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Research paper

Emotion dysregulation in nonsuicidal self-injury: Dissociations between global self-reports and real-time responses to emotional challenge

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ABSTRACT

Introduction: Prominent theories of nonsuicidal self-injury (NSSI) propose that the behaviour is characterised by amplified emotional responses. However, little is known about how people who self-injure respond during emotional challenge.

Methods: We measured subjective and physiological responding (heart rate, heart rate variability, and electrodermal responding) among young adults with past-year NSSI ($n = 51$) and those with no lifetime NSSI ($n = 50$) during a resting baseline, a stress induction, and a post-stress resting phase. Participants reported the extent to which they spontaneously used cognitive reappraisal and expressive suppression during the post-stress phase. Two weeks later, a subset of the sample ($n = 42$) reported how they remembered feeling during the laboratory session.

Results: Although the NSSI group reported considerably greater emotion dysregulation than Controls, both groups showed similar subjective and psychological reactivity to, and recovery from, emotional challenge. Both groups used reappraisal and suppression regulation strategies following acute stress to a similar extent, and later came to remember the emotional challenge in a similar manner.

Limitations: Within the NSSI group, past-year self-injury tended to be infrequent and sporadic. Only 43.6% of the sample participated in the follow-up survey assessing memory of emotional challenge.

Conclusions: Findings demonstrate that the role of emotion in NSSI is more complex than prominent theories can account for, raising substantial questions regarding the nature of emotion in NSSI. A more comprehensive understanding of the role of emotion in NSSI is needed to inform intervention strategies to better support people who self-injure.

1. Introduction

Approximately 23 % of young people report engaging in nonsuicidal self-injury (NSSI; Gillies et al., 2018), typically to down-regulate unwanted emotions (Edmondson et al., 2016). Compared to their peers, people who self-injure report poorer psychosocial wellbeing (Rotolone and Martin, 2012) and higher rates of psychopathology (Nock et al., 2006). NSSI also prospectively predicts poorer socio-emotional functioning (Gandhi et al., 2017; Robinson et al., 2019) and the onset of psychiatric disorders, suicidal ideation, and suicide attempts (Ribeiro et al., 2016; Wilkinson et al., 2018). People who self-injure consistently report greater emotion dysregulation than their peers (Wolff et al., 2019), providing support for prominent theories of NSSI that propose an amplified emotional response to emotional challenge underlies NSSI (Chapman et al., 2006; Hasking et al., 2016; Nock, 2010). However, overall evaluation of one's typical affective experience is ill-suited to isolating precise alterations in emotional responding that may serve as intervention targets. Emotions represent the coordinated activity of subjective, physiological, and behavioural systems that prepare us to deal with challenges, filtered through our appraisal of the situation and our personal histories (Barrett, 2009; Scherer, 2009). Retrospective judgements of subjective experience rely on heuristics which can introduce bias to reports (Hoogerheide and Paas, 2012; Kahneman et al., 1993). In addition, global self-reports capture only *subjective* aspects of emotion, leaving it unclear how physiological channels of emotion operate in people who self-injure. Instead, multi-modal assessments

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capturing individuals' responses to, and recovery from emotional challenge are needed to establish if NSSI is characterised by amplified emotional responding.

Changes in subjective and physiological channels capture an individuals' response to, and recovery from emotional challenges. Subjective channels comprise changes in experiential 'feeling', conceptualised along dimensions of arousal and valence (Bradley and Lang, 1994; Russell, 1980). Physiological channels comprise changes in the regulation of organ functioning by sympathetic and parasympathetic branches of the autonomic nervous system, typically assessed by investigating innervation of the skin and heart. Changes in electrical conductivity of the skin reflect sympathetic influence on sweat gland secretion and are sensitive to emotional arousal (Bradley et al., 2001). Heart Rate (HR; beats per minute) reflects both parasympathetic and sympathetic influence and typically accelerates in response to strong emotional challenge (Kreibig, 2010). In contrast, high-frequency heart rate variability (HRV; moment-to-moment changes in the interval between heartbeats) reflects only parasympathetic influence, providing both state and trait measures of emotional responding. As a state measure, HRV typically decreases under emotional challenge (Kim et al., 2018). As a trait measure, resting-state HRV provides an index of cardiac system capacity to respond to challenge; lower resting-state HRV marks weaker cardiac responsivity to momentary changes (i.e., less regulation potential; Beauchaine and Thayer, 2015; Thayer and Lane, 2000).

