completed an online self-report version of the SITBI (Nock et al., 2007) prior to the CGT. The SITBI assesses NSSI history, as well as presence, frequency, and other characteristics (e.g., methods) of self-injurious thoughts and behaviors. It has strong inter-rater reliability (mean $\kappa = 0.99$), 6-month test-retest reliability (mean $\kappa = 0.70$), and convergent validity with other measures of self-injury (Nock et al., 2007). The online and standard versions of the SITBI derive comparable estimates of NSSI status and frequency (Franklin et al., 2014). NSSI frequency variables were calculated as composites of self-cutting, burning, hitting, scraping skin to the point of drawing blood, inserting objects under the skin, and other methods comprising "moderate" NSSI (e.g., self-flagellation) causing observable tissue damage (i.e., causing bleeding or scarring). We adjusted outliers in past-year and lifetime frequency to account for potential recall biases and improve correlation estimates.[3]

5.2.2. Visual Analog Scales (VAS)—We evaluated negative mood before and after the CGT using VASs. Participants were asked to rate their negative mood "right now" on a scale from 0 (*not at all*) to 100 (*extremely*) using a digital slider on their screen. We have used such scales to assess mood in previous studies, which have demonstrated convergent validity with depressive symptoms (e.g., Fox et al., 2017; Hooley and St. Germain, 2014).

5.3. Data analysis

Prior to analyses, we determined that all participants spent a reasonable amount of time on the CGT to ensure they completed the task according to instructions. After calculating descriptive statistics characterizing sample demographics and self-injury (restricted to moderate NSSI, which resulted in the exclusion of two participants reporting only mild NSSI and/or indirect self-injury, e.g., binge-drinking), we used independent and paired *t*-tests to compare participants' CGT performance across studies and to perform a manipulation check on VAS scores before and after the CGT. We then conducted a one-way repeated-measures ANOVA on CGT performance during each block to assess decision-making throughout the task. As in Study 1, we calculated correlations to determine relationships among CGT impulsivity, NSSI frequency, suicide attempt history, self-criticism, and depressive symptoms, and subsequently constructed ZINB models[4] predicting NSSI frequency across different time periods from correlated variables. One participant had missing year/lifetime NSSI frequency data and another had missing VAS data; both were excluded from appropriate analyses.

6. Results

After adjusting outliers[3], participants reported an average of 839.88 lifetime NSSI episodes ($SD = 2{,}267.53$; $Mdn = 110.00$). Fifty-nine participants (89.4%) reported past-year NSSI (*M*

[3]Values above three standard deviations from the mean were replaced with the next value higher than the largest reported number of episodes beneath this threshold, resulting in one adjustment each in past-year and lifetime frequency.

[4]We constructed a standard negative binomial (NB) regression model for lifetime episodes, as all participants reported NSSI history. We also evaluated Poisson models when the dispersion parameter was non-significant, but Vuong statistics indicated superiority of the NB models in each case (results available upon request).

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= 40.89; *SD* =86.32; *Mdn* = 8.0), 34 (50.8%) in the past month (*M* = 7.12; *SD* = 19.43; *Mdn* = 1.0), and 21 (31.3%) in the past week (*M* = 1.96; *SD* = 5.48; *Mdn* = 0). Although all participants responded affirmatively to engaging in past-year NSSI on the initial screening measure, *n* = 10 (14.5%) described past-year episodes that qualified only as mild NSSI, but endorsed a history of confirmed moderate NSSI episodes prior to the past year. We retained these individuals in analyses to maximize study variance. The mean age of onset was 14.10 years (*SD* = 3.12), and participants had engaged in NSSI for an average of 9.54 years (*SD* = 6.08). The most common form of NSSI was cutting (*n* = 61; 91.0%), followed by self-battery (*n* = 48; 71.6%), and scraping to draw blood (*n* = 43; 64.2%). The majority (*n* = 59; 88.1%) endorsed two or more methods (*M* = 3.02; *SD* = 1.31; *Mdn* = 3.00). Most participants also reported psychological treatment history (*n* = 58; 86.6%) and seven (11.7%) had received medical treatment for NSSI-related damage. Over half (*n* = 43; 64.2%) were prescribed psychiatric medication, mainly antidepressants (*n* = 32; 47.8%). Twenty-nine participants (43.3%) additionally reported a suicide attempt history (past-year *n* = 6; 9%), with an average of 1.48 lifetime attempts (*SD* = 3.34).

