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High emotion differentiation buffers against internalizing symptoms following exposure to stressful life events in adolescence: An intensive longitudinal study

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ABSTRACT

Exposure to stressful life events is strongly associated with internalizing psychopathology, and identifying factors that reduce vulnerability to stress-related internalizing problems is critical for development of early interventions. Drawing on research from affective science, we tested whether high emotion differentiation—the ability to specifically identify one’s feelings—buffers adolescents from developing internalizing symptoms when exposed to stress. Thirty adolescents completed a laboratory measure of emotion differentiation before an intensive year-long longitudinal study in which exposure to stress and internalizing problems were assessed at both the moment-level (n=4,921 experience sampling assessments) and monthly-level (n=355 monthly assessments). High negative and positive emotion differentiation attenuated moment-level coupling between perceived stress and feelings of depression, and high negative emotion differentiation eliminated monthly-level associations between stressful life events and anxiety symptoms. These results suggest that high emotion differentiation buffers adolescents against anxiety and depression in the face of stress, perhaps by facilitating adaptive emotion regulation.

Keywords: Adolescence, stress, emotion differentiation, internalizing psychopathology

Adolescence is a period of heightened risk for the development of internalizing psychopathology, including depression and anxiety (Hankin et al., 1998; Kessler et al., 2005; Somerville & McLaughlin, 2018). Exposure to stressful life events is a potent risk factor for internalizing problems, particularly during adolescence (Grant et al., 2006; Larson & Ham, 1993; McLaughlin & Hatzenbuehler, 2009; Michl, McLaughlin, Shepherd, & Nolen-Hoeksema, 2013). Given this tight coupling between stress and internalizing psychopathology, identifying factors that buffer against the emergence of internalizing problems following stressful experiences may inform the development of early interventions aimed at preventing stress-related psychopathology. Here, we use an intensive year-long longitudinal study of adolescents to test whether the ability to specifically identify what one is feeling—a skill called *emotion differentiation* or *emotion granularity* (Barrett, Gross, Christensen, & Benvenuto, 2001; Kashdan, Barrett, & McKnight, 2015)—might be one such factor that buffers adolescents from developing internalizing problems following stressful experiences.

Stress is commonly defined as the cascade of psychological and physiological changes that occur when an individual perceives the demands of their environment as exceeding their resources to cope (Lazarus & Folkman, 1984). As such, stress emerges through a transaction between an individual and their environment, allowing for multiple methods for measuring stress (Monroe, 2008). Measuring environmental sources of stress involves assessment of events that require significant adaptation, ranging from daily hassles (e.g., missing the bus) to instances of threat, loss, or upheaval in one's life (e.g., death of a loved one). Alternatively, stress can be measured by focusing on *perceptions* of environmental events as stressful (i.e., appraisals of events as exceeding one's resources to cope; e.g., Cohen, Kamarck, & Mermelstein, 1983). A wealth of evidence using both of these measurement approaches shows that individuals who

experience greater exposure to stressful life events and/or higher levels of perceived stress are at elevated risk for developing internalizing psychopathology (Brown & Harris, 1989; Cohen, Gianaros, & Manuck, 2016; Cohen et al., 1983; Cohen, Kessler, & Underwood Gordon, 1995; Hammen, Henry, & Daley, 2000; Monroe, Rohde, Seeley, & Lewinsohn, 1999).

Most studies that establish associations between stress and psychopathology take a between-subjects approach and show that individuals who experience greater stress are at higher risk for developing psychopathology. More recent work has also revealed strong coupling between stress and psychopathology at the within-person level. For example, a recent study from our group demonstrated that within-person increases in stressful events (i.e., experiencing greater stressful life events than is typical for an individual) predicted subsequent within-person increases in symptoms of depression and anxiety during adolescence (Jenness, Peverill, King, Hankin, & McLaughlin, 2019). Taking an idiographic, within-person focus on processes that contribute to psychopathology is a necessary step in the field's movement towards precision medicine and personalized care (Fisher, 2015; Wright & Woods, 2020). As such, additional studies that use intensive sampling to examine within-person processes are crucial to understand the etiological pathways connecting stress to psychopathology.

Even though stressful events often precede the onset of internalizing problems at both the between-person and within-person level, stressors do not invariably lead to the emergence of psychopathology. Stressors frequently arise in people's lives, but these events alone do not always instigate symptoms. Instead, psychological and environmental factors can moderate the association of stress with psychopathology. These moderating factors are theoretically understood through the lens of diathesis-stress models, which posit that psychopathology emerges through an interaction between an individual's underlying vulnerabilities—called

diatheses—and environmental stressors (Alloy, Abramson, & Francis, 1999; Bernstein et al., 2019; Hammen et al., 2000; Hankin & Abramson, 2001; Hilsman & Garber, 1995; Hooley & Gotlib, 2000; Monroe & Simons, 1991; Nook, Dodell-Feder, et al., 2018; Shapero, McClung, Bangasser, Abramson, & Alloy, 2017). Conversely, protective factors are conceptualized as variables that reduce vulnerability to psychopathology following exposure to stressors (Rutter, 1985). For example, social support buffers against the development of internalizing problems following stressful experiences (Cohen, 2004; Cohen & Wills, 1985). Heightened neural sensitivity to reward also buffers against the emergence of depression following exposure to stressors (Dennison et al., 2016; Nikolova, Bogdan, Brigidi, & Hariri, 2012).

As such, the field has identified both interpersonal and neurobiological factors that reduce vulnerability to stress. Here we extend the search for resilience factors by focusing on processes that facilitate adaptive emotion regulation (i.e., the set of strategies people use to change how they feel; Gross, 1998, 2015). Factors that improve emotion regulation are key candidates for buffering the association of stress with psychopathology because (i) stressful experiences reliably induce negative affect (Bolger, DeLongis, Kessler, & Schilling, 1989; Mroczek & Almeida, 2004) and (ii) dysregulation of negative emotion is thought to be a central component of internalizing psychopathology (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Gross & Jazaieri, 2014). In fact, difficulties with emotion regulation have been shown to mediate the association between stress exposure and the development of internalizing symptoms in adolescents (McLaughlin & Hatzenbuehler, 2009), suggesting that skills that boost regulation may mitigate the links between stress and psychopathology.

Emerging work in the field of affective science indicates that emotion differentiation (i.e., the ability to specifically identify what one is feeling) may be one such factor that can facilitate

effective emotion regulation and protect against psychopathology. To illustrate this phenomenon, people with high emotion differentiation can easily distinguish when they are feeling “disappointed” from when they are feeling “annoyed” or “angry,” whereas people with low emotion differentiation struggle to make such fine-grained distinctions and simply consider both of these states as feeling “bad.” Prior work has consistently linked high emotion differentiation to better mental health and emotion regulation. Low emotion differentiation has been documented in several mental disorders including depression, social anxiety, eating disorders, and borderline personality disorder (Demiralp et al., 2012; Kashdan & Farmer, 2014; Selby et al., 2014; Suvak et al., 2011). Similarly, high emotion differentiation is associated with greater self-reported use of adaptive emotion regulation strategies (Barrett et al., 2001), more successful emotion regulation (Kalokerinos, Erbas, Ceulemans, & Kuppens, 2019), and the absence of self-destructive emotion regulation strategies like non-suicidal self-injury or alcohol consumption (Anand, Chen, Lindquist, & Daughters, 2017; Kashdan, Ferssizidis, Collins, & Muraven, 2010; Zaki, Coifman, Rafaeli, Berenson, & Downey, 2013). This body of work supports a model in which high emotion differentiation is associated with better mental health outcomes by enhancing emotion regulation. As such, high emotion differentiation may be a factor that buffers individuals from developing internalizing problems following stress.

Indeed, this model has been supported by recent studies. First, Starr, Hershenberg, Li, & Shaw (2017) conducted two ecological momentary assessment studies showing that high emotion differentiation buffers both undergraduate students and veterans from experiencing depression symptoms in response to negative life events. Second, Starr, Hershenberg, Shaw, Li, & Santee (2019) showed that emotion differentiation attenuated the concurrent association between daily hassles and depressed mood over the course of one week as well as the

prospective relationship between stressful life events and depression symptoms in adolescents.

These studies provided evidence supporting the model described above: High emotion differentiation may play a moderating role in buffering individuals from the impact of stress.

