JOURNAL OF RESEARCH ON ADOLESCENCE, 17(3), 587–600

Longitudinal Patterns of Daily Affect and Global Mood During Adolescence

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This study examined grade and sex patterns in real-time measures of daily mood using Ecological Momentary Assessments via palmtop computers among 8th ($N = 296$) and 10th graders ($N = 266$) for 1 year using a three-wave longitudinal design. Participants responded to five to seven random prompts/day for 7 consecutive days; when prompted, participants rated eight mood adjectives assessing positive affect (PA) and negative affect (NA). Global depressed mood was also assessed via self-report questionnaire at every wave. Mixed-effects regression analyses indicated that PA modestly but significantly declined across Grade 8 to 11, but NA was relatively stable over time. Sex by time interactions showed that boys experienced greater declines in daily mood over time than did girls. In contrast, global depressed mood did not change over time, and girls reported higher

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depressed mood than boys. Findings suggest that normative mood declines in adolescence may be driven by deteriorations in PA, rather than increases in NA.

In recent years, real-time data assessments have increasingly been used to study phenomena in the context in which they occur (Stone & Shiffman, 1994). The present study was designed to add to the real-time literature on adolescent mood (Larson & Lampman-Petraitis, 1989; Larson, Moneta, Richards, & Wilson, 2002) by using a three-wave longitudinal design to examine prospectively gradations in positive and negative mood patterns among adolescents.

Previous studies utilizing real-time methods identified a worsening trend in mood across early adolescence (Larson & Lampman-Petraitis, 1989), with affective declines stabilizing by mid-high school (Larson et al., 2002; Moneta, Schneider, & Csikszentmihalyi, 2001). Similarly, longitudinal investigations using global questionnaires have shown that depressed mood and symptoms rise in early adolescence (e.g., Garber, Keiley, & Martin, 2002; Ge, Lorenz, Conger, Elder, & Simons, 1994). Of note, past studies primarily have focused on negative or depressive affect, whereas few studies have longitudinally examined positive mood patterns in adolescence. Positive affect (PA) is an integral part of well-being, and leading models conceptualize PA as a distinct construct from negative affect (NA; e.g., Watson & Tellegen, 1985). Thus, understanding developmental trends in emotional experience relies on the examination of both PA and NA. Although the empirical emphasis on positive moods is scarce, the available adolescent research indicates that the frequency and valence of PA is greater among pre- and early adolescents than among high school students (Jacques & Mash, 2004; Larson et al., 2002).

Findings concerning sex differences in mood patterns have been mixed, perhaps due in part to heterogeneity in the measurement of mood across studies. Larson et al. (2002) found that girls' affect across adolescence, assessed using real-time methods, was more positive than boys' affect overall. In contrast, studies using self-report questionnaires of global mood report that girls experience an increase in depressed mood in early adolescence whereas for boys, mood remains relatively stable (Garber et al., 2002; Ge et al., 1994; Twenge & Nolen-Hoeksema, 2002). Given the increased prevalence rates of clinical depression among girls by middle adolescence (Hankin et al., 1998), these discrepant findings warrant further study.

Existing research on adolescent affect has been limited by self-report measures of global mood, which are subject to retrospective recall biases (Stone & Shiffman, 1994) and do not fully capture the day-to-day

experiences of adolescents (Larson et al., 2002). Real-time assessments of PA and NA using Ecological Momentary Assessments (EMAs) allow for random, repeated assessments of mood, increasing the sensitivity to detect change in mood patterns (Stone & Shiffman, 1994). Previous real-time studies have been limited by cross-sectional designs (e.g., Larson & Lampman-Petraitis, 1989) or single-item measures of affect (e.g., Moneta et al., 2001).

The present study builds on previous real-time research by (1) longitudinally examining daily PA and NA across shorter periods of development (grades 8–9 and 10–11); and (2) by using a multimethod approach to assess how daily mood via EMAs correspond to self-reports of global mood and depressive symptoms. We addressed these questions within the context of a sample at slightly elevated risk for mood declines. Adolescence is a period of vulnerability for both mood disorders and for cigarette smoking (Jamner et al., 2003). Research suggests that smoking in adolescence is linked to NA and depressive symptoms (e.g., Windle & Windle, 2001). The current data were drawn from a longitudinal study of adolescent smoking, and the sample was selected based on smoking intentions and/or prior smoking experience. As such, the sample chosen may be one at risk for deteriorations in mood.

We hypothesized that adolescents would experience significant declines in PA and NA over time. In light of previous research indicating that mood declines stabilize by mid-adolescence (Larson et al., 2002; Moneta et al., 2001), we expected that the eighth grade cohort would experience greater mood declines than a 10th grade cohort over time.

