The Mindful Adolescent: Developmental Changes in Nonreactivity to Inner Experiences during
the Transition to High School, and Relations to Stress and Positive Affect

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Abstract

Little is known about the naturalistic development of mindfulness in adolescence, and whether changes in this mental faculty are associated with perceived stress and emotional well-being. The current longitudinal study examined the development of one dimension of mindfulness, nonreactivity to inner experience, in a racially and socioeconomically diverse sample ($N = 1,657$) during the transition from middle school to high school. Students participated in up to four assessment waves, from fall of 8th grade through spring of 9th grade, during which they completed self-report measures assessing nonreactivity, perceived stress, and positive affect. Latent growth curve models indicated that levels of nonreactivity increased linearly during the two-year study period. Developmental change in nonreactivity varied minimally by gender, socioeconomic status, and race/ethnicity. Parallel process latent growth curve models showed that changes in nonreactivity were associated with concomitant reductions in perceived stress and increases in positive affect. Random intercept cross-lagged panel models showed that within-person nonreactivity prospectively predicted changes in perceived stress and positive affect. This is the first study to track naturalistic developmental change in mindfulness during adolescence. Results suggest that the nonreactivity dimension of mindfulness may boost resilience during the transition from middle school to high school.

Keywords: adolescence; mindfulness; nonreactivity; stress; well-being

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Mindfulness training is a large and growing industry (Wieczner, March 12, 2016).

Beyond hospitals and businesses, mindfulness training has made its way into the public school system, reaching thousands of youth each year. In a special section in *Developmental Psychology*, Roeser and Eccles (2015) made an appeal to understand mindfulness from an explicitly developmental perspective. Now, three years later, the field has yet to make progress toward understanding how mindfulness develops naturally across the life span or how such changes may influence positive development. In fact, we are unaware of a single published study that has ever tracked the naturalistic development of mindfulness. We therefore know nothing about how the expression of mindfulness may change across adolescence and whether it differs across demographic subgroups. Moreover, foundational assumptions about the nature of mindfulness—that changes prospectively predict reductions in stress and improvements in well-being—have never been tested empirically.

Motivated by these core theoretical concerns, the current study applied a developmental approach to track normative changes in mindfulness during adolescence and examine the concomitant and prospective effects of such change for stress reduction and positive affect. The study focused on one core dimension of mindfulness, *nonreactivity to difficult inner experiences*, which has recently been hypothesized to be a key ingredient for stress relief and flourishing (Lindsay & Creswell, 2015, 2017). All analyses are based on a novel longitudinal dataset involving a large socioeconomically and racially diverse sample of adolescents during the transition from middle to high school. Because nonreactivity and the key outcomes of stress and positive affect were assessed on multiple occasions, this dataset provided a unique opportunity to

track developmental change across time and apply a rigorous test of core theoretical assumptions about the relationship between mindfulness and well-being.

What is Mindfulness?

Mindfulness is a term with roots in early Buddhism (Analayo, 2003; Bodhi, 2011). Classically, mindfulness is understood simply as a mental faculty for becoming consciously aware of ongoing subjective experience (Bodhi, 2011; Van Dam et al., 2018). Though specific definitions vary, Western psychological science commonly operationalizes mindfulness as involving two interrelated dimensions: self-regulation of attention and a balanced mental attitude (Bishop et al., 2004). The attention dimension refers to the conscious monitoring of subjective experience, without forgetfulness or distraction, and the balanced attitude dimension refers to the accepting and nonreactive orientation taken toward the experiences that arise in conscious awareness. Mindfulness is viewed both as a set of mental faculties whose expression varies naturally across individuals (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006; Brown & Ryan, 2003), and as faculties that can be cultivated through various meditation practices.

In the current study, we examined the nonreactive orientation toward subjective experience because nonreactivity (and the balanced mental attitude dimension, more generally) has been proposed as the active ingredient underlying the stress reduction and mental health-enhancing qualities of mindfulness (Lindsay & Creswell, 2017). Though the conscious monitoring of unpleasant subjective experience serves as the foundation for developing perceptual clarity and discernment (Vago & Silbersweig, 2012), the accepting and equanimous orientation taken toward experience serves to counter affective distortions and maladaptive reactions that perpetuate stress (Analayo, 2003; Creswell & Lindsay, 2014).

What is mindful nonreactivity, exactly? Nonreactivity is about becoming consciously aware of distressing thoughts, emotions, and mental images without reacting to them (Baer et al., 2006; Chadwick et al., 2008; Lindsay & Creswell, 2017). It involves being able to “take a step back from” unpleasant mental experiences and to view them from a more dispassionate, objective perspective (Bernstein et al., 2015). It is not about avoiding or rejecting unpleasant experiences, nor does it inherently involve attempts to alter what arises in conscious awareness. Nonreactivity may enable more thoughtful, adaptive responses to difficult experiences, since the individual is able to think more clearly and dispassionately about their experience. But it is fundamentally about taking note of what is happening in subjective experience while maintaining mental composure (Lindsay & Creswell, 2017). The conceptual opposite of nonreactivity would entail the automatic and unconscious filtering of thoughts, emotions, and mental images through habitual judgments and evaluations, leading to impulsive, and potentially maladaptive, behavior.

Developmental Changes in Nonreactivity across Adolescence

Does the capacity to remain nonreactive in the face of difficult experiences change across adolescence? If so, does it increase or decrease with age? Adolescence is a period of life characterized by gradual reorganization and maturation of the cognitive control neural system (Casey, Getz, & Galvan, 2008; Steinberg, 2008). Development of the cognitive control system tracks observed improvements in numerous cognitive faculties that appear conceptually related to the expression of nonreactivity in particular and of mindfulness more generally. For example, improvements in abstract thinking and logical reasoning enable adolescents to transcend immediate situational details and solve problems from a less egocentric perspective (Dumontheil, 2014). Likewise, improvements in metacognition facilitate more effective introspection of one's own mental states (Schneider, 2008; Weil et al., 2013). And advances in executive function

enable more effective inhibition of maladaptive impulses and pursuit of long-term goals (Shulman et al., 2016; Steinberg et al., 2008; Steinberg et al., 2009). Indeed, dimensions of mindfulness have been shown to be positively correlated with executive functioning in adolescence (Oberle, Schonert-Reichl, Lawlor, & Thomson, 2012; Riggs, Black, & Ritt-Olson, 2015; Shin, Black, Shonkoff, Riggs, & Pentz, 2016).

Cognitive control development also tracks changes in how emotions are regulated. For example, activation in cognitive control networks during reappraisal of negative stimuli increases linearly from childhood to adulthood (McRae et al., 2012). A related study found that the effectiveness of reappraisal for reducing negative emotions increased from childhood to adolescence (Silvers et al., 2012), presumably tracking development of cognitive control processes. More recently, a naturalistic study found that the effectiveness of self-distancing for down-regulating negative affect in relation to an interpersonal stressor linearly improved across adolescence (White, Kross, & Duckworth, 2015). The empirical links between the nonreactivity dimension and different emotion regulation strategies, including rumination, have also been demonstrated in several prior correlational studies (Ciesla, Reilly, Dickson, Emanuel, & Updegraff, 2012; Galla, 2016). To the degree that taking a nonreactive stance toward difficult experiences is supported at least in part by development of the cognitive control system (Tang, Holzel, & Posner, 2015), then it might be surprising if nonreactivity did not also change across adolescence.

But this may not be the full story. Development of subcortical regions implicated in reward processing also occurs during adolescence (Casey, Tottenham, Liston, & Durston, 2005; Steinberg, 2008). These regions mature rapidly around the time of puberty (Blakemore, Burnett, & Dahl, 2010), far earlier than the cognitive control system which does not fully mature until

adulthood (Steinberg, 2008). Compared to children and adults then, adolescents are highly attentive to and deeply motivated to pursue experiences that carry the potential for reward (Galván, 2013). Among the most salient rewards sought by adolescents is social status and peer approval (Yeager, Dahl, & Dweck, 2018). This sensitivity to and desire for peer approval—coupled with a comparatively less mature cognitive control system—can lead to more intense affective reactions in interpersonal situations where this desire is thwarted. Studies show that, compared to children, adolescents exhibit greater stress reactivity to social threats, such as social evaluation (Gunnar, Wewerka, Frenn, Long, & Griggs, 2009). Other research shows that simply informing adolescents that their peers are watching them elicits self-conscious emotions and autonomic arousal (Somerville et al., 2013). Thus, while available data suggest that a nonreactive mindful state mirrors activation of the cognitive control system (Tang et al., 2015), its naturalistic expression during adolescence may be tempered by normative increases in sensitivity to motivationally-salient experiences. Consequently, nonreactivity, and mindfulness more generally, may not necessarily increase or follow a linear trajectory.

