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# Examining associations between negative affect arousal dimensions and self-injurious thoughts: Findings from two real-time monitoring studies with psychiatrically acute adolescents

Kinjal K. Patel [a,b,*], Elizabeth A. Edershile [c], Abigail J. Luce [a], Emelyn C. Auad [a], Richard T. Liu [d,e], Evan M. Kleiman [c], Catherine R. Glenn [a,b]

[a] Old Dominion University, College of Sciences, Department of Psychology, Norfolk, VA, USA
[b] Virginia Consortium Program in Clinical Psychology, Norfolk, VA, USA
[c] Rutgers, The State University of New Jersey, School of Arts and Sciences, Department of Psychology, New Brunswick, NJ, USA
[d] Massachusetts General Hospital, Boston, MA, USA
[e] Harvard Medical School, Boston, MA, USA

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ABSTRACT

Adolescence is a critical period for the onset of self-injurious thoughts and behaviors (SITBs). This study examined the proximal associations between negative affect (NA) arousal dimensions and self-injurious thoughts using ecological momentary assessment in two independent samples of psychiatrically acute adolescents. Several times a day for 28 days, adolescents reported high arousal NA (e.g., anger, agitation), low arousal NA (e.g., sadness, guilt), passive suicidal thought intensity, active suicidal thought intensity, and nonsuicidal self-injury (NSSI) thought intensity. Multilevel modeling revealed that both high and low arousal NA were associated with increased passive suicidal thought intensity, active suicidal thought intensity, and NSSI thought intensity in contemporaneous models across samples, with low arousal NA prospectively predicting greater passive and active suicidal thought intensity at subsequent within-day time points. Findings highlight the importance of distinguishing NA arousal dimensions to inform real-time prediction of self-injurious thoughts. Future research is needed in larger samples to examine between-person associations and to explore additional affect dynamic components of NA arousal dimensions to augment understanding of SITB risk in adolescents.

## 1. Introduction

Self-injurious thoughts and behaviors (SITBs) increase drastically during adolescence (Centers for Disease Control and Prevention [CDC], 2023b; Nock et al., 2013) and are associated with significant interpersonal and health impairments (Copeland et al., 2017; Glenn and Klonsky, 2013). SITBs include *suicidal* self-injurious thoughts and behaviors (i.e., with intent to die) and *nonsuicidal* self-injurious (NSSI) thoughts and behaviors (i.e., without intent to die; Nock, 2010). Although the literature on SITBs includes both self-injurious thoughts and behaviors, we focus exclusively on self-injurious thoughts, given their high prevalence, clinical significance, and greater feasibility for intensive longitudinal assessment.

Research highlights the fluctuating nature of SITBs, particularly the transient nature of self-injurious thoughts (Kleiman et al., 2017), which underscores the importance of characterizing short-term, time-varying, and within-person predictors of SITBs, to better understand *when* risk for SITBs may increase (Czyz et al., 2023; Kleiman et al., 2019). This is especially critical during high-risk periods, such as the months following discharge from acute psychiatric care (Chung et al., 2017). Compared to long-term longitudinal methods (e.g., assessments at six-month intervals), short-term, within-person approaches are unique in offering an opportunity to examine the dynamic processes that unfold over minutes, hours, or days – scales that may be more appropriate to measure SITBs and associated risk factors. These designs allow for a more nuanced understanding about proximal risk factors and have important clinical implications, such as informing real-time safety planning tools and just-in-time adaptive interventions (i.e., deployment of interventions at the moment a person may benefit the most; Nahum-Shani et al., 2017).

Emotional and psychological pain are central to several major

* Corresponding author at: Old Dominion University, 1320 44th Street, Room 328, Norfolk, VA 23508.
*E-mail address:* kpate026@odu.edu (K.K. Patel).

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theoretical models of SITBs. Shneidman's (1993) theory posits that suicide arises when psychological pain becomes intolerable, and Baumeister's (1990) escape theory similarly describes suicidal behavior as a means of escaping psychological pain and suffering. The Three-Step Theory (3ST; Klonsky and May, 2015) identifies emotional or psychological pain (e.g., intense negative affect) as a primary driver of suicidal desire.

In parallel, emotion regulation difficulties are widely recognized as a transdiagnostic risk factor for NSSI (Fox et al., 2015; Wolff et al., 2019). Prominent theoretical models characterize NSSI as a maladaptive strategy to regulate aversive affective states (Hooley and Franklin, 2018; Klonsky, 2007; Nock and Prinstein, 2004), and a growing body of research supports affect regulation as the most frequently endorsed function of NSSI (Bentley et al., 2014; Nock, 2009).

Although most of the empirical work has examined negative affect (NA) as a risk factor over the longer term, real-time monitoring studies in adults have provided compelling evidence linking elevated NA to the emergence of SITBs over shorter time periods. Among suicidal adults, momentary experiences of NA states such as sadness, boredom, anxiety, and tension predicted suicidal thoughts over the day (Ben-Zeev et al., 2012; Husky et al., 2017). Research also implicates rejection, anger, and sadness in the occurrence of later same-day NSSI urges (Dillon et al., 2021; Victor et al., 2019).

However, data in adolescents remain limited. In a high-risk adolescent sample, thoughts of NSSI and suicide most often occurred alongside NA states such as anxiety, sadness, and self-hatred (Nock et al., 2009). More recently, Schatten et al., 2021 found that daily experiences of misery and anger predicted same-day suicidal thoughts in adolescents following psychiatric hospital discharge. These emerging findings highlight the importance of examining dynamic links between NA and SITBs in adolescent populations.