Preliminary evidence that people who self-injure show an amplified subjective response to emotional challenge is mixed. Some studies found that, compared to controls, people who self-injure experienced greater negative mood reactivity during interpersonal conflict (Kaufman et al., 2020) and after writing about personal failure (Fox et al., 2019; Stacy et al., 2022) or discrimination (Smith et al., 2020). In contrast, others found no difference in how people with and without NSSI subjectively respond to anger inductions (Weinberg and Klonsky, 2012), sad film clips (Davis et al., 2014; Mettler et al., 2021), acute social stress (Kaess et al., 2012), social exclusion paradigms (Robinson et al., 2023; Schatten et al., 2015) or personally-relevant social distress or criticism scripts (Allen et al., 2019; Gratz et al., 2011, 2019). Still other studies found that people who self-injure show *reduced* subjective reactivity compared to controls when writing about a personal failure (Bresin and Gordon, 2013) or watching a sad film clip (Boyes et al., 2020). Subjective recovery from emotional challenge is also mixed, with young adults who self-injure have showed both prolonged negative affect (Boyes et al., 2020) and similar recovery (Mettler et al., 2021) following a sad film clip compared to their peers.

Investigation into physiological responding in NSSI is more limited, although findings are equally mixed. Some studies found that, compared to controls, people who self-injure show greater electrodermal responding (EDR; Nock and Mendes, 2008) and respiratory sinus arrhythmia (RSA; HRV created by the respiration cycle; Crowell et al., 2005) reactivity, while others found no difference in EDR (Crowell et al., 2005; Tatnell et al., 2018), RSA (Kaufman et al., 2020), or HR (Kaess et al., 2012) reactivity. Still other studies found that, compared to controls, people who self-injure show *reduced* HR (Koenig et al., 2022; Naoum et al., 2016) and HRV (Koenig et al., 2022; Reitz et al., 2015) reactivity. In terms of physiological recovery from challenge, people who self-injure showed similar RSA and EDR recovery from a sad film clip compared to controls (Crowell et al., 2005). Findings are also mixed when considering group-level differences in resting-state HRV as a biological marker of regulation capacity, with self-injury groups showing both reduced resting-state RSA (Crowell et al., 2005) and similar levels of resting-state HRV (Koenig et al., 2017) as controls.

Interpreting these mixed findings is difficult because previous investigation has focused largely on subjective reactivity to challenge among people with lifetime NSSI (i.e., likely including a substantial proportion who no longer self-injure; Wilkinson et al., 2018). A more comprehensive investigation of subjective and physiological reactivity to, and recovery from, emotional challenge among people with *recent* NSSI is needed to evaluate if NSSI is characterised by altered emotional responding.

Alternative explanations for elevated emotion dysregulation self-reports among people who self-injure also warrant exploration. Perhaps the initial process generation of emotion is similar, but people who self-injure choose to employ ineffective emotion regulation strategies when faced with emotional challenge. Although people who self-injure are less effective at reducing their negative affect following reappraisal instructions (Davis et al., 2014), it remains unclear how people who self-injure *spontaneously* implement regulation strategies after emotional challenge. Alternatively, global differences might lie outside of the emotional response altogether, but rather reflect how the emotional response is later remembered. Global self-report assessments typically require people to reflect on past emotional experiences and indicate how they usually feel and respond, making them subject to memory and inferential biases (Schwartz et al., 1999; Solhan et al., 2009). Given NSSI is associated with the tendency to ruminate on unpleasant events (Hoff and Muehlenkamp, 2009; Selby et al., 2013), these biases may disproportionally influence people who self-injure. Psychological research more broadly has found only small to moderate associations between self-report and performance-based or objective measures of psychological characteristics such as executive functioning (Buchanan, 2016) and impulsivity (Sharma et al., 2014), as well as behaviours such as sleep (Cudney et al., 2022) and social media use (Mahalingham et al., 2023). Taken together, previous research suggests that a more nuanced understanding of emotional responding in NSSI requires capturing both trait self-report measures as well as subjective and physiological responses to emotional challenge.

In the current study we tested whether, relative to controls, people who self-injure: a) generate a more intense subjective and/or physiological response to emotional challenge[1]; (b) show less subjective and/or physiological recovery from emotional challenge; c) engage in less effective emotion regulation strategies; or (d) later remember their emotional experience as more intense. Preregistration, materials, and data are available at https://osf.io/px534/.

2. Method

2.1. Participants

Participants ($n = 101$) were young adults (M age = 18.73, $SD = 1.29$) recruited from the research pool of a public university in Aotearoa New Zealand; 51 reported past-year NSSI and 50 reported no lifetime NSSI. Supplementary Materials detail power analyses. Eligible participants were women[2] aged 17–25 years old, fluent in English, able to use a computer mouse and keyboard, with normal (or corrected to normal) eyesight, and who consented to participate in self-injury research. Most participants (87.0 %) identified as Pākehā/ New Zealand European (10.2 % Māori, 3.7 % Samoan, 2.8 % Chinese, 0.9 % Indian, and 9.3 % identified as a non-listed ethnicity). The NSSI group were more likely to report a mental health diagnosis than controls ($\chi^2(1) = 11.69$, $p < .001$, Cramer's $V = 0.34$), but groups were equally likely to report taking prescribed medications ($\chi^2(1) = 2.09$, $p = .149$, Cramer's $V = 0.14$). Table 1 provides the clinical characteristics of each group.

