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Maciejewski, Dominique F.; Keijsers, Loes; van Lier, Pol A.C.; Branje, Susan J.T.; Meeus, Wim H.J.; Koot, Hans M.

published in
Developmental Psychology
2019

DOI (link to publisher)
10.1037/dev0000650

document version
Publisher's PDF, also known as Version of record

citation for published version (APA)
Maciejewski, D. F., Keijsers, L., van Lier, P. A. C., Branje, S. J. T., Meeus, W. H. J., & Koot, H. M. (2019). Most fare well - but some do not: Distinct profiles of mood variability development and their association with adjustment during adolescence. *Developmental Psychology*, *55*(2), 434-448. https://doi.org/10.1037/dev0000650

American Psychological Association

Developmental Psychology

0012-1649/19/$12.00

2019, Vol. 55, No. 2, 434–448
http://dx.doi.org/10.1037/dev0000650

Most Fare Well—But Some Do Not: Distinct Profiles of Mood Variability Development and Their Association With Adjustment During Adolescence

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One particular developmental task during adolescence is to regulate fluctuating moods to successfully transition through this period. The aim of this person-centered study was to identify distinct developmental trajectories of adolescent mood variability and to compare adolescents in different trajectories on changes in depressive symptoms, delinquency, and alcohol consumption in early to middle (ages 13–16) and middle to late adolescence (ages 16–20). Dutch adolescents (n = 482, 57.1% male) rated their daily emotions three weeks per year for five years using Internet daily diaries (ages 13–18). Day-to-day mood changes were calculated as an indicator of mood variability. Adolescents provided annual reports on depressive symptoms, delinquent acts, and alcohol consumption (ages 13–20). Results showed that most adolescents (88%) followed a trajectory characterized by decreases in mood variability (i.e., more stable moods). However, a minority (12%) followed a trajectory of increases in mood variability with a peak during middle adolescence. Adolescents with an increasing mood variability trajectory showed stable depressive and delinquency symptoms in early to middle adolescence compared with adolescents with a decreasing mood variability trajectory, who showed a decline in these symptoms. At age 16, there was a significant difference between the groups in depressive and delinquency symptoms, which stayed stable toward late adolescence. Although the two groups did not differ concerning alcohol consumption in early to middle adolescence, adolescents from the increasing mood variability class experienced less steep increases in alcohol use from middle to late adolescence compared with adolescents from the decreasing mood variability class.

Keywords: adolescence, daily diaries, longitudinal, mood variability, person-centered

Supplemental materials: http://dx.doi.org/10.1037/dev0000650.supp

This article was published Online First December 3, 2018.

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Data from the Research on Adolescent Development and Relationships (RADAR) study were used. RADAR has been financially supported by main grants from the Netherlands Organisation for Scientific Research (GB-MAGW 480-03-005, GB-MAGW 480-08-006), the Stichting Achmea Slachtoffer en Samenleving (SASS), a grant from the Netherlands Organisation for Scientific Research to the Consortium Individual Development (CID; 024.001.003), and various other grants from the Netherlands Organisation for Scientific Research, the VU University Amsterdam, and Utrecht University. We thank Alexis Brieant for critically reviewing the manuscript and Sari van Rooij for calculating within-person reliabilities.

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During adolescence, many developmental changes take place. Although it has long been thought to be a period of inevitable storm and stress and increases in emotional turmoil (Hall, 1904), it is now increasingly recognized that this does not apply to all adolescents (Arnett, 1999; Dahl, 2004; Steinberg, 2001). Indeed, longitudinal studies have shown that adolescents' mood typically becomes more stable across adolescence (Larson, Moneta, Richards, & Wilson, 2002; Maciejewski, van Lier, Branje, Meeus, & Koot, 2015). However, until now, less attention has been paid to understanding interindividual differences in these developmental trends. Not all adolescents may succeed at downregulating their mood swings. Increasing levels of mood variability in turn may make them more susceptible to the development of psychopathology (Cole & Hall, 2008; Meeus, 2016). Identifying distinct trajectories of mood variability and relating these to adjustment may provide key information for our understanding of youths at risk for adverse outcomes. The objective of this daily diary study was to use a person-centered approach to identify possible subgroups of adolescents with distinct mood variability trajectories to better understand normative and non-normative development of mood variability. Moreover, a second goal was to study correlates of normative and nonnormative mood variability trajectories by relating distinct mood variability trajectories to changes in mean levels of three prominent adolescent adjustment problems, namely depressive symptoms, delinquency, and alcohol consumption across ages 13 to 20.