Several limitations of existing research guide the current study. First, it is unclear if different types of NA, based on arousal dimensions, are differentially linked to self-injurious thoughts. In the current study, our conceptualization of affect is guided by the circumplex model of affect which posits two dimensions of affect: valence (positive, negative), and arousal (high, low) as an organizational method for understanding emotional experiences (Posner et al., 2005; Russell, 1980). Most studies either: 1) collapse all NA into one broad construct, missing nuanced relationships, or 2) focus narrowly on specific NA states, potentially overlooking diverse distressing experiences that may precipitate a self-injurious crisis. Meta-analytic findings suggest that high arousal NA (i.e., severe anxiety or agitation) poses greater risk for SITBs and may better indicate imminent suicide risk (Rogers et al., 2016) compared to low arousal NA, such as sadness (Nock et al., 2010). As such, categorizing NA by arousal dimensions may be critical to understanding its role in self-injurious thoughts, particularly among psychiatrically acute adolescents.

Second, research on predictors of NSSI thoughts in high-risk adolescents is limited, as NSSI thoughts are infrequently assessed. Critically, recent research has underscored the importance of understanding NSSI thoughts in youth as precursors to NSSI behavior and potential suicidal behavior, to clarify the escalation of SITBs and inform potential points for intervention (Oppenheimer et al., 2022).

Finally, little is known about predictors of different types of suicidal thoughts, ranging from passive ideation (desire to be dead) to active ideation (desire to kill oneself). Most research to date has focused on the prevalence of and risk factors for active suicide ideation only, despite meta-analytic findings showing passive ideation is similarly prevalent and clinically significant in youth (Liu et al., 2020). Understanding predictors across the continuum of suicidal thought severity, especially in adolescence, is critical for advancing suicide risk knowledge.

The goals of the current study were to examine the differential links between NA arousal dimensions (i.e., high versus low), passive and active suicidal thought intensity, and NSSI thought intensity. We investigated these associations in two separate psychiatrically acute samples of adolescents, recruited from multiple independent healthcare systems in geographically distinct areas, assessed using 28 days of ecological momentary assessments (EMA) post-discharge from acute psychiatric care. The use of two independent yet complementary samples of adolescents provides an opportunity to examine the reproducibility of findings across different hospital systems and enhance the generalizability of results. Based on adult research, we predicted high arousal NA would be more strongly associated with NSSI thought intensity and both passive and active suicidal thought intensity, as compared to low arousal NA (Bentley et al., 2021).

## 2. Method: Study 1

Given the similarities across our two study samples, we present the method for both study samples first, followed by results. Study 1 was part of a larger project examining short-term risk factors for SITBs in adolescents during the high-risk period following discharge from acute psychiatric care. A brief overview of methods related to the current study is summarized below (for more details see Glenn, Kleiman, Kearns, et al., 2022).

### 2.1. Participants

The sample included 48 adolescents (ages 12–18, see Table 1) recently discharged from acute psychiatric care (e.g., emergency department, inpatient, or partial hospitalization) for suicidal thoughts and behaviors. Exclusion criteria were inability to provide informed consent (e.g., language barriers, cognitive impairment, severe mania or psychosis), unwillingness to complete EMA surveys, lack of caregiver permission, or imminent safety concerns. Adolescents without a compatible smartphone were provided an Android with a pre-paid data plan.

### 2.2. Procedure

Adolescents were enrolled in the study within two weeks of discharge from acute psychiatric care. Prior to study participation, informed consent was obtained from the adolescent (assent if 12–17-year-olds, consent if 18-years-old) and one parent or legal guardian (parental permission, if applicable, and consent for their own participation). All study procedures were approved by the University of Rochester's Institutional Review Board (RSRB00066408).

For the current study, participation included a baseline assessment and a 28-day EMA phase. The baseline assessment included clinical interviews, the Columbia Suicide Severity Rating Scale (C-SSRS; Posner et al., 2011) and the Self-Injurious Thoughts and Behaviors Interview (SITBI; Nock et al., 2007), to assess lifetime, past-year, and past-month SITBs, and the Beck Depression Inventory for Youth (Beck, 2005) to assess depression symptoms. Participants were also introduced to the MetricWire (www.metricwire.com) EMA app for the 28-day monitoring period.

#### 2.2.1. EMA study phase

Following the baseline assessment, adolescents completed 28 days of EMA. The research team monitored adherence and risk flags throughout the study. Participants provided their typical sleep/wake times and daily availability to customize EMA schedules, minimizing missed or inconvenient alerts (e.g., during sleep or school hours). Signal-contingent surveys were completed 3–6 times daily (number daily varied based on availability, $M = 62.36$, $SD$=31.03, Range=6–116).[1] Risk monitoring details are provided in the supplement.

[1] Surveys are reported as raw numbers instead of percentages because the number of total prompts varied across participants depending on the number of days enrolled in the study and number of daily prompts based on availability.

**Table 1**
Demographic characteristics and history of self-injurious thoughts and behaviors.

| Sample 1 | Adolescents ($n = 48$) |
|---|---|
| Age (years): *M (SD)* | 14.96 (1.60) |
| Race/Ethnicity: % (*n/N*) | |
| Black/African American | 8.3% (4/48) |
| White | 77.1% (37/48) |
| Multi-racial | 10.4% (5/48) |
| Other/Do not wish to answer | 4.17% (2/48) |
| Hispanic/Latinx[a] | 13.6% (6/44) |
| Gender Identity: % (*n/N*) | |
| Cisgender female | 64.6% (31/48) |
| Cisgender male | 16.7% (8/48) |
| Nonbinary | 18.8% (9/48) |
| Suicide ideation (lifetime): % *(n/N)* | 100% (48/48) |
| Suicide attempt (lifetime): % *(n/N)* | 85.4% (41/48) |
| Multiple attempts | 61.0% (25/41) |
| Nonsuicidal self-injury (lifetime): % *(n/N)* | 81.3% (39/48) |
| Depression (BDI-Y T score; $n = 44$): *M (SD)* | 69.78 (15.20) |
| **Sample 2** | **Adolescents ($n = 101$)** |
| Age (years): *M (SD)* | 14.27 (1.63) |
| Race/Ethnicity: % *(n/N)* | |
| Asian | 4.95% (5/101) |
| Black | 27.7% (28/101) |
| White | 48.5% (49/101) |
| Multi-racial | 12.87% (13/101) |
| Other/Do not wish to answer | 5.9% (6/101) |
| Hispanic/Latinx | 18.81% (19/101) |
| Gender Identity[b]: % *(n/N)* | |
| Cisgender male | 20.0% (19/95) |
| Cisgender female | 47.36% (45/95) |
| Transgender | 11.57% (11/95) |
| Non-binary | 7.36% (7/95) |
| Gender fluid | 6.31% (6/95) |
| Questioning/unsure about gender | 4.21% (4/95) |
| Genderqueer/Prefer to self-identify | 3.15% (3/95) |
| Suicide ideation (lifetime)[c]: % *(n/N)* | 100% (83/83) |
| Suicide attempt (lifetime): % *(n/N)* | 55.4% (46/83) |
| Multiple attempts | 58.7% (27/46) |
| Nonsuicidal self-injury (lifetime): % *(n/N)* | 83.9% (68/81) |
| Depression (PROMIS Depression T score; $n = 82$): *M (SD)* | 62.62 (12.05) |

