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Anxious and Overwhelming Affects and Repetitive Negative Thinking as Ecological Predictors of Self-Injurious Thoughts and Behaviors

Christopher D. Hughes[1] · Alexandra M. King[1] · Amy Kranzler[2] · Kara Fehling[1] · Alec Miller[2,3] · Janne Lindqvist[1] · Edward A. Selby[1]

Abstract

Nonsuicidal self-injury (NSSI) refers to purposely injuring one's body without suicidal intent via methods such as cutting or hitting oneself, and is a serious health concern that has been linked to detrimental behavioral and physical health consequences. One of the primary reasons that people report engaging in NSSI is that it appears to help them cope with intense affective states and upsetting thoughts, both of which they perceive as unbearable at the time. However, empirical investigation into the affective and cognitive states preceding NSSI has been limited, especially during daily life. The current study utilized ecological momentary assessment to measure multiple daily recordings of negative affect, repetitive negative thinking (RNT), and NSSI thoughts and behaviors among a community sample of adolescents and young adults (N = 47). Findings indicated that anxiety and feeling overwhelmed predicted NSSI most strongly when RNT was elevated, suggesting that these three factors may interact in a process creating an aversive affective state that self-injurers attempt to "escape" by engaging in NSSI.

Keywords Nonsuicidal self-injury · Repetitive negative thinking · Ecological momentary · Assessment · Negative affect · Anxiety

[She] was using [self-injury] primarily to 'get control' of intense anxiety triggered by distressing interpersonal situations or when feeling especially 'overwhelmed' by her school work and demands. (Bentley 2017, p. 3)

Nonsuicidal self-injury (NSSI), or engaging in intentional, self-inflicted harm behaviors without the intent to die is a serious behavioral health concern, with 5.5–5.9% of adults reporting at least one instance at some point in their lifetime (Klonsky 2011; Swannell et al. 2014) and 0.9% in the last year (Klonsky 2011). Physical harm resulting from

NSSI can cause lasting physical injury and/or accidental death (Andrewes et al. 2016; Chapman et al. 2005), and the self-injuring population heavily utilizes emergency services, accounting for approximately 400,000 ER admissions annually (Doshi et al. 2005). Although NSSI lacks intent to die, it is one of the strongest predictors of future suicide *attempts*, and it increases risk of *dying* by suicide (Hamza et al. 2012). Non-lethal attempts can lead to serious health problems, such as renal failure from overdosing on medication (De Giorgi et al. 2013), and NSSI can lead to bleeding out and tissue damage requiring surgical repair (i.e. from using sharp objects to self-injure; Lee et al. 2016). This population also has high rates of other risky health behaviors (Laye-Gindhu and Schonert-Reichl 2005) and comorbidities that have physical health impacts, such as substance use disorders (Doshi et al. 2005; Fox et al. 2015) and eating disorders (Claes et al. 2005; Muehlenkamp et al. 2009).

Onset of NSSI typically begins between ages 12–16 (Cipriano et al. 2017; Klonsky 2011), and these behaviors are particularly prominent in adolescents: 17–18% of community samples report engaging in NSSI in their lifetime and 8.5–11.1% in the last year (Muehlenkamp et al. 2012). Given its higher prevalence in adolescents, an increased

✉ Edward A. Selby
edward.selby@rutgers.edu

[1] Rutgers, The State University of New Jersey, Tillett 101, 53 Avenue E., Piscataway NJ 07821, USA

[2] Montefiore Medical Center, Albert Einstein College of Medicine, New York, USA

[3] Cognitive and Behavioral Consultants, LLP, New York, USA

understanding of the processes involved in NSSI's development and maintenance in this particularly vulnerable population is needed.

There are several theories regarding the onset and maintenance of NSSI, many purporting that it serves as a form of escape from intense affective states—which is the most common reason reported for the behavior (Bentley et al. 2014; Muehlenkamp et al. 2012; Nock et al. 2009). Some models highlight behavioral reinforcers of non-suicidal self-injury (Chapman et al. 2006; Nock and Prinstein 2004), and recently researchers have begun to incorporate cognitive processes as well, with rumination being one of the most prominent (Cohen et al. 2015; Hilt et al. 2008; Hoff and Muehlenkamp 2009). The Emotional Cascade Model (Selby et al. 2008) offers one such explanation for the cognitive and affective precursors to NSSI, which focuses on NSSI serving an escape function from repetitive negative thinking (RNT; such as ruminating on the past or worrying about the future; Ehring and Watkins 2008).

The Emotional Cascade Model theorizes that RNT, initially prompted by distress, leads to an increase in negative affect, and these thoughts and affect interact, which creates a feedback loop that intensifies both negative affect and RNT (Selby et al. 2013). Then, an overwhelming "cascade" of negative thoughts and emotions occurs (Selby et al. 2013), during which the individual may make catastrophic misinterpretations (i.e. that they cannot tolerate the negative affect), feel hopeless, and have difficulties problem solving (Raes et al. 2005; Starr et al. 2016). At this point, the individual often seeks to escape the aversive state by engaging in dysfunctional behaviors. NSSI may serve this function by providing a distraction with physical sensations and through relief from endogenous opioids (Chapman et al. 2006; Selby et al. 2013). Although the various models of NSSI share many elements, the emotion cascade model may provide added insight into the cognitive states of individuals prior to and during self-injury. However, more empirical investigation of the role of RNT in NSSI is needed, particularly with regard to specific affective experiences.

Studies have shown NSSI to be predicted by overall negative affect as well as by specific affective states including anxiety, sadness, and anger (Armey et al. 2011; Nock et al. 2009). Anxiety may have a particularly unique role within the Emotional Cascade Model's framework as it may not only serve as a catalyst of a cascade, but also may relate to other components of the model, thus contributing to NSSI through multiple pathways. First, repetitive negative thinking, low distress tolerance, and avoidance are core aspects of anxiety (Keough et al. 2010; Michl et al. 2013; Tull and Gratz 2008). Many anxiety disorders include some form of RNT, catastrophic interpretations, and/or avoidance as diagnostic criteria or associated features (e.g. social anxiety, panic, and generalized anxiety disorders; American

Psychiatric Association 2013). Second, in the Emotional Cascade Model of NSSI, when an affective response has "cascaded" the individual may feel overwhelmed—an emotion distinct from, but often related, to anxiety (Meyer et al. 1990; Schimmenti and Caretti 2016). Third, following NSSI individuals often feels a sense of relief due to the negative reinforcement of the behavior, which is analogous to the relief experienced following avoidance in anxiety. This model may be useful in understanding how these constructs (anxiety, RNT, emotional cascades, feeling overwhelmed, and NSSI) are related and how best to address them in treatment.

