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EMPIRICAL RESEARCH

Affective Development from Middle Childhood to Late Adolescence: Trajectories of Mean-Level Change in Negative and Positive Affect

Julianne M. Griffith[1] · Hannah M. Clark[1] · Dustin A. Haraden[1] · Jami F. Young[2,3] · Benjamin L. Hankin[1]

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Abstract

Adolescence has long been purported to be a period of emotional upheaval, yet relatively little is known regarding normative patterns of change in youth positive and negative affect across the adolescent transition. This study addressed this gap by examining normative patterns of mean-level change in youth positive and negative affect from middle childhood through late adolescence, encompassing the full span of adolescent development. Participants included 665 youth recruited in 3rd, 6th, and 9th grade cohorts (55.0% female; age 9–16 at baseline) who provided self-report ratings of positive and negative affect every 18 months for a period of three years in an accelerated longitudinal cohort design. Multi-level growth curve models revealed that adolescence is characterized by declines in positive affect and non-linear patterns of alternating decreases and increases in negative affect. Patterns of change differed across boys and girls. The findings from this study indicate that adolescence is characterized by normative reductions in positive affect in the context of labile negative affect, with implications for understanding processes of risk and resilience across the adolescent transition.

Keywords Adolescent development · Affective development · Negative affect · Positive affect · Developmental trajectories

Introduction

The transition from middle childhood through adolescence has long been characterized in the popular consciousness as a period of emotional tumult (i.e., "storm and stress"). Theories of youth emotional development propose that the myriad neurological, physiological, cognitive, and social changes that occur during adolescence contribute to patterns of normative change in youth affective experience, and these theories suggest that adolescence may be a key period of reorganization in affective systems (see Coe-Odess et al., 2019). Trajectories of positive and negative affective experiences as they unfold across adolescent development are highly consequential, as adolescence may represent an important foundational period during which long-term patterns of health and wellbeing begin to crystallize (Sawyer et al., 2012). In an effort to begin mapping the affective topography of adolescent development, previous work has examined patterns of change in emotional reactivity and regulation (Zimmermann & Iwanski, 2018), as well as mood variability (Maciejewski et al., 2015) as it unfolds across the adolescent transition. In order to contextualize and interpret such patterns of change in emotional processing, however, research is needed to describe normative trajectories of mean-level change in positive and negative affect. Additionally, there are gender differences in positive and negative affect, yet a clear descriptive trajectory for when these gender differences emerge and how positive and negative affect unfold across development for boys and girls has not been explicated. The current study aimed to elucidate normative patterns of mean-level change in adolescent affective experience across the period spanning middle childhood through late adolescence, for youth in general and separately for each gender, with the goal of clarifying core mood processes typifying affective development across the pubertal transition and through the teenage years.

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✉ Julianne M. Griffith
jmg6@illinois.edu

[1] Department of Psychology, University of Illinois Urbana-Champaign, 603 E. Daniel Street, Champaign, IL 61820, USA

[2] Children's Hospital of Philadelphia, 3401 Civic Center Blvd., Philadelphia, PA 19104, USA

[3] University of Pennsylvania Perelman School of Medicine, 3400 Civic Center Blvd, Philadelphia, PA 19104, USA

Affect and Development: A Brief Conceptual Background

The study of emotion and emotional development has a rich history within the field of psychological science, and decades of research have yielded a host of theoretical perspectives regarding the nature and phenomenology of emotion. Although a single, unifying definition of emotion continues to be contested, emotions can be broadly understood as multimodal, focused, and fundamentally affective experiences that vary along dimensions of valence (i.e., pleasant/positive to unpleasant/negative) and intensity. Structural models of emotion organize discrete emotional experiences into two higher order factors: negative affect and positive affect (Watson, 2000). Affect, in this context, is used to refer to feeling states that, when persisting over time, comprise the core of an individual's subjective, diffuse experience of mood (see Fox et al., 2018 for a review). Negative affect reflecting the experience of such emotions as fear, guilt, and sadness, demonstrates relationships with outcomes including health complaints (Pressman et al., 2013), substance abuse (Baker et al., 2004), and eating pathology (Stice, 2001). Positive affect reflecting the experience of such emotions as cheerfulness, joy, interest, and self-assuredness, has been found to facilitate effective coping and recovery from stress (Tugade & Fredrickson, 2004), as well as potentiate processes of wellbeing, including resilience (Cohn et al., 2009), interpersonal closeness and relationship quality (Griffith et al., 2021; Ramsey & Gentzler, 2015) and physical health (Pressman et al., 2019).

Positive and negative affect can be further decomposed into state and trait elements. State affects comprise relatively transient emotional experiences, reflecting fluctuating "streams of affect" (Watson, 2000) that can be measured in real-time and largely correspond to proximal situational stimuli and demands. Trait affects, in contrast, represent relatively enduring tendencies toward the experience of certain emotion states (e.g., fearfulness, joy, exuberance) that are endogenous to the individual and predict individual differences in intra- and interpersonal functioning and behavior across contexts (Naragon-Gainey, 2018). State and trait affects are conceptually distinct and have been associated with divergent neurophysiological signatures (e.g., Li et al., 2020). Moreover, trait affect functions as an important context against which state affects are superimposed, moderating the effects of state affects on key outcomes of interest, including cardiovascular recovery from stress (Qin et al., 2019) and patterns of cortisol activity (Adam, 2006). Thus, developmental patterns in youth trait affective experience may have particularly pronounced influences on adolescent risk and resilience.

Theories of emotional development across childhood and adolescence emphasize the contextual embeddedness of affective systems, and highlight the role of evolving physiological, cognitive, and environmental inputs and demands in shaping affective experience (Buss et al., 2019). Functionalist theories of emotion, for example, situate emotional experience within a relational framework wherein emotions facilitate processes of goal attainment and broader situational adaptation. In a complementary manner, dynamic system theories of emotional development propose that emotion itself comprises a system of coordinated action across multiple units of analyses (e.g., goals, physiology, perception), and that macro-longitudinal changes in trait affectivity across development are driven by micro-longitudinal processes of emotional system reorganization and adaptation triggered by evolving contextual demands (Witherington & Crichton, 2007). Such theories converge to suggest that developmental transitions, particularly transitions characterized by rapid change in diverse aspects of both psychophysiological and social functioning, may represent a critical sensitive period for the development of positive and negative affective experiences.