BDI-*Y* = Beck Depression Inventory for Youth. PROMIS = Patient-Reported Outcomes Measurement Information System.

[a] Four adolescents preferred to not report their ethnicity.

[b] Six participants were not presented with the measure assessing self-reported gender identity, and as such total N for this variable is 95.

[c] 18 participants were not administered the Columbia Suicide Severity Rating Scale, and as such total N for these variables are 83. Suicide ideation/attempts prevalence were based on all available data (i.e., clinical interviews, medical records).

#### 2.2.2. EMA measures

**Negative affect intensity.** Current NA was assessed with items adapted from the Positive and Negative Affect Schedule (PANAS) short form (Mackinnon et al., 1999) and prior EMA research on SITBs (Nock et al., 2009). Adolescents rated feelings of anger, sadness, agitation, guilt, and nervousness on a 5-point Likert scale from 0-*Very slightly/not at all* to 4-*Extremely*, consistent with prior work (Kleiman et al., 2017). Multilevel reliabilities were calculated using the *multilevelTools* package in R (Wiley, 2020), revealing acceptable reliability at both the within-person ($\underline{\omega}$_within=0.71) and between-person ($\underline{\omega}$_between=0.81) level.

**Passive suicidal thought intensity (reduced wish to live).** Passive suicidal thoughts were assessed with one item adapted from prior EMA studies (Kleiman et al., 2017; Nock et al., 2009), "How strong is your desire to live right now?" on a scale from 1-*very strong* to 5-*very weak*.

**Active suicidal thought intensity.** Active suicidal thoughts were assessed with items adapted from prior EMA studies (Kleiman et al., 2017; Nock et al., 2009) assessing current active suicide ideation ("How intense is your desire to kill yourself right now?") and current suicide intent ("How strong is your intent to kill yourself right now?") on a scale from 0-*absent* to 5-*extremely strong*. These items were selected for their strong factor loadings onto a latent suicidal thoughts variable in prior analyses (Glenn et al., 2022). To capture the complexity of these thoughts, we created a composite variable (see Data Preparation section below), supported empirically (Wastler et al., 2023).

**NSSI thought intensity.** NSSI thoughts were assessed with two items adapted from a prior EMA study (Nock et al., 2009), "Are you right now (or were you recently) thinking about hurting yourself (but not to die)?" (yes/no). If participants responded "yes," they rated NSSI thought intensity from 0-*not at all intense* to 4-*extremely intense*. We merged items that examined presence and intensity of NSSI thoughts to match the item for active suicidal thought intensity (Magnus and Chen, 2022). Specifically, absence of NSSI thoughts remained coded as 0, and presence of NSSI thoughts was integrated with the item assessing intensity on a scale from 1-*not at all intense* to 5-*extremely intense*.

### 2.3. Data preparation

EMA data were missing at the survey level (entire surveys not completed) rather than the item level (all items completed within a survey).[2] This type of missingness, expected in multilevel modeling, was not imputed.

NA arousal variables were computed as within-person composites: low arousal (average of sad and guilty) and high arousal (average of angry, nervous, and agitated), following Bentley et al. (2021). These scores reflect mean levels of arousal states for each EMA observation, capturing within-person changes relative to the participant's own baseline (Bentley et al., 2021; Silk et al., 2003). The active suicidal thought intensity composite was the average of two items: current suicide ideation and intent for each EMA observation.

## 3. Method: Study 2

This study is part of a larger, currently ongoing multi-site project examining proximal risk factors for suicidal thoughts and behaviors in youth recently discharged from acute psychiatric care for suicide risk. Data for this study are from the first wave of participants. A brief overview of methods related to the current study are summarized below.

### 3.1. Participants

The sample includes 101 adolescents (ages 12–18, see Table 1). Participants were recruited from pediatric psychiatric inpatient units, emergency departments, and partial hospitalization programs across three geographically diverse sites. Across all sites, inclusion criteria are: 1) age 12–18 years (18-year-olds must still be in high school), 2) psychiatric hospitalization due to suicidal thoughts and behaviors over the past three months, 3) access to a smartphone or willingness to use a loaner phone for EMA. Exclusion criteria are the same as in Study 1.

### 3.2. Procedures

Adolescents were enrolled in the study within three months of discharge from acute psychiatric care. Before study initiation, informed consent was obtained from the adolescent (assent if 12–17-year-olds, consent if 18-years-old) and at least one caregiver or legal guardian (parental permission, if applicable, and consent for their own participation). All study procedures are approved by the prime site university's

[2] Missing signal-contingent surveys (e.g., NA, suicidal thoughts, NSSI thought intensity) were handled by including other signal-contingent surveys from the same day in the model. The configuration of our missing data involved a completely missing survey rather than a missing item from an otherwise complete survey.

Institutional Review Board (Rutgers University: Pro2020002962).

For the current study, we include data from the baseline assessment and 28-day EMA phase. Like Study 1, during the baseline session adolescents were administered the C-SSRS (Posner et al., 2011), a supplemental SITBI (Nock et al., 2007), and the pediatric PROMIS depression scale (Irwin et al., 2010) to assess depression symptoms. At the end of the baseline, participants were introduced to the MetricWire EMA app for the 28-day monitoring period.