[1] Our preregistration describes two mutually exclusive predictions that, relative to controls: (i), people who self-injure generate a more intense subjective and physiological response to emotional challenge; or (ii) or generate a similar physiological response but appraise it as more intense. We combine these predictions here to improve readability.

[2] Eligibility was assessed during the screening survey. During the laboratory session, one participant reported their gender as genderfluid. Therefore, we refer to our participants as young adults.

Table 1
Participants' clinical characteristics, separated by nonsuicidal self-injury status.

Variable		NSSI % / *M* (*SD*)	Control % / *M* (*SD*)
Any prescribed medication(s)		37.3 %	24.0 %
Self-reported mental health diagnosis		45.1 %	14.0 %
	Depressive disorders	27.5 %	2.0 %
	Anxiety disorders	19.6 %	8.0 %
	Eating disorders	13.7 %	4.0 %
	Trauma and stressor related disorders	9.8 %	–
	Obsessive compulsive and related disorders	3.9 %	–
	Neurodevelopmental disorders	2.0 %	–
	Personality disorders	–	–
Past year NSSI frequency		100 %	0 %
	1–3	49.0 %	–
	4–5	11.8 %	–
	6–10	21.6 %	–
	11–20	11.8 %	–
	21–50	3.9 %	–
	50+	2.0 %	–
Number of lifetime NSSI methods		3.45 (2.01)	0
Lifetime engagement in NSSI methods			
	Severe scratching	70.6 %	–
	Cutting	60.8 %	–
	Punching or banging self	60.8 %	–
	Stuck sharp objects	35.3 %	–
	Prevented wounds from healing	31.4 %	–
	Biting	29.4 %	–
	Carving words, pictures, designs	23.5 %	–
	Burning	22.0 %	–
	Rubbed glass into skin	5.9 %	–
	Used bleach or oven cleaner to scrub skin	3.9 %	–
	Created acid burns	2.0 %	–
	Rubbing sandpaper	0 %	–
	Broken bones	0 %	–

Note. NSSI = Nonsuicidal Self-Injury.

2.2. Procedure

Victoria University of Wellington's Human Ethics Committee provided ethical approval. Potential participants ($n = 1450$) reported their NSSI via an online screening survey. Those who met study criteria were invited to participate in a laboratory session and provided written consent. During the laboratory session, participants completed resting baseline, stress induction, and post-test resting phases while we assessed negative mood, HR, HRV and EDR. Two weeks after the laboratory session, participants were invited to an online survey assessing how they remembered feeling during the laboratory session. Forty-two participants completed the follow-up survey (NSSI $n = 23$, Control $n = 21$; $\chi^2(1) = 0.51$, $p = .474$, Cramer's $V = 0.07$). Participants completed the laboratory session for research participation credit, and voluntarily participated in the follow-up survey.

2.3. Nonsuicidal self-injury

Participants reported their NSSI using the simplified Deliberate Self-Harm Inventory (DSHI-s; Lundh et al., 2007). The DSHI-s asks *'Have you ever deliberately (but without wanting to kill yourself) …'* before listing 13 common NSSI behaviours, such as *'cut your wrist, arms, or other areas of your body'* to which participants respond on a 5-point scale ranging from '*0 – I've never thought about doing this*' to '*4 – I've done this many times*'. As in previous research (Robinson et al., 2021), the DSHI-s response format was modified to include NSSI ideation and to be culturally appropriate within an Aotearoa New Zealand context. Participants who indicated lifetime NSSI reported how often they had self-injured in the past year: *'In the last year, how many times have you deliberately hurt yourself (but without wanting to kill yourself)?'*, with the response format: *'never'*, *'1–3 times'*, *'4–5 times'*, *'6–10 times'*, *'11–20 times'*, *'21–50 times'*, and *'>50 times'*. Participants recruited to the NSSI group reported engaging in one or more NSSI behaviours at least once in their lifetime and engaging in NSSI once or more in the past year. Participants recruited to the Control group reported no lifetime engagement in any NSSI behaviour.

2.4. Self-reported emotion reactivity and dysregulation

Global emotion reactivity was assessed with the 21–item Emotion Reactivity Scale (Nock et al., 2008). Participants responded to items such as *'I tend to get very emotional very easily'*, on a 5-point scale ranging from *'0– not at all like me'* to *'4– completely like me'* and item scores were averaged (α = 0.93). Global emotion dysregulation was assessed with the 16-item brief version of the Difficulties in Emotion Regulation Scale (Bjureberg et al., 2016). Participants respond to items such as *'When I'm upset, I believe that I will remain that way for a long time'* on a 5-point scale from *'1– almost never (0-10%)'* and *'5 – almost always (91-100%)'*. Item scores were averaged (α = 0.94).