Another unanswered question is whether the pattern of change in nonreactivity varies across demographic subgroups. Though we expect increases in nonreactivity across time, we also assume there will be heterogeneity in these trajectories. Prior work suggests differences in the ways emotions are experienced, socialized, expressed, and regulated across gender (Chaplin, Cole, & Zahn-Waxler, 2005; Silk, Steinberg, & Sheffield Morris, 2003), culture (Markus & Kitayama, 1991; Qu & Telzer, 2017), and socioeconomic strata (Blair & Raver, 2012). For example, girls show a tendency to seek social support, use problem solving, and ruminate to cope with stress, whereas boys show a tendency to avoid dealing with the stressor (Eschenbeck, Kohlmann, & Lohaus, 2007; Silk et al., 2003). It is possible that these factors influence

affordances for the expression of nonreactivity, shaping its development across time. Thus, we examine, in an exploratory manner, gender, race/ethnicity, and socioeconomic status as potential moderators of nonreactivity trajectories.

Associations with Stress and Well-Being

How does nonreactivity reduce stress and improve well-being? Nonreactivity is viewed as a dynamic and complex emotion regulation skill (Lindsay & Creswell, 2017). By consciously “opening up to” and observing a difficult experience in a dispassionate, receptive manner, individuals may be able to bring additional cognitive resources to bear on it (Garland, Farb, Philippe, & Fredrickson, 2015). These additional cognitive resources—that have not been co-opted by emotional distortions—may help an individual get a better grasp of the problem, leading them to perceive that they have the necessary resources to successfully manage it. Difficult experiences may therefore not seem as overwhelming or threatening. By contrast, when individuals react automatically to difficult experiences, the door is closed to gaining a balanced perspective of the problem and their ability to manage it. This in turn might exaggerate the perceived threat posed by the experience.

Numerous studies show that individual differences in mindfulness, measured using self-report questionnaires (Baer et al., 2006; Brown, West, Loverich, & Biegel, 2011; Greco, Baer, & Smith, 2011), are correlated with social-emotional well-being and stress coping. In particular, nonreactivity (and associated “attitudinal” constructs) has been shown to correlate negatively with internalizing and externalizing symptoms (Greco et al., 2011), rumination (Ciesla et al., 2012), perceived stress (Bluth & Blanton, 2014), and depression (Royuela-Colomer & Calvete, 2016), and correlate positively with quality of life (Bluth & Blanton, 2014; Greco et al., 2011)

and positive affect (Ciarrochi, Kashdan, Leeson, Heaven, & Jordan, 2011). Yet these results are based almost entirely on cross-sectional studies.

Two longitudinal studies have found that mindfulness predicted reductions in stress and increases in well-being (Ciarrochi et al., 2011; Royuela-Colomer & Calvete, 2016). However, because mindfulness was only assessed at a single time point, its association with changes in stress and well-being remained vulnerable to other between-person confounds that may be correlated with both mindfulness and changes in outcomes. Several intervention studies have shown that changes in mindfulness following mindfulness-based training programs were correlated with changes in stress and well-being (Bluth & Eisenlohr-Moul, 2017; Brown et al., 2011; Galla, 2016). These studies suggest that the development of mindfulness tracks concomitant reductions in stress and improvements in well-being, but they did not assess prospective effects of mindfulness. Consequently, a critical hypothesis that undergirds much of the mindfulness literature and interventions in particular—that changes in mindfulness prospectively predict resilience—has not been tested empirically. To assess directionality and help rule against the possibility of third-variable, between-person confounds, additional research is required to examine the prospective effect of within-person mindfulness on within-person changes in outcomes.

Nonreactivity during the Transition to High School

We examined developmental changes in nonreactivity in the context of students making the transition from middle school to high school. Though individual students' experiences vary, the transition to high school presents common academic, social, and procedural challenges. Academically, high school students often take more rigorous coursework with greater workload, are held to higher standards by teachers, and are expected to learn and study independently.

Students must also think about how their academic performance will have consequences for life beyond high school, including admission into college. Socially, students making the transition to high school must form and maintain relationships with many new teachers, make new friends and fit in, and they may also have to contend with bullying. Procedurally, students learn to navigate a new building and set of rules for behavior, and adjust to new and complex class schedules. It may not be surprising then that engagement and performance in school typically decline during the high school transition (Benner, 2011). The ninth grade is a pivotal year, though, since students who fail to make a successful to high school are at greater risk of dropping out. For example, one analysis of students in the Chicago Public School system found that only 22% of ninth graders who failed more than one core class and who did not earn a full year of course credits graduated in four years compared to 81% of students designated as “on track” during ninth grade (Allensworth & Easton, 2005).

Thus, our analysis of nonreactivity during the high school transition is important for both theoretical and practical reasons. Theoretically, nonreactivity should be more strongly correlated with stress and well-being in demanding contexts (Creswell & Lindsay, 2014). Practically, if nonreactivity is found to be associated with lower stress and greater well-being during this important life transition, it could suggest a window of opportunity for cultivating this capacity through interventions.

The Current Study

The current study is the first to examine how a core dimension of mindfulness, nonreactivity to difficult inner experiences, develops during adolescence. It is also the first to examine how naturalistic changes in nonreactivity may relate to, and prospectively influence, stress and well-being. We used data from a racially and socioeconomically diverse longitudinal

study of adolescents transitioning from middle to high school. In the first part of this study, we examined developmental change in nonreactivity using latent growth curve models. We tested whether nonreactivity matured across time, and further, whether it did so in a linear or non-linear fashion. We generally expected to observe increases in nonreactivity from 8th through 9th grade, but anticipated variability in trajectories across individuals. To potentially account for this variability, we also explored whether the overall nonreactivity trajectory varied as a function of demographic characteristics (i.e., gender, socioeconomic status, race/ethnicity), but had no *a priori* hypotheses about whether and which characteristics might matter. Following the same procedures, we also examined developmental change in our key outcomes, perceived stress and positive affect.

After characterizing the univariate growth trajectories for each variable, in the second part of the study, we modeled multivariate change in nonreactivity and both perceived stress and positive affect through the use of parallel process latent growth curve models. Parallel process latent growth curve models chart trajectories of change in two or more variables simultaneously, making it possible to test whether initial levels (intercepts) and change (growth terms) in one variable are associated with initial levels and change in another variable. Based on theory and existing literature on nonreactivity described previously, we generally expected initial levels of nonreactivity to be negatively correlated with initial levels of perceived stress and positively associated with initial levels of positive affect. We also anticipated that adolescents who showed greater increases in nonreactivity would also show steeper reductions in perceived stress and greater increases in positive affect (Galla, 2016).

Finally, we examined reciprocal, prospective relationships between within-person nonreactivity and within-person perceived stress and positive affect using random intercept

cross-lagged panel models (Hamaker, Kuiper, & Grasman, 2015). These models focus on the within-person information from a variable (Hamaker et al., 2015). By partialing out stable, between-person relationships, random intercept cross-lagged panel models allowed us to test the critical hypothesis that an adolescent's own nonreactivity score would prospectively predict changes in that same adolescent's perceived stress and positive affect, controlling for prior levels both constructs.

Method

Participants

The analytic sample included $N = 1,657$ 8th and 9th grade students attending schools in Pennsylvania, Idaho, California, and Texas. The analytic sample was drawn from a total of 1,777 students who participated in a larger observational longitudinal study on character development during adolescence.¹ Approximately 62% ($n = 1,023$) of students in the analysis were sampled from one of two comprehensive public middle schools, and the remaining 38% ($n = 634$) were sampled from one of six charter or independent middle schools. Following 8th grade, students entered into one of seven high schools: students at the two public middle schools were funneled into a single comprehensive public high school, and students at the six charter or independent schools remained at each for high school. To maximize available data (and avoid arbitrary, post hoc exclusions), students were included in the analysis as long as they provided data for at least one key measure (i.e., nonreactivity, perceived stress, positive affect) during at least one of the four assessment waves (see Procedure for more details).

¹ The research questions, reported analyses, and conclusions reached in this article do not overlap with publications using other portions of this data set [citation blinded for review].

According to demographic information obtained from school records, 47.6% of students in the analytic sample were African American, 23.4% were Caucasian, 14.4% were Latino, 10.4% were Asian, and 1.9% were of mixed or other races and ethnicities; 48% were female. Over half (63.7%) were eligible for free or reduced-price lunch. Demographic information was missing for between 2.0% and 3.7% of participants.

Though this study relied on a convenience sample of students, our analytic sample was generally representative of the school populations from which it was drawn. See Supporting Information for more information.

Procedure

This study was approved by the [institution name blinded for review] Institutional Review Board (820576, “Character Development in Adolescence”). Data collection began during the fall of 8th grade (October 2014) and continued through the spring of 9th grade (June 2016). In fall of 8th grade, an information letter from each middle school’s principal was sent home to parents that also contained an opt-out permission form. Students whose parents did not opt them out of study participation also completed assent forms prior to data collection. There was no stopping rule for data collection; the sample size reflects the maximum number of students we were able to recruit within the allotted time provided by the schools. Students who were not available during the first assessment were still allowed to participate (and given the opportunity to provide assent) during each of the three remaining assessment waves. This means that some students did not provide study data until later in middle school or until they entered high school.

