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Suicide and Life-Threatening BEHAVIOR

ORIGINAL ARTICLE

# The role of reward sensitivity and childhood maltreatment in predicting nonsuicidal self-injury

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**Abstract**

**Objective:** Findings from prior research on reward sensitivity in nonsuicidal self-injury (NSSI) have been mixed. Childhood maltreatment is an independent risk factor for NSSI and for hyposensitivity to rewards. This study aimed to disentangle the role of reward sensitivity as a predictor of NSSI for those with an elevated severity of childhood maltreatment.

**Method:** In a diverse undergraduate sample ($N = 586$), trait reward sensitivity (i.e., behavioral approach system subscales) and the severity of maltreatment were assessed as predictors of a lifetime history of NSSI. In a subset of this sample ($n = 51$), predictors of NSSI urge intensity were measured using ecological momentary assessment.

**Results:** Individuals with elevated maltreatment who reported less positive responsiveness to rewards were more likely to have a lifetime history of NSSI. Those with elevated maltreatment who reported a *lower* likelihood to approach rewards experienced more intense NSSI urges across the ten-day observation period. However, those with elevated maltreatment who reported a *greater* likelihood to approach rewards experienced less intense NSSI urges.

**Conclusions:** The role of reward sensitivity as a cognitive risk factor for NSSI varies depending on childhood maltreatment history. Findings indicate that, for those with elevated maltreatment, hypersensitivity to approaching rewards may decrease risk for NSSI urges.

## 1 | INTRODUCTION

Nonsuicidal self-injury (NSSI), or the intentional destruction of body tissue without intent to die, is a critical public health issue that disproportionally impacts adolescents and young adults (Nock, 2010). Approximately 26.5% of adolescents (ages 12–21), 18.9% of young adults (ages 19–30), and 4.8% of adults (ages 30–92) endorse engaging in at least one type of NSSI behavior during their lifetime (Claes et al., 2014; Klonsky, 2011). Identifying distal static risk factors for NSSI, such as childhood maltreatment, allows us to determine who is at elevated risk for engaging in this behavior. However, without also identifying potentially modifiable risk factors, such as reward sensitivity, the field will continue to be stymied in its attempts to reduce NSSI (Liu, 2017). Examining the temporal relevance of modifiable risk factors in a naturalistic setting will help inform us on how best to intervene to prevent the onset or maintenance of NSSI.

## 1.1 | Childhood maltreatment as a risk factor for NSSI

Childhood maltreatment is associated with an increased probability of having both a lifetime and recent history of engaging in NSSI in community and clinical samples of adolescents and adults (Glassman et al., 2007; Di Pierro et al., 2012; Swannell et al., 2012; Thomassin et al., 2016; Weierich & Nock, 2008). Although the strength of this relationship varies depending on the type of maltreatment experienced, meta-analyses have found that emotional abuse, physical abuse, physical neglect, and sexual abuse are associated with NSSI (Liu et al., 2018; Maniglio, 2011). There is strong support for childhood maltreatment as an independent, distal risk factor for NSSI, which is illustrated in the four-function model, the biosocial theory of emotion dysregulation, and the more recent benefits and barriers model of NSSI (Courtney-Seidler et al., 2014; Hooley & Franklin, 2018; Nock, 2010). Specifically, the benefits and barriers model conceptualizes childhood maltreatment as prompting the development of a highly negative view of the self, which may reduce barriers to self-injury engagement, thus leading to greater risk for NSSI (Hooley & Franklin, 2018). Because childhood maltreatment is a consistent risk factor for NSSI that also is associated with changes in reward processing, we propose that maltreatment may account for variations in the relationship between reward sensitivity and NSSI.

## 1.2 | NSSI as rewarding stimuli

The four-function model conceptualizes NSSI as rewarding for both intrapersonal and interpersonal reasons because the behavior functions to reduce negative affect, increase positive or satisfying emotional states, increase positive social support, and/or decrease negative social interactions (Nock, 2010). According to a recent meta-analysis on NSSI functions, approximately 66%–81% of individuals report engaging for intrapersonal functions and approximately 32%–56% for interpersonal functions. Among those endorsing intrapersonal functions, inducing a positive state was endorsed by about half of participants (42%–57%), supporting the idea that NSSI is experienced as cognitively rewarding (Taylor et al., 2018). At a biological level, NSSI may be experienced as rewarding due to the release of endogenous opiates following self-injurious behaviors, which can lead to feelings of euphoria (Nock, 2010). Neurocognitive data also support the conception of NSSI as rewarding; adolescents and young adults with a lifetime history of NSSI behaviors had increased neural activation in reward-related brain regions in response to a mild pain induction, a proxy for NSSI (Osuch et al., 2014). Similar to other risky habitual behaviors (e.g., substance use), operant learning principles suggest that the receipt of a proximal and often instantaneous reward reinforces engagement in a behavior. Therefore, *hypersensitivity* to rewards may make an individual more vulnerable to the self-reinforcing properties of NSSI, especially over repeated engagement. Counterintuitively, prior work has indicated that those with a history of childhood maltreatment are *hyposensitive* to rewards. This study aimed to disentangle the risk or protective role for NSSI that reward sensitivity may play for those with elevated maltreatment severity.

## 1.3 | Reward sensitivity as a risk factor for NSSI

A significant portion of extant NSSI-related research has focused on reward learning. However, there remains a gap in our understanding of sensitivity to reward attainment and goal seeking as a potentially modifiable cognitive risk factor for NSSI. The behavioral approach system (BAS) is a neurobiological system that is posited to regulate motivation or goal-oriented approach behaviors and is proposed to regulate the negative and positive reinforcement value of both conditioned and unconditioned rewards (Pickering & Gray, 2001). Initial studies of trait BAS sensitivity levels and BAS-related brain activation have indicated that this system may serve as a biobehavioral mechanism influencing the onset and maintenance of NSSI. Greater levels of trait BAS activation have been associated with lifetime history and frequency of NSSI behaviors (Ammerman et al., 2017; Burke et al., 2015; Cerutti et al., 2012; Jenkins et al., 2013). Although few studies have examined the differentiation between the BAS subscales in relation to self-injury, the frequency of prior NSSI behaviors was found to be associated with greater trait BAS-Fun Seeking subscale scores (willingness to approach rewards impulsively) in two studies and with greater trait BAS-Drive subscale scores (a general tendency to approach rewards) in one study (Cerutti et al., 2012; Jenkins et al., 2013). There is a lack of research examining reward sensitivity in parallel with longitudinal assessments of NSSI thoughts or behaviors, particularly when accounting for maltreatment (Westlund et al., 2015).