#### 3.2.1. EMA study phase

Participants used the same EMA application and procedure outlined previously for Study 1. Several EMA surveys are included during this study phase. Most relevant to the present study are signal-contingent surveys, which are completed up to 6 times per day (number daily varied based on availability, $M = 42.48$, $SD$=29.91, Range =1–105) .[3] Risk monitoring details are in the supplement.

#### 3.2.2. EMA measures

**Negative affect intensity.** Current NA was assessed using modified items from the PANAS-C (Ebesutani et al., 2012) on a scale from 0-*not at all* to 10-*extremely* (see Data Preparation section for specific affect states). Multilevel reliabilities were calculated using the same approach as Study 1, revealing acceptable reliability at both the within-person ($\underline{\omega}$_within=0.84) and between-person ($\underline{\omega}$_between=0.92) level.

**Passive suicidal thought intensity (wish to die).** Current intensity of passive suicidal thoughts was assessed with an item revised from a prior study (Glenn et al., 2022), "Right now, how strongly do you wish you weren't alive anymore?" on scale from 0-*not at all* to 10-*extremely*.

**Active suicidal thought intensity.** Active suicidal thoughts were assessed with items adapted from prior studies (Glenn et al., 2022; Kleiman et al., 2017; Nock et al., 2009), assessing current active suicide ideation ("Right now, how strongly do you want to kill yourself?") and current suicide intent ("Right now, how strong is your intent to kill yourself?"), on a scale from 0-*not at all* to 10-*extremely*. Like Study 1, we created a composite variable incorporating both active suicide ideation and intent (see Data preparation).

**NSSI thought intensity.** Current NSSI thought intensity was assessed with one item adapted from a prior study (Nock et al., 2009), "Right now, how strongly do you want to hurt yourself *without* trying to die?" on scale from 0-*not at all* to 10-*extremely*.

### 3.3. Data preparation

For EMA, data may be missing at the item level, due to participants' ability to skip items while completing EMA surveys.[4] This type of missingness is expected in multilevel modeling (Bloom et al., 2024).

NA arousal variables were computed as within-person composites: low arousal (average of lonely, empty, guilty, and sad) and high arousal (average of mad, scared, and stressed), following Bentley et al. (2021). These scores reflect mean levels of arousal states for each EMA observation, capturing within-person changes relative to the participant's own baseline (Bentley et al., 2021; Silk et al., 2003). The active suicidal thought intensity composite variable was computed as an average of two items: 1) current active suicide ideation and 2) current suicide intent for each EMA observation.

### 3.4. Data analytic plan for both samples

Given the similarities across our two studies in terms of data structure and constructs assessed, we present a shared data analytic plan to be used across both studies. Additional data analytic plan details, including decisions to use random slopes versus fixed slopes, are in the supplement.

We used multilevel modeling to analyze EMA data, accounting for the nested structure. Models included two levels: observations (level 1) within people (level 2), enabling examination of within-person (level 1) effects. High and low NA arousal dimensions (predictors, entered simultaneously) were tested against self-injurious thought outcomes (NSSI thought intensity, passive suicidal thought intensity, and active suicidal thought intensity) in separate models. Predictors were entered simultaneously to test the unique contributions of high and low arousal NA intensity in accounting for variance in the self-injurious thought outcomes. Both contemporaneous (same-survey NA arousal and self-injurious thought outcomes) and lagged effects (NA arousal predicting next-point, within-same-day, self-injurious thought outcomes)[5] were analyzed using the *lme4* (Bates et al., 2015) and *EMAtools* (Kleiman, 2017) R packages with restricted maximum likelihood estimation to reduce bias in random effects. NA arousal dimensions were person-mean centered (using EMAtools' 'pcenter' function) for within-person effect interpretation. No transformations to predictors or outcomes were made prior to analyses. Effect sizes were computed to descriptively compare predictor-outcome associations across models. Age was covaried in all analyses given its potential association with outcome variables (Burstein et al., 2019; Twenge et al., 2019). We report findings from these models in text below (see Tables 2–4 for full results of these models) .[6]

We also computed models including high and low arousal NA intensity as separate predictors (see Tables S1-S3 for full results of these models) and compared model fit (via a likelihood ratio test) to models with predictors included simultaneously. This allowed us to determine if models with predictors included simultaneously produced better model fit and accounted for significantly more variance than either predictor alone (see Supplement).

## 4. Results: Study 1

See Tables 2–3 for descriptives, repeated measure correlations, and ICCs for main study variables.

### 4.1. Passive suicidal thought intensity outcome

In the contemporaneous model, both high ($B = 0.23$, $p<.001$) and low arousal NA intensity ($B = 0.25$, $p<.001$) were associated with greater passive suicidal thought intensity. In the lagged effect model, both high ($B = 0.14$, $p<.001$) and low arousal NA intensity ($B = 0.15$, $p<.001$) predicted greater passive suicidal thought intensity at the next within-day time-point (see Table 4).

### 4.2. Active suicidal thought intensity outcome

In the contemporaneous model, both high ($B = 0.15$, $p<.001$) and low arousal NA intensity ($B = 0.22$, $p<.001$) were associated with greater active suicidal thought intensity. In the lagged effect model, greater low arousal NA intensity ($B = 0.13$, $p<.001$) predicted greater active suicidal thought intensity at the next within-day time-point,

[3] Surveys are reported as raw numbers instead of percentages because the number of total prompts varied across participants depending on the number of days enrolled in the study and number of daily prompts based on availability.

[4] In Study 2, missingness values for major study variables were very low: high arousal NA: 0.76%; low arousal NA: 0.71%; passive suicidal thought intensity: 1.78%; active suicidal thought intensity: 1.67%; NSSI thought intensity: 1.84%.

[5] Only time points within the same day were considered in lagged models, and lagged effects across day boundaries were not included in models. In Study 1, the average length of time between completed surveys was 103 minutes. In Study 2, the average length of time between completed surveys was 157 minutes.

[6] Model estimates provided are unstandardized.