Past research on RNT and anxiety in NSSI has primarily been limited to retrospective self-report measures or laboratory studies. Self-report methods can provide some insight into these problems, but they often measure trait-level characteristics and cannot establish whether momentary thoughts or affective experiences are preceding NSSI. Methods with better temporal granularity are needed, as temporary increases in RNT have been shown to be more predictive of NSSI than high trait rumination (Selby et al. 2013). Laboratory studies can induce affective experiences in the moment, but the experience of anxiety in the real world may not be accurately recreated in a laboratory setting. One method that is particularly well suited to address these issues is real time ecological momentary assessment (EMA). In EMA, multiple measurements of cognitive and affective states are taken as they fluctuate throughout the day.

The present study aimed to investigate the role of the anxiety-related cognitive and affective factors and processes in the context of nonsuicidal self-injurious thoughts and behaviors using EMA. 47 adolescents and young adults reported NSSI thoughts and behaviors and concurrent levels of affect and RNT via EMA, five times per day for two weeks. It was hypothesized that: (1) Higher levels of negative affect, anxiety, feeling overwhelmed, and RNT at prior EMAs would each independently predict more intense NSSI thoughts reported at the subsequent assessment; (2) Higher levels of negative affect, anxiety, feeling overwhelmed, RNT, and NSSI thoughts at prior assessments would each independently predict increased rates of NSSI behaviors reported at the subsequent assessment; (3) Higher prior ratings of negative affect, anxiety, and feeling overwhelmed would predict subsequent ratings of RNT; (4) Prior negative affect, anxiety, and feeling overwhelmed would each interact with prior RNT to predict more intense NSSI thoughts at the subsequent assessment; (5) Prior levels of RNT would interact with prior levels of negative affect, anxiety, feeling overwhelmed, and NSSI thought intensity, with higher levels of RNT and independent variables predicting increased intensity/frequency of NSSI thoughts and behaviors at the subsequent assessment; and (6) Prior ratings of RNT would interact with prior ratings of negative affect and anxiety,

such that higher ratings of RNT and independent variables would predict higher ratings of feeling overwhelmed at the subsequent assessment.

Method

Participants

Participants consisted of 47 self-injuring adolescents and young adults drawn from the general community, recruited via referrals from local treatment centers as well as print and online ads placed throughout the community. Participants were eligible if they: (1) were ages 15–21; and (2) had self-injured two or more times in the past 2 weeks. Exclusion criteria were: (1) non-fluent English speakers; (2) rated at severe or extreme risk for suicide during baseline assessment (as indicated by presence of a suicide plan and intent to act); and (3) diagnoses of a psychotic disorder, life-threatening anorexia, or developmental delays.

The final sample consisted of 47 individuals ages 15–21 ($M = 19.1$, $SD = 1.77$). 32 participants (68%) identified as female, 14 (30%) as male, and one (2%) as transgendered. 18 (38%) participants identified as white, seven (15%) as black/ African American, nine (19%) as Asian, eight (17%) as Hispanic/Latino, and five (11%) as multi-racial. This study was approved by the Institutional Review Board; all participants provided written informed consent prior to participation in the study, and parental consent along with participant assent was obtained for participants under the age of 18.

Procedure

The procedures for this study have previously been reported in Kranzler et al. (2018). Participants were recruited from primary care and mental health outpatient clinics; flyers were placed throughout the community, and online ads were posted. Eligible participants completed an initial baseline assessment that consisted of a number of self-report questionnaires and clinical interviews to further ensure eligibility and collect baseline information. Participants determined to be eligible were then trained in how to use the "Track It" EMA app, which they could use either on their personal smart phone or on one provided to them for the duration of the study. Participants then practiced monitoring for 2 days, followed by 2 weeks of monitoring for data collection. During that time, participants completed five signal-contingent entries daily as well as self-initiated event-contingent entries after experiencing a NSSI thought or behavior. Signal-contingent entries were scheduled to prompt participants to respond at random times within five predetermined windows: 9:00am–11:30am, 11:30am–2:00 pm, 2:00 pm–4:30 pm, 4:30 pm–7:00 pm, and 7:00 pm–9:00 pm.

This was done to prevent participants from "anticipating" an assessment signal. During these momentary assessments, participants were asked questions about their behaviors, cognitions, and affect since the last assessment (details for which are further explained below). At the conclusion of the two-week monitoring period, participants were debriefed and compensated for their participation.

Measures

Participants completed a number of questionnaire and interview-based self-report measures during their baseline visit assessing a wide variety of psychological and behavioral variables as part of a larger study (Kranzler et al. 2018). However, only measures germane to the present study's analyses are described below[1].

Demographics

Standard demographic information (gender, age, race/ethnicity, and household income) were collected from participants during their baseline assessment.

Momentary Affect

In each EMA, participants were asked to rate their current affective state by responding to 19 specific affect items, rating them each on a 0–10 Likert-type scale. Affect items included eight positive affect items (not used in the present study's analyses) and 11 negative affect items (sad, angry, hurt/emotionally rejected, frustrated, anxious/afraid, lonely, empty/numb, guilty, physically numb, ashamed, overwhelmed), summed to compute a total negative affect score (Cronbach's alpha in present sample = .87). For the present study, we focused our analyses on the specific roles of anxiety, feeling overwhelmed, and total negative affect; other specific affective states were not examined. Of note, anxiety and overwhelmed were single items of a negative affect scale, which may have reduced variability on these indices. Ideally, a more comprehensive assessment of anxiety or feelings of being overwhelmed would be included, but given the focus of EMA on repeated, brief assessments,

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[1] Several measures of psychopathology (Inventory of statements about self-injury, Klonsky and Glenn 2009; Beck Depression Inventory; Beck et al. 1996; Beck Anxiety Inventory; Beck and Steer 1990; Difficulties with Emotion Regulation Scale; Gratz and Roemer 2004; & Ruminative Response Scale; Nolen-Hoeksema and Morrow 1991) completed by participants were also included as potential covariates in our analyses, however none were significant predictors of variables of interest (described below in analysis plan) when included in models containing momentary assessment items. Therefore, in the interest of clarity and brevity, the measures were not described in the methods or results sections of this paper.

using single items to measure a construct is common and valid approach to investigation (Nock et al. 2009; Victor and Klonsky 2014), even if still somewhat limited.