There are mixed findings within this body of literature, which may be dependent on the type of NSSI engagement and type of reward stimuli measured, as well as the lack of accounting for maltreatment. For example, Jenkins et al. (2013) found that greater self-reported reward sensitivity was associated with the frequency of NSSI and the number of self-injurious methods, but not with the likelihood of having a lifetime history of NSSI (Jenkins et al., 2013). When exploring reward sensitivity as a risk factor, it is critical to examine multiple dimensions of NSSI, such as NSSI thoughts and behaviors. Recent analyses of EEG and blood oxygen level-dependent ("BOLD") responses in adolescent samples

have indicated that NSSI thoughts and behaviors are related to hyper-activation of BAS-related brain regions following the loss *and* the gain of monetary rewards (Poon et al., 2018; Tsypes et al., 2018; Vega et al., 2018) and hypo-activation in BAS-related regions when anticipating a monetary reward (Sauder et al., 2016). Although behavioral and neuroimaging measures of reward sensitivity have focused on monetary rewards, self-report measures of reward sensitivity, including the BAS subscales, inquire about tendencies to respond to both social and monetary rewards. Varying levels of sensitivity to different types of rewards (e.g., social vs monetary) and different stages of reward processing (anticipation/BAS-Drive vs consumption/BAS-Reward Responsiveness) may contribute to the mixed associations with NSSI engagement (Taylor et al., 2018). Finally, Ammerman et al. (2017) found that individuals with a history of NSSI had higher trait BAS levels, but that these differences were no longer significant after accounting for mutual risk factors related to reward sensitivity, NSSI, *and* childhood maltreatment (e.g., anxiety, depressive symptomology, impulsivity, substance use). None of these prior studies accounted for the role of childhood maltreatment, despite it being BAS-related and a consistent risk factor for engagement in NSSI. Our study will account for the type of NSSI engagement, the type of reward stimuli measured, and the severity of childhood maltreatment in our assessment of reward sensitivity as a risk factor for a lifetime history of NSSI behaviors and, for the first time, real-time observations of NSSI thoughts.

## 1.4 | The compounding effect of childhood maltreatment and reward sensitivity

Examining the compound effects of trait BAS levels and childhood maltreatment may help to reconcile the mixed results in regard to reward sensitivity as a risk factor for self-injury. Indeed, prior work has demonstrated that individuals with histories of childhood maltreatment experience lower reward sensitivity measured through differences in brain activation and corresponding trait BAS levels. Specifically, Marusak et al. (2015) found that children and adolescents who experienced at least one traumatic event during childhood reported lower levels of trait BAS-Reward Responsiveness (the degree to which one experiences positive responses to rewards), but not the Drive or Fun Seeking subscales. Results from behavioral task-based methods indicate that adolescents and young adults with a history of maltreatment were more likely to select riskier options faster than controls in monetary reward tasks and they did not adjust the speed of their selections in relationship to increases in the chance of winning (Birn et al., 2017; Guyer et al., 2006). Overall, this pattern demonstrates a suppression of sensitivity to the receipt of potential rewards and a lack of behavioral modification in order to optimally receive rewards for those individuals with a history of childhood maltreatment.

Prior neurobehavioral research consistently has shown blunted BOLD response in the ventral striatum, ACC, and orbitofrontal cortex in response to receiving or anticipating monetary rewards in individuals who have experienced childhood maltreatment (Teicher & Samson, 2016). This blunted response has been found in samples who have experienced many types of childhood adversity, including children, young adults, and adults who have experienced abuse (emotional, physical, or sexual), institutional neglect, and early family adversity (Boecker et al., 2014; Dillon et al., 2009; Hanson et al., 2015; Mehta et al., 2010). Specially, neuroimaging findings have indicated blunted neural response to the anticipation and receipt of rewards in youth with a history of maltreatment (McCrory et al., 2017).

Although this pattern of blunted reward sensitivity observed in those with a history of child maltreatment has been supported across measurement modalities, not all individuals who experience childhood maltreatment exhibit reward hyposensitivity. Indeed, heightened sensitivity to rewarding stimuli has been theorized to function as a potential buffer against the risk for developing psychopathology following the experience of childhood maltreatment (McLaughlin & Lambert, 2017). Therefore, for those with elevated severity of childhood maltreatment, greater BAS levels may function to protect against a propensity for NSSI.

## 1.5 | The present study

Current models of NSSI have theorized that childhood maltreatment and reward sensitivity both contribute to risk for the onset and maintenance of self-injurious thoughts and behaviors (Hooley & Franklin, 2018; Nock, 2010), but prior work has not investigated the interplay of these factors simultaneously. Although it is helpful to identify stable risk factors (i.e., childhood maltreatment), it is critical also to identify potentially modifiable cognitive risk factors (i.e., reward sensitivity) in order to advance treatments for NSSI. Identifying cognitive risk factors could allow us to further understand which young adults with a history of childhood maltreatment are at elevated risk for engaging in self-harming behaviors. Moreover, examining how self-injurious urges change over time is critical for understanding how cognitive risk factors, such as BAS levels, function to promote or suppress risk for self-harming behaviors (Liu, 2017). The current study fills these gaps by examining how the severity of childhood maltreatment affects the relationship between trait BAS-Reward Responsiveness, Drive, and Fun Seeking subscales and (a) the probability of having a lifetime history of repetitive NSSI, and (b) the intensity of NSSI urges experienced in real time over a 10-day

period utilizing ecological momentary assessment (EMA) methodology.