Students participated in up to four assessment waves, each spaced approximately six months apart, during which they completed self-report measures assessing nonreactivity,

perceived stress, and positive affect (in addition to other measures not analyzed here). The four assessment waves are henceforth referred to as T1, T2, T3, and T4, respectively. Two assessments (T1, T2) were administered during 8th grade, and two assessments (T3, T4) were administered during 9th grade. All measures were completed on school computers during regular school hours. Demographic information (gender, eligibility for free or reduced-price lunch, race/ethnicity) was collected from school records.

Survey completion rates were as follows: 878 (53%) students provided data on nonreactivity, perceived stress, and/or positive affect during all four assessment waves, 187 (11%) provided data during three waves, 418 (25%) provided data during two waves, and 174 (11%) provided data during one wave. Survey completion rates did not differ significantly by gender (girls vs. boys), $\chi^2(3) = 4.44, p = .217$. They did differ significantly by students' race/ethnicity, $\chi^2(12) = 103.67, p < .001$, eligibility for free or reduced-price lunch, $\chi^2(3) = 17.55, p = .001$, and middle school attended, $\chi^2(21) = 110.72, p < .001$. Due to the significant associations between demographic characteristics and survey completion rates (and key variables themselves; see Supporting Information), demographic characteristics were included in all models as either missing data correlates (i.e., auxiliary variable) or as covariates (see Analytic Plan for more details).

Measures²

Nonreactivity. Students completed three items taken from the Nonreactivity to Inner Experiences subscale of the Five Facet Mindfulness Questionnaire (Baer et al., 2006; Baer et al., 2008). The Five Facet Mindfulness Questionnaire is among the most widely used scales for measuring individual differences in mindfulness with adults, and at least four published studies

² Items for self-report scales used in this study are reported in the Supporting Information.

have documented evidence of its reliability and validity in adolescent samples (Calvete, Gámez-Guadix, & Cortazar, 2017; Ciesla et al., 2012; Galla, 2016; Royuela-Colomer & Calvete, 2016).

The nonreactivity scale measures the tendency to be aware of difficult thoughts and feelings without getting overtaken by them. Because the nonreactivity scale was embedded in a larger battery of survey instruments, space and time constraints limited us to a maximum of three items.³ We chose items with high factor loadings in the initial validation study (Baer et al., 2006) that also appeared to capture the full content of the subscale. Similar short-form (3-item and 4-item) versions of the nonreactivity scale in adults have demonstrated evidence of adequate internal reliability, convergent validity with the full scale, and predictive validity for theoretically-related constructs (Baer, Carmody, & Hunsinger, 2012; Gu et al., 2016; Tran, Glück, & Nader, 2013). Our own research has also found evidence for the reliability and validity of a 4-item nonreactivity scale in an adolescent sample that incorporates two of the three items used in this study (manuscript under review/blinded for review). The current items (“When I have upsetting thoughts or images, I ‘step back’ and am aware of the thought or image without getting taken over by it;” “I can be aware of my feelings and emotions without having to react to them;” and “I watch my feelings without getting lost in them”) were lightly edited from the original scale to increase comprehension and were endorsed using a 6-point scale, from 1 = *strongly disagree* to 6 = *strongly agree*. The three items were averaged to calculate a scale score at each assessment wave. The observed alphas were .79 (T1), .78 (T2), .80 (T3), and .82 (T4).

Perceived stress. Students reported on the degree to which they have recently worried and felt their life was stressful, unpredictable, and uncontrollable using items adapted from the

³ Beyond the 3-item nonreactivity scale, no other mindfulness measures were administered at any point during the two-year study.

widely used Perceived Stress Scale (e.g., During the past month "...how often have you felt stressed?" "...how often have you felt confident in your ability to handle your personal problems?" "...how often have you felt you were unable to control the important things in your life?;" Cohen, Kamarck, & Mermelstein, 1983). Items were endorsed using a five-point scale from 1 = *never* to 5 = *always*. During T1 the scale contained six items, and during T2 through T4 an additional item was included (During the past month "...how often have you been upset because of something that happened unexpectedly?") for a total of seven items. The items were averaged to calculate a scale score at each assessment wave. The observed alphas were .69 (T1), .77 (T2), .75 (T3), and .76 (T4).

Positive affect. Students completed four items assessing positive affect (good, happy, joyful, satisfied) adapted from the Scale of Positive and Negative Experience (Diener et al., 2010). Participants were asked to consider how often they felt each emotion during the past month using a 5-point scale from 1 = *never* to 5 = *always*. The four items were averaged to calculate a scale score at each assessment wave. The observed alphas were .77 (T1), .82 (T2), .84 (T3), and .85 (T4).

Demographic characteristics. Students' gender, eligibility for free or reduced-price lunch, and race/ethnicity was obtained from school records. In analyses reported below, demographic characteristics were scored using a series of dummy codes, where male, paid lunch, and African American (including $n = 31$ mixed/other race students) served as reference categories. We also included a series of seven dummy codes to account for the fact that students were sampled from different middle (and high) schools. Sample sizes were $n = 446$ and 577 at the two comprehensive, public middle schools, and ranged from $n = 41$ to 169 at the six

independent/charter schools. The school with the largest sample size ($n = 577$) served as the reference category.

Overview of Analytic Framework

All analyses were conducted using *Mplus* Version 7.2 (Muthén & Muthén, 2012). Data for nonreactivity, perceived stress, and positive affect were available for between 69.0% and 79.8% of cases across assessment waves (see Table 1). Students with missing data were included in all models by using full information maximum likelihood (FIML), which produces less biased and more efficient results compared with conventional methods of dealing with missing data, such as listwise deletion (Collins, Schafer, & Kam, 2001; Enders & Bandalos, 2001; Schafer & Graham, 2002). Thus, the sample for all analyses reported below is 1,657. FIML was enabled by treating demographic characteristics (gender, eligibility for free or reduced-price lunch, race/ethnicity, school attended) as missing data correlates (i.e., auxiliary variables; `AUXILIARY=(m)variable names...;`). All analyses used robust maximum likelihood (MLR) estimation. In models where demographic characteristics were relevant to hypotheses being tested (either as predictor variables or covariates), they were included as independent variables rather than auxiliary variables.

Model fit was assessed using common indices and their corresponding cutoffs, according to standard conventions. Values of .90 or higher for the Comparative Fit Index (CFI) indicate acceptable fit to the data, and values of .95 or higher indicate excellent fit (Bentler & Bonett, 1980; Hu & Bentler, 1999; Schumacker & Lomax, 2010). Root Mean Square Error of Approximation (RMSEA) values of .08 or less indicate acceptable fit, and values of .05 or less indicate excellent fit (Browne & Cudeck, 1993; Schumacker & Lomax, 2010). In general, we used chi-square difference tests with MLR correction to compare nested models (Satorra &

Bentler, 2001), but did not rely solely on this test due to its sensitivity to sample size (Bentler & Bonett, 1980). In latent growth curve models, we also used a combination of Bayesian Information Criteria (BIC) and Akaike Information Criteria (AIC) values to compare models, where lower values indicate better fit. Moreover, we examined how well the models estimated the growth trajectory relative to the observed data, with a preference toward retaining the most parsimonious model. And in the random intercept cross-lagged panel models, we followed prior recommendations where a change in model fit of $\leq .010$ in CFI and a change of $\leq .015$ in RMSEA would indicate that the more restrictive model does not fit worse than the unrestricted model (Chen, 2007).

Results

Descriptive Statistics

Means, standard deviations, and observed ranges for the variables are provided in Table 1. The mean values for nonreactivity were above the midpoint (3.5) at each assessment wave ($M = 3.91$ to 4.06), although they varied substantially across participants (range = 1 to 6). Scores on positive affect were also higher than the midpoint ($M = 3.56$ to 3.71), and about at the midpoint for perceived stress ($M = 2.83$ to 3.00).

Bivariate correlations among variables were in the expected direction: Nonreactivity was negatively correlated with perceived stress, $r = -.30$ to $-.37$, $ps < .001$, and positively correlated with positive affect, $r = .30$ to $.37$, $ps < .001$, at each assessment wave. The magnitude of the correlations within waves suggests medium-sized effects. See Supporting Information for the full correlation matrix.

Univariate Change in Nonreactivity, Perceived Stress, and Positive Affect

We examined developmental change in nonreactivity, perceived stress, and positive affect from the fall of 8th grade to the spring of 9th grade through a series of latent growth curve models. In these models, time was centered so that the growth curve intercept represented initial levels of the outcome in fall of 8th grade (0 = fall 8th grade, 1 = spring 8th grade, 2 = fall 9th grade, and 3 = spring 9th grade). We compared three models, (1) a no-growth model, (2) a linear change model, and (3) a quadratic (non-linear) change model. After adequately modeling the shape of the growth trajectories, we proceeded to test conditional effects of demographic characteristics (gender, race/ethnicity, eligibility for free or reduced-price lunch, school attended) on the intercept and growth trajectories. Due to the large number of comparisons in these conditional models, we focus our main results reporting to statistically significant ($p < .05$) associations of greatest theoretical interest (gender, race/ethnicity, SES). The Supporting Information includes full results of all unconditional and conditional latent growth models.