NSSI Thoughts and Behaviors

In each EMA prompt, participants were asked whether they had had thoughts of NSSI (yes/no) since the previous entry as well as whether they had engaged in any NSSI behaviors (yes/no) since the previous entry. If they endorsed NSSI thoughts, they were asked to rate the intensity, duration, and ability to resist acting on the thoughts using a 0–10 Likert-type scale. If they endorsed any NSSI behaviors, they were asked about the type(s) of NSSI they engaged in (e.g. cutting, hitting, burning), the number of NSSI behaviors since the last assessment (NSSI behavior frequency), and the intended function of the behavior(s).

Momentary RNT

During each EMA, participants rated eight items assessing their RNT since the previous assessment on a 0–10 Likert-type scale. Items were based on the core characteristics of RNT: thinking that is repetitive, passive, difficult to control, and negatively focused (Ehring and Watkins 2008; "I am experiencing many thoughts that are repeating over and over," "I am experiencing many repetitive thoughts about how I am currently feeling," "My thoughts are flowing from one thought to the next more quickly than they usually do," and "I am experiencing many thoughts that are difficult for me to control or change."). Given the fact that specific content and temporal direction are the most significant distinction between the different types of RNT (i.e. rumination and worry; Ehring and Watkins 2008), items were past, present, *and* future focused ("I am experiencing many thoughts about past personally-relevant problems," "I am experiencing many thoughts about current personally-relevant problems," "I am experiencing many thoughts about how a current problem may impact my future," and "I am experiencing many thoughts about personally-relevant problems that may occur in the future.") and were not specific about the content of thoughts. In the current sample, the scale demonstrated strong internal consistency: with an overall Cronbach's alpha of .91. Because there is no commonly accepted measurement of RNT for use in EMA research, we provided further validation of the momentary RNT scale in the "Results" section.

Data Analytic Strategy

All analyses were conducted using SPSS 25.0 statistical software. First, we examined preliminary data regarding negative affect, RNT, and NSSI. We then examined the items from our momentary RNT measure to ensure that they were consistently measuring the construct of interest. For this analysis, we conducted an exploratory factor analysis with a direct Oblimin rotation. We also examined the intraclass correlation of the scale and inter-item correlations.

Next, in order to account for the multilevel nature of the data (multiple observations nested within participants), analyses were conducted using multilevel regression models (Bryk and Raudenbush 1992) in SPSS's mixed models analysis package. The outcome variables were count variables (i.e. number of times they engaged in NSSI behaviors since the last assessment) and Likert-scale responses prone to over-dispersion (e.g. NSSI thought intensity, level of RNT, and affect intensity). Ratings were frequently low or absent, but occasionally exhibited substantial elevations—which can result in violations to assumptions of regression-based procedures, such as homoscedasticity. Therefore, we used SPSS's Generalized Linear Mixed Models (GLMM) package to test our hypotheses.

In order to test our hypotheses regarding prior assessments' NSSI thought intensity ratings, RNT, and affect as predictors of the subsequent ratings and NSSI behaviors on that day, we created a series of new, time-lagged variables, with the first recording for each day (in which case the previous assessment was completed the day before) excluded from lag variables analyses—a common practice in EMA research (Selby and Joiner 2013).

We first examined the descriptive statistics of relevant variables in the dataset, testing the assumptions of GLMM models. While we anticipated that our outcome variables (RNT, negative affect, overwhelmed, NSSI behaviors, and NSSI thought intensity) would be skewed and/or kurtotic, GLMM is intended to be used with such data and does not have the same assumptions as Linear Mixed Models. Therefore, no transformations were made to any variables. Instead, we examined outcome variables with a Poisson distribution and a loglinear link function in GLMM regressions.

We tested our hypotheses with series of multivariate GLMM regressions. First, we examined the main effects of our lagged variables (anxiety, negative affect, overwhelmed, RNT, & NSSI thought intensity) on subsequent ratings of outcome variables of interest (RNT, overwhelmed, NSSI thought intensity, & NSSI behavior frequency) using a series of multivariate GLMM regressions with the lagged variable entered as a fixed-effect Level-1 (within-subject) predictor, while also including the lagged version of the outcome variable as fixed-effect Level-1 predictor variables to control for the effect of prior levels on subsequent ratings. An "unconditional model" was used for Level-2 (between-subjects), meaning no variables were entered but the variance explained by the individual

providing the ratings was controlled for by giving each participant a separate Level-1 intercept. All predictor variables were centered around the group mean to facilitate interpretations of the results and reduce potential issues with multicollinearity. For example, as illustrated in the example equation below, lagged (previous assessment's) RNT levels were used to predict current ratings of feeling overwhelmed at the next assessment that day while also controlling for prior assessment's rating of feeling overwhelmed. With π_{0i} representing the random intercept for each participant and r_{0i} representing residual error. For ease of interpretation, models were first run with fixed effects for predictors, allowing for interpretation of directional effects, and then the analyses were re-run including random effects for the main effects of predictors (but not interactions) to determine if there was unique between-person variance in the slopes of predictors on the outcomes. Accordingly, most models took the present form:

Level-1 (within-subject) Model:
$$E\left(OVER_{ti}|\pi_i\right) = \lambda_{ti}$$
$$\log\left[\lambda_{ti}\right] = \eta_{ti}$$
$$\eta_{ti} = \pi_{0i} + \pi_{1i}*(LagRNT_{ti}) + \pi_{2i}*(LagOVER_{ti})$$

Level-2 (between-subjects) Model:
$$\pi_{0i} = \beta_{00} + r_{0i}$$
$$\pi_{1i} = \beta_{10}$$
$$\pi_{2i} = \beta_{20}$$

Level-1 variance = $1/\lambda_{ti}$
Level-1 distribution = Poisson

Next, we determined whether various potential confounds (gender, age, & SES) needed to be controlled for in subsequent models by entering them into the equations as fixed-effect

Level-2 variables, creating a series of multivariate GLMM regressions taking the form of the equation below:

Level-1:
$$E\left(OVER_{ti}|\pi_i\right) = \lambda_{ti}$$
$$\log\left[\lambda_{ti}\right] = \eta_{ti}$$
$$\eta_{ti} = \pi_{0i} + \pi_{1i}*\left(LGRNT2_{ti}\right) + \pi_{2i}*\left(LGOVR_{ti}\right)$$

Level-2:
$$\pi_{0i} = \beta_{00} + \beta_{01}*GENDER_i + r_{0i}$$
$$\pi_{1i} = \beta_{10}$$
$$\pi_{2i} = \beta_{20}$$

Level-1 variance = $1/\lambda_{ti}$; Level-1 distribution = Poisson

Then, we tested whether variables with significant main effects in prior models also interacted to produce unique effects. For example, the equation below was used to test whether prior assessments' levels of RNT and anxiety interacted with each other such that low levels of lagged RNT and

anxiety led to different levels of feeling overwhelmed in subsequent assessments compared to higher levels of previous RNT and anxiety.