Based on extant evidence, more elevated childhood maltreatment and greater BAS levels were expected to be independently associated with a greater likelihood of having a lifetime history of NSSI behavior and with a greater intensity of NSSI urges over the 10-day EMA period (Liu et al., 2018). However, heightened reward sensitivity has been found to potentially protect against the development of psychopathology following the experience of childhood maltreatment. Thus, it was hypothesized that for participants with elevated severity of childhood maltreatment, those with higher BAS levels would have a lower propensity for NSSI (e.g., lower likelihood of a history of NSSI, lower intensity of NSSI urges) and those with lower BAS levels would have a higher propensity for NSSI (McLaughlin & Lambert, 2017).

## 2 | METHOD

### 2.1 | Participants and procedures

Participants were young adults from an urban university recruited to participate in a study of sleep, cognition, and self-destructive behaviors. Inclusion criteria for the primary study were being ages 18–25 and having written and verbal English proficiency. A total of 813 participants consented to participate in the screening protocol (45.3% non-white, 78.7% female) and completed questionnaires online through the Temple Psychology Research Participation System. A subset of participants ($n = 123$) who completed the screener were eligible to complete the primary study, which included two parts, an in-person assessment followed by an EMA protocol. To be included in the primary study, participants must have had either a history of repetitive NSSI (at least two acts during their lifetime) or no history of NSSI reported. These two groups were determined by a self-report questionnaire from the screener assessing NSSI behavior (Deliberate Self-Harm Inventory; Gratz, 2001) and confirmed by an in-person interview measure (Self-Injurious Thoughts and Behaviors Interview; Nock et al., 2007).

The young adults from the screener and primary study samples who completed measures of childhood maltreatment and reward sensitivity were selected for the current analytic sample. The analytic screener sample ($n = 586$) was ethnically diverse, but predominantly female ($M^{age}$ =20 years old, 45.9% non-white, 78.0% female; see Table 1 for additional descriptive statistics). Although 125 participants completed the EMA portion of the study, the analytic primary study sample ($n = 51$; control group: $n = 19$ and NSSI group: $n = 32$) was comprised of those who participated in the EMA portion of the study who met study eligibility criteria and who completed the measure of childhood maltreatment (added in a later modification to the study protocol); this sample was equally diverse as those included in the analytic screener sample ($M^{age}$ =20 years old, 32.7% non-white, 91.2% female).

Participants who enrolled in the primary study completed initial in-person diagnostic interviews and behavioral tasks, then began the 10-day EMA protocol the following day. For this 10-day period, links to a self-report questionnaire administered through Qualtrics were texted to participants three times per day at randomly determined times within each of three intervals (morning, afternoon, evening) throughout a 12-hour window of the participants' choosing. Each questionnaire took about 2–4 minutes to complete, and the participants were instructed to complete the assessments within 30 minutes of receiving the text message alerts. Participants completed 87.3% of the total possible EMA alerts; thus, the sample included 1335 observations. For this analytic sample, 214 observations were excluded because the participant did not respond to the text message alert within 30 minutes of receipt. This resulted in 1121 observations ($n = 51$) for the final analytic sample.

### 2.2 | Measures

#### 2.2.1 | Screener assessment

##### *2.2.1.1 | Childhood maltreatment severity*

The Childhood Trauma Questionnaire (CTQ; Bernstein et al., 2003) is a 28-item self-report questionnaire that measures the severity of emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect. Participants were asked to rate each item using a 5-point Likert scale ranging from 1 (*Never True*) to 5 (*Very Often True*). Higher scores indicate a more elevated history of childhood maltreatment. This measure has demonstrated good criterion-related validity and has been psychometrically validated in samples of adult and adolescent psychiatric and community samples (Bernstein et al., 2003). Internal consistency of the total score on the CTQ was $\alpha = 0.93$.

##### *2.2.1.2 | Trait reward sensitivity*

Reward sensitivity was measured by the Behavioral Activation subscales, including Drive, Fun Seeking, and Reward Responsiveness, from the Behavioral Inhibition System/Behavioral Activation System Scales (BIS/BAS; Carver & White, 1994). Specifically, the BAS-Fun Seeking subscale measures a willingness or desire to approach novel rewards spontaneously (e.g., "I'm always willing to try something new if I think it will be fun"), the Drive subscale measures a tendency to approach rewards (e.g., "When I want something I usually go all-out to get it"), and the Reward Responsiveness subscale measures the degree to

**TABLE 1** Means, standard deviations, and correlations for study variables

| Variable | *M/n* | *SD/%* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Screener variables ($n = 586$) | | | | | | | | | | | | | |
| 1. CTQ Total Score | 37.58 | 14.13 | | | | | | | | | | | |
| 2. NSSI Lifetime History (Ref. Yes) | 128 | 21.8 | .23** | | | | | | | | | | |
| 3. Suicidality Lifetime History (Ref. Yes) | 87 | 14.8 | .31** | .40** | | | | | | | | | |
| 4. Age | 20.04 | 1.52 | .02 | .01 | .03 | | | | | | | | |
| 5. Gender (Ref. Non-male) | 457 | 78.0 | .08* | .10* | .13** | −.06 | | | | | | | |
| 6. Race (Ref. Non-white) | 269 | 45.9 | .14** | −.20** | −.02 | .05 | −.05 | | | | | | |
| 7. BAS-DR Subscale | 11.45 | 2.45 | −.02 | −.15** | −.11** | −.02 | −.06 | .08 | | | | | |
| 8. BAS-FS Subscale | 12.30 | 2.31 | −.00 | −.10* | −.04 | −.08 | −.06 | .01 | .56** | | | | |
| 9. BAS-RR Subscale | 17.37 | 2.21 | −.24** | −.18** | −.14** | −.06 | −.01 | .04 | .50** | .52** | | | |
| Momentary assessment variables ($n = 51$, observations = 1,121) | | | | | | | | | | | | | |
| 10. Intensity of NSSI Momentary Urge | 0.38 | 1.40 | .21** | .24** | .13** | −.06 | .08** | −.02 | −.12** | .02 | −.04 | | |
| 11. NSSI Lifetime History EMA Group (Ref. Yes) | 32 | 62.7 | .49** | .83** | .39** | .10** | .21** | −.19** | −.01 | −.08** | −.13** | .21** | |
| 12. Momentary Intensity of Sadness | 1.85 | 2.37 | .39** | .39** | .33** | .06* | .16** | −.07* | −.05 | .03 | −.03 | .48** | .39** |