The current study provides yet another test of this model. Our methods replicate and extend those of Starr et al. (2019), even though these studies were designed and implemented without mutual knowledge. Both studies investigate whether high emotion differentiation moderates the association between stress and symptoms in adolescents using parallel experience sampling and interview methods. Replication is an important scientific pursuit in its own right (Zwaan, Etz, Lucas, & Donnellan, 2018), but the current study also provides several key points of extension from prior work. First, the current study adopts an intensive year-long approach and focuses on within-person relationships between stress and psychopathology, rather than using a large between-person sample and focusing on a shorter observation period. Second, the current study uses a laboratory measure of emotion differentiation rather than extracting a measure of emotion differentiation from daily emotion ratings. This allows measures of emotion differentiation and daily affect to be totally separated. Third, the current study examines internalizing problems (i.e., both anxiety and depression) more broadly, rather than focusing on depression alone. Finally, we included measures of both positive and negative emotion differentiation. Although the lion's share of research has focused on negative emotion differentiation, several studies have found that positive emotion differentiation has adaptive correlates (e.g., higher endorsement of healthy coping strategies and lower odds of binge eating problems; Dixon-Gordon, Chapman, Weiss, & Rosenthal, 2014; Mikhail et al., 2019; Tugade, Fredrickson, & Barrett, 2004). That said, evidence is mixed, with only 6 of 16 recent studies that included measures of positive emotion differentiation showed adaptive associations (Liu, Gilbert,

& Thompson, 2020). Consequently, we included a measure of positive emotion differentiation to test whether it could also help individuals adaptively respond to stressors. Even though stress is often thought of as occurring within negative situations, it can also emerge in the context of positive events (e.g., being selected over one's friends as the starting member of a sports team can induce feelings of pride but also cause interpersonal stress; Shimizu & Pelham, 2004). Together, the current study aims to both strengthen and extend the field's evidence that emotion differentiation protects adolescence from stress-related psychopathology.

From a developmental perspective, there are several reasons for focusing on adolescents when investigating whether emotion differentiation buffers individuals from the impact of stress. Adolescence is a developmental period characterized by elevated exposure to stressors, heightened emotional reactivity to stress, and elevated risk of the onset of internalizing psychopathology (Kessler et al., 2005; Larson & Ham, 1993; Larson, Moneta, Richards, & Wilson, 2002). Moreover, although conceptual understanding of emotions continues to develop through the adolescent years (Nook, Sasse, Lambert, McLaughlin, & Somerville, 2017; Nook et al., 2020), emotion differentiation actually *declines* from childhood into adolescence, making adolescence a normatively low period of emotion differentiation (Nook, Sasse, Lambert, McLaughlin, & Somerville, 2018; Starr, Shaw, Li, Santee, & Hershenberg, 2020). As such, adolescence is a period characterized by low emotion differentiation, high exposure to stressors, and increased risk for internalizing psychopathology. Although prior research has not examined whether low emotion differentiation explains elevated risk for psychopathology in this age range, evidence that emotion differentiation protects against stress-related psychopathology would suggest that high emotion differentiation may be especially important for buffering against maladaptive responses to elevated stressors during this developmental period.

Here, we use an intensive year-long longitudinal study of adolescent girls to test whether high emotion differentiation buffers adolescents from the deleterious influence of stress. Specifically, we use a combination of experience sampling methods—in which participants report on momentary subjective experiences of perceived stress and depressed and anxious affect several times daily—and gold-standard monthly interviews designed to provide objective measures of stressful life events, paired with monthly symptom assessments, to test whether emotion differentiation moderates the within-person associations of stress exposure and internalizing problems. This design provides opportunities to examine factors that moderate the associations of stress with internalizing psychopathology at multiple timescales and levels of analysis. Determining whether emotion differentiation moderates the impact of stress on adolescents' risk for internalizing problems is a crucial step in targeted interventions for preventing the onset of psychopathology in youth.

Methods

Participants

This study was designed to examine within-person associations between stress and psychopathology. Thirty female adolescents aged 15-17 participated in a year-long longitudinal study that included 12 in-lab assessments conducted each month ($n = 355$ monthly assessments) and a total of 12 weeks of ecological momentary assessments (EMA) spread across four waves of three-week periods in which participants reported on stress and affect three times daily ($n = 4,921$ momentary assessments). We focused on adolescent girls as this is a group well documented to be at elevated risk for anxiety and depression and for whom the coupling between

stressors and internalizing psychopathology is pronounced (Hankin & Abramson, 2001; Prinstein & Aikins, 2004).

Participants were recruited in Seattle, WA via fliers and word of mouth between January 2015 and June 2017 for a large neuroimaging and EMA study from which the current data are drawn. Inclusion criteria included being an English-speaking female aged 15-17 who was committed to completing all study assessments. Exclusion criteria included: non-English speaking, IQ < 80, active substance dependence, psychosis, presence of pervasive developmental disorders (e.g. autism), MRI scan ineligibility (e.g. metal implants, metal braces, claustrophobia, pregnancy), psychiatric medication use, active safety concerns, and inability to attend the 12 study visits. Mood and anxiety disorders were assessed using the Kiddie Schedule for Affective Disorders and Schizophrenia at the beginning and end of the year (K-SADS; Kaufman et al., 1997). More than half (60%) of the sample had experienced a lifetime mood or anxiety disorder when they enrolled in the study, and 40% met criteria for an internalizing disorder during the year of the study. All procedures were approved by the Institutional Review Board at the University of Washington. Participants provided written assent, and legal guardians provided written informed consent.

Procedures

Overview. The study design included parallel measures of stress and internalizing symptoms at both experience-sampling and monthly levels. These are referred to as *moment-level* and *monthly-level* observations throughout the paper. Moment-level assessments focused on participants' perceptions of stress, depression, and anxiety and were collected via smartphone (through the MetricWire app; www.metricwire.com). Monthly-level assessments focused on

interview-based measures of stressful life events that were coded by interviewers to quantify the severity and impact of each event as objectively as possible and self-reported clinical symptoms of depression and anxiety. These were collected at each of the 12 monthly visits. Emotion differentiation was measured in the laboratory using a behavioral task at the initial baseline session.

To give an overview of the study's timing and procedures (see **Supplemental Materials** for an illustrative figure), the study commenced with participants completing a laboratory session in which they completed the emotion differentiation task and their first monthly-level assessments (i.e., measures of stressful life events, depression symptoms, and anxiety symptoms). Participants were then enrolled in the study for a full year and returned to the lab to complete monthly-level assessments each month. Interspersed between these monthly visits, participants completed four waves of moment-level measures. Each wave involved three weeks of moment-level measures, and waves were spread throughout the year. Further details of these procedures are provided below.

Moment-level assessment procedures. Moment-level assessments of perceived stress and affect were collected three times a day for three weeks at four separate times across the year-long study (i.e., a total of 12 weeks of moment-level assessments across four waves). Participants were counterbalanced to receive the first wave either in the first or second month of the study, and subsequent waves occurred during a random month within each quarter of the rest of the year-long study (i.e., approximately every 3 months). Adopting a multi-wave approach to experience sampling aimed to provide broad coverage of participants' momentary experiences without overburdening them. During experience-sampling periods, participants received three prompts each day spread across the morning, afternoon, and evening (i.e., at 7am, 12pm, and

5pm) directing them to complete a short survey measuring how they felt “right now.”

Participants were instructed to complete surveys in accordance with their school’s policy on cellphone use, and participants were able to delay surveys for up to 2 hours if they were unable to complete them immediately.

Participants responded to a total of 4,921 prompts, and 4,865 of these included responses to measures of perceived stress, depressed affect, and anxious affect (i.e., 98.9% usable for all analyses, although observations are only excluded from an analysis if they do not include data needed for that analysis). Compliance with study procedures was encouraged by financially rewarding participants for completing moment-level assessments (see **Supplemental Materials** for details). Unfortunately, a number of issues in the MetricWire (versions 3.1.0 - 3.5.1) tool made it impossible to compute the exact proportion of moment-level assessments that participants completed. Specifically, the software did not consistently record when prompts were sent to participants. Additionally, errors in the MetricWire tool led to some prompts not being sent to respondents, making it impossible to know whether a prompt was ignored by the respondent or not actually sent. Although these issues have been resolved in newer versions of the tool, they had not yet been addressed in the version that was available at the time we started the study. As such, it is not possible to compute the response rate for moment-level assessments, but the upper level of the number of surveys that could have been sent to participants is 7,560 surveys.