Level-1:
$$E\left(OVER_{ti}|\pi_i\right) = \lambda_{ti}$$
$$\log\left[\lambda_{ti}\right] = \eta_{ti}$$
$$\eta_{ti} = \pi_{0i} + \pi_{1i}*\left(LagRNT_{ti}\right) + \pi_{2i}*\left(LagANX_{ti}\right) + \pi_{3i}*\left(LGOVER_{ti}\right)$$
$$+\pi_{4i}*\left(LagRNT*LagANX_{ti}\right)$$

Level-2:
$$\pi_{0i} = \beta_{00} + r_{0i}$$
$$\pi_{1i} = \beta_{10}$$
$$\pi_{2i} = \beta_{20}$$
$$\pi_{3i} = \beta_{30}$$
$$\pi_{4i} = \beta_{40}$$

Level-1 variance = $1/\lambda_{ti}$; Level-1 distribution = Poisson

Finally, significant confound variables (gender) from main effects models were controlled for by adding them to the corresponding interaction models as Level-2 (gender) fixed-effect predictors.

Level-1: $\mathrm{E}(\mathrm{OVER}_{ti}|\pi_i) = \lambda_{ti}$

$\log[\lambda_{ti}] = \eta_{ti}$

$\eta_{ti} = \pi_{0i} + \pi_{1i} * (\mathrm{LagRNT}_{ti}) + \pi_{2i} * (\mathrm{LagANX}_{ti}) + \pi_{3i} * (\mathrm{LGOVER}_{ti})$
$+ \pi_{4i} * (\mathrm{LagRNT} * \mathrm{LagANX}_{ti})$

Level-2: $\pi_{0i} = \beta_{00} + \beta_{01} * \mathrm{GENDER}_i + r_{0i}$

$\pi_{1i} = \beta_{10}$

$\pi_{2i} = \beta_{20}$

$\pi_{3i} = \beta_{30}$

$\pi_{4i} = \beta_{40}$

Level-1 variance $= 1/\lambda_{ti}$; Level-1 distribution $=$ Poisson

Results

Descriptive Analyses

There were no dropouts during the study, and 84% of participants met criteria for good compliance: completing at least 80% of the prompted assessments. A total of 3,356 momentary assessments were collected over the course of the study, with each participant completing between 20 and 109 assessments ($M = 71$; $SD = 16.55$). NSSI was reported in 145 assessments, with 442 discrete NSSI behaviors reported during the study (some participants reported multiple NSSI behaviors at the same assessment). Eighty-five percent of participants reported at least one instance of NSSI (range 0–15; $M = 3.23$; $SD = 2.83$) during the study period. The most frequent forms of NSSI behaviors reported were cutting (40.7%), punching (32.4%), severe scratching (17.9%), biting (9.7%), and burning (9%).

Descriptive statistics for all variables are displayed in Table 3 of the Supplemental Materials. As expected, outcome variables were both skewed and kurtotic, further justifying the necessity of our generalized linear modeling approach. There were no concerns with missing data because the EMA app only recorded initiated entries and mixed modeling techniques are robust to differing frequencies of observations for each individual.

Results of the exploratory factor analysis of our momentary RNT measure (See Table 4 in Supplemental Materials) indicated all items loaded onto a single factor and demonstrated good internal validity: Individual inter-item correlations were significant, ranging from .26 to .75, and the intraclass correlation coefficient was .70 (indicating that the individual responding to the item accounted for 69.95% of the scale's total variance in the sample). Furthermore, all items loaded well onto a single factor, with an Eigen value of 4.93 and factor weights ranging from .52 to .85.

Main Effects

Supporting hypotheses 1 and 2, results indicated that there were significant positive main effects for each of our predictor variables in their respective GLMM models with the exception of prior NSSI thought intensity predicting feeling overwhelmed, which was not significant (see Table 1; all other regression coefficients were positive with p-values less than .01). Greater levels of anxiety ($RR_{\mathrm{Thoughts}} = 1.05$; $RR_{\mathrm{Behaviors}} = 1.08$), feeling overwhelmed ($RR_{\mathrm{Thoughts}} = 1.05$; $RR_{\mathrm{Behaviors}} = 1.09$), overall negative affect ($RR_{\mathrm{Thoughts}} = 1.01$; $RR_{\mathrm{Behaviors}} = 1.03$), and RNT ($RR_{\mathrm{Thoughts}} = 1.01$; $RR_{\mathrm{Behaviors}} = 1.03$) were predictive of worse NSSI outcomes in a variety of ways. Of note, RR (relative risk) values indicated an incremental risk in the outcome variable for every one-unit increase in the predictor scale, accordingly, higher prior assessment ratings of each were predictive of higher outcomes, such as more intense NSSI thoughts reported at the subsequent assessment (see Table 1). Participants who felt more distressed (higher reported anxiety, feeling overwhelmed, and negative affect) and/or who were experiencing more RNT were more likely to experience more intense thoughts about NSSI later that day. In addition to thinking more intensely about NSSI, participants were also at greater risk for actually engaging in NSSI behaviors, and doing so with greater frequency, when they were more distressed and/or experiencing more RNT earlier that day: higher reported levels of anxiety, feeling overwhelmed, overall negative affect, and RNT predicted more NSSI behaviors reported at the subsequent assessment (see Table 1). Greater NSSI thought intensity ratings at the prior assessment also predicted more NSSI behaviors reported at the subsequent assessment. Finally, when random effects of the predictor variables were entered into the equations, there were significant random effects for both predictor variables in all four models predicting NSSI thoughts (all p-values < .001; see Table 1), indicating that there was significant between-person variability in the slopes of the predictor variables, representing differential effects of distress and RNT on NSSI thought intensity across individuals. For the models