*Note<del author="Lauren B Alloy" command="Delete" timestamp="1603919068275" title="Deleted by Lauren B Alloy on 10/28/2020, 5:04:28 PM" class="reU3">.</del>: M* and *SD* are used to represent mean and standard deviation, respectively. Pearson's correlation coefficients are displayed. All predictors were mean centered. NSSI =Nonsuicidal self-injury; CTQ = Childhood Trauma Questionnaire; BAS = Behavioral Activation System; BAS-RR =Reward Responsiveness subscale; BAS-DR = Drive subscale; BAS-FS = Fun Seeking subscale.

*$p < 0.05$,

**$p < 0.01$.

which one experiences positive responses to rewards (e.g., "When good things happen to me, it affects me strongly"). Participants are asked to respond to 20 items on the self-report questionnaire using a 4-point Likert-type scale ranging from 1 (*Very false for me*) to 4 (*Very true for me*). The BIS/BAS scales have demonstrated good internal consistency and retest reliability (Carver & White, 1994). Higher BAS subscale scores represent greater reward sensitivity. Internal consistency was relatively consistent across the BAS subscales (Drive: α = .78; Fun Seeking: α = .69; Reward Responsiveness: α = 0.76).

#### *2.2.1.3 | Lifetime history of NSSI*

A lifetime history of repetitive NSSI was operationalized as at least two past NSSI acts assessed with the Deliberate Self-harm Inventory (DSHI). The DSHI (Gratz, 2001) assesses how often participants have "intentionally (i.e., on purpose)" engaged in each of 17 types of NSSI behaviors (e.g., cutting, carving, burning) and, if a behavior was endorsed, participants then were asked follow-up questions about frequency and severity of behaviors. To ensure only NSSI was endorsed on this questionnaire, we modified the DSHI to add the clause, "without intending to kill yourself"

to the end of each prompt. Prior work has supported the DSHI's internal consistency, test–retest reliability, and construct, discriminant, and convergent validity (Fliege et al., 2006; Gratz, 2001). Internal consistency was $\alpha = .67$, which is adequate given the checklist nature of the measure.

In conjunction with DSHI screener responses, lifetime history of repetitive NSSI group classification was confirmed for participants in the EMA protocol with the clinician-rated Self-Injurious Thoughts and Behaviors Interview (SITBI; Nock et al., 2007). The SITBI is a semi-structured interview measuring the presence of self-injurious thoughts and behaviors, including NSSI, suicidal ideation, suicide plans, gestures, and attempts. The frequency and characteristics of endorsed types of self-injury were assessed. In clinical and non-clinical settings, this interview demonstrated strong psychometric properties, such as inter-rater reliability ($K = 0.99$), construct validity, and test–retest reliability ($K = 0.70$; Nock et al., 2007).

#### *2.2.1.4 | Lifetime history of suicidal behavior*

A lifetime history of suicidal behavior was assessed using a modified version of the Beck Scale for Suicide Ideation (BSS; Beck & Steer, 1991). The BSS includes two questions inquiring about any prior suicide attempts across the lifetime, and in the current study, two questions were added inquiring about a history of aborted suicide attempts and interrupted suicide attempts. In the current study, history of suicidal behavior was operationalized as at least one report of a past suicide attempt, interrupted suicide attempt, or aborted suicide attempt. NSSI and childhood maltreatment both have been repeatedly identified as strong risk factors for suicidal behaviors (Ribeiro et al., 2016). Therefore, we chose to include a lifetime history of suicidal behavior as a covariate in study analyses (Asarnow et al., 2011; Wilkinson et al., 2011).

### 2.2.2 | Ecological momentary assessment

#### *2.2.2.1 | Momentary urges of NSSI*

At each daily signal contingent alert sent over the 10-day EMA observation period, participants were asked about the intensity of their urge to engage in NSSI "since the last alert" and "right now." Items were scored on a scale of 0-9, with 0 (*None at All*) and 9 (*Very Intense*). These two scores were compared within each individual at each alert interval and the higher score was selected to represent the highest intensity of the NSSI urge experienced at each of the 30 EMA assessments.

#### *2.2.2.2 | Momentary intensity of sadness*

At each daily signal contingent alert, participants were asked about the current intensity of their sadness ("Right now, to what extent are you feeling sadness?"). Items were scored on a scale of 0-9, with 0 (*Not at All*) and 9 (*Very Much*).

### 2.2.3 | Statistical analysis

Initial correlations and logistic regressions were conducted in SPSS version 24 (IBM Corp, 2016). Preliminary analyses examined Pearson's correlations between theory-driven potential covariates (i.e., age, gender, race, observation-level sadness, suicidal behavior history) and outcome variables. Significant variables were included as covariates in primary analyses.

The relationship between trait BAS levels, childhood maltreatment severity, and the probability of having a lifetime history of repetitive NSSI was assessed with binary logistic regressions. Mixed-effects regression models were utilized to assess whether trait BAS levels and childhood maltreatment severity predicted the momentary intensity of NSSI urges. Analyses of model fit for the mixed-effects regressions were assessed based on the Akaike information criterion (AIC), overdispersion testing, and testing for the underfitting of predicted and observed zeros in the outcome variable. The momentary intensity of NSSI urges was positively skewed and included an excess of zeros with 115 non-zero observations out of the 1121 total observations. Therefore, zero-inflated negative binomial mixed-effects models were fitted for these analyses using the R version 3.5.1 package glmmTMB (Brooks et al., 2017).