Monthly-level assessment procedures. Monthly-level measures of stressful life events and internalizing symptoms were administered at each of the 12 monthly assessments (i.e., 12 observations per participant). This intensive longitudinal design resulted in a total of 360 possible monthly-level observations of stressful life events and symptoms over the study period,

with participants attending 355 out of 360 assessments (98.6% completion rate). Similar to moment-level assessments, participants were encouraged to complete monthly visits by providing increasing financial compensation for each monthly visit (see **Supplemental Materials** for details).

Assessments

Emotion differentiation task. At the baseline laboratory session, participants completed a standard laboratory-based emotion differentiation task (Erbas, Ceulemans, Lee Pe, Koval, & Kuppens, 2014; Nook, Sasse, et al., 2018). Participants viewed 20 negative and 20 positive images from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) and rated how strongly each induced a set of emotions on a 10-point scale (1 = *not at all*, 10 = *extremely*). For negative images, they rated how strongly they felt five negative emotions (i.e., angry, ashamed, disgusted, sad, and scared) and for positive images, they rated how strongly they felt five positive emotions (i.e., calm, excited, happy, inspired, and interested). Images were selected to induce a range of negative or positive emotions. Images were presented for 5 seconds, and rating was self-paced. Images and emotions were presented in random order for each participant.

Following prior work, we computed negative emotion differentiation scores by calculating the intraclass correlation (ICC) between negative emotion ratings across the 20 images (Erbas et al., 2014; Kalokerinos et al., 2019; Nook, Sasse, et al., 2018; Pond et al., 2012; Tugade et al., 2004). Specifically, we followed the methods shared by Kalokerinos et al. (2019) and computed emotion differentiation scores by fisher-r-to-z transforming the ICC of consistency in average ratings across emotions (i.e., ICC(3,k)). Higher ICCs indicate greater

similarity in how participants used each emotion scale (i.e., lower differentiation across emotions) and lower ICCs indicate less similarity across emotions. For interpretability, Fisher-transformed intraclass correlation coefficients were reverse scored by subtracting them from 1 so that higher scores represented greater emotion differentiation. A similar process was used to compute positive emotion differentiation scores from participants' endorsement of positive emotions in response to positive images.

Moment-level assessments.

Perceived stress. When prompted by the MetricWire app, participants responded to questions assessing perceived stress and affect in the current moment. In each prompt, stress was defined for participants through the text: “stress is a situation where a person feels upset because of something that happened unexpectedly or when they are unable to control important things in their life.” Participants then responded to the question “do you feel this kind of stress right now?” on a 7-point scale (1 = *not at all*, 7 = *very stressed*). We refer to these ratings as *perceived stress scores*.

Depressed and anxious affect. At each MetricWire prompt, participants also rated their current feelings of depression and anxiety by responding to the questions “how depressed do you feel right now?” and “how anxious do you feel right now?” on 7-point scales (1 = *not at all*, 7 = *very depressed/anxious*). To distinguish these ratings from symptom inventories collected at the month-level, we refer to these ratings as *depressed affect* and *anxious affect* ratings, respectively.

Month-level assessments.

Stressful Life Events. Exposure to stressful life events was assessed at each monthly visit using the UCLA Life Stress Interview (Hammen et al., 2000) adapted for children and adolescents. This semi-structured interview was administered by a trained experimenter and

assesses the impact of life events as objectively as possible in terms of both chronic stressors (e.g., interpersonal conflict with peers or family) and acute stressful life events (e.g., failing a test, break-up of a romantic relationship). The interview has been extensively validated and is widely considered to be the gold standard approach for assessing stressful life events and chronic stress.

Structured prompts query several domains of the participant's life (i.e., peers, parents, household/extended family, neighborhood, school, academics, health, finance, and discrimination) for stressful life events. Each stressful event is then probed to determine timing, duration, impact, and coping resources. Trained experimenters objectively coded the impact of each event on an individual of the participant's age and sex on a 10-point scale (1.0 = no negative impact, 5.0 = extremely severe negative impact, half-points included). Following prior work, we produced a *stress impact score* by taking the sum of the impact scores of all reported events (excluding those coded as 1). This score provides a weighted average of both the number and severity of stressors that occurred (Hammen et al., 2000). The interview was administered at baseline and at each of the monthly visits to measure stressful experiences occurring in the prior month. Stress measures were not obtained for four (i.e., 1.11%) observations.

Depression and anxiety symptoms. Symptoms of depression were collected using the Personal Health Questionnaire-9 (PHQ-9), a well-validated and widely-used measure of depression (Kroenke, Spitzer, & Williams, 2001). At each session, participants reported on their depressive symptoms over the last two weeks. Item scores ranged from 0 to 2, with higher scores indicating higher depressive symptom severity. Responses demonstrated strong internal consistency across all time points in the current study ($\alpha = 0.84$). Symptoms of generalized anxiety disorder were measured with the Generalized Anxiety Disorder-7 (GAD-7) (Spitzer,

Kroenke, Williams, & Löwe, 2006). Like the PHQ-9, participants reported on anxiety symptoms occurring in the last two weeks. Item scores ranged from 0 to 3, with higher scores indicating greater symptoms severity. Reliability of the GAD-7 was high in the current study ($\alpha = 0.87$). We refer to sums of monthly symptom inventories as measures of *depression symptoms* and *anxiety symptoms*, respectively.

Beyond the four missing stress measures, anxiety and depression symptom scores were not obtained for one additional observation (i.e., 1.39% total month-level observations). Within the remaining observations, participants did not respond to two GAD-7 items (i.e., < 1% of 2,485 total items) and to 14 PHQ-9 items (i.e., < 1% of 3,195 total items). These missing items were imputed when calculating depression and anxiety scores for each observation by assigning the mean value for the total scale at that assessment for these items.

Analyses and Hypotheses

Overall analytic approach. At a broad level, mixed-effects models—which allow longitudinal data to be nested within participants—were used to test whether emotion differentiation scores moderated the associations between stress and depression or anxiety. Parallel analyses were performed across both moment-level and monthly-level data to test whether these patterns emerged across both time-scales and for both perceived stress and objective coding of stressful events.

To evaluate how within-person fluctuations in stress were associated with internalizing symptoms, we transformed stress measures using both within-person centering (i.e., centering stress scores around participant-specific means) and between-person centering (i.e., computing each participant's mean stress level for the entire study period relative to the overall mean for the entire sample). This approach orthogonalizes variation in a given predictor into within- and

between-person variability (Bolger & Laurenceau, 2013; Enders & Tofighi, 2007), ultimately allowing us to test whether emotion differentiation moderates the association between within-person fluctuations in stress and internalizing problems, while controlling for between-person differences in average levels of stress exposure.

Bivariate associations. Before testing primary moderation analyses described above, we conducted analyses that allowed us to observe the strength of simple bivariate associations between all variables. One way to measure bivariate associations between variables is to average all data into single participant-level means and compute simple correlations. However, for this study, we sought to exploit the high temporal granularity of our data and examine how strongly variables covaried when they were sampled repeatedly within participants. As such, we used the *statsBy* function in the *psych* package (Revelle, 2016) to compute correlations between measures at both the within-person and between-person levels. These correlations were conducted at the most temporally granular level possible for each measure. For example, the correlation between depressed affect (a moment-level variable) and symptoms of depression (a monthly-level variable) was computed by merging monthly-level symptom data into a dataset that captured moment-level fluctuations in affect. However, the correlation between symptoms of depression (a monthly-level variable) and negative emotion differentiation (a person-level variable) was computed by merging person-level data into a dataset that captured monthly-level variations in symptoms. Finally, to measure how strongly negative and positive emotion differentiation covaried (two person-level variables), a regression at the person-level was conducted. Because negative and positive emotion differentiation did not vary within an individual, no within-person correlation coefficients could be computed for these measures.