Nonreactivity. The linear change model, $\chi^2(5) = 10.84$, $p = .055$, RMSEA = .027, CFI = .989, BIC = 20,013.18, AIC = 19,217.50, best reproduced the development of nonreactivity, because it showed better fit than the no-growth model, $\Delta\chi^2(3) = 29.84$, $p < .001$, and was not significantly worse than the quadratic model, $\Delta\chi^2(4) = 6.84$, $p = .145$. Moreover, the BIC and AIC values for the linear model were nearly identical or lower than both the no-growth, 20,028.43 and 19,248.99, and quadratic, 20,033.89 and 19,216.56, models, respectively. As shown in Table 2, nonreactivity increased linearly from 8th grade through 9th grade, $b = .04$, $SE = .01$, $p = .001$. The intercept and slope variances were statistically significant, suggesting that initial levels and changes in nonreactivity varied across students. The intercept and slope were also significantly negatively correlated, $r = -.45$, $p < .001$, indicating that higher initial levels of nonreactivity were associated with a slower rate of increase across time.

We next fit a conditional growth model to examine the moderating effect of gender, race/ethnicity, and eligibility for free or reduced-price lunch on the nonreactivity intercept and linear trajectory. Compared to boys, girls reported lower initial nonreactivity (fall of 8th grade), $b = -.31$, $SE = .05$, $p < .001$. And compared to African American youth, Latino youth, $b = -.45$, $SE = .11$, $p < .001$, and Caucasian youth, $b = -.21$, $SE = .09$, $p = .022$, reported lower initial nonreactivity.

Perceived stress. Though the quadratic change model had the best fit by standard conventions (RMSEA = 0, CFI = 1), we retained the linear change model because it also showed excellent fit to the data, $\chi^2(5) = 27.27$, $p < .001$, RMSEA = .052, CFI = .985, BIC = 15,428.72, AIC = 14,633.04. Moreover, the linear model had lower BIC and AIC values compared to the no-growth model, 15,532.37 and 14,752.94, respectively, and a nearly identical BIC value to the quadratic growth model, 15,428.88 (although the AIC value for the quadratic model was lower, 14,611.55). As shown in Figure 1, the linear trajectory appeared to adequately capture observed changes in perceived stress across time. Because the non-linear effect was not dramatic, we selected the linear model over the quadratic model as the basis for our final model for interpretability and parsimony. As shown in Table 2, perceived stress increased linearly from 8th grade through 9th grade, $b = .06$, $SE = .01$, $p < .001$. The intercept and slope variances were statistically significant, suggesting that initial levels and changes in perceived stress varied across students. The intercept and slope were also significantly negatively correlated, $r = -.34$, $p < .001$, indicating that higher initial levels of perceived stress were associated with slower rate of increase across time.

The conditional model showed that compared to boys, girls had higher initial (fall of 8th grade) perceived stress, $b = .31$, $SE = .04$, $p < .001$, and a steeper increase in perceived stress, $b =$

.06, $SE = .01$, $p < .001$. Moreover, compared to African American youth, Asian youth, $b = .14$, $SE = .06$, $p = .027$, and Caucasian youth, $b = .18$, $SE = .06$, $p = .003$, had higher initial perceived stress.

Positive affect. As with perceived stress, the quadratic change model had the best fit statistics by standard conventions ($RMSEA = 0$, $CFI = 1$), but we retained the linear change model because it also showed excellent fit to the data, $\chi^2(5) = 20.09$, $p = .001$, $RMSEA = .043$, $CFI = .981$, $BIC = 16901.61$, $AIC = 16,105.93$. The linear model had the lowest BIC value of all three models (no-growth $BIC = 16,939.94$; quadratic $BIC = 16,908.25$), a lower AIC value compared to the no-growth model, 16,160.50, but slightly higher AIC value compared to the quadratic model, 16,090.93. Moreover, the quadratic effect for positive affect was not statistically significant, $b = .001$, $SE = .008$, $p = .941$. (The improvement in fit from the linear to quadratic model was likely due to the addition of a marginally statistically significant quadratic variance component ($p = .061$).) As shown in Figure 1, the linear trajectory appeared to adequately capture observed changes in perceived stress across time. Thus, we selected the linear model for interpretability and parsimony. As shown in Table 2, positive affect decreased linearly from 8th grade through 9th grade, $b = -.05$, $SE = .01$, $p < .001$. The intercept and slope variances were statistically significant, suggesting that initial levels and changes in positive affect varied across students. The intercept and slope were not significantly correlated, $r = -.04$, $p = .824$, indicating that initial levels of positive affect did not relate to changes across time.

The conditional model showed that compared to boys, girls had lower initial (fall 8th grade) positive affect, $b = -.15$, $SE = .04$, $p < .001$. Moreover, compared to African American youth, Caucasian youth had lower initial positive affect, $b = -.21$, $SE = .06$, $p = .001$, but steeper increases across time, $b = .05$, $SE = .02$, $p = .029$.

Co-Development of Nonreactivity with Perceived Stress and Positive Affect

After identifying linear developmental trajectories in nonreactivity, perceived stress, and positive affect, we fit parallel process latent growth curve models to assess the association (i.e., co-development) between latent slopes. One model examined the association between nonreactivity and perceived stress growth slopes and another examined the association between nonreactivity and positive affect growth slopes. The primary interest for this study was examining the covariance between the linear slopes, or the degree to which change in one variable tracked change in another. In both models, we permitted the two intercepts to covary, indicating the degree to which initial levels of variables were correlated. These models also included several other paths: first, each growth slope was regressed on its corresponding intercept (e.g., nonreactivity slope regressed on nonreactivity intercept); second, the growth slope for one variable was regressed on the intercept from the other variable (e.g., nonreactivity slope regressed on perceived stress intercept); third, residuals for variables at each assessment wave were allowed to covary (e.g., T1 nonreactivity was correlated with T1 perceived stress); and finally, the effect of gender, race/ethnicity, socioeconomic status, and school attended were included as covariates of the initial levels (fall of 8th grade) and trajectories of change by regressing the latent intercept and growth slope on each.

Regarding nonreactivity and perceived stress, the model fit the data well, $\chi^2(66) = 103.17$, $p = .002$, RMSEA = .018, CFI = .988. As shown in Table 3, the nonreactivity and perceived stress intercepts were negatively correlated, $r = -.49$, $p < .001$, and importantly, the slopes were also significantly negatively correlated, $r = -.51$, $p < .001$. These results show that adolescents who in fall of 8th grade reported higher nonreactivity also reported lower stress. Moreover,

increases in nonreactivity from fall of 8th grade through spring of 9th grade were also associated with steeper declines in perceived stress.

Regarding nonreactivity and positive affect, the model also fit the data well, $\chi^2(66) = 93.62$, $p = .014$, RMSEA = .016, CFI = .989. As shown in Table 3, the nonreactivity and positive affect intercepts were positively correlated, $r = .52$, $p < .001$, and importantly, the slopes were also significantly positively correlated, $r = .87$, $p = .037$. These results show that adolescents who in fall of 8th grade reported higher nonreactivity also reported higher positive affect. Moreover, increases in nonreactivity from fall of 8th grade through spring of 9th grade were also associated with steeper increases in positive affect.

Cross-Lagged Associations between Nonreactivity and Perceived Stress and Positive Affect

Finally, we examined reciprocal, prospective associations between nonreactivity and perceived stress and positive affect using random intercept cross-lagged panel models. In two separate models, we specified cross-lagged paths between nonreactivity and perceived stress, and between nonreactivity and positive affect, which estimated prospective effects of one variable on another. We included wave-to-wave stability (autoregressive) paths and within-wave covariances among variables. We also specified random intercepts for each construct by creating latent factors with loadings across all four waves constrained to 1. The random intercept partials out stable, between-person variance in the variables, so that the cross-lagged paths only reflect within-person relationships.

To enhance parsimony and interpretability, we tested a series of models where cross-lagged paths (M2) and autoregressive paths (M3), and their combination (M4), were constrained to be time-invariant. These models were compared to the unconstrained baseline model (M1). Table 4 shows model fit and model comparisons for each of these models. For models predicting

both perceived stress and positive affect, the constrained models fit the data as well as the unconstrained model. Therefore, we report results from the most parsimonious model (M4) in which cross-lagged and autoregressive paths were time-invariant (within-wave covariances were allowed to freely estimate).

The between-person part of the two models showed that time-invariant individual differences (i.e., random intercept) in nonreactivity were negatively correlated with perceived stress, $r = -.48, p < .001$, and positively correlated with positive affect, $r = .43, p < .001$.