2.5. Laboratory session

2.5.1. Emotional challenge

To capture baseline subjective and physiological measures of affect, participants completed a seated five-minute task where they were asked to report the number of times a rectangle on the computer screen changed to blue, providing the count at the end of the task. The colour of the rectangle (red, green, blue, yellow, purple, or orange; randomized) changed every 1000 ms (inter-trial interval: 500 ms). This 'vanilla baseline' was designed to be minimally demanding and results in less anxiety than sitting quietly without instruction (Jennings et al., 1992; Koenig et al., 2022).

We then induced emotional challenge for five minutes using the mathematics component of the Trier Social Stress Test (Kirschbaum et al., 1993). Participants were told they would complete a mental arithmetic task assessing working memory and verbal intelligence, administered by an evaluator trained to assess verbal and non-verbal

Table 2
Descriptive statistics of trait measures, real-time emotional responding, and memory of negative mood, separated by nonsuicidal self-injury status.

Variable		Overall sample *Mean (SD)*	NSSI group *Mean (SD)*	Control group *Mean (SD)*
Global self-report measures				
Emotion dysregulation (1–5)		2.58 (0.90)	3.05 (0.82)	2.11 (0.73)
Emotion reactivity (0–4)		1.99 (0.80)	2.30 (0.79)	1.68 (0.67)
Real-time emotional responding				
Negative Mood (0−100)				
	Baseline	14.27 (10.42)	16.06 (10.78)	12.48 (9.84)
	Stress	39.57 (25.04)	41.26 (23.69)	37.85 (26.48)
	Recovery	20.97 (18.15)	21.90 (17.13)	20.01 (19.27)
Heart Rate (BPM)				
	Baseline	78.76 (11.72)	79.16 (13.02)	78.34 (10.32)
	Stress	94.53 (15.43)	95.95 (14.70)	93.06 (16.19)
	Recovery	74.80 (11.59)	75.10 (12.73)	74.49 (10.40)
Electrodermal Response (μS)				
	Baseline	3.91 (4.40)	3.46 (4.51)	4.37 (4.28)
	Stress	15.48 (7.85)	15.55 (8.76)	15.41 (6.87)
	Recovery	11.07 (7.18)	10.58 (8.43)	11.59 (5.62)
HRV (RMSSD)				
	Baseline	3.66 (0.61)	3.61 (0.64)	3.72 (0.58)
	Stress	3.39 (0.62)	3.36 (0.61)	3.42 (0.64)
	Recovery	3.86 (0.59)	3.85 (0.62)	3.87 (0.56)
Emotion regulation strategy use				
	Reappraisal (0–7)	5.08 (1.13)	5.02 (1.27)	5.15 (0.97)
	Suppression (0–7)	4.21 (1.21)	4.29 (1.27)	4.13 (1.60)
*Memory of negative mood**				
Laboratory session (0–100)				
	Baseline	14.88 (10.20)	18.32 (10.52)	11.26 (8.68)
	Stress	36.67 (23.09)	38.96 (22.28)	34.17 (24.24)
	Recovery	17.93 (15.82)	21.23 (14.88)	14.32 (16.37)
Follow-up session (0–100)				
	Baseline	14.78 (12.01)	20.43 (13.19)	8.60 (6.48)
	Stress	51.45 (25.41)	55.45 (22.30)	47.08 (28.34)
	Recovery	21.37 (20.60)	22.82 (15.83)	19.79 (25.13)

Note. BPM = Beats Per Minute, HRV = Heart Rate Variability, NSSI = Nonsuicidal Self-Injury. RMSSD = Root Mean Square of Successive Differences. *Sample who completed follow-up survey only.

behaviour (in reality, an older male confederate). The confederate maintained a neutral, professional manner and instructed the participant to count aloud backwards from 2023 in intervals of 17 quickly and accurately. Participants were instructed to restart each time they made an error, and those who performed well were pressed to count faster. This task has been shown to reliably induce acute psychophysiological stress and negative affect within laboratory settings (Kudielka et al., 2007). Both experimenter and confederate were blind to participant's NSSI-status.

To capture recovery from emotional challenge, participants were told the arithmetic task was finished, and asked to sit and relax. Our goal was to assess spontaneous (i.e., uninstructed) recovery, and so participants were left to sit alone in the testing room for five minutes without further instruction.

2.5.2. Subjective emotional response

Mood was assessed immediately following baseline, stress, and recovery phases using visual analogue scales. Participants rated the degree to which they currently experienced nine feelings (happy, sad, angry, anxious, stressed, jittery, frustrated, embarrassed, and ashamed) using a 17.8 cm visual analogue scale ranging from '*0 – Not at All*' to '*100 – Extremely*', presented on the computer screen. Participants responded by moving the marker with the computer mouse from its original placement at the midpoint (i.e., 50). The order of the nine scales was randomized at each assessment and for each participant. Happiness was reverse coded, and item scores were averaged to create a negative mood score.