Adolescence as Developmental Transition: Implications for Affective Functioning

The transition from middle childhood through the preteen and teenage years represents a period of marked change across domains of functioning, from the neurobiological to the social-contextual. During this developmental period, youth are tasked with negotiating evolving physiologies and cognitive abilities in the context of novel social demands and changing relational dynamics with parents and peers, and patterns of adjustment across this period have been described as setting the foundation for enduring trajectories of health and wellbeing (Sawyer et al., 2012). Although theories of emotional development as it unfolds during childhood have largely focused on earlier periods of the human lifespan (e.g., infancy), the evolving psychophysiological and social stimuli and demands inherent to the adolescent transition are likely to be highly consequential for youth affective experience. Indeed, developmentalists have long recognized the challenges inherent in navigating this developmental transition, and although adolescent "storm and stress" has been likely been historically overstated (Hollenstein & Lougheed, 2013), it is nevertheless the case that affective systems undergo normative, potentially tumultuous changes across the adolescent transition. The topography of these changes in terms of trait positive and negative affective experience, however, are not as of yet well understood.

Affective development across the adolescent transition must be contextualized in light of marked neural and

biophysiological changes that occur during this developmental period. A wealth of research supports increased activity in limbic regions of the brain, such as the amygdala and striatum, in response to salient affective stimuli during adolescence, suggesting that adolescent development may be characterized by heightened neural sensitivity to emotional cues (Crone & Dahl, 2012). Moreover, neural systems associated with social information processing appear to be enhanced across the adolescent transition, in what has been termed a "social reorientation" wherein youth demonstrate increased attunement to social threats and rewards (Nelson et al., 2016). Pubertal development, in particular, appears to be associated with patterns of activation and functional dynamics within and between regions of the brain relevant to emotion and emotion regulation, including the amygdala, striatum, and prefrontal cortex (Guyer et al., 2016). Importantly, lags have been observed between developmental trajectories of affective versus cognitive brain regions across youth development, with increased activation in regions associated with neural sensitivity to rewards and social appetitive cues coming online before corresponding increases in cognitive control and emotion regulatory functions, contributing to vulnerability for emotional lability and dysregulation during this period (Shulman et al., 2016).

Co-occurring with these changes in neural affective and social information processing are notable changes in youth's social ecologies. Indeed, as youth transition from middle childhood through adolescence, peers become increasingly important, with implications for youth daily moods (Weinstein et al., 2006) and behaviors (Dishion & Tipsord, 2011). At the same time, youth's relationships with parents change to accommodate youth's growing need for autonomy (Steinberg, 2001), although parents nevertheless play a prominent role in youth emotion socialization through late adolescence (Morris et al., 2017). The quality of adolescents' relationships with both parents and peers have been found to co-develop with youth trait affect over time, supporting mutually reinforcing patterns of relations between youth social functioning and emotional development (Griffith et al., 2021). In light of neurophysiological changes associated with increased affective reactivity and sensitivity to social cues occurring during the adolescent transition, the evolving social topography of adolescent development may potentiate particularly pronounced changes in trait affectivity across this period of development, which may subsequently contribute to patterns of ongoing social functioning across the lifespan.

Summary of Previous Research

Existing work indicates that the adolescent transition is indeed a period of affective change, although normative trajectories of trait positive and negative affect have not yet been continuously mapped across this period. Specifically, large-scale cross-sectional work indicates that adolescent development is characterized by increases in the intensity of negative affective responses to sadness-, anxiety-, and anger-inducing stimuli (Zimmermann & Iwanski, 2018), as well as non-linear changes in emotion regulation strategy use such that youth emotion regulation repertoires decrease from late childhood to middle adolescence before increasing through late adolescence and emerging adulthood (Zimmermann & Iwanski, 2014). With regard to positive emotions, cross-sectional research supports negative associations between pubertal development and neural response to reward, as well as youth subjective daily experience of positive affect in naturalistic settings (Forbes et al., 2010), suggesting that changes associated with puberty may be especially salient to youth positive affective experience. Moreover, research using daily diary designs has documented decreasing trajectories of affective variability between ages 13 and 18 (Maciejewski et al., 2015), suggesting that both positive and negative mood becomes increasingly stable as youth near emerging adulthood. Among this same sample, daily positive affect was observed to decrease, and daily negative affect was largely observed to increase, across this same follow up period, with girls reporting lower mean-levels of positive affect and high mean-levels of negative affect relative to boys (Maciejewski et al., 2017). Of note, however, this sample comprised predominantly post-pubertal youth, and the way in which affect develops across pubertal development has not been well described.

Additional inferences regarding normative patterns of trait affect from middle childhood through late adolescence can be drawn from studies examining related constructs. Trajectories of personality development during this developmental stage show patterns of mean-level change in extraversion and neuroticism, which are related to the experience of positive and negative affect, respectively (Watson, 2000). In a large, cross-sectional study of personality trait development across the lifespan, positive trends in neuroticism (suggesting increasing negative affect) and negative trends in extraversion (suggesting decreasing positive affect) between ages 10 and 17 were observed (Soto et al., 2011). In a longitudinal study of personality development from age 12 to 22, additional research detected quadratic growth in extraversion and neuroticism, such that these traits demonstrated "U" (in the case of extraversion) and inverted "U" (in the case of neuroticism) shaped trajectories (Borghuis et al., 2017). While no gender differences in extraversion were observed, curvilinear growth in neuroticism was observed among girls only; among boys, neuroticism remained stable (Borghuis et al., 2017). It is important to note, however, that personality traits are not

isomorphic with youth's affective experiences; personality traits comprise cognitive and behavioral tendencies in addition to trait emotion. Indeed, empirical work supports that neuroticism and negative affect are distinct, but conceptually related phenomena (Borghuis et al., 2020; Miller et al., 2009).

