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A comparison of affective-cognitive states in daily life between emerging adults with and without past-year non-suicidal self-injury

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https://osf.io/tnyk7/?view_only=180ec639e10c435bbabf67d6b889fe2f).

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Abstract

Although the literature suggests trait-like differences in affective and cognitive vulnerabilities between individuals with and without a history of non-suicidal self-injury (NSSI), little is known about how these dispositional differences are experienced in the natural environment. The present study compares the intensity, inertia, interaction, and variability of affective (negative and positive affect) and cognitive states (rumination, self-criticism) in the everyday lives of individuals who do and do not engage in NSSI. Using experience sampling methodology (ESM), 60 emerging adults (ages=18-22 years) with and without past-year NSSI (equally distributed) completed a baseline battery of questionnaires and an ESM sampling protocol consisting of eight questionnaires per day for 12 days (in total, 96 questionnaires per participant), resulting in 4,587 assessments (median compliance=83.3%; IQR=71.9-91.7). In a dynamic structural equation modeling framework, dynamic parameters (i.e., mean intensity, carryover effects, spillover effects, and within-person variability) were evaluated using multilevel vector autoregressive models. Emerging adults who engage in NSSI experience higher intensity and greater variability of negative affect, rumination, and self-criticism, whereas lower intensity and greater variability of positive affect. In addition, past-year NSSI predicted stronger affective-cognitive interactions over time, with stronger spillover effects of negative and positive affect on subsequent rumination and self-criticism in individuals who engage in NSSI. Depressive symptoms and trait levels of emotion dysregulation and self-criticism partially negated these differences. Our findings provide evidence that emerging adults who self-injure experience more negative affective-cognitive states in daily life and point to the potential relevance of boosting positive emotions to buffer negative cognitions.

Keywords: non-suicidal self-injury, NSSI, experience sampling, ecological momentary assessment, emotion, self-criticism, rumination

Introduction

Non-suicidal self-injury (NSSI), the intentional damage of body tissue for reasons other than ending one's life (e.g., cutting, scratching, and hitting oneself; International Society for the Study of Self-Injury, 2022), is a significant public health concern among young people. Whereas NSSI typically has its onset in adolescence (Gandhi et al., 2018), close to 8% of emerging adults (aged 18-25 years) report past-year NSSI (Kiekens et al., 2023). Engaging in NSSI is associated with an increased risk for various negative outcomes, including future psychiatric disorders (Kiekens et al., 2023; Wilkinson et al., 2018) and suicidal thoughts and behaviors (Hamza & Willoughby, 2016; Kiekens et al., 2018). These findings indicate the importance of understanding the psychological processes underlying NSSI to advance prevention and treatment — a viewpoint that the American Psychiatric Association (APA, 2013) emphasized with its inclusion of NSSI as a condition requiring further study in DSM-5.

Given that NSSI is frequently used to regulate aversive feelings and thoughts (Bentley et al., 2014; Brown et al., 2022; Kuehn et al., 2022; Taylor et al., 2018), contemporary theoretical models posit that affective and cognitive vulnerabilities explain the onset and persistence of NSSI. For example, rumination as a cognitive style (i.e., negative mood-congruent thinking and repetitively thinking about the same problem; Watkins & Roberts, 2020) and negative affect are theorized to reinforce each other in the Emotional Cascade Model (Selby et al., 2008). These cyclic reinforcing effects are expected to lead to intolerable distress levels that require behaviors with intense potent physical sensations such as NSSI to short-circuit these perpetuating emotional cascades (Hughes et al., 2019; Selby et al., 2008). Alternatively, the Benefits and Barriers Model (Hooley & Franklin, 2017) proposes a unique role for self-criticism (i.e., negative self-evaluation when perceived expectations of oneself are not met) in explaining who will choose NSSI to regulate aversive emotions and cognitions. Specifically, self-critical individuals are considered more likely to use NSSI because it gratifies self-punishment desires and is congruent with a highly negative self-view (Hooley & Franklin, 2017). In line with these theories, cross-sectional research consistently

shows a positive association between trait levels of negative affect, rumination, self-criticism, and a history of NSSI (Coleman et al., 2021; Tonta et al., 2022; Zerkowicz & Cole, 2019). Longitudinal studies have linked these traits to an increased risk of NSSI (Burke et al., 2018; Fox et al., 2018; Nicolai et al., 2016). Importantly, however, these dispositional vulnerabilities do not occur in isolation. For example, Burke and colleagues (2018) found that young individuals with higher negative affect, rumination, and self-criticism, but lower positive affect were most likely to engage in NSSI one year later. Although positive affect has received much less empirical attention than negative affect in both empirical literature and theoretical models of NSSI, scholars have recently argued that positive affect may also play a crucial role in understanding the generation of risk for NSSI (Perini et al., 2021). For instance, recent work suggests less intense and less perseveration of positive affect among individuals who engage in NSSI (Boyes et al., 2020) and that positive affect may attenuate risk for NSSI (Cohen et al., 2015; Hasking et al., 2018).

Despite the knowledge that a stronger tendency to experience negative affect and negative cognitions underpin self-injury, few studies have considered how these trait-like differences are experienced in daily life. Emotions and cognitions are not stable factors but dynamic psychological processes that unfold within individuals over time in the natural environment (Hjartarson et al., 2021; Kuppens & Verduyn, 2017; Zuroff et al., 2016); meaning that people differ in meaningful ways in the intensity (mean), inertia (carryover), and deviation (variability) of affective and cognitive states. Prior work has linked higher intensity and variability of negative affect to higher levels of psychopathology (Dejonckheere et al., 2019; Scott et al., 2020). While momentary fluctuations in negative affect, rumination, and self-criticism have been identified as precipitants of NSSI (Brown et al., 2022; Burke et al., 2021a; Hughes et al., 2019; Kuehn et al., 2022), we must also clarify whether their dynamic blueprint varies between people who do and do not engage in NSSI to inform how affective and cognitive vulnerabilities theorized to increase susceptibility for NSSI play out in daily life. However, this is not possible with cross-sectional designs. Further, cohort studies

generally carry out 2-5 measurements months to years apart, which does not allow for capturing short-term variation. One way to address these shortcomings is to use ecologically valid assessment procedures.