METHODS

Design Overview

Data for this study come from a longitudinal natural history study of adolescent smoking. The longitudinal study included 7-day time/event sampling via palmtop computers (EMA), self-report questionnaires, and in-depth interviews at baseline, 6-, and 12-month waves. Data for the current study included the baseline, 6-, and 12-month EMA and questionnaire measures.

Participants

Participants were 562 eighth and 10th grade students from 14 Chicago area schools, invited to participate in the longitudinal study based on

responses to a brief survey about smoking. Survey responses were used to identify students who were contemplating smoking or experimenting with cigarettes; 5,278 students were screened, 2,153 met inclusion criteria, and 1,457 were invited to participate in the study. Of those invited, 713 agreed to participate (48%), and 562 (81%) completed the baseline wave. Failure to complete baseline was due to (1) students were sick or absent for their data collection visit and were unable to reschedule ($n = 25$, 17%); (2) failure to bring parental consent forms ($n = 12$, 8%); or (3) students were turned away by research staff because enrollment in a particular school was overfilled ($n = 114$, 76%). Among the eighth grade cohort ($N = 296$), mean age was 13.94 years ($SD = .40$); 52% were girls; and racial/ethnic composition was as follows: 68% White, 3% African American, 18% Latino, and 12% Other/Bi-racial. Among the 10th grade cohort ($N = 266$), mean age was 16.01 years ($SD = .42$); 58% were girls; and racial/ethnic composition was 74% White, 8% African American, 8% Latino, and 4% Other/Bi-Racial. Average parental education for the sample was as follows: 30% completed high school or less, 17% completed some college, and 45% completed college or more.

Procedures

All participants received training on the use of the EMA device at the beginning of the data collection week, and carried the device for 7 consecutive days at each wave. Participants were instructed to deactivate the device at their bedtime, and to program the device's alarm clock for morning activation. Once activated, the device randomly prompted the adolescents five to seven times per day to answer questions about their mood, behavior, and situation; only mood items were analyzed in the current study. Participants received a payment of $40 at the end of each data week. In addition, participants completed questionnaires at the beginning of each wave, and were paid $10 upon receipt of each completed questionnaire. Baseline visits were staggered throughout the fall and spring at various schools. All participants were in either eighth or 10th grade at baseline, and had transitioned into ninth or 11th grade by the 12-month wave.

Measures

Daily affect. Participants were asked on each EMA interview to rate their mood just before the random prompt; for example, ''Before the signal, I felt happy.'' Subjects responded to mood adjectives using a

10-point Likert-type scale. The mood adjectives were originally derived through pilot work with adolescents. Factor analyses on pilot work and the current data set revealed a ''PA'' factor (i.e., happy, relaxed, and cheerful) all with factor loadings of at least .74 (Cronbach's α in the current sample ranged from .72 to .73 across waves). A ''NA'' factor was formed by lonely, embarrassed, sad, angry, and left-out, all with factor loadings >.50 (Cronbach's α ranged from .73 to .78 across waves). PA and NA correlated $-.44$ to $-.36$ across waves.

Global depressed mood. Global depressed mood and depressive symptoms were measured with the Children's Depression Inventory (CDI; Kovacs, 1985), a self-report measure that assesses the severity of current symptoms such as disturbed moods, hedonic capacities, self-evaluations, and vegetative functions. Cronbach's α for the CDI ranged from .87 to .90.

Demographics and smoking history. Age, grade, sex, race/ethnicity, parental education, and smoking history were assessed via paper-and-pencil questionnaires. For the present study, adolescents were categorized into one of two smoking groups: (1) Nonsmokers, those reporting having never, ever, or recently tried smoking across the entire study ($N = 379$); and (2) Experimenters, those reporting more frequent experimentation ($N = 183$). This division was based on the assumption that youth who experiment with smoking may be more vulnerable to a variety of problem behaviors than youth who try once or twice (Jamner et al., 2003). Average number of days smoking in the past 30 days for nonsmokers was 1.27 ($SD = .57$), versus 3.99 days ($SD = 2.30$) for experimenters.

RESULTS

Analytic Approach

Longitudinal mood patterns were analyzed using mixed-effects regression models (MRMs; Laird & Ware, 1982) via SAS PROC MIXED. MRMs are well-suited for the analysis of individual change over time, particularly analyses involving the multiple observations collected via EMA. The current study used random intercept and trend modeling, a subclass of MRM that accounts for each individual's distinct initial level of affect and rate of change across time, rather than focusing only on average mood changes over time. Thus all available data points are used and not summary scores.