**Table 2**
Descriptives for main study variables.

| Sample 1 | *M* | *SD* | *ICC [95% CI]* |
|---|---|---|---|
| High arousal negative affect (0–4) | .93 | .95 | .46 (0.36 - 0.57) |
| Angry | .60 | .98 | .21 (0.15 - 0.31) |
| Nervous | 1.10 | 1.33 | .53 (0.44 - 0.64) |
| Agitated | 1.10 | 1.28 | .38 (0.30 - 0.50) |
| Low arousal negative affect (0–4) | 1.09 | 1.14 | .56 (0.46 - 0.66) |
| Sad | 1.31 | 1.35 | .43 (0.34 - 0.55) |
| Guilty | .86 | 1.29 | .59 (0.50 - 0.69) |
| Passive suicidal thought intensity (1–5) | 2.71 | 1.26 | .70 (0.62 - 0.79) |
| Active suicidal thought intensity (0–5) | .46 | .75 | .46 (0.37 - 0.58) |
| Suicide desire | .65 | 1.03 | .46 (0.37 - 0.57) |
| Suicide intent | .27 | .62 | .45 (0.36 - 0.57) |
| NSSI thought intensity (0–5) | .14 | .72 | .09 (0.06 - 0.15) |
| **Sample 2** | ***M*** | ***SD*** | ***ICC [95% CI]*** |
| High arousal negative affect (0–10) | 2.28 | 2.39 | .50 (0.43 - 0.58) |
| Mad | 1.92 | 2.72 | .38 (0.31 - 0.45) |
| Scared | 1.65 | 2.63 | .47 (0.40 - 0.55) |
| Stressed | 3.27 | 3.17 | .44 (0.37 - 0.51) |
| Low arousal negative affect (0–10) | 2.63 | 2.66 | .57 (0.50 - 0.64) |
| Lonely | 3.20 | 3.43 | .50 (0.43 - 0.58) |
| Empty | 2.96 | 3.50 | .55 (0.49 - 0.63) |
| Guilty | 1.85 | 2.75 | .49 (0.42 - 0.56) |
| Sad | 2.52 | 3.00 | .40 (0.33 - 0.47) |
| Passive suicidal thought intensity (0–10) | 1.00 | 2.09 | .48 (0.42 - 0.56) |
| Active suicidal thought intensity (0–10) | .62 | 1.45 | .49 (0.42 - 0.57) |
| Active suicide ideation | .74 | 1.74 | .49 (0.42 - 0.56) |
| Suicide intent | .49 | 1.33 | .47 (0.40 - 0.54) |
| NSSI thought intensity (0–10) | 1.08 | 2.21 | .44 (0.38 - 0.53) |

ICC = intraclass correlation; 95 % CI = 95 % confidence interval; *M* = mean; *SD* = standard deviation; NSSI = nonsuicidal self-injury. Please note, means and SDs were calculated by taking the mean of the individual mean (iMean) and the individual standard deviation (iSD).

**Table 3**
Repeated measures correlation table for main study variables.

| Sample 1 | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|
| 1. High arousal negative affect | – | | | | |
| 2. Low arousal negative affect | .50*** | – | | | |
| 3. Passive suicidal thought intensity | .37*** | .40*** | – | | |
| 4. Active suicidal thought intensity | .31*** | .36*** | .55*** | – | |
| 5. NSSI thought intensity | .15*** | .15*** | .18*** | .17*** | – |
| **Sample 2** | **1.** | **2.** | **3.** | **4.** | **5.** |
| 1. High arousal negative affect | – | | | | |
| 2. Low arousal negative affect | .66*** | – | | | |
| 3. Passive suicidal thought intensity | .34*** | .37*** | – | | |
| 4. Active suicidal thought intensity | .29*** | .31*** | .73*** | – | |
| 5. NSSI thought intensity | .37*** | .36*** | .66*** | .57*** | – |

NSSI = nonsuicidal self-injury.
*** $p < .001$.

whereas high arousal NA intensity did not ($B = 0.06$, $p$=.17, see Table 5).

### 4.3. NSSI thought intensity outcome

In the contemporaneous model, both high ($B = 0.11$, $p$=.005) and low arousal NA intensity ($B = 0.12$, $p$=.03) were associated with greater NSSI thought intensity. In the lagged effect model (fixed slopes, due to convergence errors), greater low arousal NA intensity ($B = 0.07$, $p$=.004) predicted greater NSSI thought intensity at the next within-day time-point, whereas high arousal NA intensity did not ($B$=−0.01, $p$=.72, see Table 6).

## 5. Results: Study 2

See Tables 2–3 for descriptives, repeated measure correlations, and ICCs for main study variables.