Experience Sampling Methodology (ESM, also called ecological momentary assessment or real-time monitoring) is a structured self-report diary technique in which individuals provide information on their emotions, cognitions, and contexts as they are experienced in the flow of everyday life (Kiekens et al., 2021; Myin-Germeys et al., 2018; Shiffman et al., 2008). Daily diary studies which assess constructs once per day have found that individuals who engage in NSSI report a higher intensity of negative affect and a lower mean intensity and lower inertia (carryover) of positive affect (i.e., previous-day positive affect is less self-predictive of the intensity of positive affect the next day; Bresin, 2014; Victor & Klonsky, 2014). However, daily diaries still require participants to reflect across an entire day retrospectively, leading to memory biases, mood-congruency effects (i.e., reporting mood consistent with how they are feeling at the time of assessment; Matt et al., 1992), and making detection of variation throughout the day difficult. Recently, Victor and colleagues (2021) examined affective dynamics up to seven times per day among 166 young adult women (16 of whom reported past-year NSSI). They found that women who reported past-year NSSI experienced more intense and variable negative affect than those who did not engage in NSSI. In addition, although there were no differences in average positive affect, these authors observed a smaller carryover effect of positive affect among the women reporting past-year NSSI (Victor et al., 2021). While these initial studies provide insight into the dynamic emotional signature of people who self-injure, research should replicate and extend previous knowledge in three critical ways.

First, while most work has focused on negative affect, more attention is needed on positive affect and negative cognitions in the everyday lives of young people who engage in NSSI. For instance, evidence is emerging that those who engage in NSSI experience more momentary self-criticism and more variability in self-critical thinking (Burke et al., 2021b).

However, it remains unclear whether rumination is experienced differently among those with and without a history of NSSI. Better clarifying the blueprint of emotional (negative and positive affect) *and* cognitive states (rumination, self-criticism) among emerging adults who do and do not engage in NSSI would provide meaningful information about the ecological validity of findings observed in traditional study designs.

Second, emotions and cognitions (self-criticism, rumination) do not occur in a vacuum but interact with each other in the natural environment (Hjartarson et al., 2021; Selby et al., 2016; Zuroff et al., 2016), which implies there is a need to investigate the short-term spillover effects of affective-cognitive states in daily life. These effects capture a predictive relationship over time and may represent causal mechanisms (Hamaker et al., 2018). For instance, research suggests that positive affect may buffer subsequent negative states (Fredrickson et al., 2000; Wichers et al., 2012). Nevertheless, evidence is mixed regarding whether young people who engage in NSSI experience less intense positive emotion than those who do not self-injure (Bresin, 2014; Victor & Klonsky, 2014; Victor et al., 2019) and, if so, benefit in the same way from its potentially dampening effect (Hoorelbeke et al., 2019). Moreover, according to the Emotional Cascade Model and Benefits and Barriers Model, there will be strong relationships between negative affect and rumination (Arbuthnott et al., 2015; Selby et al., 2008; Selby et al., 2016) and negative affect and self-criticism (Hooley & Franklin, 2017) among individuals who self-injure. However, no study to date has investigated whether the associations between negative and positive affect, on the one hand, and rumination and self-criticism, on the other hand, unfold differently over time in the natural environment for people who do and do not engage in NSSI. Addressing this knowledge gap would provide a test of the affect-cognition interactions postulated by these theories and generate insights into how affect and cognition might work together to increase or buffer risk for NSSI.

Finally, future work is needed to better understand why affective and cognitive states might be experienced differently between individuals who do and do not engage in NSSI. Theoretical models and emerging work suggest that higher dispositional emotion

dysregulation and self-criticism may account for this (Selby et al., 2008; Vansteelandt et al., 2020). For instance, Vansteelandt and colleagues (2020) recently observed that higher trait self-criticism explained higher variability in both negative and positive affective states in a clinical sample of patients with borderline personality disorder (of whom up to 95% generally report self-injury; Goodman et al., 2017). Moreover, based on the Emotional Cascade Model (Selby et al., 2008; Selby & Joiner, 2009), reinforcing cyclical cascades can be hypothesized between rumination and negative affect among people with lower trait emotional regulation abilities. Finally, recent studies have found that higher emotional intensity and stability of negative emotions in emerging adults with a history of NSSI might also be accounted for by higher levels of depression (Boyes et al., 2020; Jacobson et al., 2015). Building on these findings, addressing why emotions and cognitions might be experienced differently in daily life would offer valuable information for researchers and scientist-practitioners that work with young people who engage in NSSI.

This study

This study was designed to evaluate whether emerging adults who have self-injured in the past year (a) show different dynamic properties in terms of intensity (mean), inertia (carryover), and deviation (variability) of affective-cognitive states, and (b) experience stronger relationships across hours (spillover effects) than those without a history of NSSI. Additionally, we tentatively explored whether group differences could potentially be explained by depressive symptoms, trait emotion dysregulation, and trait self-criticism among people who self-injure.

Material and methods

Procedure and participants

Emerging adults in an ongoing study of college students in Flanders (Belgium; MASKED) could voluntarily sign up to participate in this study between March and October 2018. To be eligible, individuals had to have sufficient proficiency in the Dutch language and own a smartphone with at least 4G coverage. Inclusion criteria for the NSSI group were based

on the DSM-5 frequency criteria: NSSI on five or more days in the past year and NSSI urges in the past month. The inclusion criteria for the reference group were no lifetime history of NSSI and no prior history of DSM-5 mental disorders. People who met these criteria and wanted to participate were invited for an introductory session. During this session, participants were briefed and conducted the baseline assessment, consisting of an online survey via Qualtrics and a clinical interview. The presence of mental disorders was assessed with the *Structured Clinical Interview for DSM-5* (SCID; First et al., 2015). In addition, NSSI characteristics and suicidal thoughts and behaviors were assessed with the well-validated Self-Injurious Thoughts and Behaviors Interview (SITBI; Latimer et al., 2013; Nock et al., 2007). The session concluded with training on completing the ESM protocol via ExpiWell, a user-friendly and secure app for intensive assessment in daily life (<https://app.expiwell.com>). When needed, the research team provided participants with a study phone.

The next day, participants began a 12-day ESM protocol in which they were prompted semi-randomly eight times per day, between 9 a.m. and 9 p.m., in blocks of 1.5hr segments (with a minimum of 15 minutes between assessments). To minimize retrospective reporting, we required responses to be registered within 15 minutes of each prompt. In addition, participants were provided with written contact details of clinical psychologists (first and last author), and a popup with additional resources was presented in the app when participants reported experiencing suicidal thoughts. Reimbursement was structured to encourage ESM compliance, with a financial compensation of €25 if compliance ranged between 25% and 50% or if the follow-up questionnaire was not completed, €50 if compliance ranged between 50% and 85%, and €75 if compliance exceeded 85%. The University's Ethical Review Board approved the study, and all procedures aligned with the 1964 Helsinki Declaration and its later amendments.