2.5.3. Physiological responding

HR and EDR measures were recorded continuously using ADInstruments ML408 Dual Bio Amp/Stimulator and LabChart Pro 8.0 software (ADInstruments, Australia). HR was determined from raw electrocardiogram (ECG), sampled at 1000 Hz. Analogue signals were converted to digital via a PowerLab 16/30 Amplifier (ML880; ADInstruments, Australia). ECG data was filtered offline using LabChart version 8 and an 8–40 Hz band-pass filter. R-wave spikes more than two standard deviations above mean activity were identified as peaks, with HR calculated using the inter-beat interval (the time between R-wave spikes) converted to number of beats per minute. To capture HRV, we used the LabChart HRV module to automatically detect all normal R peaks in the signal. R peaks were inspected, and any ectopic beats or beats obscured by artifacts were manually deleted (and therefore not analysed). The root-mean square differences of successive R-R intervals (RMSSD) was calculated using the standard LabChart HRV calculations. EDR was recorded using ADInstruments MLT116F EDR dry electrodes from the medial phalanx of the index and ring fingers of the right hand at a sampling rate of 1000 Hz and amplified using a EDR Amp (ML116; AD Instruments, Australia). EDR was subject-zeroed at the beginning of the experimental session (i.e., values are relative to the participant's initial level), converted offline from volts to micro-Siemens (μS) and smoothed at 999 samples per second using a median filter.

Physiology data recorded during the first 30 s of each of the three phases was excluded to allow the participant to habituate to the experience of the task and to allow the experimenter to exit the recording room. The ECG and EDR signals were visually inspected to ensure the rejection of artifacts. In total, 0.2 % of ECG data and 1.5 % of EDR data was removed due to artifacts. The proportion of removed data was similar across phases (Baseline: HR < 0.13 %, EDR = 0.2 %; Stress: HR = 0.6 %, EDR = 3.3 %; Recovery: HR = 0.1 %, EDR = 0.8 %; *ps* range from 0.831 to 0.086) and groups (HR: NSSI = 1.0 %, Control = 0.4 %, $\chi^2(1) = 0.11$, $p = .743$; EDR: NSSI = 3.8 %, Control = 4.9 %, $\chi^2(1) = 0.07$, $p = .788$). Raw averages of HR and EDR in the baseline, stress, and recovery phases were used for analysis. As anticipated, RMSSD differed from a normal distribution at all phases, exhibiting a substantial right skew. We therefore submitted RMSSD to natural log transformation, resulting in lnRMSSD data which was normally distributed.

2.5.4. Emotion regulation strategy use

A modified version of the 10-item Emotion Regulation Questionnaire (Gross and John, 2003) assessed the extent to which participants used cognitive reappraisal and expressive suppression to regulate during the post-challenge Recovery Phase Participants responded to items such as '*During the resting task, when I wanted to feel more positive emotion (such as joy or amusement) I changed what I was thinking about*') on a 7-point scale ranging from '*1–Strongly Disagree*' to '*7–Strongly Agree*'. Items within each subscale were averaged (Reappraisal α =0.91, Suppression α =0.81).

2.6. Follow-up measures

Two weeks after the laboratory session, participants completed a follow-up online survey assessing how they *remembered* feeling (rather than how they currently felt) during the laboratory session. Participants reported how they felt during the baseline, stress, and recovery phases of the laboratory session using the visual analogue scales described previously.

2.7. Missing data

108 young adults initially participated. Seven participants were excluded; one whose responses were not correctly recorded, and six (NSSI $n = 4$, Control $n = 2$) who chose to withdraw from the study during, or immediately after, the stress phase. The NSSI group were no more or less likely to withdraw than the Control group, $\chi^2(1) = 0.67$, $p =$ .414, Cramer's $V = 0.08$. Within subjective responding analyses, one participant did not report baseline mood data and one participant left one item of the mood report blank when reporting their mood following the stress phase. Given: a) the scale marker participants moved to indicate their response was automatically set at 50 (i.e., the midpoint), and b) the participant reported no ratings between 45 and 60 over the course of the laboratory session, this missing value was interpreted as a 50 response. Within physiological responding analyses, one Control group participant was excluded from cardiac analysis due to equipment failure. Three participants were excluded from the EDR analysis: two with artifacts comprising >40 % of a phase, and one who was classified as a EDR non-responder (relative to baseline, maximum EDR $\Delta = 2.02$ μS). There were no other missing responses.

2.8. Analysis plan

Statistical analyses were conducted using jamovi (The jamovi project, 2022). Statistical significance was set at $p < .05$, with $p < .10$ considered a trend for predicted effects only. Cohen's *d*, and partial eta squared provide effect sizes. None of the analyses using HRV were preregistered as its relevance became clear after the study was conducted. However, these analyses (using HRV in each phase as a dependent measure of emotional responding) follow the same analysis plan as the preregistered analyses. Exploratory analyses were not corrected for multiple comparisons.