**Table 4**
High arousal and low arousal negative affect intensity as predictors of passive suicidal thought intensity.

| | Outcome: Passive suicidal thought intensity | | | Outcome: Next-point passive suicidal thought intensity | | |
|---|---|---|---|---|---|---|
| *Predictors* | *B* | *95% CI* | *p* | *B* | *95% CI* | *p* |
| **Sample 1** | | | | | | |
| (Intercept) | **2.67** | **2.34 – 2.99** | **<0.001** | **2.65** | **2.32 – 2.98** | **<0.001** |
| High arousal negative affect | **.23** | **.16 – 0.30** | **<0.001** | **.14** | **.08 – 0.21** | **<0.001** |
| Low arousal negative affect | **.25** | **.17 – 0.32** | **<0.001** | **.15** | **.09 – 0.22** | **<0.001** |
| Age | .08 | −0.13 – 0.28 | .45 | .08 | −0.12 – 0.28 | .43 |
| *Random Effects* | | | | | | |
| $\sigma^2$ | **.33** | | | **.40** | | |
| $\tau_{00}$ | **1.29** | | | **1.31** | | |
| $\tau_{11}$(High arousal) | **.03** | | | **.01** | | |
| $\tau_{11}$(Low arousal) | **.05** | | | **.02** | | |
| $\rho_{01}$ | **−0.05 .05** | | | **−0.03 .44** | | |
| ICC | .80 | | | .77 | | |
| $N_{Subject\_ID}$ | 48 | | | 48 | | |
| Observations | 2728 | | | 1771 | | |
| Marginal $R^2$ / Conditional $R^2$ | .06 / 0.81 | | | .03 / 0.78 | | |
| **Sample 2** | | | | | | |
| (Intercept) | **1.02** | **.73 – 1.31** | **<0.001** | **1.01** | **.70 – 1.33** | **<0.001** |
| High arousal negative affect | **.13** | **.07 – 0.19** | **<0.001** | .01 | −0.03 – 0.06 | .62 |
| Low arousal negative affect | **.23** | **.16 – 0.31** | **<0.001** | **.13** | **.09 – 0.18** | **<0.001** |
| Age | .01 | −0.13 – 0.16 | .84 | .03 | −0.16 – 0.23 | .73 |
| *Random Effects* | | | | | | |
| $\sigma^2$ | **1.54** | | | **2.14** | | |
| $\tau_{00}$ | **2.12** | | | **2.21** | | |
| $\tau_{11}$(High arousal) | **.05** | | | N/A | | |
| $\tau_{11}$(Low arousal) | **.10** | | | N/A | | |
| $\rho_{01}$ | **.26 .60** | | | N/A | | |
| ICC | .62 | | | .51 | | |
| $N_{Subject\_ID}$ | 101 | | | 93 | | |
| Observations | 4349 | | | 2570 | | |
| Marginal $R^2$ / Conditional $R^2$ | .07 / 0.65 | | | .01 / 0.52 | | |

*Note.* $p$ = $p$-value; *95% CI* = 95% confidence interval; ICC = intraclass correlation; $N_{ID}$ = number of participants; Negative affect arousal dimensions are observation-level variables and were person-mean centered. Age is a person-level variable and was grand-mean centered. Bold values indicate statistically significant difference ($p < .05$).

### 5.1. Passive suicidal thought intensity outcome

In the contemporaneous model, both high ($B = 0.13$, $p$<.001) and low arousal NA intensity ($B = 0.23$, $p$<.001) were associated with greater passive suicidal thought intensity. In the lagged effect model (fixed slopes due to convergence errors), greater low arousal NA intensity ($B = 0.13$, $p$<.001) predicted greater passive suicidal thought

**Table 5**
High arousal and low arousal negative affect intensity as predictors of active suicidal thought intensity.

| | Outcome: Active suicidal thought intensity | | | Outcome: Next-point active suicidal thought intensity | | |
|---|---|---|---|---|---|---|
| *Predictors* | *B* | *95% CI* | *p* | *B* | *95% CI* | *p* |
| **Sample 1** | | | | | | |
| (Intercept) | **.49** | **.33 – 0.64** | **<0.001** | **.48** | **.33 – 0.64** | **<0.001** |
| High arousal negative affect | **.15** | **.08 – 0.23** | **<0.001** | .06 | −0.02 – 0.14 | .17 |
| Low arousal negative affect | **.22** | **.14 – 0.29** | **<0.001** | **.13** | **.07 – 0.20** | **<0.001** |
| Age | .00 | −0.06 – 0.06 | .99 | .00 | −0.07 – 0.07 | .94 |
| *Random Effects* | | | | | | |
| $\sigma^2$ | **.22** | | | **.26** | | |
| $\tau_{00}$ | **.29** | | | **.28** | | |
| $\tau_{11}$(High arousal) | **.05** | | | .05 | | |
| $\tau_{11}$(Low arousal) | **.05** | | | **.03** | | |
| $\rho_{01}$ | **.77** | | | **.64** | | |
| | **.31** | | | .53 | | |
| ICC | .62 | | | .55 | | |
| $N_{Subject\_ID}$ | 48 | | | 48 | | |
| Observations | 2728 | | | 1771 | | |
| Marginal $R^2$ / Conditional $R^2$ | .09 / 0.65 | | | .03 / 0.56 | | |
| **Sample 2** | | | | | | |
| (Intercept) | **.61** | **.40 – 0.81** | **<0.001** | **.62** | **.39 – 0.85** | **<0.001** |
| High arousal negative affect | **.08** | **.03 – 0.12** | **.001** | −0.00 | −0.03 – 0.03 | .97 |
| Low arousal negative affect | **.12** | **.07 – 0.17** | **<0.001** | **.08** | **.05 – 0.11** | **<0.001** |
| Age | .02 | −0.07 – 0.12 | .66 | .01 | −0.13 – 0.15 | .88 |
| *Random Effects* | | | | | | |
| $\sigma^2$ | **.73** | | | **1.11** | | |
| $\tau_{00}$ | **1.02** | | | **1.16** | | |
| $\tau_{11}$(High arousal) | **.03** | | | N/A | | |
| $\tau_{11}$(Low arousal) | **.04** | | | N/A | | |
| $\rho_{01}$ | **.31** | | | N/A | | |
| | **.64** | | | | | |
| ICC | .62 | | | .51 | | |
| $N_{Subject\_ID}$ | 101 | | | 93 | | |
| Observations | 4349 | | | 2570 | | |
| Marginal $R^2$ / Conditional $R^2$ | .05 / 0.64 | | | .007 / 0.52 | | |

*Note.* $p$ = $p$-value; *95% CI* = 95% confidence interval; ICC = intraclass correlation; $N_{ID}$ = number of participants; Negative affect arousal dimensions are observation-level variables and were person-mean centered. Age is a person-level variable and was grand-mean centered. Bold values indicate statistically significant difference ($p < .05$).