Heterogeneity in Mood Variability Development During Adolescence

Emotions are inherently dynamic and change over time. They arise in response to meaningful events and stimulate actions to cope with these events (Kuppens, 2015). There are important differences between individuals, hereafter interindividual differences, in the frequency and intensity of mood changes. For instance, individuals who attend more to negative stimuli or use less effective regulation strategies are likely to experience more fluctuations in their mood (Larsen, 2000; Wichers, Wigman, & Myin-Germeys, 2015). As such, high levels of mood variability can be seen as an indicator of emotion dysregulation, because variability reflects problems keeping moods within appropriate boundaries (Cole & Hall, 2008; Hoeksma, Oosterlaan, & Schipper, 2004).

Adolescence is a period in which interindividual differences in mood variability may become especially pronounced. Over the adolescent years, youths are confronted with a number of emotion-provoking changes such as spending less time with their parents and more time with their peers, dealing with school pressure, and developing a coherent identity. Such changes have been shown to be associated with fluctuations in adolescent daily moods (Flook, 2011; Klimstra et al., 2016; Lehman & Repetti, 2007; Schneiders et al., 2006). Learning to regulate the fluctuating positive and negative emotions that are often characteristic of adolescence is an important task during this period (Gilbert, 2012; Heller & Casey, 2016). Indeed, a prominent study by Larson and colleagues (2002) measured within-day emotional experiences in 220 adolescents from ages 10–18 and found that emotions showed the lowest rank-order stability during early adolescence with increasing stability toward late adolescence. Similarly, a more recent study in 474 adolescents that was conducted using the present sample used daily diary data to construct within-person variability indices. Using latent growth curve modeling, they found that levels of within-person variability declined with age, indicating that overall adolescents developed more stable moods with less pronounced day-to-day mood swings across adolescence (Maciejewski et al., 2015). However, this study also concluded that there were considerable interindividual differences in the rate of change across adolescence, possibly indicating that not all adolescents experienced decreases in mood variability. Identification of adolescents deviating from the normative pattern of decreasing mood variability could be vital information for identifying adolescents at risk for increased irritability during adolescence. One way of better understanding such heterogeneity is to use person-centered instead of variable-centered approaches. For instance, conventional growth curve methods assume that participants come from one population and can be described by one overall trajectory, while allowing for variation in individual starting levels and changes. Growth mixture models are person-centered approaches that assume that participants come from different subpopulations with distinct starting levels and patterns of change (Jung & Wickrama, 2008).

Theoretically, it is plausible that there are subgroups of adolescents with distinct developmental trajectories of mood variability. Although most may transition through adolescence without increasing emotional turmoil, a minority may be susceptible to development of more fluctuating moods, potentially because of dispositional factors or early experiences. Studies have shown that genetic vulnerability (Conway, Slavich, & Hammen, 2015), certain personality characteristics (e.g., neuroticism; Dunkley, Mandel, & Ma, 2014), and early adverse childhood experiences (Infurna, Rivers, Reich, & Zautra, 2015) are associated with greater mood fluctuations in response to stressful events. Thus, a minority of adolescents who are in general more vulnerable to experience mood fluctuations may be especially susceptible to the impact of developmental stressors that are characteristic of the adolescent period, especially during early to middle adolescence when most developmental changes peak (e.g., parent–child relationship transformations; De Goede, Branje, & Meeus, 2009). Although the hypothesis on distinct developmental trajectories seems plausible, we are not aware of any study that has systematically addressed this question. Being able to identify subgroups of adolescents with distinct trajectories of mood variability is vital to not only understand the phenomena of mood variability during adolescence, but can also be facilitate identification of at-risk adolescents. The first objective of this study was to test the heterogeneity in mood variability development to identify whether these interindividual differences represent a variation around the average or whether they signal the presence of distinct subgroups of adolescents following different mood variability trajectories.