Overall CGT impulsivity scores were similar in this sample (*M* = 7.61, *SD* = 34.69) to Study 1 (*M* = 4.24, *SD* = 33.68), *t*(129) = 0.56, *p* = 0.57, Cohen's *d* = 0.10. Participants again reported increased negative mood post-CGT (*M* = 58.80, *SD* = 27.45) relative to baseline (*M* = 52.47, *SD* = 25.91), *t*(65) = 4.62, *p* < 0.001, Cohen's *d* = 0.24. Unlike Study 1, there was no effect of CGT Block [*F*(3.34, 220.295) = 1.83, *p* = 0.14, partial η^2 = 0.03], indicating that Study 2 participants did not make fewer risky choices as the task progressed.

Correlational analyses revealed associations between CGT impulsivity and NSSI frequency in the past week, month, year, and lifetime (Table 4). Most frequency measures were associated with higher self-criticism and depressive symptoms, which we included in all regression models to facilitate comparisons across studies. Only CGT impulsivity accounted for significant variance in NSSI frequency in each model except past-month NSSI, on which self-criticism and depressive symptoms had effects (Table 5).

7. Discussion

Study 2 generally replicated findings from Study 1 in a larger sample of individuals with more recent, frequent, and better-characterized NSSI. Specifically, we again observed elevated negative mood post-CGT using a different assessment measure than Study 1. Participants also rated the criticism stimuli as moderately realistic and personally relevant. Impulsive decision-making during criticism was associated with more frequent NSSI, more recent (i.e., past-week and -month) NSSI, as well as a longer history of NSSI engagement (i.e., past-year and lifetime). Moreover, in regression models that also included self-criticism and depressive symptoms –established NSSI correlates – only CGT performance statistically predicted more NSSI episodes over the previous week, year, and lifetime.

Participants did not show improvement over the course of the CGT, in contrast to Study 1 and normative performance on the standard IGT (Bechara, 2007). Although Study 1 results suggested no group differences related to the presence of lifetime NSSI history in CGT performance across the task, statistical power to detect an interaction was limited. It is

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possible that NSSI is associated with failure to learn about the payoff schedule of the decks or simply with less concern about making risky choices. Alternatively, such a deficit may be restricted to recent NSSI, although again we lacked statistical power to adequately evaluate interactions between recent NSSI history and CGT block. However, findings also indicated that self-criticism and current depressive symptoms better account for past-month NSSI, whereas CGT impulsivity was more strongly associated with NSSI frequency over longer periods. It seems reasonable that depressive symptoms measured over the past two weeks account for greater variance in past-month NSSI than decision-making during *presently* elevated negative mood. Conversely, although the SRS is thought to capture stable tendencies towards self-criticism, participants may be biased towards recent cognitive patterns. These findings raise the possibility that CGT performance is sensitive both to state (e.g., current self-critical thoughts/feelings) and traits (e.g., negative urgency) involved in NSSI, reflected in its relationships with past-week and past-year/lifetime episodes, respectively.

Limitations of this study include reliance on web-based procedures, which introduced potential validity concerns regarding the CGT. We accordingly confirmed that participants completed the task in a comparable amount of time to the laboratory version before conducting analyses. These findings are further strengthened by concordance with CGT performance and increased negative mood in Study 1 (although to a lesser magnitude, possibly due to high baseline NA in this all-NSSI sample and/or use of a single-item measure, another limitation). Although participants were demographically similar, we did not assess impulsive personality or psychiatric diagnoses in Study 2, limiting cross-study comparison.

8. General Discussion

Prior work indicates a relationship between NSSI and self-reported impulsivity – particularly negative urgency – but not impulsive behavior, even during negative mood. Based on research showing heightened self-criticism and interpersonal conflict among people engaging in NSSI, this research examined the association between NSSI history and neurocognitive impulsivity in response to actual criticism. These studies used a novel approach to induce negative affect with ecological relevance to NSSI: critical feedback meant to be perceived in the context of an intimate relationship, embedded within a neuropsychological task. This manipulation increased negative mood in both studies. Results help reconcile inconsistencies between self-reported and task-based impulsivity, suggesting that NSSI may involve impulsive behavior while experiencing specific negative affective states, consistent with elevated negative urgency in this population.