Chi-squared analyses tested for group differences in medication use and clinical diagnoses, and independent *t*-tests for group differences in global emotion reactivity and dysregulation self-reports and resting HRV. Mixed-model ANOVAs tested the hypotheses that people who self-injure have a more reactive and/or more sustained response to emotional challenge (within-subjects factor: Phase [Baseline, Stress, Recovery], between-subjects factor: NSSI status [NSSI, Control]), implement less effective emotion regulation strategies following emotional challenge (within-subjects factor: Strategy Type [Reappraisal, Suppression], between-subjects factor: NSSI status [NSSI, Control]), and/or amplify emotional experiences in memory (within-subjects factors: Phase [Recovery, Stress, Recovery], Time [During Session, Follow-Up], between-subjects factor: NSSI status [NSSI, Control]). Geisser corrections were applied when sphericity was violated.

3. Results

3.1. Trait emotion reactivity and regulation

Table 2 provides descriptive statistics. Consistent with previous research, the NSSI group reported greater global emotion reactivity, $t(99) = 4.27$, $p <. 001$, $d = 0.85$, and dysregulation, $t(99) = 6.07$, $p <. 001$, $d = 1.21$, than controls. These group differences were maintained when self-reported mental health diagnosis was included as a covariate (emotion reactivity: $F(1, 98) = 15.33$, $p <. 001$, $\eta_p^2 = 0.14$; emotion dysregulation: $F(1, 98) = 30.65$, $p <. 001$, $\eta_p^2 = 0.24$). Exploratory analyses showed no difference by NSSI status in resting-state HRV (i.e., baseline), $t(98) = 0.90$, $p = .517$, $d = 0.18$, suggesting groups did not differ in their biological capacity for emotion regulation.

3.2. Responding to emotional challenge

3.2.1. Manipulation check

Emotional responding was investigated with 3 (Phase: Baseline, Stress, Recovery) × 2 (NSSI status: NSSI, Control) mixed-model ANOVAs. All four measures of emotion changed over laboratory session (Negative Mood: $F(1.54, 1502.56)$ =109.01, $p < .001$, $\eta_p^2 = 0.52$; HR: $F(1.25, 124.11) = 251.65$, $p < .001$, $\eta_p^2 = 0.72$; HRV: $F(1.45, 143.28) = 54.92$, $p < .001$, $\eta_p^2 = 0.36$; and EDR: $F(1.52, 147.90) = 169.23$, $p < .001$, $\eta_p^2 = 0.64$). Follow-up *t*-tests revealed the acute stress induction effectively created emotional challenge: negative mood, HR, and EDR significantly increased from Baseline to Stress phases (Negative Mood ($t(99) = 11.46$, $p < .001$, $d = 1.15$; HR: $t(99) = 14.54$, $p < .001$, $d = 1.45$; EDR: $t(97) = 15.13$, $p < .001$, $d = 1.53$), while HRV decreased ($t(99) = 5.17$, $p < .001$, $d = 0.52$). Participants also recovered from challenge: negative mood, HR, and EDR significantly decreased from Stress to Recovery phases (Negative Mood: $t(100) = 12.25$, $p < .001$, $d = 1.22$; HR: $t(99) = 17.85$, $p < .001$, $d = 1.78$; EDR: $t(97) = 9.92$, $p < .001$, $d = 1.00$) while HRV increased ($t(99) = -9.33$, $p < .001$, $d = -0.93$). In terms of absolute emotional recovery, negative mood and EDR remained elevated compared to baseline levels (Negative Mood: $t(99) = 4.48$, $p <$ .001, $d = 0.45$; EDR ($t(97) = 10.96$, $p < .001$, $d = 1.11$), whereas both HR and HRV recovered to below Baseline levels (HR: $t(99) = 8.89$, $p <$ .001, $d = 0.89$; HRV: $t(99) = 7.10$, $p < .001$, $d = 0.71$), indicating a substantial "rebound" in cardiac measures following stress.

3.2.2. Emotional responding by self-injury status

We considered how young adults who self-injure subjectively and physiologically responded to emotional challenge by adding NSSI status as a between-subjects variable in each ANOVA. There was no evidence of a main effect of NSSI Status on any of the four emotion measures (Negative Mood: $F(1, 98) = 0.91$, $p = .343$, $\eta_p^2 = 0.01$; HR: $F(1, 98) = 0.37$, $p = .546$, $\eta_p^2 < 0.01$; EDR $F(1, 96) = 0.28$, $p = .601$, $\eta_p^2 < 0.01$; HRV: $F(1, 98) = 0.31$, $p = .560$, $\eta_p^2 < 0.01$), suggesting groups did not differ in overall responding. Counter to hypotheses that people who self-injure show an amplified or more sustained response to emotional challenge, we found no evidence of a NSSI Status × Phase interaction across subjective ($F(1.54, 150.75) = 0.13$, $p = .819$, $\eta_p^2 < 0.01$) or physiological measures (HR: $F(1.26, 123.10) = 0.92$, $p = .360$, $\eta_p^2 = 0.01$; EDR: $F(1.52, 145.84) = 0.50$, $p = .557$, $\eta_p^2 = 0.01$; HRV: $F(1.44, 140.74) = 0.53$, $p =$ .533, $\eta_p^2 = 0.01$). In a similar manner, exploratory analyses found no differences in subjective or physiological emotional responding by NSSI severity (see Supplementary Materials).