Moment-level analyses. Primary analyses involved mixed-effects models testing whether emotion differentiation assessed at the beginning of the study moderated the associations between moment-level assessments of perceived stress and affect. Given that this study included both negative and positive emotion differentiation and both depression and anxiety, four separate analyses were conducted (i.e., negative differentiation $\times$ perceived stress in predicting depressed affect, negative differentiation $\times$ perceived stress in predicting anxious affect, positive differentiation $\times$ perceived stress in predicting depressed affect, and positive differentiation $\times$ perceived stress in predicting anxious affect). All analyses modeled affect as the outcome variable and included within-person centered perceived stress scores, emotion differentiation scores, the interaction between these two variables, and between-person centered perceived stress scores as fixed effects. Observations were nested within subject (i.e., the intercept was allowed to vary across participants as a random effect). Day since the baseline laboratory session was included in models as the measure of time. Finally, we included two control variables to ensure they did not confound results: school vs. summer (0 = not during school year, 1 = during school year) and the participant's average endorsement of negative emotions (in analyses involving negative emotion differentiation) or positive emotions (in analyses involving positive emotion differentiation) across all trials in the emotion differentiation task. Significance of results did not differ depending on inclusion of control variables. Continuous predictors other than perceived stress scores were grand-mean centered.

Decisions to include random slopes in analyses is debated in the literature, with some statisticians favoring simple models that only include necessary random effects (Bates, Kliegl, Vasishth, & Baayen, 2015; Matuschek, Kliegl, Vasishth, Baayen, & Bates, 2017) and others favoring complex “maximized” models in which all random effects and slopes are included

(Barr, Levy, Scheepers, & Tily, 2013). Here, our models were designed *a priori* to prioritize simplicity (i.e., with no random slopes), and including random slopes led to convergence issues in some of our models. Nonetheless, for thoroughness we conducted supplemental analyses to verify that the strength of key results were similar when random slopes were included (though the significance of one result changes, see **Supplemental Materials**).

We hypothesized a significant interaction between within-person perceived stress scores and emotion differentiation in predicting depressed and anxious affect, such that the association between perceived stress and feelings of depression and anxiety would be lower among those with high emotion differentiation. When this interaction was significant, we conducted simple-slopes analyses to clarify how variation in emotion differentiation influenced the relationship between perceived stress and affect.

Monthly-level analyses. Monthly-level analyses used a parallel structure to the analyses described above. We analyzed depression and anxiety symptoms using mixed-effects models that included within-person centered objective stress scores, emotion differentiation scores, the interaction between these two variables, and between-person centered objective stress scores as fixed effects. Again, observations were nested within subject (i.e., the intercept was allowed to vary across participants as a random effect), and four separate models were used to examine how negative and positive emotion differentiation related to both depression and anxiety symptoms. Month was included in the model as the measure of time. Monthly-level control variables included school vs. summer (0 = summer month, 1 = school month), and the participant's average endorsement of negative emotions (for analyses involving negative emotion differentiation) or positive emotions (for analyses involving positive emotion differentiation) across all trials in the emotion differentiation task. We controlled for average endorsement of

emotion in the emotion differentiation task given that prior work shows that average endorsement weakly correlates with emotion differentiation (Erbas et al., 2014; Nook, Sasse, et al., 2018), but it is not the primary measure of interest to the current study. Including control variables did not affect the significance of primary results, and a single change in significance is noted in a table footnote. Continuous predictors other than stress impact scores were grand-mean centered.

Again, the key hypothesized result was a significant interaction between within-person stressful impact scores and negative emotion differentiation, such that the association of stressful life events with symptoms of depression and anxiety would be lower among those with high emotion differentiation. Simple-slopes analyses were used to clarify this interaction when significant.

Secondary analyses: Differentiation of depressed and anxious affect. As a secondary analysis, we tested whether people with higher emotion differentiation also tended to differentiate depression from anxiety in their moment-level affect ratings. We consequently conducted two additional mixed-effects models that paralleled the moment-level analyses described above. Specifically, we modeled depressed affect as the outcome variable and included anxious affect, negative emotion differentiation (or positive emotion differentiation, in the second analysis), the interaction between anxious affect and differentiation, and the same control variables listed above as fixed effects. We hypothesized a significant interaction between differentiation and anxious affect in predicting depressed affect, as this would suggest that people who are better at differentiating their emotions also tend to conceptualize depression and anxiety as more dissimilar emotional states. We conducted simple slopes analyses to unpack this interaction when significant.

Supplemental analyses: Lagged impact of stress on affect and vice versa. Although stress can be measured either in terms of objective ratings of how taxing or impactful an event is or by how severely an individual perceives the event as taxing their resources (Cohen et al., 2016; Hammen et al., 2000), concerns have been raised that measures of perceived stress conflate exposure to stressful events with an individual's emotional reactions to events (Harkness & Monroe, 2016). If perceived stress ratings transcended “emotional” reactions and indeed measure a component of how demanding or taxing a situation was, we would expect perceived stress ratings to more strongly predict later affect ratings, rather than the reverse. In a set of supplemental analyses, we explored how strongly moment-level perceived stress ratings predicted subsequent ratings of depressed/anxious affect vs. how strongly ratings of depressed/anxious affect predicted subsequent perceived stress ratings. Although we overall found bidirectional relationships between stress and affect (as would be predicted by the stress-generation hypothesis; Adrian & Hammen, 1993; Davila, Hammen, Burge, Paley, & Daley, 1995), we indeed found that perceived stress ratings had a numerically stronger relationship with subsequent affect ratings than the reverse (see **Supplemental Materials**), supporting the notion that moment-level perceived stress scores measure the stressfulness of events beyond participants' emotional reactions to them.

Software. Mixed-effects models were conducted in R (version 3.6.2; R Core Team, 2019) using the *lme4* (version 1.1-21; Bates, Mächler, Bolker, & Walker, 2015) and *lmerTest* packages (version 3.1-1; Kuznetsova, Brockhoff, & Christensen, 2017). Standardized betas were extracted using the *reghelper* package (version 0.3.5; Hughes, 2020), which standardizes by z-scoring regression variables within the full sample. Simple slopes functions were implemented using the *interactions* package (version 1.1.1; Long, 2019). Mixed-effects models utilized

restricted maximum likelihood estimation (REML). We confirmed that adding an autocorrelated residual structure to both moment-level and month-level models was not necessary using tools from the *nlme* package (version 3.1-143; Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2019). Specifically, autocorrelations at lag 1 were weak for all monthly-level ($< .18$) and moment-level ($< .37$) analyses, and so they were deemed unnecessary for parsimonious model fitting. Standard residual checks for normality were performed and produced satisfactory results.

Data and analytic code availability. Data and analytic code are available at <https://osf.io/nhfsc/>.

Results

Bivariate Associations

Table 1 presents within-person and between-person correlations between dependent variables. At the within-person level, significant positive associations emerged between all measures, suggesting that stress, affect, and internalizing symptoms overall tend to fluctuate in tandem. Importantly, within-person fluctuations in moment-level measures were correlated significantly with within-person fluctuations in their parallel month-level measures (e.g., fluctuations in moment-level depressed affect correlated with fluctuations in month-level depression symptoms). Similar results emerged at the between-person level, with significant relationships emerging between moment-level and monthly-level variables thought to assess overlapping constructs. All between-subjects correlations were significant except (i) the between-person correlation between stress impact scores and anxious affect failed to reach significance ($r = .34, p = .069$) and (ii) even though relations between dependent variables and

negative and positive emotion differentiation were in the negative direction, none reached significance.

Moment-Level Results

Emotion differentiation, perceived stress, and depressed affect. As hypothesized, within-person fluctuations in perceived stress were associated with depressed affect, such that at moments when adolescents experienced greater perceived stress than typical, they also reported higher levels of depressed affect (**Table 2**). However, negative emotion differentiation moderated this association, as evident by a significant interaction between negative emotion differentiation and within-person perceived stress (**Table 2**). Simple-slopes analyses showed that within-person fluctuations in perceived stress were more strongly associated with depressed affect in participants with low negative emotion differentiation scores (i.e., 1 SD below mean, $b = 0.38, p < .001$), compared to those with high differentiation scores (i.e., 1 SD above mean, $b = 0.30, p < .001$, **Figure 1a**). Note that negative emotion differentiation scores for 17% of participants fell < 1 SD below the mean and 17% fell > 1 SD above the sample mean.

Positive emotion differentiation also significantly moderated the relationship between within-person fluctuations in perceived stress and depressed affect (**Table 2**). Simple-slopes analyses showed that within-person fluctuations in perceived stress were more strongly associated with depressed affect in participants with low positive emotion differentiation scores (i.e., 1 SD below mean, $b = 0.43, p < .001$), compared to those with high differentiation scores (i.e., 1 SD above mean, $b = 0.24, p < .001$). Note that positive emotion differentiation scores for 20% of participants fell < 1 SD below the mean and 13% fell > 1 SD above the sample mean.