These personality trait development findings are consistent with experience sampling method research assessing trends in state affect across adolescence. Experience sampling method research indicates declines in global mood (Larson et al., 2002), and reductions in positive affect, specifically (Weinstein et al., 2007) during adolescence. Importantly, however, changes in state affectivity cannot be interpreted without knowledge of underlying patterns of trait affective change, given interactive effects of trait and state affective experience (Adam, 2006; Qin et al., 2019). Thus, research is needed to evaluate trajectories of trait affective experience from middle childhood, through the pubertal transition, and into late adolescence in order to advance knowledge of affective development and identify key leverage points in development during which to promote affective health and positive adaptation.

Gender and Trait Affect

There are both conceptual and empirical reasons to believe that developmental trajectories of trait affect may differ across boys and girls. Conceptually, many of the neurophysiological and social changes implicated as drivers in affective development unfold differently across boys and girls, suggesting that patterns of change in trait affect may differ according to youth's gender identity. The pubertal transition, for example, occurs earlier in girls relative to boys (Herman-Giddens et al., 2012; Sørensen et al., 2012), which may contribute to accelerated change in trait affective systems among biological females relative to biological males during earlier periods of adolescent development. Moreover, girls demonstrate enhanced sensitivity to social cues during adolescence relative to boys and may experience a more pronounced social reorientation during this period, such that girls' trait affective experience may be particularly susceptible to changing social-contextual factors and relational dynamics characteristic of adolescent development (Rose & Rudolph, 2006).

Empirically, both state affect and personality development literatures support the existence of gender differences in trajectories from late childhood across adolescence. Specifically, boys have been found to demonstrate steeper declines in positive affect/extraversion, and girls have been found to demonstrate more marked increases in negative affect/neuroticism from late childhood through adolescence (Soto et al., 2011; Weinstein et al., 2007). Of note, however, other work has observed steeper declines in positive emotions among girls relative to boys between the ages of 13 and 18 (Maciejewski et al., 2017). Additional research also suggests that girls experience greater variability in happy and sad emotions during this period (Maciejewski et al., 2015). Further, trajectories of affective disorders diverge by middle adolescence among boys and girls, with girls demonstrating more rapid growth in affective disorders including depression (characterized by high negative affect and low positive affect) and anxiety (characterized by high negative affect) relative to boys during this period (Zahn-Waxler et al., 2008). Of note, trajectories of non-affective disorders, including externalizing disorders, which are also common across the adolescent transition, do not demonstrate such gender differences in developmental trajectories, although boys tend to be consistently higher in externalizing relative to girls (Bongers et al., 2004). Together, this research suggests that trait positive and negative affect may develop differently across boys and girls.

Current Study

As noted in recent reviews of adolescent emotional development (e.g., Coe-Odess et al., 2019), descriptive knowledge of normative trajectories of mean-level change in positive and negative affect across the adolescent transition is lacking, and such research is needed in order to contextualize change in emotion regulation and state affect during this period of development, as well as to identify periods of heightened vulnerability to affective dysfunction. Thus, the present study investigated developmental trajectories of trait positive affect and negative affect using longitudinal, repeated measures of trait affect among a moderately large sample of youth assessed using an accelerated longitudinal cohort design. The primary aim of this study was to map normative trajectories of mean-level positive and negative affect as they continuously unfold from middle childhood (age 9) through late adolescence (age 17). Further, the present work aimed to test gender differences in both the magnitude and shape of change in positive and negative affect across the adolescent transition. Based on previous research, it was hypothesized that the developmental period spanning middle childhood through late adolescence would be characterized by decreasing trajectories of trait positive affect and increasing trajectories of trait negative affect. No a priori hypotheses regarding expected shapes (e.g., linear, non-linear) of developmental growth were made. Additionally, it was hypothesized that a gender difference in trait affective trajectories would emerge around mid-adolescence, at which point steeper increases in negative affect would be observed among girls relative to boys. It was tentatively hypothesized that steeper decreases in positive affect would be observed among boys

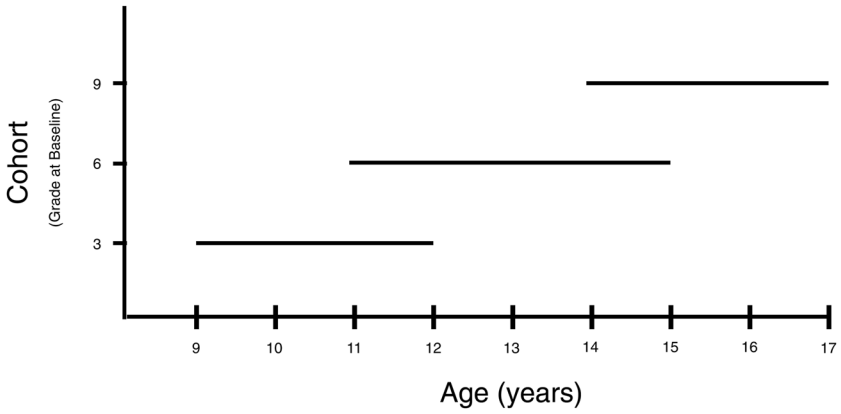

Fig. 1 Visual representation of the accelerated longitudinal cohort design implemented in the present study to model continuous trajectories of growth from age 9 to age 17. Solid horizontal lines represent the span of ages across which each cohort was sampled

relative to girls, consistent with trends observed for state affect and personality, although previous findings have been somewhat conflicted (cf. Maciejewski et al., 2017). No a priori hypotheses were made regarding whether shapes of trait affective change would differ between boys and girls.

Methods

Participants and Procedures

Participants comprised 665 youth recruited in 3rd ($N = 196$), 6th ($N = 248$), and 9th ($N = 221$) grade cohorts (age 8–16 at baseline, $M_{age} = 11.85$, $SD_{age} = 2.42$, 56% female). Inclusion criteria included English language fluency, absence of autism or psychotic disorder diagnosis, and IQ > 70 as assessed via parent report. Sample demographics were approximately representative of the ethnic and racial characteristics of the United States population (62.2% White, 11.3% African American, 9.6% Asian/Pacific Islander, 9.3% Multiracial or Other racial identity, with 7.5% identifying as Latinx). Further details regarding sampling procedures and participant characteristics are described in Hankin et al. (2007). All procedures were approved by the Institutional Review Board.[1] Informed consent was obtained from all participating caregivers, and assent was obtained from all participating youth.