The within-person part of the models showed that the cross-lagged paths from nonreactivity to perceived stress, $b = -.05, SE = .02, p = .016$, and positive affect, $b = .10, SE = .02, p < .001$, were statistically significant. The cross-lagged paths from perceived stress to nonreactivity, $b = -.18, SE = .06, p = .005$, and from positive affect to nonreactivity, $b = .11, SE = .05, p = .022$, were also statistically significant. Full results of these models are depicted in Figures 2 and 3.

Discussion

To our knowledge, this is the first study to track the normative development of dimensions of mindfulness during adolescence and test how developmental changes are associated with stress and positive emotions. Results of latent growth curve models showed that from 8th through 9th grade, adolescents matured linearly in their capacity to become aware of, yet remain nonreactive toward difficult experiences. This finding is consistent with a large body of research showing that cognitive control system, which subserves executive function and emotion regulation, matures during adolescence (Steinberg, 2014). Though our analyses did not speak directly to the potential causes of this growth, they did allow us to test for demographic factors that may have influenced the rate of change. Interestingly, results showed that the nonreactivity

growth trajectory varied minimally by gender, race/ethnicity, and socioeconomic status. Despite potential demographic differences in how emotions are expressed and regulated, the pattern of developmental change we observed in nonreactivity was similar across girls and boys, adolescents from higher and lower-income households, and across African American, Caucasian, Asian, and Latino adolescents.

Beyond describing the developmental trajectory of nonreactivity, our study also examined the relationship between changes in nonreactivity and outcomes. Results of parallel process latent growth curve models showed that naturalistic developmental changes in nonreactivity tracked concomitant reductions in perceived stress and improvements in positive affect. These findings indicate that adolescents who matured in their capacity for observing difficult experiences in a nonreactive, balanced way were more likely to simultaneously experience decreases in the degree to which they felt stressed and worried and overwhelmed by the problems in their life. Likewise, these same adolescents were also more likely to report increases in their experience of joy, happiness, and life satisfaction.

Finally, results of random intercept cross-lagged panel models showed that within-person nonreactivity prospectively predicted within-person changes in perceived stress and positive affect. It is commonly assumed that changes in dimensions of mindfulness are not only associated with, but also predict improvements in well-being and reductions in stress. Consistent with this assumption, adolescents who improved in their capacity for nonreactive observation of difficult inner experiences reported less perceived stress and more positive affect six months later. Because these associations were observed within individual adolescents (not across adolescents), the possibility of unmeasured, time-invariant confounds was ruled out. Third-variable between-person confounds are a problem for many published studies examining

correlations between individual differences in mindfulness and well-being. These results therefore provide strong evidence that naturalistic changes in the capacity for nonreactive observation of experience are prospectively associated with improvements in stress and emotional well-being.

Implications for Theory and Practice

This study is supportive of the broader idea that consciously approaching and opening up to difficult experiences in a nonreactive manner can reduce stress and improve well-being. How? Exact mechanisms remain to be studied, but we suggest that a nonreactive awareness leads people to appraise demanding and difficult experiences as challenges rather than threats (Weinstein, Brown, & Ryan, 2009). From a biopsychosocial perspective (Jamieson, Hangen, Lee, & Yeager, 2018), nonreactivity might enhance appraisals of coping resources, reduce appraisals of demands, or both. Appraising situational demands as challenges to be overcome (or adapted to), rather than as threats to be avoided, may in turn promote more adaptive responding. If true, it may be possible to improve adolescents' performance and affective experience in stressful situations through the training and application of mindful nonreactivity. Future experimental research is needed to test these propositions.

This study also makes a novel theoretical contribution that dimensions of mindfulness can change in the absence of formal meditation training. Admitting of this possibility opens the door to considering many other environmental, interpersonal, and intrapersonal inputs that may play a role in shaping the development and expression of mindfulness. Prior research shows that parents are powerful socializers of their children's emotion regulation strategies (Eisenberg, Cumberland, & Spinrad, 1998; Eisenberg, Fabes, & Murphy, 1996). Likewise, early temperamental dispositions, including effortful control, play a role in shaping the development of

self-regulatory capacities (Eisenberg, Duckworth, Spinrad, & Valiente, 2014). It seems plausible that these and other factors (e.g., teacher and peer interactions) may contribute to the naturalistic development of dimensions of mindfulness across adolescence (Riggs & Brown, 2017), and even the life span. Our own finding that changes in perceived stress and positive affect prospectively predicted changes in adolescents' nonreactivity further reinforces the idea that dimensions of mindfulness are malleable to different inputs. As the social ecology of mindfulness is clarified in future studies, there may be new opportunities to harness these external and internal processes in interventions designed to cultivate mindfulness.

Of course a counterargument is that naturalistic changes in nonreactivity outside of formal meditation training contexts speaks only to the lack of construct validity of self-report measures. We are sympathetic to criticisms of self-report mindfulness scales (Grossman & Van Dam, 2011), but suggest that this explanation alone would be incomplete. For example, if naturalistic changes in self-reported nonreactivity scores only characterized the scale's lack of validity, then it seems unlikely that they would be correlated with changes in other outcomes (i.e., perceived stress, positive affect) in theoretically hypothesized ways. Though there is much progress to be made in the conceptualization and measurement of mindfulness (and clarifying its more foundational cognitive processes; Lutz, Jha, Dunne, & Saron, 2015), it seems premature to entirely dismiss the role that self-report scales can play. Given the limitations of any single metric (Duckworth & Yeager, 2015), we recommend a more holistic approach to operationalizing mindfulness, including the judicious use of self-report, ecological momentary assessment (Shoham, Hadash, & Bernstein, 2018), and performance measures (Levinson, Stoll, Kindy, Merry, & Davidson, 2014).

What practical implications can be drawn from this study? Specific intervention recommendations are beyond the scope of this investigation. However, the discovery that adolescents reported increases in perceived stress and decreases in positive emotions during the two-year study period supports the view that the transition to high school may be a period of heightened risk (Benner, 2011). This suggests, at a minimum, that the transition to high school be given careful consideration when timing mindfulness-based interventions. Over four million students make the transition to high school each year (National Center for Education Statistics, 2017b), and many may lack the knowledge and skills necessary to thrive academically and socially. Mindfulness interventions—if properly timed and delivered with care and fidelity, and whose curricula are aligned with adolescents’ developmental needs and motivational priorities (Yeager et al., 2018)—may play a role in helping more students succeed during the high school transition and beyond.

Limitations and Future Directions

This study has several limitations that suggest important directions for future research. We focused on a relatively narrow span of adolescence. It is therefore unclear how nonreactivity in particular, and mindfulness in general, might change during the rest of adolescence or adulthood. Relatedly, though this study included a racially and socioeconomically diverse sample of adolescents, it was not representative of the population of American adolescents. Thus, future research is required to determine whether the observed pattern of developmental change in nonreactivity replicates across more representative samples.

Our study relied on one dimension of mindfulness, nonreactivity to difficult inner experiences. Though this has been hypothesized to be a key ingredient underlying the salutary effects of mindfulness (Lindsay & Creswell, 2017), mindfulness is a multidimensional, complex

construct, and other dimensions have been associated with stress and well-being. Future research will have to examine how other dimensions of mindfulness, including self-regulation of attention, change across adolescence, and whether changes in these dimensions are related to changes in well-being. It would also be interesting to explore the co-development of multiple mindfulness dimensions simultaneously to see whether changes in one dimension facilitate changes in the other. We also invite studies that examine how changes in nonreactivity may relate to changes in other well-being outcomes, as well as academic and social outcomes, and how demographic characteristics may alter growth trajectories of multiple dimensions of mindfulness.

This study was non-experimental and thus causality cannot be inferred. The random intercept cross-lagged panel models did rule out time-invariant between-person confounds, and helped to hint at directionality of associations between nonreactivity and outcomes. Nevertheless, the results are based on correlational data. Our analysis did not rule out the possibility that unmeasured time-varying variables that track changes in nonreactivity and causally influence outcomes might have accounted for the observed relationships. Experiments are needed to demonstrate causal relationships among nonreactivity, perceived stress, and positive affect.

Finally, our results are based on self-report data. Nonreactivity, stress, and affect are fundamentally about individuals' subjective perceptions of their own internal experience, and we are unaware of any validated performance or informant-report measures of mindfulness, and in particular nonreactivity, for adolescents. Future studies might incorporate daily diary and ecological momentary assessments to minimize potential method effects.

Conclusion

Despite a growing movement to bring mindfulness training to adolescents, little is known about the naturalistic development of mindfulness. Our results show that the capacity to become aware of difficult experiences in a nonreactive manner—which is considered a core dimension of mindfulness—may develop linearly during parts of adolescence. Adolescents who improved in this mental quality reported less stress and more happiness during the transition from middle school to high school. The present study provides an initial step toward a social ecology of the mindful adolescent. Future research is needed to determine external and internal processes that naturally alter the development of nonreactivity and of mindfulness more generally. Such an understanding may reveal new avenues for potentiating this quality of mind during a critical period of social-emotional development.