Emotion differentiation, perceived stress, and anxious affect. Within-person fluctuations in perceived stress were significantly related to anxious affect (**Table 2**). When participants experienced greater perceived stress than was typical for them, they also reported increased anxious affect. However, no significant interaction between perceived stress and negative emotion differentiation emerged, suggesting that negative emotion differentiation did not moderate this relationship (**Table 2**). Similarly, positive emotion differentiation also did not moderate the relationship between within-person fluctuations in perceived stress and anxious affect (**Table 2**).

Monthly-Level Results

Emotion differentiation, stressful life events, and symptoms of depression and anxiety. Contrary to hypotheses, there was not a significant relationship between within-person fluctuations in stress impact scores and symptoms of depression assessed at the month level (**Table 3**). Additionally, the interaction between within-person fluctuations in stress impact scores and negative emotion differentiation was not significant (**Table 3**).

As hypothesized, within-person fluctuations in stress impact scores were associated with anxiety symptoms, such that on months when adolescents experienced greater stressful life events than typical, they also reported more anxiety symptoms (**Table 3**). However, negative emotion differentiation moderated this association (**Table 3**). Simple-slopes analyses showed that within-person fluctuations in stressful life events were positively associated with anxiety symptoms in participants with low negative emotion differentiation scores (i.e., 1 SD below mean, $b = 0.26, p < .001$), but not in those with high differentiation scores (i.e., 1 SD above mean, $b = 0.04, p = .564$, **Figure 1b**). Positive emotion differentiation did not moderate the

association between within-person fluctuations in stress impact scores and either depression or anxiety symptoms (**Table 3**).

Secondary Analyses

Emotion differentiation and dissociation of depressed and anxious affect. A mixed-effect model tested whether moment-level ratings of depressed and anxious affect were less correlated in participants with higher negative emotion differentiation. Indeed, although anxious affect was a strong predictor of depressed affect, $\beta = .38$, $SE = .01$, $t = 27.65$, $p < .001$, negative emotion differentiation significantly moderated this association, $\beta = -.07$, $SE = .01$, $t = -4.96$, $p < .001$. Simple slopes analyses revealed that anxious and depressed affect were more strongly related in participants with low negative emotion differentiation scores (i.e., 1 SD below mean, $b = 0.39$, $p < .001$), compared to those with high differentiation scores (i.e., 1 SD above mean, $b = 0.27$, $p < .001$).

Positive emotion differentiation also moderated the relationship between moment-level ratings of depressed and anxious affect, $\beta = -.05$, $SE = .01$, $t = -3.48$, $p < .001$. Again, ratings of anxious and depressed affect were more strongly related in participants with low positive emotion differentiation scores (i.e., 1 SD below mean, $b = 0.37$, $p < .001$), compared to those with high differentiation scores (i.e., 1 SD above mean, $b = 0.29$, $p < .001$).

Discussion

The current study used an intensive year-long longitudinal design to test whether adolescents who are better able to differentiate their emotions were less likely to develop internalizing problems in the face of stressful experiences. Both momentary experience-sampling

methods and monthly interviews support the notion that high emotion differentiation may help protect against the emergence of stress-related internalizing problems. High negative and positive emotion differentiation attenuated moment-level coupling between perceived stress and depressed affect, and high negative emotion differentiation eliminated the association between stressful life events and anxiety symptoms at the monthly-level. Additionally, the association between depressed and anxious affect was lower in participants with high positive and negative emotion differentiation, showing that a laboratory measure of emotion differentiation generalized to moment-level measures of real-world affect. Overall, these findings advance knowledge in both clinical psychology and affective science regarding: (i) protective factors that may buffer against the negative mental health consequences of stress, and (ii) the pathways through which high emotion differentiation may reduce risk for internalizing problems.

Although stressful life events are potent risk factors for the development of internalizing problems in both adolescents and adults (Grant et al., 2006; Hammen, 2005; LeMoult et al., 2019; McLaughlin & Hatzenbuehler, 2009), many people who experience stressors do not go on to develop psychopathology. Prior work on factors that confer vulnerability or protection to stress-related psychopathology have primarily focused on cognitive, neurobiological, and social factors (Alloy et al., 1999; Cheng, Lau, & Chan, 2014; Cohen, 2004; Dennison et al., 2016; Hooley & Gotlib, 2000; Hooley et al., 2009; Nikolova et al., 2012; Russo, Murrough, Han, Charney, & Nestler, 2012; Swartz, Knodt, Radtke, & Hariri, 2015). However, recent studies have revealed that aspects of *emotion understanding* may shape stress responding and the development of psychopathology (Armstrong, Galligan, & Critchley, 2011; Kranzler et al., 2016; Nook & Somerville, 2020; Southam-Gerow & Kendall, 2002; Weissman et al., 2020). Here, we

extend this body of knowledge by showing that emotion differentiation in particular moderates the link between stress and internalizing problems in adolescence.

We find that high emotion differentiation attenuates associations between experiences of stress and internalizing problems at both the moment and monthly levels. These findings are consistent with another recent study examining emotion differentiation and stress-related psychopathology. Specifically, Starr and colleagues (2017) showed that negative emotion differentiation attenuated the association between daily negative life events and depressive symptoms in both young adults and veterans, and in Starr et al. (2019) they found that emotion differentiation also attenuated associations between both daily hassles and depressed mood at the daily level and between stressful life events and symptoms of depression over a 1.5 year period in adolescents. The current study conceptually replicates these findings and provides several key methodological extensions. First, as compared to 7 days of experience sampling and a single follow-up session 1.5 years later (Starr et al., 2019), we replicate the stress-buffering role of emotion differentiation at the momentary level using much more intensive sampling of stress and affect over a longer period of time (i.e., four months of sampling spread over a year), providing greater confidence in the results given the thousands of within-person observations collected in the current study. Second, we extend the between-person finding that high emotion differentiation reduces the association of stressful life events and depression to the within-person level using an intensive longitudinal design assessing stressful life events using an objective gold-standard interview and measures of clinical symptoms at the monthly level. This consistency across methods and levels of analysis is a strength of the current study, as the perceived stress measure focused on distress in response to uncontrollable events, whereas the interview-based stress measure focused on the objective impact of stressful life events.

Third, we used a task-based measure of emotion differentiation, rather than an experience-sampling method as in prior work, which allows our measure of emotion differentiation to be entirely separated from outcome measures. In fact, the evidence that our lab-based emotion differentiation measure moderated relationships between EMA ratings of anxious and depressed affect provides support for the notion that lab-based and EMA-based measures of emotion differentiation assess the same underlying construct (see also Erbas et al., 2014). Finally, the current study examined how emotion differentiation related to broader internalizing problems, as opposed to focusing on symptoms of depression alone. Whereas many studies have examined emotion differentiation specifically in relation to depression (Demiralp et al., 2012; Erbas et al., 2019, 2014; Kalokerinos et al., 2019; Liu et al., 2020; Mankus, Boden, & Thompson, 2016; Starr et al., 2017, 2019; Willroth, Flett, & Mauss, 2019), only a single study has examined emotion differentiation in generalized anxiety disorder (Decker, Turk, Hess, & Murray, 2008). Interestingly, that study found that mean levels of emotion differentiation did not differ between individuals who did or did not have generalized anxiety disorder. Similarly, we find no main effect of emotion differentiation on generalized anxiety symptoms in our sample. However, the interaction between stress and emotion differentiation predicting anxiety suggests that the association of emotion differentiation with symptoms of anxiety may only emerge at certain levels of stress exposure (see Starr et al., 2019, for a similar result in depression).