A total of 65 students initially consented to participate, with the final sample after eligibility assessment comprising 60 emerging adults (81.67% identified as female; Mean age = 19.53, $SD = 1.28$, range 18-22 years), evenly distributed across the group with (n=30) and

without past-year NSSI ($n=30$). Of these, most (96.67%) were studying full-time, except for two participants in the NSSI group who were part-time students. Participants in the NSSI group (Mean = 20.10, $SD = 1.13$) were slightly older than those in the reference group (Mean = 18.97, $SD = 1.2$, $t_{(58)}=3.79$, $p < .001$). There was no significant difference in the composition of gender across groups (83.33% identified as female and 16.67% as male in the reference group versus 80.0% female and 20% male in the NSSI group, $\chi^2_{1df}=0.11$, $p = .739$). Of the sample, 85.0% identified as heterosexual, 8.33% as bisexual, 5.0% as homosexual/lesbian, and 1.67% as asexual. The proportion of participants identifying as heterosexual did not differ significantly across groups (93.33% in the reference group versus 76.67% in the NSSI group, *Fisher exact test*, $p = .145$). Participants who engaged in NSSI met the criteria for a median of two mental disorders in the last 12 months, with DSM-5 anxiety and mood disorders being the most prevalent (33.3%–50%). In addition, participants reported a median of NSSI on 17.5 days in the past year (range 5–360 days). For a detailed description of the NSSI sample, see [MASKED]. Compliance with the ESM protocol was good (Median = 83.33%; IQR = 71.88-91.67%). Participants completed an average of 76.45 out of 96 assessments (range 33-95), resulting in 4,587 observations. The groups did not differ significantly in the number of assessments (Mean reference group = 78.83, $SD = 13.07$; Mean NSSI group = 74.07, $SD = 15.59$, $t(58)=1.28$, $p = .205$).

Baseline measures

Depressive symptoms. We assessed depressive symptoms using the depression subscale of the Dutch 21-item Depression, Anxiety, and Stress Scales (DASS; Henry & Crawford, 2005), which assesses depressive symptoms during the past week (e.g., "*I felt down-hearted and blue*"). The DASS items are scored on a 4-point scale ranging from 0 (did not apply to me at all) to 3 (applied to me very much, or most of the time), and the internal consistency of the depression subscale was excellent ($\alpha = .92$).

Trait emotion-dysregulation. The Difficulties in Emotion Regulation Scale Short Form was used to assess emotion dysregulation (DERS; Gratz & Roemer, 2004; Kaufman et

al., 2015). The DERS assesses six aspects of emotion dysregulation, including: nonacceptance of emotional response (e.g., "*When I'm upset, I become embarrassed for feeling that way*"), difficulty in goal-directed behavior (e.g., "*When I'm upset, I have difficulty focusing on other things*"), impulse control (e.g., "*When I'm upset, I become out of control*"), emotional awareness (e.g., "*I care about what I am feeling*"), limited access to emotion regulation strategies (e.g., "*When I am upset, it takes me a long time to feel better*"), and lack of emotional clarity ("*I am confused about how I feel*"). Participants respond to each item on a 5-point scale (0 = almost never, 4 = almost always) regarding how often they use each strategy. Kaufman and colleagues (2015) recently reduced the 36-item DERS into an 18-item short version, which correlated strongly with the original measure ($r \geq .90$) and had comparable psychometric properties. The internal consistency of the total score was excellent ($\alpha = .91$).

Trait self-criticism. The Forms of Self-Criticizing/Attacking and Self-Reassuring Scale (Gilbert et al., 2004) was used to operationalize self-criticism. This is a 22-item self-report questionnaire that consists of three subscales, being hated-self (e.g., "*I have a sense of disgust with myself*"), inadequate-self (e.g., "*I am easily disappointed with myself*"), and reassuring-self (e.g., "*I am able to remind myself of positive things about myself*").

Participants are asked to rate how these statements reflect themselves following setbacks on a five-point Likert scale ranging from 0 (not at all like me) to 4 (extremely like me). For the present study, we calculated a composite score based on the inadequate-self and hated-self subscales, but to avoid conceptual overlap with NSSI group membership, we excluded the hated-self subscale item "*I have become so angry with myself that I want to hurt or injure myself*". The scale's internal consistency was excellent ($\alpha = .94$).

Experience sampling measures

State negative and positive affect. Participants rated a range of momentary negative (i.e., stressed, irritated, anxious, sad, hopeless, insecure) and positive emotions (i.e., excited, cheerful, satisfied, relaxed) at each prompt: "*Right now, I feel [emotion]*." The order of these emotions was randomized across assessments and rated on a 7-point scale ranging from 0 (not

at all) to 6 (very much). These emotions were weighted equally to compute negative and positive affect and selected because they represent all four quadrants of the affective circumplex defined by valence and arousal dimensions (Russell, 2003). Using methods described by Shrout and Lane (2012), negative and positive affect demonstrated excellent between-person ($RKR = 0.99$) and good within-person reliability ($RC = 0.75-0.82$).

State rumination and self-criticism. Items to assess state rumination and self-criticism were drawn from prior ESM studies and modified from established survey questionnaires (Gilbert et al., 2004; Kircanski et al., 2015; Selby et al., 2016). Momentary rumination was assessed by asking at each assessment the extent to which participants were dwelling on problems ("*Right now, I am repeatedly thinking about the same problem*") and emotions ("*Right now, my emotions keep me busy*") rated on a 7-point scale ranging from 0 (not at all) to 6 (very much). This captures both the aspect of rumination as mood-congruent thinking and its interference with problem-solving (Watkins & Roberts, 2020). Rumination demonstrated excellent between-person ($RKR = 0.99$) and reasonable within-person reliability ($RC = 0.64$). Self-critical thinking was also assessed through two items at each assessment on a 7-point scale ranging from 0 (not at all) to 6 (very much): "*Right now, I am disappointed in myself*", "*Right now, I am angry at myself*". These items directly tap into the two main studied forms of self-criticism (i.e., inadequate- and hated-self; Gilbert et al., 2004). Our measure of state self-criticism showed excellent between-person ($RKR = 0.99$) and good within-person reliability ($RC = 0.75$).