Youth were invited to the laboratory to complete a battery of measures every 18 months for 3 years. Measures were administered via paper questionnaires, and participants were permitted to complete the questionnaire measure at their leisure within the laboratory. Participants completed the PANAS-C at each time point, yielding three assessment points per participant, or seven total assessment points spanning 3rd to 12th grade (ages 9–17) using an accelerated longitudinal cohort design (see Fig. 1). Accelerated longitudinal cohort designs capitalize on data sampled from adjacent age cohorts over time-limited longitudinal intervals to estimate a single, continuous growth curve characterizing trajectories of growth across time (Duncan et al., 1996). Participants who completed all time points were not significantly different from participants that did not complete all time points on measures of positive or negative affect at any time point (all $p > 0.05$). Data collection occurred between 2008 and 2013. Participants were compensated $30 at each time point in appreciation for their time and effort.

Measures

Demographics

At baseline, participants completed a brief questionnaire assessing basic demographic information, including child age, gender, racial/ethnic identity, and socioeconomic status.

Trait affect: positive affect and negative affect

Trait affect was assessed every 18 months using the Positive and Negative Affect Scale for Children (PANAS-C; Laurent et al., 1999). The version of the PANAS-C used in the present study prompted participants to reflect on how much they have experienced each emotion in "the past few weeks." The PANAS-C is a reliable and commonly used questionnaire measure assessing youth's experience of 27 discrete emotion states (e.g., "interested", "sad", "excited") on a 5-point Likert scale from (1) very slightly or not at all to (5) extremely. The positive affect subscale comprises 12 items assessing youth's experience of such positive emotion states as "cheerful", "delighted", and "calm". The negative affect subscale comprises an analogous 15 items assessing youth's feelings of such emotion states as "frightened",

[1] Study procedures received the following Institutional Review Board approvals: Rutgers University Protocol #08-436c, University of Denver Protocol #2008-0810, Children's Hospital of Philadelphia Protocol #17-014212, and the University of Illinois at Urbana-Champaign Protocol #17605.

"ashamed", and "upset". The positive affect and negative affect subscales of the PANAS-C demonstrate strong psychometric properties among adolescent samples and evidence good convergent and discriminant validity in both clinical (Hughes & Kendall, 2009) and community samples (Laurent et al., 1999). Overall, the positive affect and negative affect subscales demonstrated good reliability at all assessment points in the present sample ($\alpha = 0.86–0.89$ and 0.89–0.91 for positive affect and negative affect, respectively). Scale authors suggest that affect adjectives may not be well understood by children prior to achieving a grade 4 reading level (Laurent et al., 1999). Thus, PANAS-C data were not included in analyses for participants prior to age 9.

Analytic Strategy

Due to nesting of repeated measures within subjects, longitudinal multi-level modeling was used to characterize developmental trajectories of positive affect and negative affect. For both positive affect and negative affect, two-level growth models were specified with measurement occasion by age (level 1) nested within individual (level 2). Multi-level modeling was chosen because it is robust to unbalanced designs and accounts for correlations between repeated measures (Raudenbush & Bryk, 2002). Participants were included in analyses provided that data were complete for at least one time point. Any missing data at any given time point were handled via maximum likelihood estimation procedures that can address potential missing data and yield accurate parameter estimates in an unbiased manner assuming data are at least missing at random. Complete data were available for 89% of the original sample at Time 2 and for 78% of the original sample at Time 3. There were no significant differences in terms of mean positive and negative affect between participants who were lost to attrition over the course of the study and those who were retained, and the gender distribution of the sample was consistent across time points (57% girls at Time 2 and 56% girls at Time 3). All analyses were implemented using the 'lme4' package in R (Bates et al., 2015; R Core Team, 2020).

Prior to testing the multi-level models, intra-class correlation coefficients (ICCs) were calculated for both positive affect and negative affect by specifying the intercept-only model for each outcome. In longitudinal multi-level modeling, the ICC measures within-subject variance and thus provides support for the appropriateness of the multi-level approach for modeling developmental trajectories.

Next, data were visually inspected to determine the likely shape (e.g., linear, quadratic, cubic) of the best-fitting model for each outcome. Fit indices, including model deviance, log-likelihood, Akaike Information Criteria (AIC), and Bayesian Information Criteria (BIC) were used to support model specification, and convergence across indices was prioritized to assess model fit, rather than reliance on any single fit statistic (Raudenbush & Bryk, 2002). Multi-level models were then specified including gender as a time-invariant covariate to evaluate overall growth in positive and negative affect over time while testing for differences between genders. Finally, changes in positive and negative affect over time were each modeled separately by gender to examine differences in the shape of the developmental trajectory between boys and girls.

Results

Preliminary Analyses

Descriptive statistics for variables of interest are reported in Table 1. Preliminary analyses indicated that negative affect was higher among girls relative to boys at Time 1 and Time 3; negative affect was higher among boys relative to girls at Time 2. Girls' positive affect was significantly higher than boys' at Time 1, but positive affect did not significantly differ between genders at Time 2 or Time 3 (see Table 1; mean-level affect plotted by age and gender is reported in Fig. 2). Age was negatively correlated with positive affect at Time 2 and Time 3 ($r = -0.16$ and -0.12, respectively) and