Association Between Mood Variability and Adolescent Adjustment

A second objective of the present study was to explore the developmental significance of following distinct developmental trajectories of mood variability by linking them to changes in mean levels of three core adjustment problems that often emerge during adolescence; namely depressive symptoms, delinquency, and alcohol consumption. Mood variability may be related to interindividual differences in the development of adolescent adjustment,

because it plays an important role in the development and maintenance of psychopathology (Cole & Hall, 2008; Houben, Van Den Noortgate, & Kuppens, 2015), especially during adolescence (Meeus, 2016). Changes in momentary emotional states may play an important mediating role between risk factors, such as negative life events or genetic vulnerability, and psychopathology (Wichers, 2014). If individuals repeatedly experience fluctuations in their moods in response to such risk factors, this might initiate cascades of alterations in emotions and behaviors, which might consequently put individuals at risk for developing symptoms of psychopathology (Wichers et al., 2015). Also, it has been hypothesized that higher mood variability is associated with a greater need to regulate such mood fluctuations, which leaves less capacity to adaptively function in other domains (Maciejewski et al., 2014). With regard to delinquency and alcohol use it has been suggested that changes in mood states are associated with a higher cognitive load by inducing rumination about mood-relevant, but task irrelevant thoughts, which in turn results in fewer capacities to devote to cognitive tasks. In other words, this loading up of cognitive sources is thought to impair executive function (Mitchell & Phillips, 2007). Deficits in executive functions have in turn been shown to be related to delinquency and criminality (Morgan & Lilienfeld, 2000) as well as alcohol use (Day, Kahler, Ahern, & Clark, 2015). Moreover, regarding alcohol use it has been suggested that substance use is a result of wanting to regulate emotions, that is, enhancing positive emotions and/or decreasing negative emotions, as a way of self-medication (Verheul, van den Brink, & Geerlings, 1999).

In addition to this theoretical explanation, empirical research, most of which is cross-sectional in nature and often restricted to adult samples, has grown in the past years and has consistently shown negative links between mood variability and well-being (for a meta-analysis see Houben et al., 2015). Research in adolescents and young adults has also shown that heightened mood variability is concurrently related to elevated levels of depressive symptoms (Silk et al., 2011; Silk, Steinberg, & Morris, 2003; van Roekel et al., 2016). Evidence regarding externalizing problems is mostly restricted to studies in which mood variability is indirectly measured using questionnaires (e.g., by asking "how unstable are your moods?") instead of directly using intensive repeated assessments (see below for a discussion). Nevertheless, this research also suggests that high mood variability is related to more aggression and delinquency symptoms (Silk et al., 2003; Stringaris & Goodman, 2009; Tackett, Herzhoff, Reardon, De Clercq, & Sharp, 2014). Regarding alcohol consumption, some studies found that higher mood variability was associated with increased alcohol consumption (e.g., Gottfredson & Hussong, 2013), whereas others only found relations with alcohol dependence symptoms, but not frequency of alcohol consumption per se (e.g., Stevenson, Dvorak, Kuvaas, Williams, & Spaeth, 2015). All in all, these cross-sectional studies suggest that higher levels of mood variability are associated with more negative outcomes. A couple of recent longitudinal studies further suggest that mood variability predicts adjustment difficulty over time. For instance, a study in college students indicated that emotional reactivity to daily stressors predicted depressive symptoms two months later, but not the other way around (Parrish, Cohen, & Laurenceau, 2011). Moreover, another study, in which adolescents were followed from ages 13 to 16, showed that mood variability predicted later depressive symptoms, but not vice versa (Maciejewski et al., 2014). This study was based on the same dataset used in the current study, but only examined associations between mood variability and depressive and anxiety symptoms in early to middle adolescence. The present study extended this to the period of late adolescence and young adulthood and additionally examined the association with delinquency and alcohol consumption. Moreover, the former study did not examine how different developmental trajectories are associated with change in adjustment problems. To summarize, though they emphasize the role of mood variability in adjustment, existing cross-sectional and longitudinal studies have not specifically clarified the developmental risk of deviant growth of mood variability during adolescence.