Our main hypotheses were partially supported. Although risky decision-making during criticism was not associated with the presence of lifetime NSSI history, it was associated with multiple measures of NSSI frequency among those with NSSI histories, even after controlling for self-criticism and depressive symptoms. In regression analyses, each disadvantageous deck choice “predicted” one additional NSSI episode over the previous week (Study 2) and year (Studies 1 & 2), and nearly three lifetime episodes (Study 2). These cross-sectional models encourage prospective research to examine whether decision-making

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during affective challenges predict *future* NSSI. Based on results indicating that a) participants with lifetime NSSI histories show no decision-making deficit relative to controls and b) NSSI frequency and recency are associated with worse CGT performance, impulsive decision-making in response to criticism could represent an informative marker of NSSI course. Further work is needed to evaluate this possibility and determine the CGT's potential clinical utility. If susceptibility to the effects of negative emotional states on decision-making precedes increased NSSI frequency, researchers ought to investigate factors influencing the development of this vulnerability and whether it is amenable to intervention.

The present results contrast with prior research suggesting no evidence for neurocognitive impulsivity in NSSI at baseline mood (Janis and Nock, 2009; McCloskey et al., 2012), or during distress (Schatten et al., 2015), as well as with other studies finding no differences in neurobehavioral impulsivity between self-injurers and control groups (Liu et al., 2017). These studies are consistent, however, with literature supporting negative urgency as the primary component of impulsive personality in NSSI (Hamza et al., 2015), and with other work suggesting that NSSI is characterized by impairment in a specific inhibitory process, negative emotional response inhibition (NERI; Allen and Hooley, 2015, 2018). NERI refers to the ability to control impulses arising from negative affect (e.g., the urge to yell or cry when upset), which might be compromised in NSSI. NERI mediates a small portion of the shared variance between negative urgency and NSSI (Allen & Hooley, 2018), implicating other cognitive mechanisms in this trait, potentially including processes involved in decision-making under distress. The idiographic nature of the mood manipulations in the CGT (i.e., thinking of an important person) is an alternative (but not mutually exclusive) potential explanation for the divergence between these studies and prior investigations of decision-making in NSSI. This literature would benefit from a multidimensional characterization of impulsivity, with concurrent assessment using self-report and task-based measures corresponding to its convergent and divergent subcomponents.

An overall limitation of this work was the lack of multiple state assessments of self- and other-focused negative affect during the CGT. Employing domain-general measures of negative affect in Study 1 (the PANAS) and Study 2 (the VAS) increased reliability but prevented a thorough examination of specific mechanisms underlying neurocognitive impulsivity during critical feedback. We included dispositional self-criticism as a covariate (rather than a mediator) in regression models based on the EMA literature implicating momentary levels of criticism-related negative affect focused both on the self and other people in ecologically-assessed NSSI episodes. As the criticism stimuli in the CGT might "activate" self-referential or other-focused negative affect, or both, decision-making deficits in NSSI may be related to self-critical thoughts, feeling criticized by others, or some combination – likely involving between- and within-individual variation. Future studies should examine these potential mechanistic processes, using repeated assessment with granular, state-sensitive metrics to clarify how and why negative affect may elicit impulsive decision-making in NSSI. For example, VAS scales indexing specific forms of negative affect (e.g., self-dislike, aggression) could be administered more frequently throughout the CGT. Relatedly and in contrast to prior work (Jollant et al., 2005), we did not observe associations between suicide attempt history and neurocognitive impulsivity. Although these correlational results warrant caution due to sample size, they suggest that neurocognitive