Table 1 Main effect models

Outcome	Predictors	β	SEβ	t-ratio	p-value	Relative risk	Random slope p-value
Next assessment NSSI thought intensity rating	Intercept	−0.50	0.13	−3.72	<.001	0.61	–
	Negative affect	0.01	<.001	10.29	<.001	1.01	<.001
	NSSI thought intensity	0.06	0.01	8.97	<.001	1.07	<.001
	Intercept	−0.48	0.13	−3.61	<.001	0.62	–
	Anxiety	0.05	0.01	6.30	<.001	1.05	<.001
	NSSI thought intensity	0.09	0.01	13.39	<.001	1.09	<.001
	Intercept	−0.48	0.13	−3.61	<.001	0.62	–
	Overwhelmed	0.05	0.01	6.79	<.001	1.05	<.001
	NSSI thought intensity	0.09	0.01	12.72	<.001	1.09	<.001
	Intercept	−0.48	0.13	−3.61	<.001	0.62	–
	RNT	0.01	<.001	6.75	<.001	1.01	<.001
	NSSI thought intensity	0.08	0.01	10.81	<.001	1.08	<.001
Next assessment reported NSSI behavior frequency	Intercept	−2.88	0.19	−14.93	<.001	0.06	–
	Negative affect	0.03	<.001	9.89	<.001	1.03	<.001
	NSSI behavior	−0.42	0.12	−3.38	<.001	0.66	>.05
	Intercept	−2.74	0.19	−14.36	<.001	0.06	–
	Anxiety	0.07	0.02	3.35	<.001	1.08	<.001
	NSSI behavior	−0.28	0.12	−2.28	0.02	0.76	>.05
	Intercept	−2.75	0.19	−14.39	<.001	0.06	–
	Overwhelmed	0.08	0.02	3.96	<.001	1.09	<.001
	NSSI behavior	−0.29	0.12	−2.34	0.02	0.75	>.05
	Intercept	−2.81	0.19	−14.76	<.001	0.06	–
	RNT	0.03	<.001	7.73	<.001	1.03	<.001
	NSSI behavior	−0.35	0.12	−2.83	<.001	0.71	>.05
	Intercept	−2.88	0.19	−15.07	<.001	0.06	–
	NSSI thought intensity	0.23	0.02	11.29	<.001	1.26	<.001
	NSSI behavior	−0.61	0.14	−4.31	<.001	0.55	>.05
Next assessment RNT rating	Intercept	3.01	0.09	31.97	<.001	20.24	–
	Negative affect	<.001	<.001	12.50	<.001	1.01	<.001
	RNT	0.01	<.001	25.17	<.001	1.01	<.001
	Intercept	3.01	0.09	31.96	<.001	20.25	–
	Anxiety	0.01	<.001	7.02	<.001	1.01	<.001
	RNT	0.01	<.001	34.63	<.001	1.01	<.001
	Intercept	3.01	0.09	31.97	<.001	20.23	–
	Overwhelmed	0.02	<.001	12.73	<.001	1.02	<.001
	RNT	0.01	<.001	32.12	<.001	1.01	<.001
	Intercept	3.01	0.09	31.97	<.001	20.26	–
	NSSI thought intensity	0.01	<.001	39.30	<.001	1.01	<.001
	RNT	0.01	<.001	2.88	<.001	1.01	<.001

Table 1 (continued)

Outcome	Predictors	β	SEβ	t-ratio	p-value	Relative risk	Random slope p-value
Next assessment overwhelmed rating	Intercept	1.02	0.11	9.13	<.001	2.77	–
	Negative affect	<.001	<.001	5.67	<.001	1.01	.001
	Overwhelmed	0.06	0.01	11.91	<.001	1.06	<.001
	Intercept	1.02	0.11	9.12	<.001	2.77	–
	Anxiety	0.03	<.001	5.30	<.001	1.03	<.001
	Overwhelmed	0.07	<.001	15.36	<.001	1.07	<.001
	Intercept	1.02	0.11	9.11	<.001	2.77	–
	RNT	0.01	<.001	7.45	<.001	1.01	<.001
	Overwhelmed	0.06	<.001	15.03	<.001	1.07	<.001
	Intercept	1.02	0.11	9.13	<.001	2.78	–
	NSSI thought intensity	<.001	<.001	0.16	0.87	1.00	>.05
	Overwhelmed	0.08	<.001	20.29	<.001	1.08	<.001

NSSI nonsuicidal self-injury; *RNT* repetitive negative thinking

predicting NSSI behaviors, results indicated that there were significant random effects for distress and RNT (p < .001; Table 1) but not prior NSSI behaviors, indicating that there was significant between-person variability in the effects of distress and RNT on subsequent NSSI behaviors. These findings were consistent with previous research identifying substantial random effects for the association between RNT and dysregulated behaviors, including NSSI (Selby et al. 2013).

Supporting hypothesis 3, results indicated that when participants were more distressed they were more likely to engage in RNT later that day: higher subsequent ratings of RNT were predicted by greater levels of negative affect, anxiety, and overwhelmed at the prior assessment (Table 1). When random effects of the predictor variables were entered into the equations, there were significant random effects for both predictor variables in all four models (all p-values < .001; see Table 1), indicating that there was significant between-person variability in the effects of distress and NSSI thought intensity, on subsequent levels of RNT. The extent to which individuals felt overwhelmed was predicted by both higher ratings of anxiety and overall negative affect, as well as greater levels of reported RNT at the prior assessment (Table 1). Furthermore, when random effects of the predictor variables were entered into the equations, there were significant random effects for both predictor variables in all three models (all p-values < .001; see Table 1), indicating that there was significant between-person variability in the effects of anxiety, negative affect, and RNT on feeling overwhelmed.

Results indicated that age and SES were not a significant Level 2 (between-persons) predictors in any models. Gender, however, was a significant predictor of NSSI thought intensity in models containing prior ratings of anxiety,

overwhelmed, and negative affect such that women provided higher ratings of NSSI thought intensity than men (see Table 5 in Supplemental Materials). However, gender was not a significant predictor in the NSSI thought intensity model containing RNT as a predictor variable (p > .05). Furthermore, there were no significant differences in ratings of NSSI behavior frequency, anxiety, negative affect, feeling overwhelmed, or RNT based on gender (all p-values > .05).

Interactions

Results of models containing interaction terms are presented numerically in Table 2 and graphically in Fig. 1. To test hypothesis 4, we ran a series of GLMM equations using previous assessment ratings of RNT and distress (anxiety, feeling overwhelmed, and negative affect) and their respective interactions to predict the next assessment's ratings of NSSI thought intensity. Results indicated that there was a significant interaction between prior RNT and feeling overwhelmed ($\beta = 0.002$, SE$\beta < 0.01$, p < .001, RR = 1.01) such that the relationship between feeling overwhelmed and the intensity of NSSI thoughts was stronger when RNT was high than when RNT was low (see Table 2; Fig. 1). Individuals were more likely to experience more intense thoughts about NSSI when they had been both feeling overwhelmed and engaging in RNT at the previous assessment. However, the interaction term was no longer significant when gender was added to the model (see Table 2). Results also indicated that there was a significant interaction between the prior RNT and anxiety ($\beta = -0.001$, SE$\beta < 0.01$, p = .001, RR = 0.99), such that RNT was a stronger predictor of more intense NSSI thoughts when anxiety at the prior assessment was lower than when it was higher (See Table 2; Fig. 1).