The Need for Intensive Repeated Assessments and Micro-Level Perspectives

In the present study, we used daily diaries to study mood variability. Specifically, adolescents rated their emotions using Internet daily diaries once per day for three weeks per year across the period of adolescence (i.e., a total of five years). Mood variability scores were calculated as day-to-day mood changes. This approach has several advantages over more traditional retrospective assessments, in which adolescents (or external raters) estimate how much and how frequently they change in their moods across a defined period (e.g., Cook, Buehler, & Blair, 2013; Stringaris & Goodman, 2009). First, repeated assessments make it possible to study within-person variability or, in other words, to model the actual changes in mood (Gunthert & Wenze, 2012). Second, daily diaries minimize recall biases and may therefore provide more reliable estimates than retrospective measures. This is because retrospective measures require raters to summarize a large amount of information and to aggregate changes in their mood over time, which may be difficult and therefore make such retrospective measures less accurate (Solhan, Trull, Jahng, & Wood, 2009; Trull, Lane, Koval, & Ebner-Priemer, 2015). Third, given that emotions are measured in real-life with daily diaries, they provide a snapshot of the participants' daily lives and therefore possess high ecological validity (Shiffman, Stone, & Hufford, 2008). Lastly, daily diaries give us a more nuanced understanding of the role of emotions in psychopathology. Indeed, it has been recently argued that one way to advance the study of the role of emotion regulation in psychopathology is to consider emotional processes at the microlevel (Nelson, McGorry, Wichers, Wigman, & Hartmann, 2017; Wichers, 2014). Daily diaries allow study of how emotions unfold on a microlevel (i.e., momentary and day-to-day) and how they influence the course of psychopathology on a macrolevel (i.e., months and years; Nelson et al., 2017; Trull et al., 2015; Wichers, 2014; Wichers et al., 2015). From the perspective of complex dynamic systems theory, increases in mood fluctuations could be an early warning sign that anticipates critical transitions from a normal state into a state with psychopathology. Studying emotions on a microlevel (e.g., days) could inform changes on a macrolevel (e.g., years) in the development of psychopathology. High mood variability could indicate a state of vulnerability which may lead to a cascade of effects between mood states in the dynamic network structure, ultimately leading to symptoms of psychopathology (Wichers et al., 2015). In other words, examining emotions on a microlevel can be used to "iden-

tify the smallest building blocks underlying the onset and course of mental-ill health" (Wichers, 2014, p. 1349). Thus, examining microlevel changes in emotions could help to better understand the association between common risk factors and how those influence microlevel emotions, which then consequently lead to changes in psychopathology (Wichers et al., 2015).

The Present Study

A growing body of research examining the association between mood variability and adjustment using experience sampling methods and daily diaries has indicated that high mood variability is related to worse adjustment (for a meta-analysis see Houben et al., 2015). A few longitudinal studies among adolescents using such methods to operationalize mood variability have shown that in adolescence mood variability is associated with important developmental changes in depression and anxiety (Maciejewski et al., 2014). We extend this research by examining different developmental trajectories of mood variability among adolescents over a prolonged period of time and their association with different types adolescent adjustment. Using a sample of adolescents that were followed from ages 13 to 20 years, the present longitudinal, person-centered study examined (a) distinct subtypes with different developmental trajectories of mood variability across adolescence and (b) how these subgroups differed in developmental mean level changes of depressive symptoms, delinquency, and alcohol consumption. We did not form hypotheses about the number of classes we would extract for the mood variability trajectories, given that growth mixture modeling is a method that is predominately hypothesis-generating. Concerning the differences in adjustment development, we expected that adolescents in subgroups with increasing mood variability trajectories would also develop more adjustment problems across the period of adolescence. Adjustment problems were measured yearly from ages 13 to 18 and biannually thereafter (seven assessments in total), whereas adolescent mood variability was measured during three separate weeks per year from ages 13 to 18 (15 assessments in total).

Method

Participants

The present study used data from the RADAR (Research on Adolescent Development and Relationships) study project, a longitudinal research project in the Netherlands, which follows adolescents, their families, and best friends from ages 13 onward. For the present study, we used adolescent data from ages 13 to 20 (Data collection: 2006–2013). The RADAR project focuses on the development of delinquency. Therefore, adolescents with borderline externalizing behavior scores at age 12 were oversampled (T score >60 on the Teacher's Report Form [TRF]; Achenbach, 1991). In total, 497 adolescents were approached successfully, agreed to participate, and provided written consent. More information on the sample selection can be found in Maciejewski et al. (2015).