3.2.3. Spontaneous emotion regulation

Although the NSSI group were largely as effective as controls at recovering from emotional challenge, perhaps they used different emotion regulation strategies. Overall, participants reported using reappraisal more than suppression to regulate their emotions during the Resting Phase, $F(1, 99) = 27.55$, $p < .001$, $\eta_p^2 = 0.22$. Counter to predictions, we found no evidence to suggest overall strategy use differed by NSSI status, $F(1, 99) = 0.01$, $p = .926$, $\eta_p^2 < 0.01$, or that NSSI status interacted with Strategy Type, $F(1, 99) = 0.81$, $p = .372$, $\eta_p^2 = 0.01$, suggesting that both groups used reappraisal and suppression strategies to a similar extent to manage their emotional experience following emotional challenge. See Supplementary Materials for exploratory analysis of spontaneous reappraisal and suppression use during emotional challenge.

3.3. Memory of emotional challenge

Finally, we tested the hypothesis that people who self-injure report poorer global emotional functioning because they amplify challenging emotional experiences in memory. These analyses are conducted in a subset of the overall sample ($n = 44$) who completed the follow-up survey two weeks after the laboratory session. Findings parallel participants' subjective reports during the laboratory session: participants remembered having greater negative affect during challenge than during baseline or recovery phases (Phase: $F(2, 82) = 71.82$, $p < .001$, $\eta_p^2 = 0.64$). Negative mood ratings changed over the follow-up period (Session: $F(1, 41) = 13.31$, $p < .001$, $\eta_p^2 = 0.25$, Phase × Session: $F(2, 82) = 14.09$, $p < .001$, $\eta_p^2 = 0.26$). Follow-up *t*-tests comparing participants negative mood during the laboratory session with their how they later remembered their negative mood found participants' accurately recalled their emotional experience during Baseline, $t(42) = 0.21$, $p = .837$, $d = 0.03$, and Recovery, $t(43) = 1.32$, $p = .194$, $d = 0.20$, phases of the laboratory session. In contrast, participants amplified their experience of emotional challenge in memory, remembering their negative mood during the Stress Phase as more intense than they initial reported, $t(43) = 5.07$, $p < .001$, $d = 0.76$. No main effect, $F(1, 41) = 3.12$, $p = .085$, $\eta_p^2 = 0.07$, or interactions involving NSSI were found (NSSI status × Phase: $F(2, 82) = 0.51$, $p = .603$, $\eta_p^2 = 0.01$; NSSI Status × Session: $F(1, 41) = 0.16$, $p = .695$, $\eta_p^2 < 0.01$; NSSI Status × Phase × Session: $F(2, 82) = 1.19$, $p = .309$, $\eta_p^2 = 0.03$). Although participants remembered their subjective response to emotional challenge as more intense than they reported during the laboratory session, we found no evidence to suggest this memory amplification process differed by NSSI status.

4. Discussion

Theoretical accounts propose that amplified emotional responses create the necessary context for NSSI (Chapman et al., 2006; Hasking et al., 2016; Nock, 2010). We compared how young adults with and without NSSI responded to, and recovered from, acute stress across subjective (negative mood) and physiological (HR, HRV, and EDR) channels of emotion. Two weeks later a subset reported how they remembered the experience. Findings emphasise a dissociation between emotion dysregulation self-reports and real-time responses to a laboratory-based emotional challenge; the NSSI group reported elevated emotion reactivity and dysregulation than controls, but both groups showed similar responses to, and recovery from, real-time emotional challenge across subjective and physiological domains. Although participants later came to remember their experience as more intense than they originally reported, both groups did so similarly.