Table 2 Interaction models

Outcome	Predictors	β	SEβ	t-Ratio	p-Value	Relative risk
Next assessment NSSI thought intensity rating	Intercept	− 0.52	0.13	− 3.90	< .001	0.60
	RNT (A)	− 0.01	< 0.01	3.12	.002	0.99
	Overwhelmed (B)	0.03	0.01	3.40	.001	1.03
	NSSI thought intensity	0.07	0.01	10.15	< .001	1.08
	Interaction (A*B)	0.002	< 0.01	4.58	< .001	1.01
	Intercept	− 1.57	0.63	− 2.50	.01	0.21
	Gender	0.54	0.34	1.56	.12	1.71
	RNT (A)	0.01	0.01	1.22	.23	1.01
	Overwhelmed (B)	− 0.01	0.03	− 0.10	.92	0.99
	NSSI thought intensity	0.06	0.02	2.96	.003	1.06
	Interaction (A*B)	0.001	< 0.01	1.53	.13	1.00
	Intercept	− 0.47	0.14	− 3.45	.001	0.63
	RNT (A)	0.01	< 0.01	4.93	< .001	1.01
	Anxiety (B)	0.04	0.01	4.56	< .001	1.04
	NSSI thought intensity	0.08	0.01	10.80	< .001	1.08
	Interaction (A*B)	− 0.001	< 0.01	− 3.31	.001	0.99
	Intercept	− 0.51	0.14	− 3.72	.001	0.60
	RNT (A)	0.002	< 0.01	0.48	.630	1.01
	NA (B)	0.01	< 0.01	3.19	.001	1.01
	NSSI thought intensity	0.06	0.02	3.11	.002	1.06
	Interaction (A*B)	< 0.001	< 0.01	0.46	.649	1.00
Next assessment reported NSSI behavior frequency	Intercept	− 3.00	0.20	− 15.21	< .001	0.05
	RNT (A)	0.003	< 0.01	0.82	.41	1.00
	Negative affect (B)	0.02	< 0.01	4.75	< .001	1.02
	NSSI behavior	− 0.50	0.12	− 4.02	< .001	0.61
	Interaction (A*B)	0.0006	< 0.01	4.56	< .001	1.001
	Intercept	− 2.87	0.19	− 14.96	< .001	0.06
	RNT (A)	0.02	< 0.01	5.96	< .001	1.02
	Overwhelmed (B)	− 0.01	0.03	− 0.47	.64	0.99
	NSSI behavior	− 0.36	0.12	− 3.00	.003	0.70
	Interaction (A*B)	0.003	< 0.01	3.01	.003	1.003
	Intercept	− 2.79	0.19	− 14.58	< .001	0.06
	RNT (A)	0.03	< 0.01	7.23	< .001	1.03
	Anxiety (B)	0.02	0.03	0.75	.454	1.02
	NSSI behavior	− 0.34	0.12	− 2.77	.006	0.71
	Interaction (A*B)	− 0.002	< 0.01	− 1.57	.116	1.00
	Intercept	− 2.90	0.19	− 15.18	< .001	0.06
	RNT (A)	0.02	< 0.01	3.88	< .001	1.02
	NSSI thought intensity (B)	0.19	0.03	6.97	< .001	1.21
	NSSI behavior	− 0.59	0.14	− 4.30	< .001	0.55
	Interaction (A*B)	> − 0.01	< 0.01	− 0.01	.990	1.00
Next assessment overwhelmed rating	Intercept	1.02	0.11	9.08	< .001	2.76
	Lag RNT (A)	0.01	< 0.01	5.91	< .001	1.01
	Lag anxiety (B)	0.03	0.01	3.72	< .001	1.03
	Lag overwhelmed	0.06	< 0.01	12.81	< .001	1.06
	Interaction (A*B)	− 0.0004	< 0.01	− 2.24	.025	0.99
	Intercept	1.02	0.11	9.05	< .001	2.76
	Lag RNT (A)	0.01	< 0.01	6.89	< .001	1.01
	Lag NA (B)	0.01	< 0.01	4.98	< .001	1.01
	Lag overwhelmed	0.05	0.01	10.56	< .001	1.06
	Interaction (A*B)	− 0.0001	< 0.01	− 4.37	< .001	0.99