Statistical analyses

Descriptive statistics (means and standard deviations) are reported for the baseline and momentary variables. Comparisons between baseline variables across groups with and without a history of NSSI were conducted using two-sample t -tests, with Welch's t -test used in case of unequal variances across groups. We also calculated the total variance and intra-class correlation coefficient (ICC) to indicate the proportion of the total variance accounted for by between-person variance of each momentary variable. Multilevel vector autoregressive

(VAR) models were constructed within a Dynamic Structural Equation Modeling Framework (DSEM) in Mplus 8.3 (Asparouhov et al., 2017; McNeish & Hamaker, 2019). This allowed us to investigate whether emerging adults who had engaged in NSSI in the past year have different affective-cognitive dynamics than those who have never self-injured. Using DSEM, we evaluated the primary study objective (i.e., evaluating differences in mean intensity, carryover and spillover effects, and within-person variability between people who do and do not self-injure) by including past-year NSSI as a between-person predictor of random effects. In our study, carryover and spillover effects (i.e., autoregressive and cross-lagged parameters; Hamaker et al., 2018) capture the extent that a state variable predicts itself (e.g., negative affect) or another state variable (i.e., rumination) on an hourly time scale.

We specified four univariate and four bivariate multilevel VAR models by pairing affective states (positive and negative affect) with cognitive states (rumination and self-criticism). Relative to the univariate models (which do not include spillover effects), the bivariate models contain two intercepts for the means, two carryover effects, two spillover effects, and two residual variances (i.e., each time one for the affective and one for the cognitive state under investigation), displaying the value of these parameters for the participants without a history of NSSI. Eight respective slopes capture the difference in these eight parameters for participants with past-year NSSI. The bivariate models included covariances for the residuals of the between-components of the means and variances, respectively. In DSEM, within-person variances are expressed as the log-normal distribution of the variance. Latent person-mean centering was used to interpret predictor variables at the within-person level in a relative fashion for each person while accounting for sampling error. Finally, we explored whether depressive symptoms, trait emotion dysregulation (for models including state rumination), and trait self-criticism (for models including state self-criticism) accounted for differences in mean intensity, carryover, spillover, and within-person variability of affective-cognitive states across the sample. These baseline variables were grand-mean centered and standardized.

Bayesian estimation was used with non-informative priors based on Markov Chain Monte Carlo using Gibbs sampling. Unstandardized point estimates were obtained by taking each parameter's median of the posterior distributions. Statistical significance was determined by estimating 95% credibility intervals (CI) around each point estimate, indicating a 95% probability that the true comparison value is not null. A 1-hour transformed time interval was specified to account for unequally spaced intervals due to missing data and random sampling within blocks. This procedure creates a new time variable (measured in hours since the first assessment) and inserts missing data records based on the defined metric when no observation is present (Asparouhov et al., 2017). DSEM handles missing data using a Kalman filter approach to maintain a constant interpretation of lagged relations in discrete-time models (McNeish & Hamaker, 2019). Each model was estimated using a minimum of 2,500 iterations with a thinning parameter of 20. Model convergence was ensured by checking that the potential scale reduction was close to one and trace plots did not contain trends or spikes.

Power estimation

Whereas Bayesian estimation has better performance in smaller samples than a frequentist approach (i.e., posterior distributions are not dependent upon large-sample theory and can be non-normal; Muthén et al., 2016), simulation-based analyses with maximum likelihood estimation were performed to provide an indication of the smallest effects that could be detected with 60 individuals distributed equally across groups. Using a multilevel autoregressive model with 1,000 Monte Carlo replications (model 10; Lafit et al., 2021), power was estimated to be adequate ($>.80$) to detect mean group differences as small as $.37$ (fixed intercept= 2.00 , $SD=0.50$) and $.09$ for carryover effects (fixed slope= 0.28 , $SD=0.05$; see parameter values and full results in Supplementary Table 1).

Results

Descriptive statistics

Table 1 displays univariate and variability statistics of the study variables. These findings show that at least half of the variability (i.e., ICC) in momentary negative affect

(61%), positive affect (50%), rumination (53%), and self-criticism (55%) was situated at the between-person level. In addition, emerging adults who engaged in NSSI in the past year reported higher mean levels of depressive symptoms (Mean NSSI group = 7.53, $SD = 5.24$; Mean reference group = 0.67, $SD = 1.27$, $t_{\text{Welch}}(32.39) = 6.98$, $p < .001$), trait emotion dysregulation (Mean NSSI group = 37.63, $SD = 10.33$; Mean reference group = 15.20, $SD = 5.48$, $t_{\text{Welch}}(44.12) = 10.51$, $p < .001$), and trait self-criticism (Mean NSSI group = 29.90, $SD = 8.37$; Mean reference group = 8.90, $SD = 6.58$, $t(58) = 10.80$, $p < .001$) than those without a history of NSSI.

[Please include Table 1 here]

Comparison of affective-cognitive states in daily life between emerging adults with and without past-year NSSI

We first examined whether emerging adults with past-year NSSI experience different mean intensity, carryover effects, and within-person variability of affective and cognitive states in daily life compared to peers who do not self-injure (Table 2). Univariate models revealed that emerging adults with past-year NSSI reported higher intensity of negative affect ($\beta_{\text{NSSI}} = 1.32$, $SD = 0.17$, $p < .001$), rumination ($\beta_{\text{NSSI}} = 1.18$, $SD = 0.21$, $p < .001$), and self-criticism ($\beta_{\text{NSSI}} = 1.11$, $SD = 0.22$, $p < .001$), and lower intensity of positive affect ($\beta_{\text{NSSI}} = -0.99$, $SD = 0.23$, $p < .001$) across the ESM period. Participants with past-year NSSI also displayed more within-person variation in affective and cognitive states than those without NSSI history (Table 2), with a standard deviation of 0.71 vs. 0.30 for negative affect, 0.83 vs. 0.64 for positive affect, 0.91 vs. 0.30 for rumination, and 0.87 vs. 0.32 for self-criticism. While we did not observe differences in the carryover effects of positive and negative affect in univariate models, higher effects across hours were found for rumination ($\beta_{\text{NSSI}} = 0.17$, $SD = 0.08$, $p = .009$) and self-criticism ($\beta_{\text{NSSI}} = 0.18$, $SD = 0.08$, $p = .011$) among emerging adults with past-year NSSI.

[Please include Table 2 here]

We then constructed bivariate models also to investigate differences in spillover effects between negative and positive affect and rumination and self-criticism. Figure 1 provides a

graphical summary of the temporal associations between affective and cognitive factors among emerging adults with and without past-year NSSI (see full models in Supplementary Table 2). Considering negative affect, the observed values of the intercepts indicate that higher-than-usual momentary negative affect predicted an increase in state rumination an hour later ($\beta_{intercept} = 0.09, SD = 0.05, p = .018$), whereas higher-than-usual momentary rumination also prospectively predicted an increase in negative affect ($\beta_{intercept} = 0.18, SD = 0.05, p = .001$). Inspecting the slopes of past-year NSSI shows that the spillover effect of negative affect on rumination was stronger for emerging adults with past-year NSSI ($\beta_{NSSI} = 0.28, SD = 0.07, p < .001$; Figure 1a), while the spillover effect of rumination on negative affect was not significantly different between groups ($\beta_{NSSI} = -0.03, SD = 0.06, p = .307$). Similarly, higher-than-usual momentary negative affect predicted an increase in state self-criticism across the sample ($\beta_{intercept} = 0.09, SD = 0.04, p = .014$), but this spillover effect was stronger for those with past-year NSSI ($\beta_{NSSI} = 0.18, SD = 0.06, p = .001$). Conversely, higher-than-usual self-criticism had a significant spillover effect on negative affect for emerging adults with past-year NSSI ($\beta_{intercept+NSSI} = 0.16, SD = 0.03, p < .001$), but not for those without a history of NSSI ($\beta_{intercept} = 0.04, SD = 0.03, p = .124$; Figure 1b).