Findings add to growing evidence against the argument that NSSI is a behaviour consistently characterised by amplified emotional responding. Across clinical and community samples, people who self-injure have demonstrated similar emotional responses to both standardised and personally-relevant challenges (e.g., Crowell et al., 2005; Gratz et al., 2011; Kaess et al., 2012; Mettler et al., 2021; Robinson et al., 2023; Weinberg and Klonsky, 2012). Studies which found greater subjective and/or physiological reactivity in NSSI also reported NSSI groups with elevated symptoms of borderline personality disorder (BPD) relative to controls (Gratz et al., 2019; Kaufman et al., 2020). Given BPD often presents with NSSI (Nock et al., 2006) and is associated with greater affect instability (Houben et al., 2015; Schmahl et al., 2014), perhaps altered emotional responding in NSSI instead reflects underlying dimensional BPD psychopathology (Hooley and Franklin, 2018; Kaess et al., 2021). In line with this proposal, Koenig et al. (2022) demonstrated negative affect and HR reactivity to stress differed between clinical adolescents with and without NSSI as a function of dimensional BPD severity. Thus, counter to prominent theories, amplified emotional responding may be comorbid with, rather than characteristic of, NSSI.

Although the focus of less investigation, recovery from challenge is a critical component of emotional responding. Consistent with the current study, previous research found limited differences in subjective (Mettler et al., 2021) or physiological (Crowell et al., 2005) recovery from emotion challenge. In contrast, Boyes et al. (2020) found young adults who self-injure initially reported less mood repair following a sad film clip than controls early in the 5-min recovery period, but by the end of the recovery period had recovered to the same extent as controls. Although people who self-injure have demonstrated impaired ability to reappraise during emotional challenge (Davis et al., 2014), we found no difference in the extent to which NSSI or Control groups reported spontaneously engaging in reappraisal or suppression during the recovery period. Perhaps people who self-injure are equally able to recover from emotional challenge, using similar regulation strategies, but take longer to do so.

Critically, these null findings occur alongside well-established differences in self-reported emotion dysregulation. Consistent with previous research finding limited convergence between self-report measures and performance-based/objective measures of psychological characteristics (Buchanan, 2016; Sharma et al., 2014) and health-related behaviours (Cudney et al., 2022; Mahalingham et al., 2023), the impaired emotional functioning reported by the NSSI group relative to controls did not correspond to meaningful differences in either subjective or physiological responses to emotional challenge. Given that self-reports of emotion functioning predict NSSI onset (Fox et al., 2015; Robinson et al., 2019) and cessation (Adrian et al., 2019; Gratz et al., 2012), it may be that an individual's *perceptions* of their emotional responses—rather their actual emotional responses—are what is critical in NSSI. Future research resolving this dissociation between self-reports and real-time responding is critical for improving our understanding of NSSI.

We conducted a preliminary test of whether differences in memory of emotional challenge may explain this dissociation. As NSSI is associated with the tendency to ruminate on unpleasant events (Hoff and Muehlenkamp, 2009; Selby et al., 2013), people who self-injure may be disproportionately susceptible to well-established memory and inferential biases (Schwartz et al., 1999; Solhan et al., 2009). Overall, participants remembered their subjective experience during the Stress phase as *more* intense than they reported initially during the laboratory session. Counter to predictions, NSSI and Control groups did not differ in the extent to which they amplified the emotional event in memory. Thus, we found no evidence elevated emotion dysregulation self-reports in NSSI can be attributed to overestimating past negative emotional experiences.

The current study has two key strengths. First, we tested our pre-registered predictions using a within-subjects emotional challenge in a sample with past-year NSSI engagement. Second, we assessed responses to, and recovery from, challenge across different four channels of emotional responding, including subjective *and* physiological indices, and all of which showed robust changes in response to, and recovery from challenge. These design choices in combination with the large group differences in emotion dysregulation self-reports provide the context in which nulls effects of NSSI status on real-time emotional responding were observed. Findings should be interpreted considering two caveats. First, only 43.6 % of the sample participated in the follow-up session two weeks after the laboratory session, resulting in analyses with less power. Second, as we recruited from a community population, NSSI tended to be infrequent and sporadic; although all participants in the NSSI Group reported self-injuring in the past year, 49.0 % had done so only 1–3 times.

Future research should aim to resolve the dissociation between emotion dysregulation self-reports and emotional responses to challenge. Perhaps current research designs have failed to capture the specific emotional contexts (e.g., personal relevant interpersonal rejection), subgroups of people who self-injure (e.g., chronic NSSI, comorbid BPD), or developmental periods (e.g., early adolescence) where amplified emotional is critical for NSSI. Alternatively, perhaps people's perceptions of their emotions, rather than their actual emotional response, is critical for NSSI. Looking to the future, a more nuanced understanding of the role of emotion in NSSI is needed to more effectively target intervention strategies to support people who self-injure.

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CRediT authorship contribution statement

Kealagh Robinson: Writing – review & editing, Writing – original draft, Project administration, Investigation, Formal analysis, Data curation, Conceptualization. **Joe P. Cornes:** Writing – review & editing, Formal analysis. **Johannes A. Karl:** Writing – review & editing, Formal analysis. **Marc S. Wilson:** Writing – review & editing, Supervision, Conceptualization. **Gina M. Grimshaw:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

All authors report no potential conflicts of interest.

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Appendix A. Supplementary data

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