Table 1 Means (and SDs) by gender and measurement occasion

	Total	Range	Boys	Girls	*t*(df)	*p*
T1 Age	12.36 (2.09)	9.00–16.69	12.29 (2.16)	12.41 (2.04)	0.71 (545.14)	0.479
T1 Positive affect	3.70 (0.71)	1.17–5.00	3.62 (0.73)	3.76 (0.69)	2.22 (531.18)	0.027
T1 Negative affect	1.87 (0.66)	1.00–4.67	1.72 (0.57)	1.98 (0.70)	4.82 (582.39)	<0.001
T2 Age	13.36 (2.26)	9.27–16.97	13.28 (2.28)	13.43 (2.25)	0.75 (488.96)	0.454
T2 Positive affect	3.63 (0.72)	1.33–5.00	3.62 (0.72)	3.64 (0.72)	0.35 (482.63)	0.724
T2 Negative affect	1.71 (0.57)	1.00–4.07	1.79 (0.61)	1.61 (0.48)	3.83 (516.32)	<0.001
T3 Age	13.77 (1.58)	10.69–17.00	13.63 (1.52)	13.88 (1.62)	1.49 (340.35)	0.138
T3 Positive affect	3.55 (0.73)	1.25–5.00	3.56 (0.71)	3.54 (0.76)	−0.22 (336.45)	0.825
T3 Negative affect	1.67 (0.58)	1.00–3.87	1.54 (0.48)	1.77 (0.63)	3.77 (347.95)	<0.001

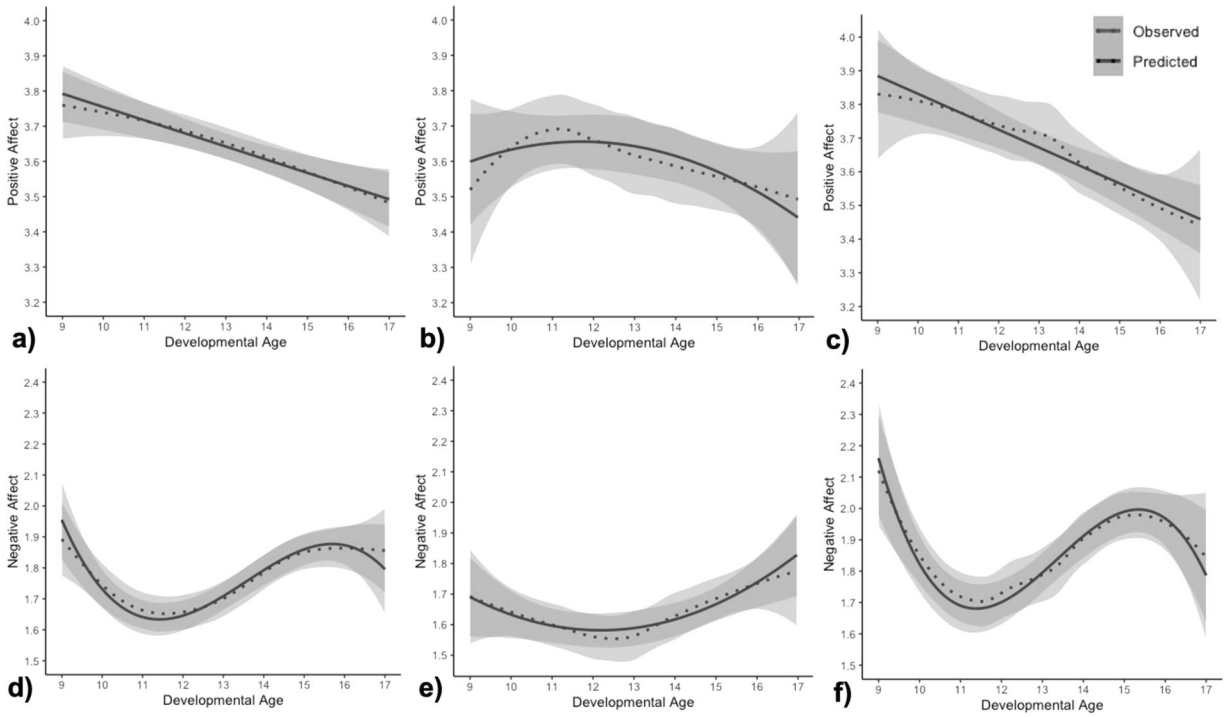

Fig. 2 Trajectories of positive affect (PA) from age 9–17 for the full sample (**a**), boys (**b**), and girls (**c**), and trajectories of negative affect (NA) from age 9–17 for the full sample (**d**), boys (**e**), and girls (**f**). Gray regions indicate standard errors

positively correlated with negative affect at Time 2 and Time 3 ($r = 0.16$ and 0.20, respectively). Positive and negative affect were also negatively associated at Time 2 and Time 3 ($r = -0.17$ and -0.26, respectively). Correlations between primary variables across time points and within genders are reported in Table 2.

The results from the unconditional means models for positive and negative affect pointed to the appropriateness of multi-level modeling as the analytic approach, revealing that 37% of the variance in positive affect and 34% of the variance in negative affect was attributable to time-invariant differences between youth (ICCs = 0.37 and 0.34, respectively).

Trajectories of Positive Affect

Visual inspection of the data as well as tests of model fit (see Supplementary Table S1) suggested that a linear model best characterized the trajectory of positive affect in the full sample. Parameter estimates indicated that youth had relatively high levels of positive affect in middle childhood, but that positive affect gradually decreased over time (see Fig. 2a). The full-sample model including gender as a time-invariant covariate revealed a significant main effect of gender indicating that boys' positive affect was lower than girls' at baseline ($b = -0.24$, $p = 0.006$), as well as a significant gender × age interaction ($b = 0.04$, $p = 0.018$), suggesting that gender moderated growth trajectories of positive affect over time.

Analysis of growth trajectories by gender revealed different patterns of change among boys and girls. When growth in positive affect was modeled separately for girls, the pattern was similar to that of the full sample—specifically, age 9 positive affect was relatively high and positive affect decreased linearly over time (see Fig. 2c). In contrast, a quadratic growth model best characterized positive affect trajectories for boys, where age 9 positive affect was lower than it was for girls but increased until approximately age 12, then decreased until age 17 (see Fig. 2b).