[Please include Figure 1 here]

Regarding positive affect, we observed that higher-than-usual momentary positive affect generally had a protective effect on later rumination ($\beta_{intercept} = -0.05, SD = 0.02, p = .005$; Figure 1c) and self-criticism one hour later ($\beta_{intercept} = -0.07, SD = 0.03, p = .006$; Figure 1d). However, these dampening effects were stronger for emerging adults who self-injured during the past year ($\beta_{NSSI} = -0.16$ to -0.14 range, $p < .001$; Supplementary Table 2). Of note, differences in the strength of carryover effects of cognitions observed in univariate models became non-significant in models that allowed for spillover effects between affective-cognitive states.

Past-year NSSI, depressive symptoms, trait emotion dysregulation, and trait self-criticism as between-person predictors of affective-cognitive dynamics

As the last step, we explored whether depressive symptoms and trait levels of emotion dysregulation and self-criticism negated differences in the experience of affective-cognitive states (i.e., slope NSSI in Tables 3-4). When considering these baseline variables, differences in the intensity of affective and cognitive states became non-significant between people who do and do not engage in NSSI. Depressive symptoms consistently explained higher mean negative affect ($\beta_{Dep} = 0.32$ to 0.34 range) and lower mean positive affect ($\beta_{Dep} = -0.37$ to -0.39) in the sample. Higher trait emotion dysregulation also incrementally accounted for higher mean negative affect ($\beta_{trait\ emodys} = 0.29$) and rumination ($\beta_{trait\ emodys} = 0.41$; Table 3). Similarly, trait self-criticism ($\beta_{trait\ crit} = 0.42$) explained a higher intensity of self-criticism during the 12-day ESM period (Table 4). Likewise, greater variability in negative affect and self-criticism observed among people with past-year NSSI became non-significant when controlling for trait self-criticism. In contrast, past-year NSSI remained a predictor of within-person variability of negative affect and rumination when controlling for depression and trait self-criticism.

[Please include Tables 3-4 here]

Considering carryover and spillover effects, we found that higher trait emotion dysregulation and trait self-criticism predicted lower carryover of negative affect across the entire sample (Tables 3-4). However, these traits did not statistically account for the stronger observed spillover effects of positive and negative affect on rumination among individuals who engage in NSSI. In contrast, higher depressive symptoms and trait self-criticism negated the observed cyclic cascade between negative affect and self-criticism among emerging adults with past-year NSSI. Finally, trait emotion dysregulation and trait self-criticism also predicted stronger spillover effects of rumination and self-criticism on negative affect in our sample.

Discussion

Using an intensive ESM protocol for 12 days among emerging adults who do and do not engage in NSSI, we observed differences regarding intensity, interaction, and variability

of affective and cognitive states in daily life. Three main findings require further comment. First, emerging adults who engage in NSSI reported greater intensity and variability of negative affect, rumination, and self-criticism than those without a history of NSSI while also experiencing lower intensity and greater variability of positive affect. Second, we observed stronger relationships across hours between emotions and cognitions among individuals who self-injure, supporting theoretical models of NSSI. Third, depressive symptoms, trait emotion dysregulation, and trait self-criticism partially explain differences between individuals who do and do not engage in NSSI.

Given the scarcity of studies that have investigated emotional and cognitive experiences in an ecologically valid way among individuals with and without a history of NSSI, a crucial aim was to evaluate whether we could replicate earlier findings. In line with previous daily diary (Bresin, 2014; Victor & Klonsky, 2014) and ESM studies (Burke et al., 2021b; Victor et al., 2021), we found that young people who self-injure experience greater intensity and variability of state negative affect and self-criticism in everyday life than peers without a history of NSSI. Extending these findings, a similar pattern was observed for state rumination, indicating more intense and variable ruminative thoughts in the lives of people who self-injure compared to those who do not. In addition, while previous results were mixed for positive affect (Bresin, 2014; Victor & Klonsky, 2014; Victor et al., 2019), individuals with past-year NSSI experienced a lower intensity and more variable positive affect than those without a history of NSSI. These results support theoretical accounts which suggest that affective and cognitive dysregulation is elevated in young people who self-injure (Hooley & Franklin, 2017; Nock, 2010; Selby et al., 2008), as well as survey studies that found higher levels of trait negative affect, rumination, and self-criticism, and lower positive affect (Boyes et al., 2020; Coleman et al., 2021; Tonta et al., 2022; Zerkowicz & Cole, 2019).

In contrast to traditional longitudinal and prior daily diary studies, we used a sampling protocol with eight assessments every 90 minutes during waking hours, which enabled us to investigate temporal effects on an hourly time scale. Thus, these are some of the highest-

resolution data on the affective and cognitive predictors of NSSI to date (Brown et al., 2022; Burke et al., 2021a; Hughes et al., 2019; Kuehn et al., 2022). Whereas higher inertia (carryover) of rumination and self-criticism was observed in univariate models, these effects disappeared when considering negative affect at the previous assessment. These findings illustrate that emotions and cognitions do not occur in isolation (Burke et al., 2018) and indicate the importance of considering spillover effects over time. In line with theoretical models of NSSI (Hooley & Franklin, 2017; Selby et al., 2008), our findings revealed stronger affective-cognitive interactions in everyday life among those who self-injure. Specifically, we observed a cyclical cascade in which negative affect and self-criticism reinforce each other over time. These results align with prior research (Burke et al., 2021a, 2021b; Fox et al., 2018) and the Benefits and Barriers Model (Hooley & Franklin, 2017), which postulates that low levels of self-criticism protect against NSSI (i.e., positive self-barrier), and that self-injury is used to cope with negative emotionality (i.e., affective benefit) and/or negative associations with the self (i.e., cognitive benefit).