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impulsivity as indexed by the IGT and the CGT potentially reflect distinct processes. It is also possible that introducing 20-second intervals alone might affect choice behavior, perhaps through providing distraction or an opportunity for deliberation, beyond the proposed effects of criticism. Future studies should therefore directly compare these tasks in healthy individuals as well as in those with a range of suicidal and nonsuicidal self-injurious behaviors. The contribution of diagnosable psychiatric illness to these findings is also unknown. Criticism stimuli were also presented non-randomly, and a female voice was used for all comments. Finally, although most participants reported that they were likely to experience the critical comments from identified persons in close relationships, we do not know whether these types of comments specifically increase proximal risk for NSSI. This limitation encourages research integrating the CGT with EMA; experiential sampling prior to the task could determine the types of comments most likely to result in NSSI, which could be personalized and integrated into each participant's CGT. Impulsive reward-seeking in the laboratory during criticism could then be evaluated in relation to subsequent naturalistic NSSI episodes in response to interpersonal conflict and self-critical thoughts during a second EMA period.

Together, these studies suggest that NSSI frequency *and* recency are associated with a specific aspect of neurocognitive impulsivity: risky decision-making during negative mood elicited by criticism. Results indicate that individuals who frequently and/or currently rely on NSSI to regulate aversive affect are more likely to make risky or impulsive decisions in response to interpersonal negative feedback. The absence of an overall deficit in emotional decision-making relative to healthy controls, in combination with associations between neurocognitive impulsivity during criticism and NSSI frequency and recency, suggests that this process operates distinctly from NERI, which was consistently impaired across a range of NSSI frequency and present in individuals who had not self-injured in years (Allen & Hooley, 2015, 2018). Since both constructs are theoretically linked to negative urgency, which increases risk for future NSSI (Riley et al., 2015), this personality trait should be examined in conjunction with negative affect-related neurocognitive (e.g., CGT performance) and neurobehavioral impulsivity (i.e., NERI) in longitudinal studies. This research may also have clinical implications: whether this process precedes or co-occurs with shifts in NSSI frequency, impulsive decision-making during negative mood – as indexed by this novel task – might inform NSSI assessment, treatment, and prevention.

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Highlights

- NSSI has not been associated with impulsive decision-making in past research.
- Research implicates self-criticism and feeling criticized in NSSI engagement.
- We examined decision-making during exposure to critical comments in two studies.
- Impulsive choices during criticism was associated with more frequent NSSI.
- NSSI may involve impulsive decision-making in specific negative affective contexts.

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Table 1

Study 1 Sample characteristics.

	NSSI (*n* = 33)	Control (*n* = 31)	Statistic (df), *p* value, effect size
Sex: *n* (%)			$\chi^2(1, 64) = 0.51$, $p = 0.48$, $\varphi = 0.09$
Female	25 (75.76)	21 (67.74)	
Male	8 (24.24)	10 (32.26)	
Ethnicity: *n* (%)			$\chi^2(4, 64) = 1.20$, $p = 0.88$, Cramer's $V = 0.14$
White/Caucasian	23 (69.7)	21 (67.74)	
Black/African-American	3 (9.1)	3 (9.68)	
Asian	5 (15.15)	3 (9.68)	
Hispanic/Latinx	1 (3.33)	2 (6.45)	
Mixed/Other	1 (3.33)	2 (6.45)	
Education: *n* (%)			$\chi^2(4, 64) = 4.13$, $p = 0.39$, Cramer's $V = 0.25$
High school diploma	2 (6.06)	4 (12.9)	
Some college or two-year degree	19 (57.58)	12 (38.71)	
Bachelor's degree	10 (30.3)	13 (41.94)	
Graduate degree	2 (6.06)	2 (6.45)	
Age	22.45 (4.36)	23.71 (7.19)	$t(62) = 0.85$, $p = 0.40$, Cohen's $d = 0.21$
Beck Depression Inventory-II***	18.30 10.51)	8.81 (7.42)	$t(62) = 4.15$, $p < 0.001$, Cohen's $d = 1.04$
SRS Self-criticism*	32.21 13.47)	24.29 10.85)	$t(62) = 2.58$, $p < 0.05$, Cohen's $d = 0.65$
SNAP-2 Impulsivity[1]	6.85 (4.37)	5.69 (4.03)	$t(60) = 1.08$, $p = 0.29$, Cohen's $d = 0.28$

Note. NSSI = nonsuicidal self-injury; SRS = Self-rating Scale; SNAP-2 = Schedule for Nonadaptive and Adaptive Personality-2. Values are *M* (*SD*) unless otherwise specified.