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Table 1
Descriptive Statistics

Variable	<i>M</i>	<i>SD</i>	Available <i>n</i>
1.Nonreactivity (T1)	3.91	1.10	1,249
2.Nonreactivity (T2)	3.96	1.03	1,314
3.Nonreactivity (T3)	4.06	1.01	1,143
4.Nonreactivity (T4)	4.01	1.03	1,153
5.Perceived Stress (T1)	2.83	0.69	1,294
6.Perceived Stress (T2)	2.92	0.73	1,322
7.Perceived Stress (T3)	2.97	0.70	1,199
8.Perceived Stress (T4)	3.00	0.71	1,186
9.Positive Affect (T1)	3.71	0.73	1,259
10.Positive Affect (T2)	3.65	0.78	1,316
11.Positive Affect (T3)	3.61	0.79	1,194
12.Positive Affect (T4)	3.56	0.78	1,181

Notes: Total *N* = 1,657. T1 to T4 = assessment waves 1 to 4. Auxiliary variables (gender, SES, race/ethnicity, school attended) were included as missing data correlates.

Table 2

Latent Growth Curve Models for Developmental Change in Nonreactivity, Perceived Stress, and Positive Affect

	Nonreactivity			Perceived Stress			Positive Affect		
	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>
Fixed effects									
Intercept	3.92	0.03	<.001	2.84	0.02	<.001	3.71	0.02	<.001
Linear slope	0.04	0.01	.001	0.06	0.01	<.001	-0.05	0.01	<.001
Variance components									
Intercept	0.58	0.06	<.001	0.34	0.02	<.001	0.29	0.02	<.001
Linear slope	0.05	0.01	<.001	0.02	0.00	<.001	0.01	0.01	.041
Intercept-slope correlation	-0.45	0.07	<.001	-0.34	0.06	<.001	-0.04	0.16	.824
Model fit									
χ^2	10.84			27.27			20.09		
<i>df</i>	5			5			5		
MLR scaling	1.25			1.10			1.15		
RMSEA	0.027			0.052			0.043		
CFI	0.989			0.985			0.981		
AIC	19,217.50			14,633.04			16,105.93		
BIC	20,013.18			15,428.72			16,901.61		

Notes: $N = 1,657$. χ^2 = chi-square; *df* = degrees of freedom; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; BIC = Bayesian Information Criteria; AIC = Akaike Information Criteria. Auxiliary variables (gender, SES, race/ethnicity, school attended) were included as missing data correlates. Time was centered at fall 8th grade.

Table 3

Parallel Process Latent Curve Models

	Nonreactivity and Perceived Stress			Nonreactivity and Positive Affect		
	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>
Model intercepts						
Mindfulness intercept	4.15	0.08	<.001	4.13	0.08	<.001
Mindfulness slope	0.69	0.24	.004	0.59	0.14	<.001
Outcome intercept	2.66	0.05	<.001	3.84	0.06	<.001
Outcome slope	0.14	0.15	.345	0.02	0.13	.875
Growth factor correlations and standardized regression coefficients						
Intercept ↔ intercept	-0.49	0.05	<.001	0.52	0.06	<.001
Slope ↔ slope	-0.51	0.14	<.001	0.87	0.42	.037
Mindfulness intercept → mindfulness slope	-0.49	0.10	<.001	-0.46	0.11	<.001
Outcome intercept → outcome slope	-0.34	0.09	<.001	0.22	0.29	.462
Mindfulness intercept → outcome slope	0.15	0.11	.170	-0.41	0.28	.150
Outcome intercept → mindfulness slope	-0.05	0.10	.637	0.01	0.12	.915
Model fit						
χ^2	103.17			93.62		
<i>df</i>	66			66		
MLR scaling	1.02			1.03		
RMSEA	0.018			0.016		
CFI	0.988			0.989		
AIC	27,626.22			29,038.79		
BIC	28,513.91			29,926.48		

Notes: $N = 1,657$. χ^2 = chi-square; *df* = degrees of freedom; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; BIC = Bayesian Information Criteria; AIC = Akaike Information Criteria. Demographic covariates (gender, SES, race/ethnicity, school attended) were included as predictors of the reported intercepts and covariances, but their effects are not displayed to ease presentation. "↔" indicate correlations, and "→" indicate regressions.

Table 4

Fit Indices and Model Comparisons for Random Intercept Cross-Lagged Panel Models

Model	Model Fit Indices					Model Fit Comparisons					
	χ^2	df	MLR Scaling Correction Factor	CFI	RMSEA	Model Comparisons	$\Delta\chi^2$	Δdf	p	ΔCFI	$\Delta RMSEA$
Nonreactivity and Perceived Stress											
M1: baseline	25.07	9	1.130	0.993	0.033						
M2: time-invariant cross lags	28.53	13	1.147	0.993	0.027	M2-M1	3.70	4	.448	0.000	-0.006
M3: time-invariant autoregressive paths	26.49	13	1.198	0.994	0.025	M3-M1	2.52	4	.642	0.001	-0.008
M4: M2+M3	30.33	17	1.192	0.994	0.022	M4-M1	6.20	8	.625	0.001	-0.011
Nonreactivity and Positive Affect											
M1: baseline	11.92	9	1.182	0.998	0.014						
M2: time-invariant cross lags	12.75	13	1.206	1.000	0.000	M2-M1	1.02	4	.907	0.002	-0.014
M3: time-invariant autoregressive paths	24.05	13	1.226	0.994	0.023	M3-M1	11.62	4	.020	-0.004	0.009
M4: M2+M3	24.88	17	1.240	0.996	0.017	M4-M1	12.85	8	.117	-0.002	0.003

Notes: χ^2 = chi-square; df = degrees of freedom; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; Δ = change in parameter; $\Delta\chi^2$ and p -values for Model Fit Comparisons are based on Satorra and Bentler's (2001) scaled χ^2 difference test for MLR estimation. Auxiliary variables (gender, SES, race/ethnicity, school attended) were included as missing data correlates.

Figure 1. Solid lines depict the average estimated linear trajectory of nonreactivity, perceived stress, and positive affect, based on unconditional latent growth curve models. The dotted lines depict the observed scores for manifest variables at each assessment wave.

Figure 2. Random intercept cross-lagged panel model with nonreactivity and perceived stress.

Unstandardized regression coefficients and covariances are presented. Auto-regressive and cross-lagged paths were constrained to be time-invariant, and within-wave covariances were freely estimated. Auxiliary variables of gender, race/ethnicity, eligibility for free or reduced-price lunch, and school attended were included as missing data correlates. The mean structure for the manifest variables was freely estimated, but is not displayed to aid visual clarity. NR = nonreactivity; PS = perceived stress. Bold lines are significant at $p < .05$.

Figure 3. Random intercept cross-lagged panel model with nonreactivity and positive affect.

Unstandardized regression coefficients and covariances are presented. Auto-regressive and cross-lagged paths were constrained to be time-invariant, and within-wave covariances were freely estimated. Auxiliary variables of gender, race/ethnicity, eligibility for free or reduced-price lunch, and school attended were included as missing data correlates. The mean structure for the manifest variables was freely estimated, but is not displayed to aid visual clarity. NR = nonreactivity; PA = positive affect. Bold lines are significant at $p < .05$.

The Mindful Adolescent: Developmental Changes in Nonreactivity to Inner Experiences during
the Transition to High School, and Relations to Stress and Positive Affect

Supporting Information

Sample characteristics. We compared our analytic sample of $N = 1,657$ students to aggregate demographic characteristics of the schools where students were drawn. Aggregate data were collected from the National Center for Education Statistics database (2017a). Data were only publicly available for six of the eight schools sampled, so that is what we base our comparisons on. Table S1 shows the comparisons:

Table S1

*Comparison of Demographic Characteristics Between
the Final Analytic Sample ($N = 1,657$) and the Overall
Demographic Characteristics of Schools from Where the
Sample was Drawn*

Variable	Analytic Sample	Aggregate School Population
Female	48.0%	48.9%
Free/reduced price lunch	66.1%	51.2%
Caucasian	23.4%	13.9%
African American	47.6%	52.4%
Latino	14.4%	22.6%
Asian	10.4%	9.8%

Note: Demographic data were missing for between 2.0% and 3.7% of the analytic sample.

Self-report instruments. Below is the list of items for each questionnaire used in the current study. For perceived stress and positive affect, students responded based their experiences in the past month.

Nonreactivity.

1. When I have upsetting thoughts or images, I “step back” and am aware of the thought or image without getting taken over by it.
2. I can be aware of my feelings and emotions without having to react to them.
3. I watch my feelings without getting lost in them.

1 = strongly disagree

2 = disagree

3 = mostly disagree

4 = mostly agree

5 = agree

6 = strongly agree

Perceived stress.

1. that you were unable to control the important things in your life?
2. confident about your ability to handle your personal problems? [reverse coded]
3. that things were going your way? [reverse coded]
4. difficulties were piling up so high that you could not overcome them?
5. worried?
6. stressed?
7. upset because of something that happened unexpectedly? [assessments T2-T4 only]

1 = never

2 = rarely

3 = sometimes

4 = often

5 = always

Positive affect.