In line with the Emotional Cascade Model (Selby et al., 2008), the temporal effect of negative affect on rumination was also more substantial for emerging adults engaging in NSSI. If replicated, the implications of these findings are clinically relevant as they suggest that perturbations in negative emotion lead to more salient activation of negative cognitive styles (i.e., self-critical and ruminative thinking) among young people who self-injure. This underscores the meaningfulness of cognitive-behavioral intervention approaches (e.g., functional analysis, challenging negative thoughts, learning self-soothing/-reassurance strategies) to becoming aware and gradually shifting from these repetitive and habitual thoughts processes toward more functional and constructive cognitive styles in response to the experience of negative affect (Watkins & Roberts, 2020; Werner et al., 2019). However, as we observed considerable variability of ruminative and self-critical thinking across hours, future developments that facilitate using ESM as a blended care tool (e.g., ecological momentary interventions) would be particularly valuable to allow individuals to practice at

the ‘very moment’ it is required in daily life (e.g., Bernstein et al., 2022) and as such prevent affective-cognitive interactions leading towards increased short-term risk for NSSI (Burke et al., 2021a; Hughes et al., 2019; Selby et al., 2016).

Contrary to what could be expected based on the Emotional Cascade Model (Selby et al., 2008; Selby & Joiner, 2009), the temporal effect of rumination on negative affect did not differ in strength between emerging adults with and without past-year NSSI. There are two potential explanations for this: (a) the stronger negative affect-rumination relationship observed among people who engage in NSSI is primarily affect-driven, and/or (b) the association between rumination and subsequent increased negative affect is a fast-occurring process on a shorter timescale than the hourly scale used in this study (Coppersmith et al., 2023). Future ESM studies with more dense sampling densities should rule out one of these explanations. Interestingly, although positive affect has received much less attention in the NSSI literature (Perini et al., 2021), we found that enhancing positive emotions might be one helpful strategy to buffer negative cognitions for individuals who engage in self-injury. Consistent with recent work with depressed patients (Hoorelbeke et al., 2019), momentary positive affect had a protective effect on subsequent state rumination and self-criticism. A clinically relevant finding is that these dampening effects were stronger for emerging adults reporting past-year NSSI than individuals without engagement in NSSI. While this could be due to floor effects of negative cognitive styles in people without a history of NSSI and mental illness (Wichers et al., 2012), it points to the relevance of focusing on both lowering negative affect *as well as* enhancing positive emotions to buffer aversive thoughts among individuals who self-injure. For instance, these findings suggest that savoring strategies (e.g., expressing positive emotions, sharing with others) that sustain and amplify positive emotions as they occur could help promote resilience (Silton et al., 2020), which might function as a protective pathway against NSSI (Kiekens et al., 2020).

The final aim of the study was to tentatively explore whether dispositional vulnerabilities and levels of depression could explain differences in affective-cognitive states

in daily life. Consistent with experimental work (Boyes et al., 2020), more depressive symptoms among emerging adults who self-injure accounted for the higher intensity of negative affect and lower intensity of positive affect. Similarly, higher trait levels of emotion dysregulation and self-criticism explained the increased intensity of rumination and self-criticism among people who engaged in NSSI in the last year. In line with recent findings (Vansteelandt et al., 2020), higher trait self-criticism also accounted for greater variability of state negative affect and self-criticism. In contrast, emotion dysregulation did not explain greater rumination variability or more potent downstream effects of affective disturbances on rumination among individuals who self-injure. Hence, more work is needed to clarify the salient activation of rumination following negative emotions among individuals who self-injure. Worth mentioning, consistent with the Emotional Cascade Model (Selby et al., 2008), emotion dysregulation was associated with lower carryover (i.e., more contextually sensitive state levels) of rumination and more substantial spillover effects on negative affect in the entire sample (see also Selby et al., 2016). Similar associations emerged for trait self-criticism and dynamics of state self-criticism and negative affect, suggesting that dispositional differences in emotion dysregulation and self-criticism might account for greater emotional reactivity following the experience of negative cognitions.

Limitations and Future Research Directions

Although this ESM study allowed for a granular comparison of affective and cognitive states in daily life between emerging adults who do and do not engage in NSSI (with 76 longitudinal assessments on average per individual across 12 days, median compliance = 83%), several limitations should be considered when interpreting the study findings. First, the sample comprised 60 emerging adults attending college in an urban city, of whom 82% were female and 85% heterosexual. Therefore, replication in larger and more diverse samples is warranted, including more males, individuals from sexual and ethnic minority groups, and emerging adults not attending college. Such studies may also detect smaller effects than for which we were powered and consider more complex level-2 analyses (e.g., looking into the

effects of specific emotions and subscales of emotion regulation and self-criticism). Second, as these findings are based on a student sample, statements about generalizability to clinical samples cannot be made and should be studied. For instance, while we purposely sampled emerging adults without a history of NSSI *and* mental illness to keep the reference group as homogenous as possible, it remains to be seen whether engagement in NSSI accounts for differences in affective-cognitive states beyond the presence of comorbid mental disorders. Alternatively, clinical samples might also show greater affective-cognitive interactions than we observed in this student sample, which could, for example, indicate a more challenging recovery process (Lewis & Hasking, 2020).

Third, although we investigated how the dynamic blueprint of theoretically-relevant affective and cognitive states might differ in meaningful ways between people who do and do not engage in NSSI, it should be mentioned that we did not evaluate the predictive utility of these dynamic parameters (mean intensity, carryover effects, spillover effects, and variability) in gauging the future risk of NSSI. Therefore, an exciting future research avenue is to evaluate whether affective-cognitive dynamics might help explain the course of NSSI across weeks, months, and years above and beyond traditional severity indicators (e.g., higher frequency and number of NSSI methods; Ammerman et al., 2020). This will require longitudinal studies incorporating ESM to shed light on the relationship between affective-cognitive dynamics with longer-term NSSI outcomes (Kiekens et al., 2021). Finally, as the sampling schedule involved a relatively high burden for participants, state assessments of rumination and self-criticism were assessed using two items. Although we observed reasonable-to-good multilevel reliability for our state measures, there is a general lack of validated items for assessing psychological constructs with ESM (Wright & Zimmermann, 2019). Hence, further methodological work is required to develop standardized state measures for intensive longitudinal designs as the field progresses (Mestdagh & Dejonckheere, 2021). Building upon the present findings, such developments would allow a comparison using state measures that

capture different forms of rumination and self-criticism (Kircanski et al., 2015; Watkins & Roberts, 2020; Werner et al., 2019).