In addition to extending the search for factors that may protect against stress-related psychopathology, our findings that emotion differentiation protects against the emergence of internalizing symptoms in the face of stress also enrich theoretical understanding of why emotion differentiation is associated with mental health. Empirical study of emotion differentiation emerged from the constructionist theory of emotion, which posits that emotion concepts—how

an individual internally represents the meaning of emotion words—play a key role in constructing individual emotional experiences (Barrett, 2006, 2017). From this view, high emotion differentiation emerges when individuals have highly granular emotion concepts, allowing people to construct a specific understanding of what they're feeling in terms of: (i) the underlying causes and characteristics that give rise to each emotional experience and (ii) how to implement regulatory strategies that will best ameliorate a given emotional experience in any specific situation (Kashdan et al., 2015; Nook et al., 2020). Consequently, analyzing and responding to one's emotional experiences using such "granular" emotion concepts and words is thought to boost adaptive responding to negative emotions (Kalokerinos et al., 2019; Kashdan et al., 2015), which are commonly induced by stressful experiences (Bolger et al., 1989; Mroczek & Almeida, 2004). This, in turn protects individuals from developing maladaptive regulatory habits (e.g., worrying, avoidance, and rumination) that can contribute to internalizing problems (Aldao et al., 2010; Kircanski, Thompson, Sorenson, Sherdell, & Gotlib, 2015).

By contrast, having a weak conceptualization of one's emotional experience (i.e., understanding any experience of negative affect as "bad") is thought to lead to ineffective and/or unhealthy regulation in response to aversive experiences. For example, people with low emotion differentiation may repetitively use maladaptive strategies like worry and rumination because their challenges in conceptualizing their affective experience prevents them from learning that these regulatory strategies actually *maintain* the negative affect they are trying to regulate or because they struggle to identify the causes of their emotions. By contrast, an individual with high emotion differentiation may notice that these strategies actually *produce* negative affect, leading them to learn to apply more adaptive regulatory responses like cognitive reappraisal, problem solving, or acceptance. These theoretical notions are supported by our finding that both

positive and negative emotion differentiation attenuates relations between stress exposure and internalizing problems when individuals experience elevated levels of stress. Furthermore, in line with this notion, recent studies have shown that high emotion differentiation reduces the extent to which rumination predicts increased depressive symptoms over a 6 month period (Liu et al., 2020), and low emotional clarity (i.e., self-reported levels of how clearly individuals understand what emotion they were feeling) is associated with increased worrying at both within-person and between-person levels (Eckland & Berenbaum, 2020). As such, results from this study joins a growing body of evidence suggesting that a specific understanding of one's emotions facilitates adaptive emotion regulation and mental health.

Emotion regulation has long been thought to play an important role in the development and maintenance of psychopathology (Aldao et al., 2010; Cludius, Mennin, & Ehring, 2020; Gross & Jazaieri, 2014; John & Gross, 2004). In fact, prior work shows that difficulties with emotion regulation mediates the relationship between stressful life events and internalizing symptoms in adolescence (McLaughlin & Hatzenbuehler, 2009; McLaughlin, Hatzenbuehler, & Hilt, 2009). Given that high emotion differentiation is associated with greater use of adaptive emotion regulation strategies and better emotion regulation efficacy (Kalokerinos et al., 2019; Kashdan et al., 2015), the current study's findings suggest that being able to identify one's emotions may disrupt this pathway. This disruption (i.e., more adaptive regulation in response to stress) provides a potential explanation for why emotion differentiation is associated with better mental health. However, future studies are needed to test whether differences in use or effectiveness of emotion regulation strategies mediate the stress buffering influence of high emotion differentiation on internalizing problems. A second possible explanation for the role of emotion differentiation in buffering stress-affect relationships is that it helps people to accurately

identify the causes of their current affect and thereby separate their distress about stressful situations from internalized experiences of depression and anxiety. Greater facility in identifying the environmental determinants of one's affect may accelerate recovery from negative emotions following stressful situations and decrease engagement in maladaptive responses, like rumination, in which one thinks incessantly about the causes and consequences of distress (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Both of these are interesting pathways, and more research is needed to gain a clearer understanding of the psychological mechanisms that explain why individuals with high emotion differentiation report fewer symptomatic disruptions in the face of stress.

Regardless of the mechanism underlying these associations, our findings highlight novel targets for interventions—specifically, boosting emotion differentiation—to prevent or reduce risk for stress-related psychopathology. Such interventions may be particularly important during adolescence, a period of heightened risk for psychopathology broadly and stress-related psychopathology specifically (Grant et al., 2006; Hankin et al., 1998; Kessler et al., 2005; Larson & Ham, 1993; McLaughlin & Hatzenbuehler, 2009; McLaughlin et al., 2009; Michl et al., 2013; Somerville & McLaughlin, 2018), increased exposure to stressors (Larson & Ham, 1993), and low emotion differentiation (Nook, Sasse, et al., 2018). For instance, mindfulness meditation has been shown to both increase emotion differentiation and reduce symptoms of internalizing disorders (Sibinga, Webb, Ghazarian, & Ellen, 2016; Van der Gucht et al., 2019). These and other interventions that focus on refining emotion concept understanding could help guide efforts to reduce the burden of stress-related internalizing psychopathology.

It is important to note that several hypothesized relationships did not emerge. No significant main effects were observed between emotion differentiation and internalizing

problems at moment-level or monthly-levels. Although this contrasts with prior work (Demiralp et al., 2012; Erbas et al., 2014), our study was optimized to detect *within-person* associations between stress and psychopathology, rather than *between-person* associations between trait-level variables and outcomes, as has been the focus in prior work on emotion differentiation and psychopathology. Nonetheless, the relationship between negative and positive differentiation was extremely low ($r = .05$), a somewhat surprising result, when an analysis of 13 studies that report this relationship revealed a weighted mean of $r = .31$ (Liu et al., 2020). It is possible that the use of a laboratory task, rather than experience sampling, explains this low correlation, but future research is needed to explain this very small effect. Additionally, emotion differentiation did not moderate associations between perceived stress and anxious affect at the moment-level or associations between stressful life events and depression symptoms at the monthly-level.

Although these inconsistent results could suggest specificity in these relationships, we would caution against drawing this interpretation. Perceived stress and anxious affect were strongly associated with one another even at the within-person level ($r = .50$, 95% CI = [.48, .52]), suggesting that they were considered by many participants as extremely similar, compared to the significantly weaker coupling between perceived stress and depressed affect ($r = .40$, 95% CI = [.38, .43]). Thus, at the monthly level, there was a significant concurrent association between stress impact scores and anxiety symptoms, but at the monthly-level, stress impact scores did not have a significant main effect on depression symptoms at all.

One potential way to synthesize these results is that the buffering impact of emotion differentiation is only likely to emerge (both statistically and conceptually) when stress-internalizing relationships are at a “moderate” strength. If the relationship is too strong (e.g., the relationship between moment-level perceived stress and anxious affect), individual differences in

emotion differentiation will have only a small impact on decoupling the relationship, and if the relationship is too weak (i.e., the relationship between monthly-level stress impact scores and depression symptoms), there is overall no relationship for emotion differentiation to “buffer.” In the latter case, even though a cross-over interaction can occur when main effects are null or weak (i.e., the relationship is negative for some individuals and positive for others) this seems unlikely in the current case, given that stress is unlikely to have an ameliorative impact on mental health for any individuals. Thus, it seems conceptually unlikely for differentiation to moderate or “buffer against” stress-psychopathology relationships when no main effect exists. Although these are speculative interpretations of our findings, we suggest future research both (i) investigate the possibility of a *sensitive range* in which emotion differentiation can moderate stress-internalizing relationships and (ii) seek to replicate whether results are similar or different across analytic timescales and measures of depression and anxiety.

Nonetheless, future research should address key limitations of the current study. First, although this study was optimized for within-person effects, future research should enhance power to detect and replicate between-person relationships. As such, the current study should be seen as a replication and extension of prior work in a focused longitudinal sample that is constrained with between-person power. Additionally, the number of individuals in a study is related to within-person power (Bolger & Laurenceau, 2013), suggesting that even within-person relationships (or the between-within interaction of emotion differentiation on stress) that did not emerge in this sample may do so in future studies that test this model in larger samples. Second, although the monthly-level measures included gold-standard interviews and symptom measures, moment-level measures were merely single-item ratings. Although single-item ratings provide face-valid measures of underlying constructs and are commonly used in EMA research (Goetz,

Frenzel, Stoeger, & Hall, 2010; Kuppens, Oravecz, & Tuerlinckx, 2010; Shiffman et al., 2002), they are weak measures from both a statistical and conceptual perspective. Future research should include more robust moment-level measures of perceived stress and negative affect. Relatedly, although the use of both perceived and objective measures of stress is a strength of the current study, it is unclear the extent to which perceived stress measures capture exposure to stressful events vs. an individual's emotional distress about events (Harkness & Monroe, 2016). In the current study, this raises the concern that moment-level analyses may merely measure how strongly individuals differentiate "feelings of stress" from "feelings of depression or anxiety." Supplemental analyses suggest that perceived stress scores are numerically more predictive of later depressed/anxious affect than the reverse, supporting the idea that perceived stress measures capture actual stress appraisals and not just a different form of negative affect. Nonetheless this limitation should be kept in mind when interpreting the current study, and future research should seek to replicate this finding using more objective or biological moment-level measures of stress.