NSSI nonsuicidal self-injury; *RNT* repetitive negative thinking; *NA* negative affect
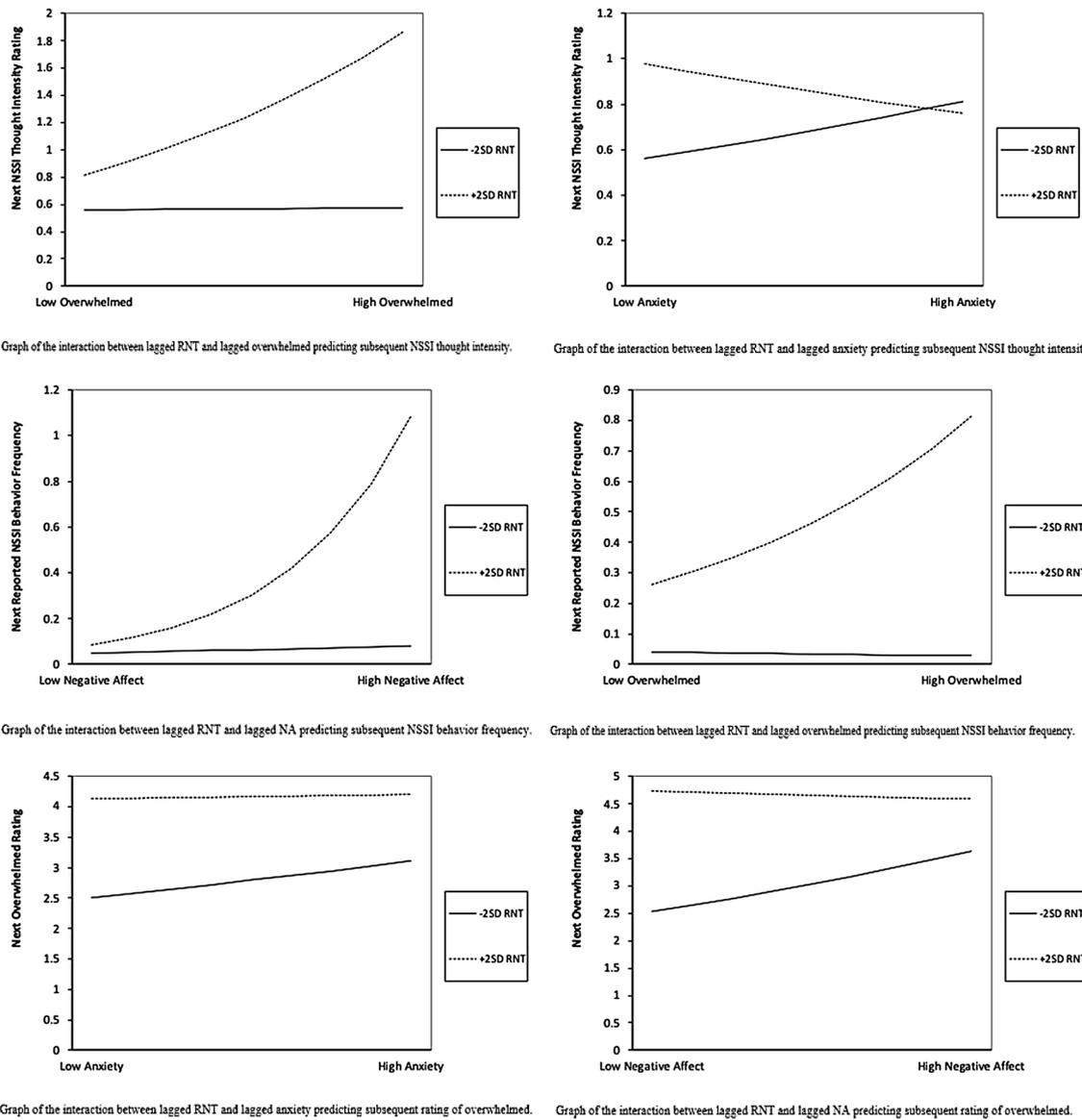
Graph of the interaction between lagged RNT and lagged overwhelmed predicting subsequent NSSI thought intensity.

Graph of the interaction between lagged RNT and lagged anxiety predicting subsequent NSSI thought intensity.

Graph of the interaction between lagged RNT and lagged NA predicting subsequent NSSI behavior frequency.

Graph of the interaction between lagged RNT and lagged overwhelmed predicting subsequent NSSI behavior frequency.

Graph of the interaction between lagged RNT and lagged anxiety predicting subsequent rating of overwhelmed.

Graph of the interaction between lagged RNT and lagged NA predicting subsequent rating of overwhelmed.

Fig. 1 Interaction graphs

Engagement in RNT at the prior assessment was more predictive of more intense NSSI thoughts at the next assessment when the individual reported experiencing less anxiety than when they reported experiencing more anxiety at the prior assessment. There was not a significant interaction between prior RNT and overall negative affect in the prediction of NSSI thought intensity (p > .05).

To test hypothesis 5, we ran a series of GLMM equations using previous ratings of RNT and distress (anxiety, feeling overwhelmed, and total negative affect) and their interactions to predict the number of NSSI behaviors reported at the next assessment. Results (see Table 2) indicated that there was a significant interaction between the previous RNT and negative affect ($\beta = 0.0006$, SE$\beta < 0.01$, p < .001,

RR = 1.001), and RNT and overwhelmed ($\beta = 0.003$, SE$\beta < 0.01$, p = .003, RR = 1.003) but not RNT and anxiety (p > .05). Specifically, the relationship between previous ratings of negative affect and overwhelmed and subsequent reports of NSSI behavior frequency was stronger when RNT was high than when RNT was low. Individuals were more likely to engage in NSSI behaviors at a higher frequency when they had been engaging in more RNT and feeling more overwhelmed or more negative affect at the previous assessment (see Table 2; Fig. 1). Next, we ran a model using prior ratings of RNT and NSSI thought intensity to predict the number of reported NSSI behaviors reported at the subsequent assessment. Results indicated that there was not a significant interaction between the two (p > .05).

To test hypothesis 6, we ran a series of GLMM equations using previous assessments' ratings of RNT and negative affect or anxiety, and their respective interactions to predict the subsequent ratings of feeling overwhelmed. Results (see Table 2) indicated that there was a significant interaction between previous RNT and anxiety ($\beta = -0.0004$, SE$\beta < 0.01$, p = .025, RR = 0.99) as well as RNT and negative affect ($\beta = -0.0001$, SE$\beta < 0.01$, p < .001, RR = 0.99) in the prediction of subsequent feeling of overwhelmed. The interactions represented the finding that even at low levels of anxiety or negative affect, RNT was associated with subsequently more overwhelmed feelings than when anxiety or negative affect and RNT were low. However, when anxiety or negative affect was high, participants were more likely to feel overwhelmed at the next assessment, even if RNT was lower (see Fig. 1).

Discussion

This study aimed to assess the theorized cognitive and affective predictors of nonsuicidal self-injurious thoughts and behaviors (i.e. negative affect, RNT, anxiety, and being overwhelmed), and their interactive processes.

As predicted, previous assessment ratings of negative affect, feeling overwhelmed, anxiety, and RNT all predicted increased subsequent assessment ratings of NSSI thoughts and behaviors, and NSSI behaviors were also predicted by previous NSSI thoughts. Negative affect, anxiety, and overwhelmed predicted RNT, while negative affect, anxiety, and RNT predicted overwhelmed. Gender had a significant effect on NSSI thoughts, with women reporting more intense thoughts, however the other variables in those models also remained significant when gender was included. This pattern of predictive relationships suggests that: when people are distressed they are more likely to later engage in RNT; when they are engaging in RNT or distressed they are more likely to become overwhelmed; and when distressed, overwhelmed, and/or engaging in RNT, they are at greater risk for later reporting more NSSI thoughts and behaviors.

In line with the Emotional Cascade Model of NSSI, these cognitive and affective variables appear to not only have independent main effects, but also to interact in unique ways to predict subsequent NSSI thoughts and behaviors. RNT interacted with feeling overwhelmed and with anxiety, but not with overall negative affect, to predict subsequent NSSI thought intensity. This suggests that individuals are more likely to have thoughts of NSSI, and with higher intensity, when overwhelmed *and* engaging in RNT than those who are engaging in RNT but are not overwhelmed (see Fig. 1). On the other hand, future NSSI thoughts are less impacted by feeling overwhelmed when the individual is not engaging

in RNT. Anxiety and RNT interacted in an opposite pattern, such that individuals reporting high anxiety reported similar levels of NSSI thought intensity, regardless of whether they were engaging in RNT. However, for those reporting low anxiety, engaging in RNT was associated with higher NSSI thought intensity.