Conclusions

The limitations notwithstanding, the findings of this ESM study provide previously unavailable information about how and why affective and cognitive states might be experienced differently in the everyday lives of young people who do and do not engage in NSSI. Perhaps the most critical finding is that we found evidence of higher intensity, variability, and temporal interactions between negative affect and rumination and self-criticism in young people who self-injure. A future meaningful research avenue is to investigate whether boosting positive emotions in daily life might be an effective intervention strategy to downregulate dysfunctional cognitions and the future risk of NSSI.

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Table 1.

Univariate and variability statistics of study variables.

Study variables	M	SD	Range in data	Total variance ^a	ICC ^b	95% CI
Momentary constructs^c						
Negative affect	1.10	1.18	0-6	1.39	0.61	0.52-0.70
Positive affect	3.42	1.40	0-6	1.95	0.50	0.41-0.60
Rumination	1.02	1.42	0-6	2.01	0.53	0.44-0.63
Self-criticism	0.85	1.35	0-6	1.83	0.55	0.46-0.65
Baseline constructs						
Depression past week	4.10	5.12	0-19			
Trait emotion-dysregulation	26.42	13.97	7-62			
Trait self-criticism	19.40	12.96	1-52			

Note: ^a Total variance represents the sum of variance within individuals across time (i.e., within-person variance) and variance in within-person means across individuals (i.e., between-person variance), ^bThe Intra-Class Correlation represents the proportion of the total variance that is accounted for by between-person variance. ^c DSEM estimates within univariate multilevel vector autoregressive model. ICC = Intra-Class Correlation, 95% CI = Credibility Interval.

Table 2.

Point estimates and 95% credibility intervals of univariate multilevel VAR models of negative affect, positive affect, rumination, and self-criticism with past-year NSSI as a between-person predictor of random effects.

Dynamic parameters	Intercept ^a		Slope past-year NSSI	
	Negative affect		Positive affect	
Mean intensity affect	0.43 (0.20, 0.67)	1.32 (0.99, 1.64)	3.91 (3.60, 4.24)	-0.99 (-1.45, -0.55)
Carryover	0.41 (0.33, 0.49)	0.10 (-0.02, 0.21)	0.53 (0.46, 0.60)	0.01 (-0.08, 0.11)
Log within-person variance	-2.38 (-2.82, -1.95)	1.68 (1.06, 2.32)	-0.89 (-1.12, -0.67)	0.52 (0.20, 0.84)
	Rumination		Self-Criticism	
Mean intensity cognition	0.37 (0.10, 0.66)	1.18 (0.78, 1.59)	0.29 (-0.01, 0.61)	1.11 (0.67, 1.54)
Carryover	0.31 (0.20, 0.41)	0.17 (0.03, 0.33)	0.26 (0.14, 0.37)	0.18 (0.03, 0.34)
Log within-person variance	-2.43 (-2.99, -1.86)	2.23 (1.42, 3.07)	-2.30 (-2.85, -1.74)	2.01 (1.23, 2.83)

Note: ^a Emerging adults without NSSI history. Credibility intervals are presented within parentheses. Boldface type indicates a 95% probability that the true value is not null (i.e., the credibility interval does not include zero). VAR = Vector Autoregressive, NSSI = Non-Suicidal Self-Injury.

Table 3.

Point estimates and 95% credibility intervals of bivariate multilevel VAR models between affective states and rumination with past-year NSSI, depressive symptoms, and trait emotion dysregulation as between-person predictors of random effects.

Dynamic parameters	Slope past-year NSSI	Slope depression	Slope trait emotion- dysregulation
Bivariate multilevel VAR model: negative affect and rumination			
Mean intensity negative affect	0.43 (-0.06, 0.92)	0.34 (0.13, 0.54)	0.29 (0.02, 0.54)
Mean intensity rumination	0.20 (-0.46, 0.86)	0.27 (-0.01, 0.57)	0.41 (0.06, 0.77)
Carryover negative affect at $t-1h$ on negative affect at t	0.28 (0.07, 0.48)	0.07 (-0.03, 0.17)	-0.20 (-0.32, -0.06)
Carryover rumination at $t-1h$ on rumination at t	-0.04 (-0.34, 0.26)	-0.03 (-0.16, 0.12)	0.10 (-0.08, 0.27)
Spillover negative affect at $t-1h$ on rumination at t	0.33 (0.10, 0.56)	0.04 (-0.08, 0.15)	-0.12 (-0.25, 0.03)
Spillover rumination at $t-1h$ on negative affect at t	-0.10 (-0.26, 0.07)	-0.04 (-0.12, 0.04)	0.12 (0.001, 0.22)
Log within-person variance negative affect	1.16 (0.13, 2.28)	0.10 (-0.36, 0.58)	0.20 (-0.43, 0.77)
Log within-person variance rumination	2.14 (0.75, 3.54)	0.00 (-0.63, 0.63)	0.04 (-0.76, 0.79)
Bivariate multilevel VAR model: positive affect and rumination			
Mean intensity positive affect	-0.15 (-0.89, 0.59)	-0.37 (-0.69, -0.05)	-0.22 (-0.63, 0.18)
Mean intensity rumination	0.19 (-0.48, 0.84)	0.27 (-0.02, 0.56)	0.41 (0.04, 0.78)
Carryover positive affect at $t-1h$ on positive affect at t	0.13 (-0.04, 0.30)	-0.03 (-0.10, 0.04)	-0.08 (-0.17, 0.02)
Carryover rumination at $t-1h$ on rumination at t	0.01 (-0.28, 0.32)	0.05 (-0.08, 0.17)	0.03 (-0.13, 0.18)
Spillover positive affect at $t-1h$ on rumination at t	-0.25 (-0.41, -0.10)	0.04 (-0.03, 0.11)	0.03 (-0.04, 0.12)
Spillover rumination at $t-1h$ on positive affect at t	-0.01 (-0.20, 0.17)	0.01 (-0.06, 0.09)	-0.04 (-0.14, 0.06)
Log within-person variance positive affect	0.32 (-0.19, 0.90)	0.12 (-0.11, 0.36)	0.01 (-0.31, 0.30)
Log within-person variance rumination	2.15 (0.73, 3.56)	-0.01 (-0.64, 0.63)	0.05 (-0.73, 0.83)

Note: Credibility intervals are presented within parentheses. Boldface type indicates a 95% probability that the true value is not null (i.e., the credibility interval does not include zero). VAR = Vector Autoregressive, NSSI = Non-Suicidal Self-Injury.

Table 4.

Point estimates and 95% credibility intervals of bivariate multilevel VAR models between affective states and self-criticism with past-year NSSI, depressive symptoms, and trait self-criticism as between-person predictors of random effects.