Separate MRMs were evaluated for PA, NA, and CDI scores. Each set of analyses tested the main effects of time (coded as 0 = baseline, 1 = 6 months, 2 = 12 months), grade cohort (coded as 0 = younger cohort), and sex (coded as 0 = boys) on mood, as well as the degree to which time trends varied by grade cohort and sex (Grade Cohort × Time, Sex × Time, and Grade Cohort × Sex × Time interactions). Smoking status (dichotomized as 0 = nonsmokers, 1 = experimenters) and Smoking Status × Time were also included to control for possible confounding effects due to differences in smoking status between the two cohorts.

Compliance and Attrition

Participants responded to (and provided mood reports for) a mean of 33.5 ($SD = 9.86$) random prompts per person per wave and missed a mean of 5.7 ($SD = 5.75$) prompts. In total, participants responded to 85% of all random prompts ($SD = .14$). Attrition in the current study was minimal. At the final 12-month wave, 507 adolescents (90%) participated in data collection. Participants who completed the final wave did not differ from noncompleters on any variables.

Preliminary Analyses

Descriptive statistics for the outcome variables at all waves for the total sample, and also stratified by grade cohort and sex, are shown in Table 1. A square root transformation was used to normalize the positively skewed CDI at all three waves; the original means and standard deviations are presented in Table 1. Mean CDI scores for boys and girls in the current sample are similar to mean scores for similar-aged boys ($M = 9.03$) and girls ($M = 10.24$) found in a recent meta-analysis of nonclinical adolescent samples (Twenge & Nolen-Hoeksema, 2002).

Adolescent mood measured with the CDI was significantly but moderately correlated with daily mood states measured via EMA; for PA, r's ranged from $-.29$ to $-.36$ across waves (p's $< .001$), and for NA, r's ranged from .36 to .44 (p's $< .001$).

Daily Mood States Across Time, Grade Cohort and Sex

For inclusion in all MRM analyses using EMA data, subjects had to provide EMA data at two or more time points, $N = 508$. There were no significant differences on any variable for those included in the analyses

TABLE 1
Means and Standard Deviations of Main Variables, for the Total Sample and by Grade Cohort and Sex

	Total			*8th Graders*			*10th Graders*			*Boys*			*Girls*		
Variable	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
Baseline															
CDI	552	10.30	7.33	290	10.37	7.69	262	10.22	6.92	251	9.12	6.69	301	11.30	7.70***
PA	517	6.73	1.23	271	6.84	1.26	246	6.61	1.19*	230	6.83	1.25	287	6.66	1.21
NA	517	2.44	0.97	271	2.39	0.91	246	2.50	1.02	230	2.42	1.02	287	2.47	.93
6 months															
CDI	521	10.01	7.94	274	10.05	8.16	247	9.97	7.70	235	9.30	7.67	286	10.60	8.12
PA	487	6.57	1.32	260	6.73	1.37	227	6.38	1.23**	223	6.55	1.42	264	6.59	1.23
NA	487	2.40	1.07	260	2.33	1.04	227	2.47	1.11	223	2.45	1.17	264	2.35	.98
12 months															
CDI	506	9.95	7.82	266	9.82	7.96	240	10.09	7.68	227	9.01	7.68	279	10.71	7.86*
PA	466	6.43	1.34	239	6.56	1.40	227	6.28	1.27*	211	6.40	1.42	255	6.45	1.28
NA	466	2.32	1.04	239	2.27	1.02	227	2.36	1.06	211	2.39	1.20	255	2.25	.88

Note. For comparison of eighth graders versus 10th graders, and boys versus girls.
*$p < .05$; **$p < .01$; ***$p < .001$.
CDI, children's depression inventory; PA, daily positive affect scale—EMA; NA, negative affect scale—EMA.

($N = 508$) and those excluded ($N = 54$). Across participants, 48,998 observations were analyzed per mood variable.

PA. An initial MRM indicated that the Sex × Grade × Time effect was not significant, and the model was re-run without the interaction. Results of the final model (see Table 2) revealed that the Grade Cohort × Time interaction was not significant. Thus, changes in PA over time did not differ as a function of grade cohort. A main effect for grade cohort indicated that the older cohort reported significantly lower PA ($M = 6.42$, $SD = 2.00$) than the younger cohort ($M = 6.72$, $SD = 2.16$), collapsing across time. The main effect of time was also significant. Paired-sample t-tests indicated that mean PA at baseline ($M = 6.73$, $SD = 2.12$) was significantly higher than mean PA at 6 months ($M = 6.58$, $SD = 2.07$), t (445) = 3.65, $p < .0001$, and at 12 months ($M = 6.43$, $SD = 2.09$), t (435), $p < .0001$; mean PA at 6 months was also significantly greater than at 12 months, t (435) = 4.87, $p < .001$. Thus, PA declined for both cohorts across the three waves. The majority of adolescents experienced this worsening of PA over time; 61% had lower PA scores at 12 months than at baseline.