**Table 6**
High arousal and low arousal negative affect intensity as predictors of NSSI thought intensity.

| | Outcome: NSSI thought intensity | | | Outcome: Next-point NSSI thought intensity | | |
|---|---|---|---|---|---|---|
| *Predictors* | *B* | *95% CI* | *p* | *B* | *95% CI* | *p* |
| **Sample 1** | | | | | | |
| (Intercept) | **.20** | **.11 – 0.30** | **<0.001** | **.21** | **.08 – 0.34** | **.002** |
| High arousal negative affect | **.11** | **.04 – 0.18** | **.002** | −0.01 | −0.06 – 0.04 | .72 |
| Low arousal negative affect | **.12** | **.02 – 0.22** | **.02** | **.07** | **.02 – 0.11** | **.005** |
| Age | .00 | −0.05 – 0.05 | .97 | −0.03 | −0.11 – 0.06 | .56 |
| *Random Effects* | | | | | | |
| $\sigma^2$ | **.41** | | | **.42** | | |
| $\tau_{00}$ | **.10** | | | **.20** | | |
| $\tau_{11}$(High arousal) | **.03** | | | N/A | | |
| $\tau_{11}$(Low arousal) | **.09** | | | N/A | | |
| $\rho_{01}$ | **.58** | | | N/A | | |
| | **.38** | | | N/A | | |
| ICC | .29 | | | .32 | | |
| $N_{Subject\_ID}$ | 48 | | | 48 | | |
| Observations | 2728 | | | 1771 | | |
| Marginal $R^2$ / Conditional $R^2$ | .04 / 0.32 | | | .01 / 0.33 | | |
| **Sample 2** | | | | | | |
| (Intercept) | **1.05** | **.75 – 1.35** | **<0.001** | **1.02** | **.71 – 1.34** | **<0.001** |
| High arousal negative affect | **.17** | **.11 – 0.22** | **<0.001** | **.07** | **.02 – 0.12** | **.009** |
| Low arousal negative affect | **.21** | **.14 – 0.28** | **<0.001** | **.10** | **.05 – 0.15** | **<0.001** |
| Age | .02 | −0.12 – 0.16 | .78 | .01 | −0.18 – 0.20 | .92 |
| *Random Effects* | | | | | | |
| $\sigma^2$ | **1.99** | | | **2.63** | | |
| $\tau_{00}$ | **2.18** | | | **2.09** | | |
| $\tau_{11}$(High arousal) | **.03** | | | N/A | | |
| $\tau_{11}$(Low arousal) | **.07** | | | N/A | | |
| $\rho_{01}$ | **.53** | | | N/A | | |
| | **.64** | | | | | |
| ICC | .56 | | | .44 | | |
| $N_{Subject\_ID}$ | 101 | | | 93 | | |
| Observations | 4349 | | | 2570 | | |
| Marginal $R^2$ / Conditional $R^2$ | .07 / 0.59 | | | .01 / 0.45 | | |

*Note.* $p$ = $p$-value; *95% CI* = 95% confidence interval; ICC = intraclass correlation; $N_{ID}$ = number of participants; Negative affect arousal dimensions are observation-level variables and were person-mean centered. Age is a person-level variable and was grand-mean centered. Bold values indicate statistically significant difference ($p < .05$).

intensity at the next within-day time-point, whereas high arousal NA intensity did not ($B = 0.01$, $p$=.62, see Table 4).

### 5.2. Active suicidal thought intensity outcome

In the contemporaneous model, both high ($B = 0.08$, $p$<.001) and low arousal NA intensity ($B = 0.12$, $p$<.001) were associated with greater active suicidal thought intensity. In the lagged effect model (fixed slopes due to convergence errors), greater low arousal NA intensity ($B = 0.08$, $p$<.001) predicted greater active suicidal thought intensity at the next within-day time-point, whereas high arousal NA intensity did not ($B$=−0.001, $p$=.97, see Table 5).

### 5.3. NSSI thought intensity outcome

In the contemporaneous model, both high ($B = 0.17$, $p$<.001) and low arousal NA intensity ($B = 0.21$, $p$<.001) were associated with greater NSSI thought intensity. In the lagged effect model (fixed slopes

due to convergence errors), both high ($B = 0.07$, $p$=.009) and low arousal NA intensity ($B = 0.10$, $p$<.001) predicted greater NSSI thought intensity at the next within-day time-point (see Table 6).

## 6. Discussion

The current study extends knowledge of the proximal associations between specific NA arousal dimensions and self-injurious thoughts using a real-time monitoring approach among psychiatrically acute adolescents. We conducted an internal replication across two unique, but complementary, samples of psychiatrically acute adolescents recruited from geographically distinct and independent hospital systems, which allowed us to test the reproducibility of findings across settings and enhance confidence in the generalizability of the results. This study is among the first to examine short-term associations between NA arousal and both passive and active suicidal thought intensity, as well as NSSI thought intensity using a temporally sensitive approach in psychiatrically acute adolescents. Novel findings from this study are summarized below.

We first considered associations between NA arousal dimensions, and passive and active suicidal thought intensity. Across both samples, high and low arousal NA were consistently associated with greater intensity of passive and active suicidal thoughts in contemporaneous models. However, only low arousal NA predicted greater next time-point active suicidal thought intensity across both samples. For passive suicidal thoughts, both high and low arousal NA predicted greater next time-point thought intensity in Study 1, but only low arousal NA emerged as a significant predictor of next time-point passive suicidal thought intensity in Study 2. One possible explanation for this divergence may be differences in item phrasing: Study 1 assessed reduced wish to live, whereas Study 2 assessed wish to die. Although both capture facets of passive suicidal thought intensity (Mandel et al., 2024; Oakey-Frost et al., 2023), they may tap into distinct underlying experiences, potentially influencing how arousal-related affective states relate to each construct.

Next, we examined associations between NA arousal states and NSSI thought intensity. Both high and low arousal NA were contemporaneously associated with greater NSSI thought intensity in both studies. In lagged models, low arousal NA predicted future NSSI thought intensity in both studies, while high arousal NA was only a significant lagged predictor in Study 2. It may be that greater endorsement of NSSI thought intensity in Study 2, as well as a larger sample size, resulted in enhanced power to detect the impact of high arousal NA on NSSI thought intensity; however, these findings should be replicated. Future investigations may also consider the differential affect regulation functions of suicidal thoughts and NSSI thoughts to clarify how high and low arousal NA may uniquely be associated with each of these SITB outcomes (Al-Dajani and Uliaszek, 2021; Coppersmith et al., 2023; Kleiman et al., 2018).