Third, recent research has revealed that emotion differentiation is not static across individuals but actually rises and falls as a function of stress (Erbas et al., 2018). This suggests the possibility of an even more interesting process model, whereby stress could not only activate negative emotions that foment internalizing problems, but it could actually *compound* risk for psychopathology by reducing emotion differentiation, thereby further increasing susceptibility to psychopathology. Collecting state-level measures of emotion differentiation longitudinally would greatly enrich the model outlined above by; (i) allowing for cyclical interactions between stress and differentiation to be tested, and (ii) motivating researchers to investigate the deeper cognitive mechanisms that produce emotion differentiation and how/why these are influenced by stress. Fourth, the model outlined above could also benefit from a deeper integration with

research on the biological bases of stress (Burghy et al., 2012; Cohen et al., 2016; Romeo & McEwen, 2006). Future work should investigate how exactly emotion differentiation buffers stress at the neural, endocrine, and psychophysiological levels.

In all, the current study knits together clinical and affective science by highlighting emotion differentiation as a key factor that moderates the association of stress with internalizing problems. In an intensive longitudinal design, we found that high emotion differentiation buffered adolescents from developing internalizing problems in response to within-person elevations in both perceived stress and exposure to environmental stressors. As such, emotion differentiation may play a key role in conferring resilience against developing stress-related psychopathology during adolescence. Further research that develops and refines a clear model of this process at psychological and biological levels could advance efforts to prevent the emergence of internalizing psychopathology, particularly in the context of stress. The current findings suggest that interventions that improve emotion differentiation may be an important clinical tool for preventing the development of internalizing problems during adolescence.

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Author Contributions

KAM designed the study and oversaw data collection. ECN and KAM jointly designed, executed, and interpreted analyses with assistance from JCF, AMR, and PM. ECN drafted the manuscript, and KAM, JCF, AMR, and PM provided critical revisions. All authors approved the final version of the paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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TABLES

Table 1. Within-person and between-person bivariate correlations between primary measures.

	1.	2.	3.	4.	5.	6.	7.
1. Perceived stress	-	.08***	.40***	.50***	.11***	.12***	-
2. Stress impact scores	.44*	-	.08***	.03*	.12*	.17**	-
3. Depressed affect	.68***	.51**	-	.39***	.26***	.16***	-
4. Anxious affect	.75***	.34†	.57**	-	.09***	.06***	-
5. Depression symptoms	.64***	.54**	.77***	.67***	-	.60***	-
6. Anxiety symptoms	.64***	.44*	.59**	.66***	.85***	-	-
7. Negative emotion differentiation	-.13	-.11	-.33†	-.06	-.27	-.23	-
8. Positive emotion differentiation	-.26	-.26	-.24	-.14	-.26	-.36†	.05

Notes: Within-person bivariate correlations are shown above the diagonal and between-person bivariate correlations are shown below the diagonal. Decomposition of correlations into within-person and between-person components computed using the *statsBy* function in the *psych* package (Revelle, 2016). Within-person correlations with emotion differentiation could not be computed because it was measured only at the person level. *** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .10$.

Table 2. Results of moment-level mixed-effects models.

	β	SE	t	p
<i>Negative emotion differentiation × perceived stress → Depressed affect</i>				
Perceived stress (within-person)	.30	.01	28.55	< .001***
Perceived stress (between-person)	.35	.09	3.76	.001**
Negative emotion differentiation	-.19	.10	-1.88	.071
Negative emotion differentiation × perceived stress (within-person)	-.03	.01	-3.40	.001**
Day	.01	.01	1.12	.264
In school	.05	.01	4.58	< .001***
Average negative emotion rating in differentiation task	-.06	.10	-0.59	.562
<i>Negative emotion differentiation × perceived stress → Anxious affect</i>				
Perceived stress (within-person)	.36	.01	38.16	< .001***
Perceived stress (between-person)	.49	.10	5.03	< .001***
Negative emotion differentiation	.04	.10	0.40	.696
Negative emotion differentiation × perceived stress (within-person)	-.01	.01	-0.58	.563
Day	-.01	.01	-0.60	.550
In school	.04	.01	3.87	< .001***
Average negative emotion rating in differentiation task	.15	.11	1.42	.169
<i>Positive emotion differentiation × perceived stress → Depressed affect</i>				
Perceived stress (within-person)	.29	.01	27.82	< .001***
Perceived stress (between-person)	.35	.10	3.44	.002**
Positive emotion differentiation	-.03	.10	-0.35	.732
Positive emotion differentiation × perceived stress (within-person)	-.08	.01	-7.95	< .001***
Day	.02	.01	1.54	.123
In school	.05	.01	4.66	< .001***
Average positive emotion rating in differentiation task	-.13	.10	-1.33	.194
<i>Positive emotion differentiation × perceived stress → Anxious affect</i>				
Perceived stress (within-person)	.36	.01	37.86	< .001***
Perceived stress (between-person)	.50	.11	4.77	< .001***
Positive emotion differentiation	.07	.10	0.67	.509
Positive emotion differentiation × perceived stress (within-person)	-.01	.01	-1.42	.157
Day	-.01	.01	-0.53	.599
In school	.04	.01	3.89	< .001***
Average positive emotion rating in differentiation task	.02	.10	0.24	.811

Notes: *** $p < .001$, ** $p < .01$, * $p < .05$.

Table 3. Results of month-level mixed-effects models.

	β	SE	t	p
<i>Negative emotion differentiation × stressful life events → Depression symptoms</i>				
Stressful life events (within-person)	.05	.03	1.68	.094 [†]
Stressful life events (between-person)	.35	.13	2.73	.011*
Negative emotion differentiation	-.25	.13	-1.90	.069
Negative emotion differentiation × stressful life events (within-person)	-.01	.03	-0.49	.622
Month	-.12	.03	-3.65	< .001***
In school	.10	.03	3.10	.002**
Average negative emotion rating in differentiation task	-.25	.13	-1.58	.126
<i>Negative emotion differentiation × stressful life events → Anxiety symptoms</i>				
Stressful life events (within-person)	.09	.03	2.79	.006**
Stressful life events (between-person)	.31	.14	2.15	.041*
Negative emotion differentiation	-.17	.15	-1.10	.283
Negative emotion differentiation × stressful life events (within-person)	-.06	.03	-2.33	.021*
Month	-.03	.03	-1.03	.302
In school	.12	.03	3.82	< .001***
Average negative emotion rating in differentiation task	-.06	.16	-0.38	.705
<i>Positive emotion differentiation × stressful life events → Depression symptoms</i>				
Stressful life events (within-person)	.05	.03	1.61	.109
Stressful life events (between-person)	.29	.13	2.13	.043*
Positive emotion differentiation	-.16	.13	-1.24	.227
Positive emotion differentiation × stressful life events (within-person)	-.02	.03	-0.77	.442
Month	-.12	.03	-3.54	< .001***
In school	.10	.03	3.08	.002**
Average positive emotion rating in differentiation task	-.28	.13	-2.13	.043*
<i>Positive emotion differentiation × stressful life events → Anxiety symptoms</i>				
Stressful life events (within-person)	.10	.03	2.91	.004**
Stressful life events (between-person)	.21	.15	1.45	.159
Positive emotion differentiation	-.24	.14	-1.76	.090
Positive emotion differentiation × stressful life events (within-person)	-.01	.03	-0.39	.693
Month	-.04	.03	-1.07	.287
In school	.12	.03	3.69	< .001***
Average positive emotion rating in differentiation task	-.19	.14	-1.31	.201

Notes: *** $p < .001$, ** $p < .01$, * $p < .05$, [†] Significant when covariates are excluded.