TABLE 2
Final MRMs of Positive and Negative Affect on Time, Grade Cohort, Sex, Grade Cohort × Time, and Sex × Time, $N = 508$

Mood Variable Effect	*Estimate*	*Standard Error*
Positive affect		
Intercept	6.9522***	.1001
Time	−.2211***	.0463
Sex	−.0868	.1118
Grade Cohort	−.2407*	.1145
Smoking Status	−.0682	.1220
Sex × Time	−.0997*	.0515
Grade Cohort × Time	.0074	.0525
Smoking Status × Time	−.0733	.0559
Negative affect		
Intercept	2,3122***	.0771
Time	−.0428	.0377
Sex	−.0024	.0861
Grade Cohort	.0930	.0882
Smoking Status	.1984*	.0940
Sex × Time	−.0759^{t}	.0420
Grade Cohort × Time	−.0315	.0429
Smoking Status × Time	−.0568	.0457

Note. Positive affect model $\chi^2(3, N = 508) = 18{,}076.91$, $p < .0001$; negative affect model $\chi^2(3, N = 508) = 22{,}307.92$.
$^{t}p < .10$; $*p < .05$; $***p < .001$.

Findings also revealed a significant Sex × Time interaction, indicating that the time trends in mean PA differed for boys and girls, collapsed across grade cohort. Follow-up analyses revealed that PA declines over time were steeper for boys than for girls: for girls, mean PA did not change significantly over time, but PA significantly declined over time for boys, $F(2, 796) = 12.25$, $p < .001$. However, within any given time point, the differences between girls' and boys' PA were not significant (see Table 1 for means and *SD*s).

NA. In the initial model, Grade Cohort × Sex × Time was not significant and thus dropped from the analyses; the final model is presented in Table 2 (bottom section). The effects of time and grade cohort were not significant, nor was Time × Grade Cohort. The main effect of sex was not significant but the Sex × Time was marginally significant ($p = .07$). Thus, the time trends in mean NA differed by sex: boys' NA

was stable across time, whereas girls' NA improved. Follow-up analyses revealed significant improvement in girls' NA across the three waves, $F(2, 796) = 3.85$, $p < .025$ (see Table 1 for means). In contrast, boys' NA did not change over time, $F(2, 796) = .86$, NS.

Global Mood/Depressive Symptoms Across Time, Grade Cohort, and Sex

To be included in the following analyses, adolescents must have provided CDI data at two or more time points, $N = 531$. There were no significant differences between the samples in the daily versus global mood analyses on any variable. An initial MRM revealed no significant interactions with time; thus, the model was re-run excluding all interactions, Model $\chi^2(3, N = 531) = 684.49$, $p < .0001$. Results of the final model indicated that global depressed mood did not significantly change over time, Estimate = $-.04$, $SE = .02$, NS, and there was no effect for grade cohort, Estimate = $-.10$, $SE = .10$, NS. A significant effect for sex, Estimate = .29, $SE = .10$, $p = .003$ indicated that girls had higher levels of global depressive mood ($M = 10.87$, $SD = 7.91$) than boys ($M = 9.14$, $SD = 7.37$). The nonsignificant sex by time interaction suggests that time trends for boys and girls were parallel.

DISCUSSION

Longitudinal Patterns of Daily Mood

Our findings indicated that adolescents experienced significant declines in daily PA across grades 8–11, and somewhat different patterns emerged with respect to changes for boys and girls. These downward trends were not driven by a subset of students: affect at 12 months was less positive than at baseline for the majority of the sample. It is important to note that there was considerable within-person variability in daily affect, although overall downward trends predominated. In contrast to PA, NA did not decline during this period.

The worsening of affect across grades 8 and 9 in the current study is consistent with findings from past real-time research (Larson & Lampman-Petraitis, 1989; Larson et al., 2002). In addition, declines in PA across grades 8–11 are in line with previous research showing that depressive mood and symptoms rise during this period (e.g., Garber et al., 2002; Ge et al., 1994; Twenge & Nolen-Hoeksema, 2002). On the other hand, NA was relatively stable from eighth through 11th grade. These different patterns

for PA and NA have important, albeit tentative, implications regarding the development of depressive mood in adolescence. The tripartite model of emotion (Clark & Watson, 1991) posits that low PA is a key component of depression, in addition to high NA. Our results suggest that deteriorations in PA, more so than increases in NA, may contribute to the rise in depressive mood/symptoms during adolescence.