All regression models first were fit to assess the main effects of childhood maltreatment and each measure of reward sensitivity; trait BAS subscales each were assessed in individual models. Then, each model was run again, adding the interaction between childhood maltreatment and each trait BAS subscale. Logistic regression models accounted for the effects of lifetime suicidal behavior, gender, and race as covariates. Mixed-effects models accounted for the effects of gender, lifetime suicidal behavior, momentary intensity of sadness, and lifetime history of repetitive NSSI based on EMA group as covariates. Mixed-effects models were estimated using restricted maximum likelihood and allowed the intercept to vary randomly by each participant. Our models assumed that the absence of momentary NSSI urges would vary by lifetime history of repetitive NSSI, and this variable was included as a zero-inflation probability factor in all mixed-effects models. The zero-inflation probability always was modeled with a logit link. When interpreting any significant interactions, childhood maltreatment was considered the moderator and the simple slopes of reward sensitivity were estimated at low (−1 SD below the mean), moderate (at the mean), and high (1 SD above the mean) levels of childhood maltreatment severity.

**TABLE 2** Log odds of a lifetime history of engaging in nonsuicidal self-injury

| | Dependent variable: NSSI Lifetime History (Yes/No) | | | | | |
|---|---|---|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** | **Model 4** | **Model 5** | **Model 6** |
| Intercept | −1.496** | −1.452** | −1.465** | −1.488** | −1.460** | −1.472** |
| | (0.285) | (0.288) | (0.285) | (0.287) | (0.285) | (0.286) |
| CTQ Total Score (Z) | 0.340** | 0.465** | 0.416** | 0.406** | 0.409** | 0.421** |
| | (0.116) | (0.125) | (0.114) | (0.115) | (0.114) | (0.114) |
| Suicidality Lifetime History (Ref. Yes) | 1.960** | 1.964** | 1.918** | 1.933** | 1.981** | 2.001** |
| | (0.282) | (0.285) | (0.283) | (0.284) | (0.282) | (0.283) |
| Gender (Ref. Non-male) | 0.314 | 0.290 | 0.276 | 0.290 | 0.287 | 0.285 |
| | (0.302) | (0.305) | (0.303) | (0.304) | (0.303) | (0.304) |
| Race (Ref. Non-white) | −1.339** | −1.314** | −1.329** | −1.321** | −1.359** | −1.370** |
| | (0.259) | (0.259) | (0.258) | (0.258) | (0.257) | (0.258) |
| BAS-RR Subscale (Z) | −0.272* | −0.404** | | | | |
| | (0.111) | (0.120) | | | | |
| CTQ Total Score X BAS-RR (Z) | | 0.306** | | | | |
| | | (0.107) | | | | |
| BAS-DR Subscale (Z) | | | −0.288* | −0.313** | | |
| | | | (0.115) | (0.119) | | |
| CTQ Total Score X BAS-DR (Z) | | | | 0.092 | | |
| | | | | (0.114) | | |
| BAS-FS Subscale (Z) | | | | | −0.236* | −0.275* |
| | | | | | (0.111) | (0.114) |
| CTQ Total Score X BAS-FS (Z) | | | | | | 0.192 |
| | | | | | | (0.119) |
| Nagelkerke $R^2$ | 0.291 | 0.309 | 0.292 | 0.293 | 0.288 | 0.294 |
| Model Chi-Square | 122.90** ($df = 5$) | 131.49** ($df = 6$) | 123.31** ($df = 5$) | 123.96** ($df = 6$) | 121.47** ($df = 5$) | 124.06** ($df = 6$) |

*Note:* Log-odds units are displayed, and standard errors are shown in parentheses ($n = 586$); NSSI = Nonsuicidal self-injury; CTQ = Childhood Trauma Questionnaire; BAS = Behavioral Activation System; BAS-RR = Reward Responsiveness subscale; BAS-DR = Drive subscale; BAS-FS = Fun Seeking subscale; Z = Z-standardized.

*$p < 0.05$.

**$p < 0.01$.

# 3 | RESULTS

## 3.1 | Initial analyses

As seen in Table 1, lifetime history of repetitive NSSI, childhood maltreatment, and lifetime history of suicidal behavior all were positively correlated with each other at a moderate level. Higher trait BAS subscales were negatively associated with a lifetime history of repetitive NSSI. Higher trait BAS-Drive scores also were negatively associated with the momentary intensity of NSSI urges. Covariates in subsequent models were determined by the initial correlations, which indicated that gender and race were associated significantly with a lifetime history of repetitive NSSI, and gender was associated with the intensity of NSSI urges.

## 3.2 | Associations with a lifetime history of NSSI

As seen in Table 2, the unconditional main effects indicate that those with more elevated childhood maltreatment and lower reward sensitivity across all three BAS subscales were more likely to have a lifetime history of repetitive NSSI, even after controlling for an individual's history of suicidal behavior, gender, and race. As seen in Table 2, Model 2, only the interaction effect of childhood maltreatment severity and trait BAS-Reward Responsiveness predicted the odds of having a lifetime history of repetitive NSSI ($\chi^2(6, N = 586) = 131.49$, $p < 0.0005$). As shown in Figure 1, those participants with more elevated childhood maltreatment who reported generally experiencing less positive responses to

rewards (i.e., lower trait BAS-Reward Responsiveness) were more likely to have a lifetime history of NSSI. Inversely, those participants with low and moderate levels of childhood maltreatment who reported experiencing more positive responses to rewards were less likely to have a lifetime history of NSSI.

### 3.3 | Predictors of NSSI urges per momentary assessment

Childhood maltreatment and trait reward sensitivity (i.e., BAS subscales) as predictors of momentary NSSI urge intensity were assessed using zero-inflated negative binomial mixed effect regressions. As seen in Table 3 (Models 1–6), those with more elevated childhood maltreatment had more intense NSSI urges. Additionally, the zero-inflation model estimates indicated that if a participant had a lifetime history of repetitive NSSI, then they were significantly more likely to have momentary NSSI urges. As seen in Model 4, only the interaction effect of childhood maltreatment severity and trait BAS-Drive predicted the intensity of NSSI urges across the EMA observation period. As shown in Figure 2, individuals with more elevated maltreatment who reported a *lower* likelihood to approach rewards (i.e., lower trait BAS-Drive) had more intense NSSI urges. However, those with more elevated maltreatment who reported a *greater* likelihood to approach rewards had less intense NSSI urges.