FIGURES

Figure 1. Simple-slopes plots showing that negative emotion differentiation moderates the relationship between within-person fluctuations in stress and internalizing problems at both moment- and monthly-levels. Solid lines show model-expected symptom severity as a function

of stress moderated by emotion differentiation. a) Participants with weak emotion differentiation (1 SD below mean, black line) showed increased depressed affect in moments with higher-than-average stressful experiences, but this relationship was attenuated for participants with strong positive and negative emotion differentiation (1 SD above mean, grey line). b) Parallel results at the monthly-level show that participants with weak emotion differentiation reported increased anxiety symptoms on months with higher-than-average stressful experiences, but this relationship was eliminated for participants with strong negative emotion differentiation. Grey shaded regions represent standard error of predicted means.

Supplemental Materials

To accompany

High emotion differentiation buffers against internalizing symptoms following exposure to stressful life events in adolescence: An intensive longitudinal study

Nook, Flourney, Rodman, Mair, & McLaughlin

Contents

- I. Study timing and structure
- II. Compensation structure
- III. Lagged analyses of moment-level perceived stress and affect
- IV. Testing random slopes

I. Study Timing and Structure

Figure S1. Overview of research design. Participants completed a baseline session in which they completed life stress interviews, surveys assessing depression and anxiety symptoms, and the emotion differentiation task. They then returned to the lab each month for a total of 12 months to repeat life stress interviews and surveys assessing depression and anxiety symptoms. For four windows of time over the course of the year, participants completed 3 weeks of experience sampling measures in which they reported their momentary experiences of perceived stress, depressed affect, and anxious affect three times each day.

II. Compensation Structure

Participants' compensation at both the moment-level and monthly-level was structured to incentivize retention and survey completion. At the moment-level, participants were paid more money if they completed more surveys within each 3-week measurement window. Specifically, within each 3-week measurement window, they earned (i) \$50 for completing 3 out of 3 surveys per day at least 6 days per week, (ii) \$25 for completing at least 2 out of 3 surveys per day at least 5 days per week, or (iii) \$10 for completing at least 1 out of 3 surveys per day, 4 days per week. Similarly, participants were paid more money for each monthly-level session that they attended (**Table S1**).

Table S1. Monthly-level compensation structure

	Earnings
Month 1 Session	\$50
Month 2 Session	\$30
Month 3 Session	\$40
Month 4 Session	\$50
Month 5 Session	\$60
Month 6 Session	\$70
Month 7 Session	\$80
Month 8 Session	\$90
Month 9 Session	\$100
Month 10 Session	\$110
Month 11 Session	\$125
Month 12 Session	\$100
Total	\$905

III. Lagged Analyses of Moment-Level Perceived Stress and Affect

To explore the extent to which moment-level perceived stress ratings actually measured exposure to stressful events (rather than merely an emotional reaction to a situation that didn't necessarily reflect how impactful or taxing it was), we explored how strongly moment-level perceived stress ratings predicted subsequent ratings of depressed/anxious affect vs. how strongly ratings of depressed/anxious affect predicted subsequent perceived stress ratings. If perceived stress ratings did indeed measure something about the stressfulness of a situation, we would expect perceived stress ratings to more strongly predict future affect than vice versa.

We first created lagged variables of moment-level ratings of perceived stress, depressed affect, and anxious affect. Variables were lagged only within each day (i.e., ratings from the previous night were not used to predict ratings on the following morning). As such, these analyses included at most 2 ratings for each day, decreasing the sample size, as naturally occurs in lagged analyses. We then conducted a series of mixed-effect models testing how perceived stress ratings at the previous timepoint predicted current depressed or anxious affect and vice versa. Critically, we included lagged ratings of the outcome variable in all analyses to isolate the impact of the lagged predictor variable on current experiences of the outcome variable. For example, in the regression testing how strongly lagged perceived stress ratings predicted current anxious affect, we controlled for lagged anxious affect ratings. As such, the current regressions test whether the lagged predictor was related to current ratings of the outcome variable over and above participants' previous experience of that variable.

Results were numerically in line with the notion that perceived stress had a stronger impact on subsequent affect than the reverse: Relationships between previous ratings of perceived stress in predicting current ratings of anxious affect, $\beta = .18$, $SE = .02$, $t = 9.10$, $p <$

.001 and depressed affect, $\beta = .09$, $SE = .02$, $t = 4.50$, $p < .001$, were stronger than the relationships between participants' previous ratings of anxious affect, $\beta = .07$, $SE = .02$, $t = 3.46$, $p < .001$, and depressed affect, $\beta = .07$, $SE = .02$, $t = 3.76$, $p < .001$, in predicting current perceived stress. These effects emerged even after controlling for lagged outcome variables, which were strongly predictive of current outcome variables in each regression, $\beta s > .31$, $ps < .001$.

These results align with the argument that our perceived stress measure was indeed measuring exposure to stress (rather than merely representing negative emotion). However, it is worth noting that prior research has shown that the relationship between stress and depression/anxiety is certainly not unidirectional: Evidence for *stress generation* is strong, indicating that depression and anxiety can actually increase later experiences of stress (Adrian, Cheri, & Hammen, 1993; Davila, Hammen, Burge, Paley, & Daley, 1995). As such, we would expect the relationship between depressed/anxious mood and later stress to be sizeable. Thus taken together, lagged relations between perceived stress and affect suggest that perceived stress and affect have bidirectional relationships, but perceived stress had a numerically stronger impact on later mood than the reverse. This provides some support of the notion that moment-level perceived stress scores measure the stressfulness of events beyond participants' emotional reactions to them.

IV. Testing Random Slopes

Our *a priori* modeling approach did not include random slopes, to favor simplicity and parsimony over complexity (Bates, Kliegl, Vasishth, & Baayen, 2015; Matuschek, Kliegl, Vasishth, Baayen, & Bates, 2017). Nonetheless, we conducted supplemental analyses to examine whether adding random slopes of within-person fluctuations in stressful experiences impacted key results. Theoretically, allowing for random slopes of within-person fluctuations in stress allows the mixed-effect model to estimate individual differences in the slope of the relationship between stress and internalizing problems. We first tested whether adding random slopes to the three analyses that returned significant results in initial analyses improved model fit using a likelihood ratio test. If so, we then tested how adding random slopes impacted the strength and significance of the key result (i.e., the interaction between emotion differentiation and within-person fluctuations in stress in predicting internalizing problems). Given that *reghelper's* *beta* function is inconsistent in how it standardizes variables that are or are not included in random slopes, we present unstandardized betas for these comparisons.

Moment-level perceived stress, depressed affect, and negative emotion

differentiation. The mixed-effect model that included random slopes for within-person fluctuations in perceived stress improved model fit when testing whether negative emotion differentiation moderated the relationship between moment-level perceived stress and depressed affect ($AIC_{\text{initial}} = 14736$, $AIC_{\text{with random slopes}} = 14308$, likelihood ratio test $p < .001$). Adding random slopes did not reduce the strength of the interaction between negative emotion differentiation and within-person fluctuations in perceived stress ($b_{\text{initial}} = -.13$, $b_{\text{with random slopes}} = -.13$), but it did alter the significance of this result ($SE = 0.16$, $t = -0.81$, $p = .424$).

Moment-level perceived stress, depressed affect, and positive emotion

differentiation. Adding random slopes for within-person fluctuations in perceived stress improved model fit when testing whether positive emotion differentiation moderated the relationship between moment-level perceived stress and depressed affect ($AIC_{\text{initial}} = 14686$, $AIC_{\text{with random slopes}} = 14306$, likelihood ratio test $p < .001$). Adding random slopes again did not reduce the strength of the interaction of the interaction between positive emotion differentiation and within-person fluctuations in perceived stress ($b_{\text{initial}} = -.22$, $b_{\text{with random slopes}} = -.23$), and this result remained statistically significant even when random slopes were included ($SE = 0.11$, $t = -2.15$, $p = .040$).

Monthly-level stress impact scores, anxiety symptoms, and negative emotion

differentiation. Adding random slopes for within-person fluctuations in stress impact scores did not improve model fit when testing whether negative emotion differentiation moderated the relationship between monthly-level stress impact scores and anxiety symptoms ($AIC_{\text{initial}} = 1704.5$, $AIC_{\text{with random slopes}} = 1707.8$, likelihood ratio test $p = .706$). The model that included random slopes also failed to converge. As such, the more parsimonious model without random slopes reported in the main text was interpreted.