Results also indicated that boys exhibited worse longitudinal patterns of daily positive mood than girls. These findings stand in contrast to the documented girl-biased prevalence of depressed mood and disorders in adolescence (Hankin et al., 1998; Twenge & Nolen-Hoeksema, 2002), but are consistent with the real-time work of Larson et al. (2002). That both real-time studies converge on the same sex patterns suggests that daily mood reports via EMA may provide a window into adolescent mood that is not captured via paper-and-pencil assessment. Lending support to this notion, Feldman Barrett, Robin, Pietromonaco, and Eysell (1998) found that women had higher global mood ratings than men on questionnaires, but sex differences disappeared in the momentary mood ratings.

In addition, divergent findings may stem from differences in the constructs tapped by the daily mood scales as compared with those examined in past research. Our daily mood scales did not measure the vegetative and somatic symptoms typically included in depression inventories, but did assess PA. Research shows that adolescent girls are more likely than boys to endorse the anxious-somatic NA symptoms of depression (e.g., fatigue, disturbances in sleep and appetite, and headaches) but are no more likely to endorse the nonvegetative/somatic features (e.g., anhedonia or low PA; Silverstein, Caceres, Perdue, & Cimarolli, 1995). Our findings are consistent with this pattern: girls were no worse than boys in their levels of PA; indeed, girls had superior PA over time. Thus, by failing to assess changes in momentary PA ratings, past investigations may have underestimated girls' emotional functioning during this period.

Longitudinal Patterns of Global Depressed Mood/Symptoms

Our second question addressed the convergence of daily and global mood ratings over time, and results revealed imperfect correspondence between these two methods. Daily and global moods were only moderately correlated and, whereas daily mood fluctuated across the 1-year period, CDI scores did not change over time. Divergent patterns may be explained, in part, by the methodology: the increased frequency of EMAs may allow youth to report greater variability in their day-to-day emotions than with a

global, summary measure. Similar inconsistencies between momentary and retrospective mood ratings have been found in cross-sectional research with adults (e.g., Thomas & Diener, 1990). Beyond methodological explanations, however, it is important to note that adolescents experienced the greatest declines in daily PA, a dimension that is only briefly and indirectly assessed on the CDI. Adolescent reports of NA, whether assessed daily via EMA or globally by the CDI, which largely taps NA, did not change over time. Thus, the CDI may be a less sensitive indicator of mood declines.

In contrast to the daily mood patterns but consistent with past studies using the CDI (Twenge & Nolen-Hoeksema, 2002), girls reported higher levels of depressive mood/symptoms than boys. That this sample behaved in a manner similar to previous samples in terms of the sex differences in CDI scores points to the importance of assessing PA and NA using real-time methods to understand the magnitude of sex differences in adolescent mood patterns.

Strengths, Limitations, and Future Directions

The present investigation extended past adolescent research by using a three-wave accelerated longitudinal design, real-time methods of mood assessment, and statistical techniques best suited for hierarchical, longitudinal data. Nonetheless, study limitations should be noted. First, the sample was selected based on smoking intentions and/or experience and, as a result, individuals at either end of the adjustment continuum may have been underrepresented. However, over the course of the study, the participants fell into all categories of smokers (e.g., from those who never smoked to regular smokers), and this increases the representativeness of the sample. Moreover, the current sample behaved similarly to past adolescent samples with regard to overall levels of negative mood. These facts suggest that findings likely generalize to other community adolescent samples. Furthermore, we statistically controlled for the effects of smoking in the analyses. Generalizability is also limited by the relatively small percentages of non-White youth in the sample. Last, possible floor effects in the NA scale may also limit findings; reduced variance may account for the lack of significant changes in NA over time.

Apart from these limitations, the present study provides important information about longitudinal trends in adolescent mood states, notably the downward trajectory in adolescent PA across grades 8–11. In addition, our findings illustrate the merit of assessing daily PA to understand adolescent well-being.

ACKNOWLEDGMENTS

This work was supported by grant #CA80266 from the National Cancer Institute; a grant from the Tobacco Etiology Research Network, funded by the Robert Wood Johnson Foundation; and training grant #2T32DA007293 from the National Institute on Drug Abuse.

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