* $p < 0.05$

*** $p \leq 0.001$.

[1] Two control participants had missing data

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Table 2

Study 1 Linear correlations (n = 64).

	1	2	3	4	5
1. CGT Impulsivity[1]					
2. Past-year NSSI	0.30*				
3. Lifetime SA history (present = 1, absent = 0)	−0.07	−0.03			
4. SRS Self-criticism	0.19	0.39**	0.14		
5. SNAP-2 Impulsivity[2]	−0.08[3]	0.25*	0.13	0.08	
6. Beck Depression Inventory-II	0.09	0.48***	0.30*	0.73***	0.25

Note. CGT = Criticism Gambling Task. SA = suicide attempt.

* $p < 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$.

[1] n = 63

[2] n = 62

[3] n = 61.

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Table 3

Study 1 Multivariate regression model of past-year NSSI (n = 61).

	Zero-inflated negative binomial regression		
Predictors	**B (SE)**	**IRR**	**95% CI**
Intercept	1.79 (1.25)	6.00	0.52 – 6.97
CGT Impulsivity***	0.04 (0.01)	1.04	1.02 – 1.06
SRS Self-criticism	0.02 (0.04)	1.02	0.95 – 1.10
SNAP-2 Impulsivity	0.05 (0.05)	1.05	0.95 – 1.16
Beck Depression Inventory-II	−0.06 (0.04)	0.09	0.87 – 1.02

Note. B = Beta; SE = Standard error; IRR = Incident Rate Ratio

*** $p \leq 0.001$.

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Table 4

Study 2 Linear correlations ($n = 67$).

	1	2	3	4	5	6	7	8
1. CGT Impulsivity								
2. Past-week NSSI	0.24*							
3. Past-month NSSI	0.26*	0.96***						
4. Past-year NSSI[1]	0.27*	0.73***	0.76***					
5. Lifetime NSSI[1]	0.31**	0.33**	0.45***	0.65***				
6. Past-year SA	0.04	−0.02	−0.01	0.09	0.19			
7. Lifetime SA	−0.00	0.05	0.06	0.16	0.15	0.87***		
8. SRS Self-criticism	−0.02	0.26*	0.26*	0.27*	0.08	0.00	0.10	
9. BDI-II	0.16	0.29*	0.28*	0.23	0.08	0.07	0.16	0.63***

Note.

* $p < 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$

[1] $n = 66$.

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Table 5

Study 2 Multivariate regression models of NSSI frequency (n = 67).

Past-week predictors (ZINB)	**B (SE)**	**IRR**	**95% CI**
Intercept	−2.93 (4.06)	0.05	0.00 – 1.52
CGT Impulsivity *	0.03 (0.01)	1.03	1.01 – 1.06
SRS Self-criticism	0.03 (0.09)	1.03	0.87 – 1.22
Beck Depression Inventory-II	0.04 (0.31)	1.05	0.98 – 1.12
Past-month predictors (ZINB)			
Intercept **	−5.27 (1.63)	0.01	0.00 – 0.13
CGT Impulsivity	0.01 (0.01)	1.01	0.99 – 1.03
SRS Self-criticism *	0.11 (0.05)	1.12	1.03 – 1.23
Beck Depression Inventory-II *	0.05 (0.24)	1.05	1.00 – 1.10
Past-year predictors (ZINB)			
Intercept	0.31 (1.27)	1.36	0.11 – 16.21
CGT Impulsivity ***	0.02 (0.01)	1.02	1.01 – 1.03
SRS Self-criticism	0.06 (0.03)	1.06	0.99 – 1.14
Beck Depression Inventory-II	0.01 (0.01)	1.01	0.98 – 1.04
Lifetime predictors (Negative Binomial)			
Intercept ***	4.32 (0.98)	86.99	82.47 – 91.73
CGT Impulsivity ***	0.02 (0.01)	2.80	2.80 – 2.80
SRS Self-criticism	0.03 (0.03)	2.87	2.86 – 2.87
Beck Depression Inventory-II	0.01 (0.02)	2.67	2.67 – 2.67

Note. ZINB = zero-inflated negative binomial.

* $p < 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$.