When predicting NSSI behaviors, negative affect and feeling overwhelmed significantly interacted with RNT, while broad anxiety and intensity of NSSI thoughts did not have any interaction effects. For both feeling overwhelmed and overall negative affect, the interactions were similar to the interactions of overwhelmed with RNT predicting NSSI thoughts—individuals not engaging in RNT were less likely to have an increase in NSSI behaviors, regardless of how overwhelmed they felt or how high their negative affect was, but those who were engaging in RNT were more likely to see a subsequent increase in NSSI behaviors when negative affect or overwhelmed were also high (see Fig. 1).

RNT also interacted with anxiety and negative affect to predict feeling overwhelmed at the subsequent assessment. These interactions had similar patterns, both indicating that when not engaging in RNT, increased anxiety or negative affect was associated with increased feeling overwhelmed. However, when engaging in RNT, feeling overwhelmed was likely to be high regardless of the individual's prior levels of anxiety or negative affect (see Fig. 1).

These findings support the Emotional Cascade Model of NSSI and highlight the specific role of anxiety-related cognitive and affective variables in this dynamic process, as they demonstrated that intense negative affect, anxiety, feeling overwhelmed, and RNT predicted increased subsequent NSSI thought intensity and behavior frequency. Additionally, feeling overwhelmed only predicted subsequent NSSI thoughts and behaviors when RNT was high. Similarly, greater negative affect only predicted increased NSSI behavior when RNT was high. Feeling overwhelmed was strongly associated with high levels of RNT, regardless of level of anxiety and negative affect, suggesting that RNT may be a mechanism in producing a state of feeling overwhelmed. These relationships support the model's suggestion that NSSI thoughts and behaviors are not only due to negative affect, but also that the experience of feeling overwhelmed and engaging in RNT greatly increase risk. Surprisingly, NSSI thought intensity was similar when anxiety was high, regardless of whether RNT was high or low, suggesting that anxiety may play a unique role in having NSSI thoughts aside from its relationship to RNT.

These findings also support the use of interventions targeting NSSI by teaching alternative skills-based strategies for regulating emotions, tolerating distress, and interrupting cognitive processes like RNT before their transaction results in an emotional cascade and a breakdown of skillful behavior. Such interventions could potentially reduce

the incidence of NSSI and its negative physical effects and health risks; future research could benefit from investigating their efficacy and mechanisms of action. Treatments focused on emotion regulation and distress tolerance skills training may be particularly well-suited for this (e.g. Dialectical Behavior Therapy; Linehan 1993); skills for coping with intense negative affect, alternative cognitive strategies to reduce RNT, and managing distressing situations in skillful, non-destructive ways may be particular mechanisms of action warranting further investigation. Based on our findings, it appears that if the cascade can be prevented (i.e. if the individual can reduce the RNT before getting overwhelmed), then individuals would be less likely to engage in NSSI behaviors. Interventions teaching such skills may be beneficial to physical health in addition to mental health, as they can be used to reduce NSSI and its associated health problems, and they may also reduce the precursory problems that are also associated with health concerns.

Given the vulnerability of the population, adolescents and young adults may be particularly worthwhile targets of intervention programs. By teaching adolescents skills for replacing RNT with more effective cognitive strategies, coping effectively with negative affect and anxiety, and alternative methods for resolving and/or tolerating distressing situations, they may be able to prevent the emotional cascade and prevent NSSI thoughts and/or behaviors. Learning and rehearsing alternative responses could prevent the continuation of NSSI into adulthood, thereby reducing its overall risks and damage to the individual. It also suggests that preventative interventions for middle- and high-school populations could have a significant impact on the physical and mental health for this age group. Given the putative learning processes involved in the maintenance of NSSI based on the Experiential Avoidance and Emotional Cascade Models, it also seems reasonable to believe that intervening earlier, while the behaviors and processes are less entrenched, may be easier, quicker, and more effective because less inhibitory learning would need to take place.

There were several limitations in this study. First, the assessment of anxiety using EMA was very brief, as it was only assessed using two face-valid self-report items. Future research could address this issue by using a more thorough anxiety assessment, by including assessment of worry specifically (separately from global RNT) as well, and including measures of physiological states. Additionally, the present study's sample had a restricted range of severity and was underpowered to adequately investigate Level-2 (between-person) effects (e.g. SES, educational attainment, and symptoms of psychopathology). Future studies could address this by including more participants in their samples and expanding their inclusion criteria, thereby increasing the power and allowing for proper analyses of Level-2 variables. Another limitation in this study was that the EMA assessments were

every few hours, a sampling frequency that is common practice in EMA research, but might have been too infrequent to capture the emotional and cognitive changes preceding NSSI. If future studies had more frequent EMA prompts (e.g. every hour), that could increase the granularity of the responses. Another future direction could be to assess whether those who self-injure experience fear in a similar or distinct manner from people with other anxiety disorders. This could include assessing whether individuals who self-injure are fearing certain affective states or other stimuli. Finally, the time-lagged analyses only included ratings from the previous assessment and did not account for level of current affect/RNT at the time of subsequent assessment. This was because the affect/RNT ratings were of the "current" moment, whereas NSSI thoughts and behaviors were rated for the entire period since the last assessment, so it is possible that current affect/RNT levels were affected by any NSSI thoughts or behaviors since the last entry. Although the analytic approach used here is consistent with previous EMA studies (Ambwani et al. 2015; Nock et al. 2009; Selby et al. 2016), future studies may benefit from exploring emotions immediately preceding and following NSSI thoughts and behaviors.

In conclusion, the present study's findings indicate that RNT, overall negative affect, anxiety, and feeling overwhelmed each play unique and interactive roles in the prediction of NSSI thoughts and behaviors. Therefore, addressing RNT, overall negative affect, broad anxiety, and a person's sense of being overwhelmed may interrupt the emotional cascades that often lead to NSSI thoughts and behaviors, which could prevent some of the negative physical health risks and consequences associated with all of these cognitive, affective, and behavioral risk factors of NSSI. Future research could benefit from continued investigation of these cognitive and affective processes in the prediction and prevention of NSSI thoughts and behaviors.

Compliance with Ethical Standards

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