1. good
2. happy
3. joyful
4. satisfied

- 1 = never
 2 = rarely
 3 = sometimes
 4 = often
 5 = always

Demographic differences in study variables. Tables S2 to S4 provide means, standard deviations, and results of inferential statistics comparing gender, eligibility for free or reduced-price lunch, and race/ethnicity on nonreactivity, perceived stress, and positive affect.

Table S2
Gender Differences in Study Variables

Variable	boy	girl	<i>t</i>	<i>p</i>
1.Nonreactivity (T1)	4.05 (1.06)	3.77 (1.12)	4.38	<.001
2.Nonreactivity (T2)	4.15 (0.95)	3.79 (1.06)	6.41	<.001
3.Nonreactivity (T3)	4.23 (0.99)	3.90 (1.00)	5.48	<.001
4.Nonreactivity (T4)	4.22 (0.99)	3.83 (1.05)	6.33	<.001
5.Perceived Stress (T1)	2.68 (0.67)	2.98 (0.68)	-8.08	<.001
6.Perceived Stress (T2)	2.72 (0.69)	3.11 (0.72)	-10.02	<.001
7.Perceived Stress (T3)	2.77 (0.66)	3.15 (0.68)	-10.00	<.001
8.Perceived Stress (T4)	2.75 (0.67)	3.22 (0.66)	-11.93	<.001
9.Positive Affect (T1)	3.77 (0.73)	3.64 (0.72)	3.08	.002
10.Positive Affect (T2)	3.76 (0.76)	3.55 (0.79)	5.01	<.001
11.Positive Affect (T3)	3.70 (0.78)	3.54 (0.79)	3.55	<.001
12.Positive Affect (T4)	3.68 (0.76)	3.46 (0.77)	4.76	<.001

Note: Observed means and standard deviations (in parentheses) are presented.

Table S3
Socioeconomic Status Differences in Study Variables

Variable	not eligible for free or reduced- price lunch	eligible for free or reduced- price lunch	<i>t</i>	<i>p</i>
1.Nonreactivity (T1)	3.88 (1.09)	3.93 (1.10)	-0.74	.460
2.Nonreactivity (T2)	3.96 (0.99)	3.98 (1.04)	-0.21	.833
3.Nonreactivity (T3)	4.05 (0.98)	4.06 (1.03)	-0.15	.880
4.Nonreactivity (T4)	4.01 (1.03)	4.02 (1.04)	-0.12	.901
5.Perceived Stress (T1)	2.85 (0.72)	2.82 (0.67)	0.57	.568
6.Perceived Stress (T2)	2.92 (0.73)	2.91 (0.74)	0.32	.746
7.Perceived Stress (T3)	2.92 (0.72)	2.98 (0.69)	-1.53	.126
8.Perceived Stress (T4)	2.97 (0.73)	2.99 (0.70)	-0.48	.631
9.Positive Affect (T1)	3.69 (0.71)	3.72 (0.74)	-0.56	.573
10.Positive Affect (T2)	3.64 (0.75)	3.67 (0.79)	-0.67	.506
11.Positive Affect (T3)	3.67 (0.75)	3.59 (0.80)	1.48	.140
12.Positive Affect (T4)	3.63 (0.76)	3.54 (0.78)	1.93	.054

Note: Observed means and standard deviations (in parentheses) are presented.

Table S4

Racial/Ethnic Differences in Study Variables

Variable	African American	Caucasian	Latino	Asian	Multiple/Other races and ethnicities	<i>F</i>	<i>p</i>
1.Nonreactivity (T1)	3.97 (1.14)	3.75 (1.08)	3.88 (1.11)	4.06 (0.94)	3.92 (1.00)	2.91	.021
2.Nonreactivity (T2)	3.99 (1.06)	3.92 (1.00)	3.85 (1.04)	4.08 (0.93)	4.32 (0.66)	1.98	.095
3.Nonreactivity (T3)	4.14 (1.01)	3.97 (1.05)	3.94 (1.03)	4.14 (0.87)	3.98 (1.02)	2.37	.051
4.Nonreactivity (T4)	4.09 (1.03)	3.90 (1.09)	4.00 (1.02)	4.02 (0.98)	3.93 (0.84)	1.58	.178
5.Perceived Stress (T1)	2.76 (0.66)	2.90 (0.75)	2.88 (0.65)	2.91 (0.70)	2.73 (0.73)	3.28	.011
6.Perceived Stress (T2)	2.88 (0.73)	2.93 (0.78)	2.91 (0.69)	3.00 (0.68)	2.89 (0.63)	0.92	.450
7.Perceived Stress (T3)	2.91 (0.70)	2.94 (0.74)	3.06 (0.61)	3.07 (0.73)	2.98 (0.67)	2.81	.024
8.Perceived Stress (T4)	2.96 (0.70)	2.96 (0.75)	3.01 (0.67)	3.11 (0.71)	2.93 (0.74)	1.50	.201
9.Positive Affect (T1)	3.75 (0.73)	3.62 (0.70)	3.70 (0.76)	3.79 (0.69)	3.50 (0.87)	2.64	.032
10.Positive Affect (T2)	3.71 (0.79)	3.58 (0.79)	3.66 (0.81)	3.62 (0.70)	3.53 (0.64)	1.61	.169
11.Positive Affect (T3)	3.66 (0.79)	3.64 (0.75)	3.55 (0.84)	3.55 (0.79)	3.35 (0.56)	1.71	.145
12.Positive Affect (T4)	3.60 (0.79)	3.63 (0.73)	3.49 (0.77)	3.48 (0.73)	3.30 (1.00)	2.19	.068

Note: Observed means and standard deviations (in parentheses) are presented.

Measurement Invariance. We tested measurement invariance in the nonreactivity, perceived stress, and positive affect instruments (and also a model with all three scales modeled simultaneously). The first measurement model assessed configural invariance, and subsequent models tested metric and scalar invariance, in which the factor loadings and intercepts, respectively, were set to equality across the four assessment waves. To test for differences in fit across models, we followed prior recommendations where a change in model fit of $\leq .010$ in CFI and a change of $\leq .015$ in RMSEA would indicate that the more restrictive model does not fit worse than the unrestricted model (Chen, 2007). As shown in Table S5, all three instruments demonstrated scalar (i.e., strong) measurement invariance (meaning there were no discernible differences in the factor loadings and intercepts) across the four assessment waves.

Table S5

Fit Indices and Model Comparisons for Measurement Invariance Models

Model	Model Fit Indices					Model Comparisons	Model Fit Comparisons				
	χ^2	df	MLR Scaling Correction Factor	CFI	RMSEA		$\Delta\chi^2$	Δdf	p	ΔCFI	$\Delta RMSEA$
Nonreactivity											
Configual Invariance (CI)	38.97	30	1.310	0.997	0.013						
Metric Invariance (MI)	46.21	36	1.318	0.997	0.013	MI vs CI	7.25	6	.299	0.000	0.000
Scalar Invariance (SI)	51.81	42	1.278	0.997	0.012	SI vs MI	5.12	6	.528	0.000	-0.001
Perceived Stress											
Configual Invariance (CI)	1189.25	279	1.152	0.894	0.044						
Metric Invariance (MI)	1212.10	296	1.152	0.893	0.043	MI vs CI	22.85	17	.154	-0.001	-0.001
Scalar Invariance (SI)	1304.78	313	1.145	0.884	0.044	SI vs MI	95.29	17	.000	-0.009	0.001
Positive Affect											
Configual Invariance (CI)	98.68	74	1.196	0.996	0.014						
Metric Invariance (MI)	107.64	83	1.190	0.996	0.013	MI vs CI	8.83	9	.453	0.000	-0.001
Scalar Invariance (SI)	117.33	92	1.174	0.996	0.013	SI vs MI	9.41	9	.401	0.000	0.000
All Variables Modeled Simultaneously											
Configual Invariance (CI)	3066.67	1283	1.154	0.919	0.029						
Metric Invariance (MI)	3101.18	1315	1.155	0.919	0.029	MI vs CI	36.33	32	.274	0.000	0.000
Scalar Invariance (SI)	3209.92	1347	1.152	0.916	0.029	SI vs MI	112.58	32	.000	-0.003	0.000

Notes: χ^2 = chi-square; *df* = degrees of freedom; CFI = comparative fit index; RMSEA = root mean square error of approximation; Δ = change in parameter; $\Delta\chi^2$ and *p*-values for Model Fit Comparisons are based on Satorra and Bentler's (2001) scaled χ^2 difference test for MLR estimation. Auxiliary variables (gender, SES, race/ethnicity, school attended) were included to account for missing values.

Bivariate Correlations among Variables. Table S6 shows bivariate correlations among manifest variables at each assessment wave.