Dynamic parameters	Slope past-year NSSI	Slope depression	Slope trait self-criticism
Bivariate multilevel VAR model: negative affect and self-criticism			
Mean intensity negative affect	0.44 (-0.06, 0.92)	0.32 (0.10, 0.55)	0.28 (-0.02, 0.58)
Mean intensity self-criticism	-0.04 (-0.68, 0.65)	0.33 (0.02, 0.65)	0.42 (0.03, 0.82)
Carryover negative affect at $t-1h$ on negative affect at t	0.18 (-0.05, 0.41)	0.10 (-0.01, 0.19)	-0.17 (-0.32, -0.03)
Carryover self-criticism at $t-1h$ self-criticism at t	-0.04 (-0.34, 0.26)	-0.08 (-0.23, 0.06)	0.18 (0.01, 0.36)
Spillover negative affect at $t-1h$ on self-criticism at t	0.19 (-0.03, 0.41)	0.07 (-0.03, 0.17)	-0.06 (-0.20, 0.08)
Spillover self-criticism at $t-1h$ on negative affect at t	0.04 (-0.11, 0.18)	-0.07 (-0.15, -0.00)	0.11 (0.01, 0.22)
Log within-person variance negative affect	0.53 (-0.44, 1.55)	-0.21 (-0.69, 0.27)	0.86 (0.22, 1.44)
Log within-person variance self-criticism	0.29 (-0.95, 1.52)	-0.34 (-0.95, 0.25)	1.31 (0.54, 2.05)
Bivariate multilevel VAR model: positive affect and self-criticism			
Mean intensity positive affect	-0.18 (-0.96, 0.59)	-0.39 (-0.75, -0.04)	-0.17 (-0.63, 0.28)
Mean intensity self-criticism	-0.02 (-0.68, 0.61)	0.34 (0.03, 0.64)	0.42 (0.02, 0.81)
Carryover positive affect at $t-1h$ on positive affect at t	0.10 (-0.09, 0.28)	-0.01 (-0.09, 0.08)	-0.08 (-0.21, 0.03)
Carryover self-criticism at $t-1h$ self-criticism at t	0.01 (-0.28, 0.30)	-0.04 (-0.18, 0.10)	0.10 (-0.07, 0.28)
Spillover positive affect at $t-1h$ on self-criticism at t	-0.06 (-0.22, 0.08)	-0.01 (-0.08, 0.08)	-0.04 (-0.13, 0.05)
Spillover self-criticism at $t-1h$ on positive affect at t	-0.05 (-0.23, 0.15)	0.08 (-0.01, 0.17)	-0.10 (-0.22, 0.03)
Log within-person variance positive affect	0.11 (-0.41, 0.68)	0.05 (-0.21, 0.32)	0.19 (-0.16, 0.52)
Log within-person variance self-criticism	0.33 (-0.87, 1.54)	-0.33 (-0.92, 0.26)	1.30 (0.54, 2.05)

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te: Credibility intervals are presented within parentheses. Boldface type indicates a 95% probability that the true value is not null (i.e., the credibility interval does not include zero). VAR = Vector Autoregressive, NSSI = Non-Suicidal Self-Injury.

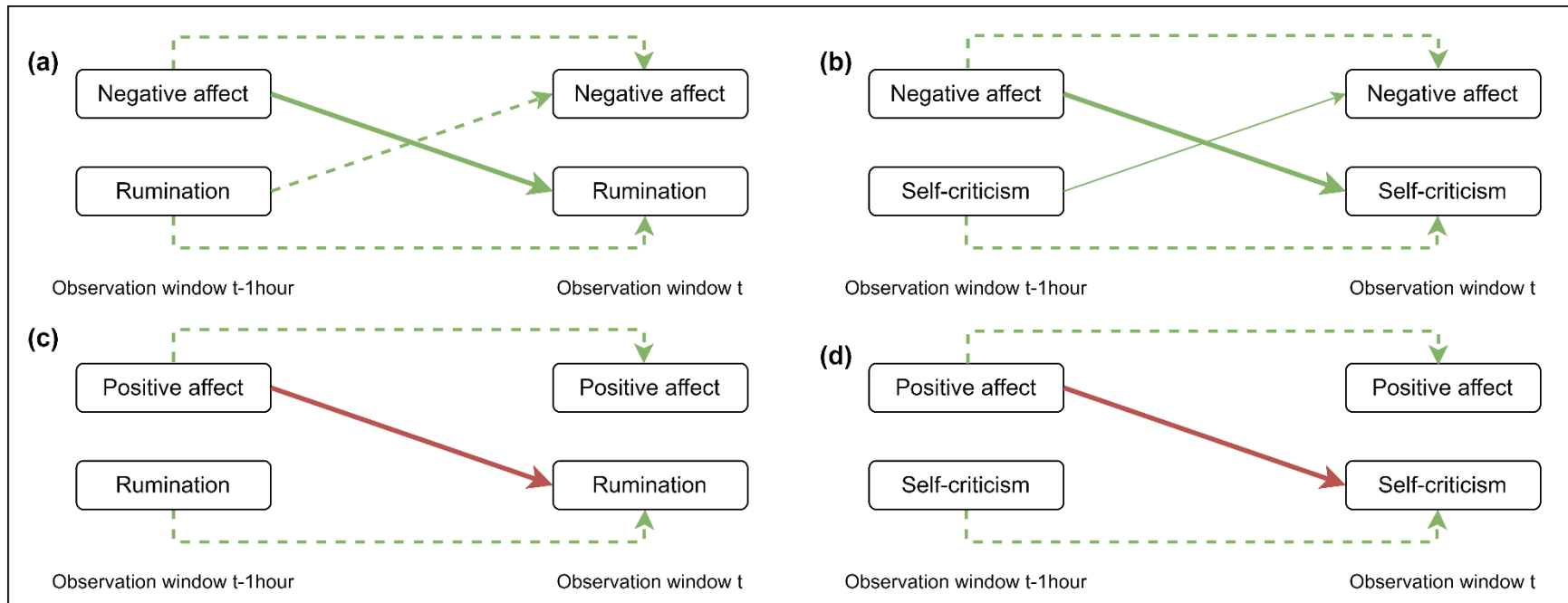


Figure 1. Graphical summary of the temporal associations between affective and cognitive factors among emerging adults with and without past-year NSSI across bivariate DSEM models: (a) negative affect and rumination (b) negative affect and self-criticism, (c) positive affect and rumination (d) positive affect and self-criticism. Note: Positive associations are depicted in green and negative associations in red (see full models in Supplementary Table 2). Solid bolded arrows represent stronger effects for emerging adults with past-year NSSI than individuals without a history of NSSI, not bolded solid arrows represent only present effects for emerging adults with past-year NSSI. Dotted arrows indicate associations that are not significantly different between groups.