## 4 | DISCUSSION

To identify novel intervention targets to reduce imminent risk of NSSI, potentially modifiable and proximal risk factors for NSSI must be ascertained. Reward sensitivity is one such candidate risk factor, but the literature on the relationship between reward sensitivity and NSSI has been mixed, with some findings indicating that the marker of elevated risk is reward *hyper*sensitivity, and others, *hypo*sensitivity (Westlund Schreiner et al., 2019). Prior evidence suggests that the presence of childhood maltreatment may clarify the conditions under which reward sensitivity serves as a risk or protective factor for NSSI. Our findings partially supported our hypotheses.

When examining maltreatment and reward sensitivity as independent risk factors, greater severity of childhood maltreatment was confirmed as a strong correlate of past NSSI behavior and as a risk factor for prospective NSSI urges. This pattern is in line with prior evidence demonstrating that the severity of childhood maltreatment is a strong risk factor for NSSI (Liu et al., 2018; Maniglio, 2011). This was the first study to demonstrate that elevated childhood

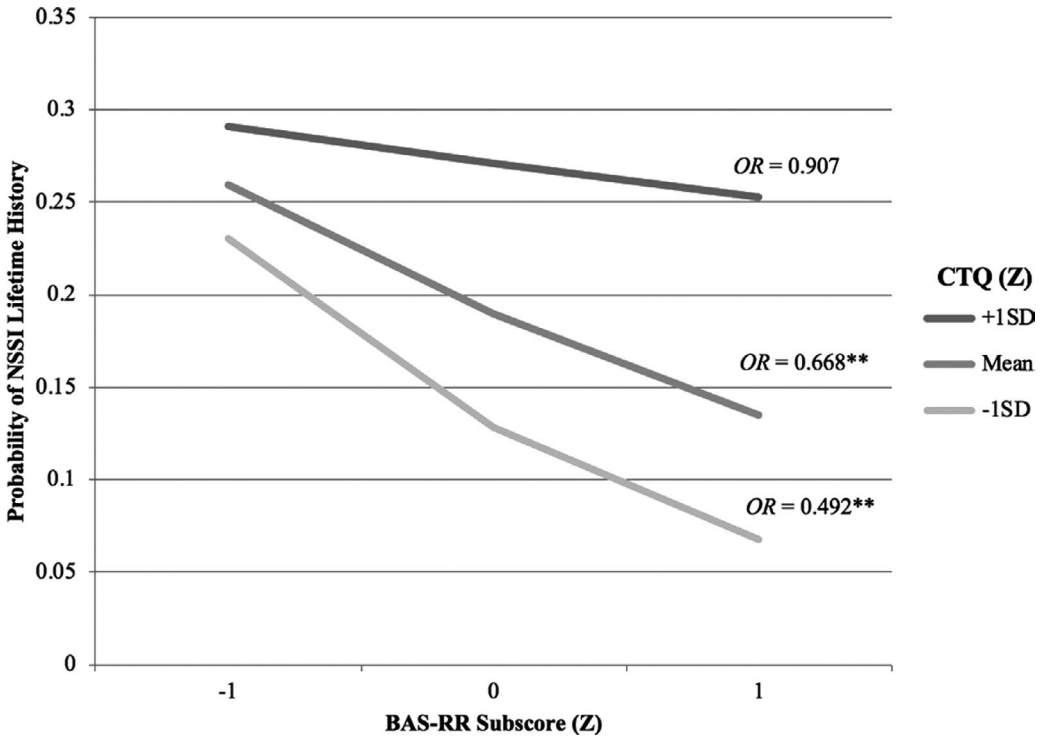


**FIGURE 1** The relationship between BAS-Reward Responsiveness and the probability of having a lifetime history of NSSI as moderated by childhood maltreatment, controlling for lifetime suicidal behavior, gender, and race. Odds ratios (OR) are displayed. NSSI = Nonsuicidal self-injury; CTQ = Childhood Trauma Questionnaire; BAS-RR = Behavioral Activation-Reward Responsiveness subscale; Z = Z-standardized; *$p < 0.05$, **$p < 0.01$

**TABLE 3** Trait behavioral activation levels predicting the momentary intensity of the urge to engage in nonsuicidal self-injury

| | Dependent variable: Momentary Intensity of NSSI Urge | | | | | |
|---|---|---|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** | **Model 4** | **Model 5** | **Model 6** |
| Intercept | 0.01* (0.00–0.48) | 0.01* (0.00–0.38) | 0.01* (0.00–0.46) | 0.02* (0.00–0.63) | 0.01* (0.00–0.54) | 0.01* (0.00–0.46) |
| CTQ total score (Z) | 2.61* (1.04–6.54) | 2.32 (0.91–5.90) | 2.87* (1.17–7.04) | 3.65** (1.46–9.11) | 2.82* (1.04–7.62) | 3.78* (1.32–10.85) |
| Suicidality lifetime history (Ref. Yes) | 0.39 (0.06–2.50) | 0.33 (0.05–2.14) | 0.41 (0.07–2.43) | 0.46 (0.09–2.46) | 0.38 (0.06–2.48) | 0.32 (0.05–1.89) |
| NSSI lifetime history (Ref. Yes) | 3.63 (0.27–49.47) | 4.14 (0.30–56.62) | 2.85 (0.22–36.37) | 2.31 (0.19–27.35) | 3.26 (0.24–44.85) | 3.60 (0.27–47.20) |
| Gender (Ref. Non-male) | 1.37 (0.05–40.51) | 1.79 (0.06–53.14) | 1.78 (0.06–52.01) | 1.31 (0.06–30.93) | 1.30 (0.04–38.43) | 1.62 (0.07–40.46) |
| Momentary intensity of sadness (Z-PC) | 2.34** (1.92–2.86) | 2.35** (1.93–2.87) | 2.34** (1.92–2.86) | 2.33** (1.92–2.84) | 2.35** (1.92–2.86) | 2.34** (1.92–2.85) |
| BAS-RR subscale (Z) | 1.02 (0.46–2.29) | 1.07 (0.47–2.40) | | | | |
| CTQ total score X BAS-RR (Z) | | 0.69 (0.28–1.74) | | | | |
| BAS-DR subscale (Z) | | | 0.51 (0.22–1.19) | 0.55 (0.24–1.25) | | |
| CTQ total score X BAS-DR (Z) | | | | 0.32* (0.11–0.97) | | |
| BAS-FS subscale (Z) | | | | | 0.84 (0.38–1.86) | 1.07 (0.48–2.40) |
| CTQ total score X BAS-FS (Z) | | | | | | 0.42 (0.14–1.22) |
| Zero-inflated model | Odds ratios | | | | | |
| Intercept | 1.93 (0.23–16.24) | 1.90 (0.22–16.30) | 2.13 (0.25–18.03) | 2.13 (0.25–18.25) | 1.97 (0.23–16.52) | 1.87 (0.22–16.15) |
| NSSI lifetime history (Ref. Yes) | 0.06* (0.01–0.60) | 0.06* (0.01–0.62) | 0.05* (0.01–0.55) | 0.05* (0.01–0.56) | 0.06* (0.01–0.59) | 0.06* (0.01–0.63) |
| Random effects | Variance components | | | | | |
| $\sigma^2$ | 6.63 | 6.63 | 6.63 | 6.63 | 6.63 | 6.63 |
| $\tau_{00}$ | 4.26* | 4.07* | 3.81* | 3.27* | 4.31* | 3.70* |
| Marginal $R^2$ | 0.210 | 0.213 | 0.243 | 0.249 | 0.211 | 0.252 |