Our results contrast with our hypotheses and findings from prior research, which suggest that high arousal NA states, such as severe anxiety or agitation, may confer stronger risk for future SITBs (Rogers et al., 2016). In our models, low arousal NA more consistently emerged as a predictor of self-injurious thoughts than high arousal NA, underscoring the potential importance of low arousal states in the prediction of thoughts specifically. Future studies could directly examine whether increases in high arousal NA indicate more salient transitions in risk trajectories (i.e., transitions from thoughts to behavior). Another explanation for our findings may be related to the complex influence of affect dynamic components that are beyond the scope of the current study. One specific component, inertia, which refers to the temporal dependency of NA arousal dimensions, or the degree to which NA arousal dimensions are linked over time (Houben et al., 2015; Koval et al., 2013, 2021), could play an important role. Once someone is in a low arousal NA state, they may get "stuck" in this state for a period of time, making it unlikely to shift from one moment to the next (for review see Houben et al., 2015). Such carryover effects and persistence of low arousal NA states (relative to each person's individual mean) may be more strongly associated with SITBs over shorter time intervals, as indicated by our study findings.

We extend the extant research base by adopting a novel approach of explicitly distinguishing between NA arousal dimensions and examining associations with SITBs. Most existing studies often overlook the nuances with NA by either aggregating NA into a broad construct or narrowly focusing on specific NA states. Based on the circumplex model of affect (Posner et al., 2005; Russell, 1980), our study examined high and low arousal NA simultaneously in models, allowing us to compare the relative contribution of each arousal dimension in predicting SITBs–a novel approach to this research question. Although our assessment of NA states differed across the two studies, the organization of NA into arousal dimensions is theoretically defined, using aspects of the circumplex model of affect (Posner et al., 2005; Russell, 1980). Importantly, our primary interest was in the broader impact of the NA arousal dimension on self-injurious thought outcomes, rather than the influence of specific affective states. Additionally, we used data from real-time monitoring studies, allowing us to investigate proximal associations between NA arousal dimensions and SITB outcomes on a temporally sensitive timescale. Consistent patterns across the two samples provide stronger support for the robustness of associations between NA arousal dimensions and SITBs, as findings were replicated across distinct samples of clinically acute youth.

Furthermore, the current study is novel in its investigation of both passive and active suicidal thoughts. We observed that predictors and patterns of effects overlapped considerably. A descriptive examination of effect sizes revealed high and low arousal NA accounted for similar amounts of variance in explaining both passive and active suicidal thoughts. Taken together, these findings underscore the importance of passive suicidal thoughts as a clinical outcome of interest (Liu et al., 2020).

### 6.1. Clinical implications

Findings from this study have several notable clinical implications. Emotions and mood are dynamic processes that importantly may be amenable to intervention, as indicated by several existing interventions including cognitive-behavioral therapy and dialectical behavior therapy (for review see Saccaro et al., 2024). Although mood tracking is a component of these existing interventions, it may be that focusing on tracking and understanding clusters of arousal dimensions could be beneficial for identifying specific types of higher risk periods. It is possible that interventions could be tailored to better suit the *specific* arousal dimensions and corresponding risk period. This information could be integrated into risk assessments or safety planning interventions during hospital discharge, helping clinicians and adolescents collaboratively identify early warning signs and targeted coping strategies. For instance, the low arousal NA dimension (i.e., sad, guilty, lonely) may be more efficiently addressed with positive affect treatment (Craske et al., 2019), whereas the high arousal NA dimension (i.e., mad, stressed, agitated) may benefit from distress tolerance skills (Asarnow et al., 2021).

### 6.2. Limitations

This study should be viewed in the context of several important limitations. First, in our lagged analyses, we utilized the next within-day time-point, resulting in varied time lag windows which may create extraneous noise in our models. Additionally, the arbitrary time lag (e.g., hours) may not accurately depict the actual time-course of how elevated risk periods unfold. Study designs providing more intensive assessments over shorter time periods, like EMA burst study designs (Smyth et al., 2017), could clarify the time course of risk conferred by these NA arousal dimensions.

Second, it is worth noting that mean levels of high and low arousal

NA were lower in Study 1 relative to Study 2, likely due to differences in the response scale for affect items across the two studies. This restricted range in Study 1 may have limited variability, potentially attenuating associations and impacting our ability to make definitive cross-sample comparisons.

Third, we did not test if distinct NA arousal dimensions were associated with the magnitude of change in SI or NSSI thought intensity over time in lagged analyses. Examining whether distinct NA arousal dimensions predict change in self-injurious thoughts over time would offer robust evidence for temporal precedence and potential causal pathways linking NA arousal dimensions to SITB risk.

Finally, although our study design was well powered to examine within-person effects, our ability to test between-person moderators (e.g., demographics, psychiatric comorbidities) was limited. Larger studies should be leveraged to both replicate findings of the current study and to test how associations may vary between key sociodemographic and psychiatric variables.

### 6.3. Conclusion

This study significantly extends prior research on short-term associations between specific NA arousal dimensions and self-injurious thoughts in psychiatrically acute adolescents. Strengths of the study include the two-sample design and intensive longitudinal methods allowing for examination of short-term predictors. Findings from this study have the potential to directly inform dynamic, real-time processes to reduce risk for suicide and self-injury in youth.

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## CRediT authorship contribution statement

**Kinjal K. Patel:** Writing – original draft, Visualization, Formal analysis, Conceptualization. **Elizabeth A. Edershile:** Writing – review & editing, Data curation. **Abigail J. Luce:** Investigation, Data curation. **Emelyn C. Auad:** Investigation, Data curation. **Richard T. Liu:** Writing – review & editing, Supervision, Project administration, Funding acquisition. **Evan M. Kleiman:** Writing – review & editing, Supervision, Project administration, Funding acquisition. **Catherine R. Glenn:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization.

## Declaration of competing interest

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All other authors have no conflicts of interest or disclosures to report.

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## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2025.116718.

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