Trajectories of Negative Affect

A cubic model best characterized negative affect in the full sample (see Supplementary Table S1). Specifically, levels of negative affect decreased between ages 9 and 11.5, increased between ages 11.5 and 15.5, then decreased between ages 15.5 and 17 (see Fig. 2d). As with positive affect, the full sample model of growth in negative affect over time that included gender as a time-invariant covariate revealed significant differences between boys and girls in terms of negative affect, both at baseline and over time. At baseline, boys' levels of negative affect were significantly lower than girls' ($b = -0.51$, $p < 0.001$), and significant interaction terms between gender and the linear, quadratic,

Table 2 Correlations between primary variables at each measurement occasion

	Full sample					
	Time 1		Time 2		Time 3	
	1	2	1	2	1	2
1. Age	–		–		–	
2. Positive affect	−0.021	–	−0.158***	–	−0.118*	–
3. Negative affect	0.060	−0.042	0.164***	−0.168***	0.196***	−0.258***
Boys						
1. Age	–		–		–	
2. Positive affect	0.056	–	−0.127	–	−0.151	–
3. Negative affect	0.075	0.003	0.159*	−0.092	0.096	−0.261**
Girls						
1. Age	–		–		–	
2. Positive affect	−0.094	–	−0.183**	–	−0.095	–
3. Negative affect	0.043	−0.102	0.163**	−0.222***	0.236***	−0.262***

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

and cubic parameters suggest that the rate of growth over time significantly differed between boys and girls.

Similar to patterns observed for positive affect, trajectories of negative affect differed according to child gender. Among boys, levels of negative affect in middle childhood were lower relative to girls, and the negative affect trajectory for boys was best captured by a quadratic model showing that negative affect decreased between ages 9 and 12.5, then increased until age 17 (see Fig. 2e). Among girls, levels of negative affect decreased between ages 9 and 11, increased steadily until age 15, then decreased until age 18 in a pattern of cubic change (see Fig. 2f). Multi-level model results for all models are summarized in Table 3.

Sensitivity Analyses

To examine the robustness of these findings, a series of sensitivity analyses were conducted incorporating youths' social characteristics (specifically, their racial identity and their caregivers' highest reported level of education) as covariates in the multi-level models.

Positive affect

When social characteristics were included in the full-sample model of positive affect over time, modest improvements in model fit were shown (log-likelihood = −1503.1, deviance = 3006.3, AIC = 3026.3, BIC = 3079.1). The results indicated significant negative change in positive affect over time ($b = -0.05$, $p < 0.001$), with no significant differences in positive affect by child racial identity or my caregiver level of education. For girls, including social characteristics in the model also modestly improved fit (log-likelihood = −849.0, deviance = 1698.1, AIC = 1718.1, BIC = 1765.2). As with the full-sample model, developmental age was negatively associated with positive affect ($b = -0.07$, $p < 0.001$) and there were no significant differences in positive affect over time by race or parent education. Growth parameters for boys' positive affect over time were similar when social characteristics were included in the model (linear $b = -1.22$, $p = 0.101$; quadratic $b = -1.50$, $p = 0.016$), and neither race nor parental education were associated with change in positive affect over time. Model fit for boys' trajectories of positive affect was slightly improved when social characteristics were included (log-likelihood = −643.1, deviance = 1286.2, AIC = 1308.2, BIC = 1357.1).

Negative affect

Sensitivity analysis modeling change in negative affect over time for the full sample indicated no significant differences in growth by race or parental education, although including these parameters in the model modestly improved fit (log-likelihood = −1283.8, deviance = 2567.5, AIC = 2591.5, BIC = 2654.9). As with positive affect, growth parameters for negative affect were similar for the full sample when social characteristics were added to the model (linear $b = 1.04$, $p = 0.101$; quadratic $b = 1.93$, $p = 0.001$; cubic $b = -2.44$, $p < 0.001$). The same pattern of results was found for girls' negative affect; model fit was improved when social characteristics were included (log-likelihood = −783.9, deviance = 1567.9, AIC = 1591.9, BIC = 1648.4) and growth parameters mirrored those for the model that did not include child race and parent education (linear $b = 0.861$, $p = 0.203$; quadratic $b = 1.78$, $p = 0.003$; cubic $b = -2.93$, $p < 0.001$). Changes in negative affect over time for boys were also not significantly affected by child race or parent education, and when these factors were included in

Table 3 Parameter estimates for best-fitting models of positive and negative affect

Positive affect—full sample				
Fixed effects	*b*	SE_b	*t*	*p*
Intercept	3.93	0.06	67.19	<0.001
Linear slope	−0.06	0.01	−5.34	<0.001
Gender	−0.24	0.09	−2.74	0.006
Gender × Time	0.04	0.02	2.37	0.018
Random effects	Variance		SD	
Individual random intercept	0.20		0.44	
Residual	0.32		0.56	
Positive affect—girls				
Fixed effects	*b*	SE_b	*t*	*p*
Intercept	3.93	0.06	67.42	<0.001
Linear slope	−0.06	0.01	−5.22	<0.001
Random effects	Variance		SD	
Individual random intercept	0.17		0.42	
Residual	0.33		0.58	
Positive affect—boys				
Fixed effects	*b*	SE_b	*t*	*p*
Intercept	3.61	0.04	100.62	<0.001
Linear slope	−1.25	0.73	−1.71	0.088
Quadratic	−1.49	0.61	−2.45	0.015
Random effects	Variance		SD	
Individual random intercept	0.23		0.48	
Residual	0.29		0.54	
Negative affect—full sample				
Fixed effects	*b*	SE_b	*t*	*p*
Intercept	2.23	0.08	27.87	<0.001
Linear	−0.48	0.08	−6.40	<0.001
Quadratic	0.14	0.02	6.21	<0.001
Cubic	−0.01	0.00	−5.64	<0.001
Gender	−0.51	0.12	−4.32	<0.001
Linear × Gender	0.39	0.11	3.46	<0.001
Quadratic × Gender	−0.12	0.03	−3.51	<0.001
Cubic × Gender	0.01	0.00	3.37	<0.001
Random effects	Variance		SD	
Individual random intercept	0.11		0.33	
Residual	0.25		0.50	
Negative affect—girls				
Fixed effects	*b*	SE_b	*t*	*p*
Intercept	1.87	0.03	69.56	<0.001
Linear slope	0.71	0.67	1.06	0.289
Quadratic	1.86	0.60	3.10	0.002
Cubic	−2.95	0.57	−5.15	<0.001
Random effects	Variance		SD	
Individual random intercept	0.13		0.35	
Residual	0.30		0.54	
Negative affect—boys				
Fixed effects	*b*	SE_b	*t*	*p*
Intercept	1.64	0.03	65.53	<0.001
Linear slope	0.41	0.54	0.75	0.451
Quadratic	0.93	0.47	1.97	0.0496
Random effects	Variance		SD	
Individual random intercept	0.09		0.31	
Residual	0.18		0.42	

the multi-level model, growth parameters were similar indicating an initial decrease in negative affect and subsequent increases until age 17 (linear $b = 0.55$, $p = 0.316$; quadratic $b = 0.93$, $p = 0.051$). Model fit for boys' negative affective trajectories was improved when social factors were included (log-likelihood = −458.3, deviance = 916.5, AIC = 938.5, BIC = 987.4).[2]