*Note::* Incidence rate ratios are displayed, and confidence intervals (95%) are shown in parentheses ($n = 51$, observations = 1,121). NSSI lifetime history was determined by EMA group status. NSSI = Nonsuicidal self-injury; CTQ = Childhood Trauma Questionnaire; BAS = Behavioral Activation System; BAS-RR = Reward Responsiveness subscale; BAS-DR = Drive subscale; BAS-FS = Fun Seeking subscale; Z = Z-standardized.

*$p < 0.05$,

**$p < 0.01$ (according to profile confidence interval for $\tau_{00}$).

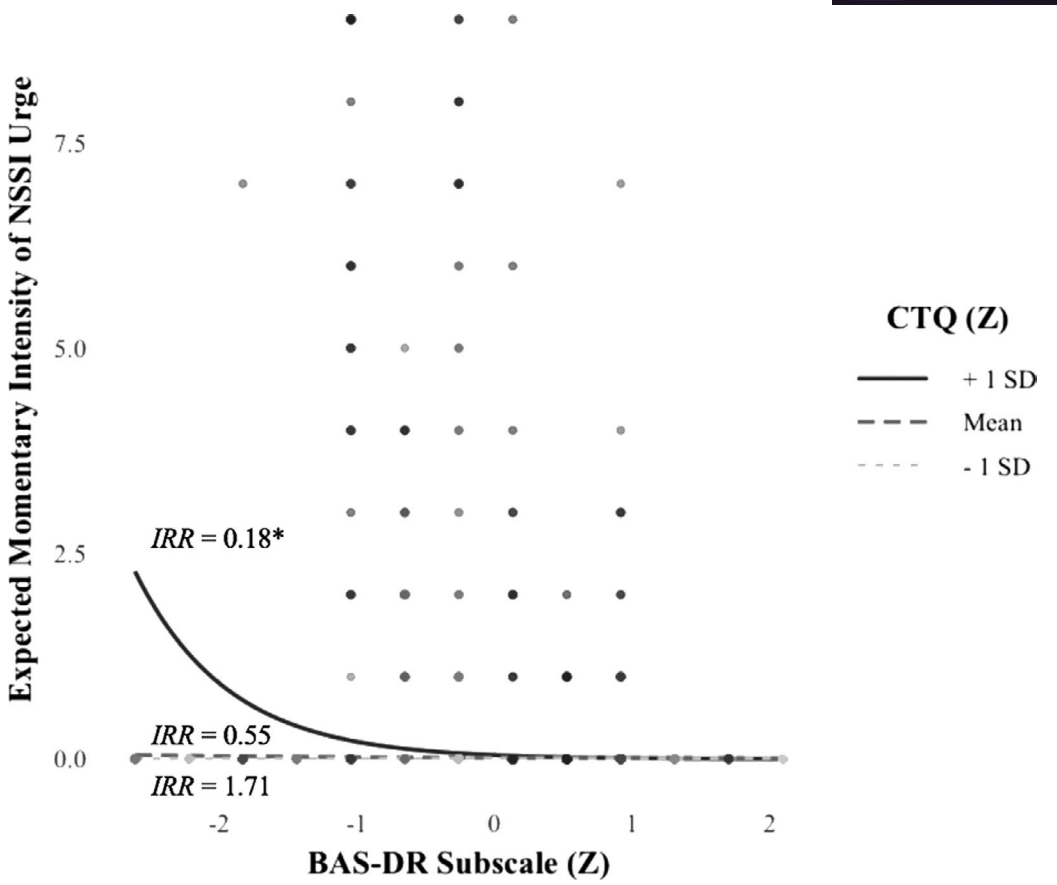


**FIGURE 2** The relationship between the trait BAS-Drive subscale and the expected intensity of an urge to engage in NSSI per momentary assessment as moderated by childhood maltreatment, controlling for the random participant effect, a lifetime suicidal behavior, lifetime NSSI based on EMA group, gender, and momentary intensity of sadness. Incidence rate ratios (IRR) are displayed. NSSI = Nonsuicidal self-injury; CTQ = Childhood Trauma Questionnaire; BAS-DR =Behavioral Activation-Drive subscale; Z = Z-standardized; $*p < 0.05$, $**p < 0.01$