Table S6

Bivariate Correlations

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1.Nonreactivity (T1)	1.00											
2.Nonreactivity (T2)	0.45	1.00										
3.Nonreactivity (T3)	0.33	0.45	1.00									
4.Nonreactivity (T4)	0.30	0.41	0.45	1.00								
5.Perceived Stress (T1)	-0.30	-0.29	-0.24	-0.22	1.00							
6.Perceived Stress (T2)	-0.24	-0.37	-0.28	-0.26	0.60	1.00						
7.Perceived Stress (T3)	-0.19	-0.33	-0.36	-0.29	0.56	0.66	1.00					
8.Perceived Stress (T4)	-0.15	-0.24	-0.26	-0.30	0.45	0.57	0.65	1.00				
9.Positive Affect (T1)	0.30	0.23	0.16	0.21	-0.40	-0.29	-0.29	-0.20	1.00			
10.Positive Affect (T2)	0.27	0.36	0.25	0.21	-0.33	-0.49	-0.35	-0.28	0.49	1.00		
11.Positive Affect (T3)	0.17	0.28	0.37	0.26	-0.27	-0.34	-0.41	-0.29	0.46	0.58	1.00	
12.Positive Affect (T4)	0.16	0.21	0.27	0.30	-0.25	-0.34	-0.38	-0.44	0.43	0.50	0.54	1.00

Notes: $N = 1,657$. All correlations are significant at $p < .001$. T1 to T4 = assessment waves 1 to 4. Auxiliary variables (gender, SES, race/ethnicity, school attended) were included to account for missing values.

Unconditional Latent Growth Curve Models. Tables S7 through S9 present full results of the unconditional latent growth curve models for nonreactivity, perceived stress, and positive affect.

Table S7

Unconditional Latent Growth Curve Models for Nonreactivity

	no-growth			linear			quadratic		
	b	SE	p	b	SE	p	b	SE	p
Fixed effects									
Intercept	3.988	0.021	<.001	3.924	0.028	<.001	3.900	0.031	<.001
Linear slope				0.042	0.012	.001	0.110	0.038	.004
Quadratic slope							-0.022	0.012	.058
Variance components									
Intercept (int)	0.447	0.027	<.001	0.575	0.055	<.001	0.767	0.139	<.001
Linear slope (lin)				0.049	0.012	<.001	0.366	0.191	.056
Quadratic slope (quad)							0.014	0.015	.350
int with lin (correlation)				-0.453	0.071	<.001	-0.593	0.131	<.001
int with quad (correlation)							0.548	0.302	.069
lin with quad (correlation)							-1.003	0.147	<.001
Model fit									
χ^2	40.783			10.842			4.562		
df	8			5			1		
MLR scaling	1.251			1.2477			1.0049		
RMSEA	0.05			0.027			0.046		
CFI	0.936			0.989			0.993		
AIC	19248.99			19217.50			19216.56		
BIC	20028.43			20013.18			20033.89		

Table S8

Unconditional Latent Growth Curve Models for Perceived Stress

	no-growth			linear			quadratic		
	b	SE	p	b	SE	p	b	SE	p
Fixed effects									
Intercept	2.928	0.015	<.001	2.843	0.018	<.001	2.829	0.018	<.001
Linear slope				0.055	0.007	<.001	0.101	0.020	<.001
Quadratic slope							-0.015	0.006	.014
Variance components									
Intercept (int)	0.301	0.013	<.001	0.339	0.020	<.001	0.323	0.041	<.001
Linear slope (lin)				0.023	0.004	<.001	0.078	0.052	.134
Quadratic slope (quad)							0.003	0.004	.439
int with lin (correlation)				-0.340	0.055	<.001	-0.035	0.267	.896
int with quad (correlation)							-0.294	0.473	.534
lin with quad (correlation)							-0.907	0.176	<.001
Model fit									
χ^2	143.047			27.271			0.451		
df	8			5			1		
MLR scaling	1.0895			1.0983			1.0189		
RMSEA	0.101			0.052			0.000		
CFI	0.909			0.985			1.000		
AIC	14752.94			14633.04			14611.55		
BIC	15532.37			15428.72			15428.88		

Table S9

Unconditional Latent Growth Curve Models for Positive Affect

	no-growth			linear			quadratic		
	b	SE	p	b	SE	p	b	SE	p
Fixed effects									
Intercept	3.638	0.016	<.001	3.711	0.019	<.001	3.711	0.020	<.001
Linear slope				-0.052	0.008	<.001	-0.053	0.025	.038
Quadratic slope							0.001	0.008	.941
Variance components									
Intercept (int)	0.300	0.015	<.001	0.285	0.024	<.001	0.286	0.058	<.001
Linear slope (lin)				0.011	0.006	.041	0.152	0.077	.048
Quadratic slope (quad)							0.013	0.007	.061
int with lin (correlation)				-0.035	0.157	.824	-0.018	0.294	.950
int with quad (correlation)							-0.048	0.274	.860
lin with quad (correlation)							-0.960	0.040	<.001
Model fit									
χ^2	70.313			20.091			0.128		
<i>df</i>	8			5			1		
MLR scaling	1.1904			1.1514			1.0036		
RMSEA	0.069			0.043			0.000		
CFI	0.923			0.981			1.000		
AIC	16160.50			16105.93			16090.93		
BIC	16939.94			16901.61			16908.25		

Conditional Growth Curve Models. Table S10 presents full results of the conditional latent growth curve models for nonreactivity, perceived stress, and positive affect.

Table S10

Conditional Latent Growth Curve Models for Nonreactivity, Perceived Stress, and Positive Affect

	Nonreactivity			Perceived Stress			Positive Affect		
	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>
Fixed effects									
intercept	4.13	0.08	<.001	2.65	0.05	<.001	3.83	0.06	<.001
linear slope	0.05	0.03	.155	0.03	0.02	.092	-0.05	0.02	.033
Intercept									
PMS2	-0.07	0.09	.391	-0.06	0.05	.235	0.03	0.06	.588
CMS1	0.45	0.13	.001	-0.07	0.09	.486	0.13	0.09	.158
CMS2	0.08	0.12	.528	0.02	0.07	.749	-0.08	0.09	.353
CMS3	-0.21	0.11	.060	-0.18	0.06	.005	-0.06	0.07	.445
CMS4	0.41	0.15	.008	-0.19	0.11	.087	0.21	0.11	.055
CMS5	0.19	0.12	.125	-0.01	0.10	.883	-0.09	0.09	.294
CMS6	0.41	0.12	.001	-0.09	0.11	.374	0.11	0.09	.203
Female	-0.31	0.05	<.001	0.31	0.04	<.001	-0.15	0.04	<.001
Caucasian	-0.21	0.09	.022	0.18	0.06	.003	-0.21	0.06	.001
Latino	-0.45	0.11	<.001	0.13	0.08	.114	-0.13	0.08	.125
Asian	0.05	0.09	.597	0.14	0.06	.027	-0.02	0.06	.713
SES	0.01	0.07	.850	0.01	0.04	.802	0.01	0.05	.821
Linear growth slope									
PMS2	0.04	0.04	.334	0.02	0.02	.390	0.02	0.02	.418
CMS1	-0.12	0.06	.057	0.00	0.04	.903	0.03	0.04	.380
CMS2	0.02	0.05	.777	0.02	0.03	.412	0.05	0.03	.120
CMS3	0.13	0.05	.010	0.08	0.03	.003	0.01	0.03	.874
CMS4	0.06	0.08	.490	-0.07	0.06	.257	0.08	0.06	.198
CMS5	-0.01	0.05	.897	0.02	0.03	.590	0.05	0.03	.146
CMS6	-0.21	0.06	<.001	0.03	0.04	.438	-0.07	0.04	.081
Female	-0.03	0.02	.218	0.06	0.01	<.001	-0.03	0.02	.086
Caucasian	0.01	0.04	.881	-0.04	0.02	.094	0.05	0.02	.029
Latino	0.09	0.06	.121	0.01	0.03	.872	-0.04	0.03	.273
Asian	-0.04	0.04	.289	0.01	0.02	.566	-0.03	0.03	.257
SES	-0.01	0.03	.785	-0.02	0.02	.311	-0.01	0.02	.426
Variance components									
Intercept	0.53	0.05	<.001	0.31	0.02	<.001	0.27	0.02	<.001
linear slope	0.05	0.01	<.001	0.02	0.00	<.001	0.01	0.01	.084
intercept-slope correlation	-0.46	0.07	<.001	-0.41	0.05	<.001	-0.01	0.18	.956
Model fit									
χ^2	36.37			62.95			41.51		
<i>df</i>	29			29			29		
MLR scaling	1.02			0.99			0.99		
RMSEA	0.012			0.027			0.016		
CFI	0.992			0.983			0.990		
AIC	19192.94			14617.30			16076.06		
BIC	19858.71			15283.07			16741.83		

Notes: $N = 1,657$. χ^2 = chi-square; *df* = degrees of freedom; CFI = comparative fit index; RMSEA = root mean square error of approximation; BIC = Bayesian Information Criteria. AIC = Akaike Information Criteria. PMS2 = Public middle school number two (in relation to the other public middle school reference category). CMS1-CMS6 = Charter/independent middle school numbers one through six (in relation to the public middle school reference category). SES = eligibility for free or reduced-price lunch.