Discussion

The transition from middle childhood through late adolescence is purported to be a time of emotional upheaval (i.e., "storm and stress"), characterized by heightened emotionality and rapid psychosocial change. Indeed, adolescent youth are normatively tasked with novel challenges and demands across domains of functioning, from neurophysiological changes predisposing them to enhanced affective reactivity, to social role changes and evolving relationship dynamics with family and friends. Previous work has described normative trajectories of state affects and emotional reactivity in adolescence; however, youth momentary affective experiences must be necessarily contextualized in light of more general dispositions toward positive and negative emotions, or trait positive and negative affect, trajectories of which have not been continuous mapped across the pubertal transition and into late adolescence. Given that adolescence is a period during which moods are crystallizing (Maciejewski et al., 2015) and during which life-course persistent trajectories of health and wellbeing may be established (Sawyer et al., 2012), such a mapping is vitally needed, as trait positive and negative affect predict a wealth of important developmental outcomes, including interpersonal functioning (e.g., Griffith et al., 2021), health outcomes (e.g., Pressman et al., 2013, 2019), and psychopathology (e.g., Rottenberg, 2017). Thus, the present study used a growth curve modeling approach to describe continuous trajectories of trait positive and negative affect from middle childhood through late adolescence, revealing normative trajectories of trait positive and negative affective development among adolescent boys and girls, with implications for understanding youth risk and resilience.

The present findings illuminate developmental trends in trait positive and negative affective trajectories that differ somewhat for boys and girls. Overall adolescence is characterized by declines in positive affect and patterns suggesting curvilinear change in negative affect from childhood to late adolescence. Importantly, average mean-level trajectories differed across boys and girls, suggesting that youth gender may influence patterns of positive and negative affective experience across development. Taken together, results add new descriptive trajectory information to

[2] Complete fit statistics for these sensitivity analyses are tabulated in Supplementary Table S2, and full model results accounting for social difference variables at reported in Supplementary Table S3.

the literature by demonstrating affective changes from childhood to late adolescence.

Results of the present growth curve analyses indicate that as youth transition across adolescence, they experience mean-level declines in the subjective experience of positive affect. Interestingly, patterns of declines differed slightly across youth gender, such that consistent, linear declines in positive affect were observed between ages 9 and 17 among youth identifying as female, and quadratic change characterized by initial increases between ages 9 and 12, and subsequent decreases between ages 12 and 17, was observed among youth identifying as male. This gender difference in trajectories of positive affective growth may be explained, at least in part, by differences in pubertal timing among girls and boys, as previous cross-sectional work has indicated that functioning in the neural reward systems, as well as the subjective experience of pleasant emotion states, are specifically associated with pubertal development relative to chronological age (Forbes et al., 2010). Given that the onset of the pubertal transition has been observed to occur earlier among girls relative to boys (e.g., Herman-Giddens et al., 2012; Sørensen et al., 2012), it is possible that normative declines in positive affect similarly onset earlier among female youth in association with other neural and physiological changes associated with pubertal development.

Curvilinear change in negative affect across the transition from middle childhood to late adolescence was observed among both boys and girls, although that pattern of curvilinear change in negative affect differed across genders. Among boys, change in negative affect was noted to occur in a manner consistent with a positive quadratic trajectory, with declines in negative affect occurring between ages 9 and 12.5 followed by subsequent increases in negative affect occurring between ages 12.5 and 17. In contrast, among girls, negative affect trajectories vacillated between increasing and decreasing trends in a pattern of cubic change. It is possible that this undulating pattern of growth in negative affective experience among girls again reflects differences in pubertal development and pubertal timing, given that pubertal development, specifically, has been associated with patterns of neural response to affective cues, with peaks in mid-adolescence (Vijayakumar et al., 2019). Girls may be especially affected by stress sensitization effects of pubertal development, given previous findings indicating enhanced interpersonal stress exposure and stress reactivity among adolescent girls relative to adolescent boys (Hankin et al., 2007). The pattern of change in negative affect observed among girls may reflect that the period spanning age 12 to age 16 represents a period of particularly heightened risk for affective dysfunction among female youth, consistent with epidemiological research indicating that rates of mood disorders rise markedly among young women during this period (Avenevoli et al., 2015; Merikangas et al., 2010). Although quadratic increases were observed among young men, these increases were relatively small in magnitude, and findings generally align with results of previous studies demonstrating relatively reduced change in negative affect and related constructs (i.e., neuroticism) among boys relative to girls (e.g., Borghuis et al., 2017). Future research is needed to evaluate factors contributing to gender differences in affective trajectories across the adolescent transition, as well as implications of these divergent trajectories for subsequent developmental outcomes.

The present study builds on prior longitudinal work investigating developmental trajectories in affect, extending this work from middle childhood to late adolescence. Present findings indicate that affective trajectories undergo a normative reversal in early adolescence. Previous research has found that the period spanning late infancy through middle childhood is characterized by linear trends of increasing positive affect and decreasing negative affect (Olino et al., 2011), whereas present results indicate declining positive affect and curvilinear change in negative affect beginning between middle childhood and early adolescence. Trajectories of mean-level trait affect detected in the current study are generally consistent with trends observed in literature on related constructs among adolescent youth. Experience sampling method studies probing developmental patterns in state affect have indicated declines in global mood state broadly (Larson et al., 2002), and state positive affect specifically (Weinstein et al., 2007), across adolescence. Similarly, studies of personality trait development have indicated increasing neuroticism (associated with negative affect) and decreasing extraversion (associated with positive affect) across this period (Soto et al., 2011; Borghuis et al., 2017).