maltreatment severity also is a risk factor for the intensity of NSSI urges assessed in a naturalistic setting through employing EMA. Additionally, it was hypothesized that individuals with *more* sensitivity to or willingness to approach rewards would be more likely to have a history of NSSI and would have more intense NSSI urges. However, this hypothesis was not supported in any of our models. For NSSI urges, no relationship was found with trait reward sensitivity as an independent predictor of momentary urge intensity. For a history of NSSI behavior, counter to our original hypothesis, participants with less sensitivity to or willingness to approach rewards (i.e., lower trait BAS subscales) were more likely to have a history of NSSI when holding childhood maltreatment constant. Our findings align with prior neuroimaging evidence indicating blunted activation in BAS-related neural regions when anticipating a monetary reward among adolescents with a history of NSSI (Sauder et al., 2016). However, these findings were counter to prior evidence showing that greater trait BAS levels have been associated with lifetime history and frequency of NSSI behaviors (Ammerman et al., 2017; Burke et al., 2015; Cerutti et al., 2012; Jenkins et al., 2013). It is possible that our analysis did not replicate the finding of reward hypersensitivity as an independent risk factor for NSSI because the previous examinations did not account for childhood maltreatment.

To clarify the conditions under which reward sensitivity might serve as a risk or protective factor for NSSI, several analyses with the severity of childhood maltreatment as the moderator were run. It was hypothesized that for participants with high childhood maltreatment, those with low BAS levels would be most likely to experience NSSI and those with higher BAS levels would be less likely to experience NSSI. As Figure 1 shows, those participants with more elevated childhood maltreatment who reported generally experiencing less positive responses to rewards (i.e., lower trait BAS-Reward Responsiveness) had the highest likelihood of prior NSSI behaviors. However, as the level of trait BAS-Reward Responsiveness levels increased, the likelihood of having a history of NSSI did not decrease to a significant degree for those with high childhood maltreatment, partially supporting our hypothesis for only BAS-Reward Responsiveness. These findings align with prior work indicating that youth who experienced childhood trauma reported lower levels of the trait

BAS-Reward Responsiveness subscale specifically (Marusak et al., 2015). Our findings extend prior evidence by indicating that this pattern of blunted positive responses to receiving rewards for those with a history of maltreatment may increase an individual's vulnerability for engaging in NSSI behaviors.

Although trait levels of BAS-Drive did not have an independent association with NSSI urges (Table 3, Model 3), the interaction between childhood maltreatment and trait BAS-Drive did predict the intensity of NSSI urges. As Figure 2 indicates, only participants with more elevated childhood maltreatment who reported being generally *less* likely to approach rewards (i.e., lower trait BAS-Drive) had more intense thoughts of NSSI. Additionally, those with more elevated childhood maltreatment who reported being *more* likely to approach rewards had less intense thoughts of NSSI, indicating that higher levels of trait BAS-Drive may function as a possible protective factor as hypothesized (Figure 2). Reward hypersensitivity has been theorized to function as a potential buffer against the risk for developing psychopathology following the experience of early life stress, including childhood maltreatment (Iadipaolo et al., 2017; McLaughlin & Lambert, 2017). Unfortunately, prior work across behavioral and neurocognitive measures has indicated a suppression of reward sensitivity for those with a history of childhood maltreatment (Birn et al., 2017; Guyer et al., 2006; Marusak et al., 2015). Our findings indicate that being more willing to approach rewards may decrease the intensity of NSSI urges for those with a history of childhood maltreatment. Willingness to approach rewards (i.e., higher trait BAS-Drive) may function protectively by increasing the diversity and frequency of alternative reward options to assist with affect regulation, a key motivator for engaging in NSSI.

There are several strengths of this study, including the relatively large sample of diverse young adults for the lifetime history of NSSI analyses. Our sample of young adults was drawn from a university, which may limit the generalizability of our findings to some degree. Another strength is the use of an ecologically valid assessment method to assess NSSI urges. As self-reports are limited due to recall biases, this momentary random sampling technique allows for an assessment of the intensity of NSSI urges that more directly mirror our participants' experiences. EMA measurement techniques may be particularly effective for young adults engaging in self-harm due to barriers to self-disclosure and help-seeking (Rowe et al., 2014).

This study employed a relatively small EMA sample covering a brief observation period with wide variation in the recency of engagement and severity of NSSI. These limitations increase the need for replication in a larger sample, particularly one that also can assess NSSI behavior engagement on a momentary basis and can investigate whether these relationships differ across specific subtypes of childhood maltreatment. Future studies should continue to investigate how general tendencies to approach rewards (i.e., BAS-Drive) and proximal (state level) changes in reward functioning may predict NSSI urges for those with histories of maltreatment. Future studies should also consider examining how reward functioning relates to the trajectory of NSSI engagement over time; indeed, while it is possible that reward hypersensitivity may lead individuals to be more affected by the reinforcing properties of NSSI in early phases of engagement, it is also possible that reward hypersensitivity may result in individuals achieving tolerance rapidly. In turn, this could result in individuals engaging in more severe and varied forms of NSSI over time to maintain reward levels. Animal and human models have indicated that the developmental timing of early traumatic events, such as maltreatment, may have a critical effect on reward sensitivity development and should be considered in future models as well (Novick et al., 2018). If the present findings are replicated in larger, independent samples, future studies should consider assessing whether experimentally modifying BAS-Drive may reduce the frequency or intensity of NSSI urges for those with elevated severity of childhood maltreatment. Prior evidence suggests interventions such as transcranial magnetic stimulation or behavioral activation therapy can increase engagement with rewarding stimuli and, thus, may be effective in activating the behavioral approach system to test this relationship (Dichter et al., 2009; Mas-Herrero et al., 2018).

In conclusion, those with elevated childhood maltreatment who were less sensitive to rewards or less willing to approach rewards were most likely to have a history of NSSI and experienced the greatest NSSI urges. Specifically, for participants with an elevated severity of childhood maltreatment, those with low trait BAS-Reward Responsiveness were more likely to have a lifetime history of NSSI and those with low trait BAS-Drive experienced more intense NSSI urges. Additional research is needed to evaluate the potential role of higher trait BAS-Drive in ameliorating the risk of NSSI urges for individuals with elevated childhood maltreatment, as well as how these interactions might be clinically targeted.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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