Moreover, the present work provides essential descriptive information needed to holistically evaluate and interpret previous research documenting increases in emotional reactivity and trends in state affective experience among adolescent youth. For example, previous work has observed steady increases in the intensity of youth emotional responses to negative affect-inducting stimuli across ages 11–19. Results of the present study, however, indicate that these increasing trajectories of negative affect reactivity are only part of the story. Indeed, youth may be most at risk not merely when the intensity of their negative affective response peaks, but rather during periods in which this heightened negative emotional reactivity occurs in the context of relatively elevated trait negative affect and restricted emotion regulation abilities (e.g., between ages 14 and 16; Zimmermann & Iwanski, 2014). Risk may be further elevated among girls, who experience sharper declines in trait positive emotionality relative to boys across this period, and may therefore lack the fortifying, resilience-boosting resources associated with trait positive affectivity (Cohn et al., 2009). This interpretation aligns with epidemiological research indicating diffuse risk for

psychological dysfunction during this developmental period, characterized by elevated rates of both internalizing and externalizing disorders (Paus et al., 2008).

The present findings should be interpreted in the context of several limitations. First, informed by leading structural models of affect (e.g., Watson, 2000), the present work aimed to elucidate trajectories of positive and negative affect broadly, and thus collapsed across a number of discrete positive and negative affects. Circumplex models of affect, however, propose that affect differs along dimensions of both valence and arousal (Posner et al., 2005), and it is possible that high- and low-arousal positive and negative affects develop in different ways. Although outside the scope of the present work, future research should aim to disentangle trajectories of high- and low-arousal affect across the adolescent transition. Of note, low-arousal positive emotions are relatively underrepresented on the PANAS-C, and future work is needed to examine the ways in which emotions including love, contentment, and gratitude develop across this period of development. Additionally, the present research provides insight into only one facet of youth's affective development (i.e., their subjective experience). Future work should aim to evaluate the way in which trajectories of youth's felt sense of positive and negative affect does or does not align with trajectories of other affective systems (e.g., physiological, neurobiological, etc.). Further, it must be noted that the present sample included predominantly White youth. Future work should aim to evaluate trajectories of affective development among more diverse samples of youth.

Despite these limitations, the present study demonstrates a number of notable strengths and represents an important addition to the extant literature on emotional development. Multi-level modeling analyses implemented in the present work permitted sophisticated modeling of affective trajectories among a large sample of community youth. Further, the present longitudinal, repeated measures design spanning middle childhood to late adolescence provided rich insight into patterns of change in mean-level positive and negative affect across a critical period of human development, elucidating trends in normative emotional experience. Importantly, by empirically mapping mean-level trajectories of positive and negative affect across ages 9 to 17, the present study addresses a critical gap in our knowledge of emotional development across a vulnerable period of the lifespan.

Conclusion

Adolescence has been historically described as a period of "storm and stress", and previous research has indicated increases in emotional reactivity and non-linear patterns of change in emotion regulation abilities during this period. Although some limited work has examined patterns of development in state affect during this time, a critical gap in the literature remains regarding normative trajectories of mean-level change in positive and negative affect from middle childhood through late adolescence. The present study advanced knowledge of adolescent emotional development by evaluating mean-level affective trajectories as they unfold continuously between ages 9 and 17 using an accelerated longitudinal cohort design. The findings of the present work indicate that the period spanning middle childhood to late adolescence is characterized by declining positive affect, with gender differences suggesting that positive affect decreases later among boys relative to girls. Alongside these normative declines in positive affect, middle childhood to late adolescence is characterized by non-linear change in negative affect such that boys demonstrate quadratic increases and girls demonstrate cubic fluctuations in mean-level negative affective experience. Together, the present study findings illustrate normative trends in adolescents' emotional experience, providing key contextual information needed to interpret changes in emotional reactivity and regulation occurring during this period. The study findings indicate that middle adolescence may be a period of particular risk for affective dysfunction, particularly among girls, as negative affect rises in the context of steadily declining positive affect. More broadly, these results may fruitfully inform interventions aimed at promoting emotional wellbeing across adolescent development, highlighting periods of relative risk across the adolescent transition.

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Data Sharing and Declaration The manuscript's data will not be deposited, as study participants did not provide consent to have their data publicly shared.

Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

Ethical Approval All study procedures were approved by the institutional review boards at the University of Denver, Rutgers University,

the University of Illinois at Urbana-Champaign, and the Children's Hospital of Philadelphia.

Informed Consent Informed consent was obtained from participating caregivers. Assent was obtained from all participating adolescents.

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Julianne M. Griffith is a graduate student at the University of Illinois at Urbana-Champaign. Her research interests include youth affective

development, with an emphasis on the way in which the dynamic interplay between youth positive affect and social-contextual factors contributes to risk for psychopathology across the adolescent transition.

Hannah M. Clark is a postdoctoral fellow at the University of Illinois at Urbana-Champaign interested in examining the social, emotional, and cognitive sequelae of adverse experiences for women and children. She has a special interest in intervention science and determining mechanisms of change in evidence-based psychotherapies in order to optimize outcomes for vulnerable populations.

Dustin A. Haraden is a graduate student at the University of Illinois at Urbana-Champaign. His research interests include the relations between circadian rhythm, pubertal development and depression in youth.

Jami F. Young is an Associate Professor of Psychiatry and Director of Psychosocial Research at Children's Hospital of Philadelphia Research Institute. Her research interests include identification, prevention, and treatment of adolescent depression.

Benjamin L. Hankin is an Endowed Professor, Associate Head, and Director of Clinical Training at University of Illinois at Urbana-Champaign. His research interests include risk factors and mechanisms in depression and related emotional disorders in children and adolescents and translation of knowledge about vulnerability into evidence-based assessments and interventions.