For the present study, 15 adolescents were excluded because they did not provide any valid Internet assessments (see Procedures). In the final sample ($n = 482$; 57.1% male), 60.0% were at low/average risk for externalizing behavior at age 12 and the majority of the sample had a medium or high socioeconomic status (SES; 90.1%). The mean age at the first assessment was 13.03 years ($SD = 0.45$). Male and female adolescents did not differ on age, $t(480) = 1.14$, $p = .25$, externalizing behavior risk status, $\chi^2(1) = 0.03$, $p = .87$, or SES, $\chi^2(1) = 3.10$, $p = .08$.

Procedures

The RADAR study was approved by the medical ethical committee of the University Medical Center Utrecht (the Netherlands). Data for this study were collected during home and Internet assessments. Trained research assistants visited the adolescents and their families each year, mostly around January and February (T1.1 in year 1, T2.1 in year 2, etc.; six annual and one biannual home assessments; ages 13–20). During these home visits, adolescents filled out questionnaires about depressive symptoms, delinquency, and alcohol consumption. Moreover, adolescents were asked to rate the intensity of their daily mood three weeks per year (one week in the months of June, September, December) using Internet diaries (T1.2, T1.3, T1.4 in year 1, T2.2, T2.3, T2.4 in year 2, etc.; 15 assessment weeks over five years; ages 13–18). Each evening of the Internet assessment, adolescents received an e-mail invitation at around 5:30 p.m. to participate in the assessment, and they received reminder e-mails, text messages, and/or phone calls if they had not completed the questionnaires 1.5 hr after the e-mail invitations. Participants could log on with their personal password to the RADAR website. For their participation, families received 100 Euros per home visit and 10 Euros per Internet assessment week.

Measures

Mood variability. Each evening of the Internet assessments, adolescents rated the intensity of their daily emotions using an Internet version of the Electronic Mood Device (Hoeksma et al., 2000). Four emotions were assessed with three items each ("Today I feel. . . ."). Happiness was measured with the items "glad," "happy," and "cheerful," anger was measured with the items "angry," "cross," and "short-tempered," sadness was measured with the items "sad," "down," and "dreary," and anxiety was measured with the items "afraid," "anxious," and "worried." Response options were 1 (*not glad/sad/anxious . . .*) to 9 (*glad/sad/anxious . . .*).

We calculated the R1F coefficient as described by Cranford et al. (2006) as an index of reliability of our diary data. Specifically the R1F coefficient is the between-person reliability estimate for one fixed day. The R1F was 0.88 for happiness, 0.88 for anger, 0.85 for anxiety, and 0.92 for sadness, indicating that all three-item emotion scales adequately differentiated persons on a single fixed day. We additionally calculated the omega coefficient, a coefficient of within-person reliability which assesses whether there are reliable within-person differences in change over time. The omega coefficient allows item loadings and error variances to vary over time. We specified a three-level multilevel confirmatory factor analysis model, where the first level was specified as overall measurement (the 75 measurement occasions for the three items of the emotion), the second level as week (the 15 weeks of the study), and the third level as the ID of the family, as all measurements were within persons. The omega coefficients were calculated sep-

arately per emotion. For happiness, the omega coefficient was 0.91, for anger 0.91, for anxiety 0.86, and for sadness 0.94, indicating high within-person reliabilities.

Using the sum scores of the items per emotion, mood variability scores (i.e., day-to-day fluctuations in emotions) were calculated using the mean absolute successive difference. Per week and per emotions, this score was calculated by taking the absolute difference between consecutive days and then dividing this score by the number of valid assessment days to control for missing data. This measure takes into account the intensity and frequency as well as the temporal ordering of day-to-day changes and provides more valid estimates than retrospective ratings (e.g., by asking "how unstable is your mood in general?"), which are likely biased (Trull et al., 2015). Mood variability scores were calculated per emotion and Internet week, provided adolescents had at least four scores in total or three scores in a row. Because exploratory factor analyses consistently extracted one overall factor per assessment week (factor loadings: .66 - .89; variance explained 61.8% - 66.9%), we calculated the mean of the variabilities of the four emotions, with higher scores indicating higher mood variability (total possible range: 0–24). Apart from the fact that the mood variability scores of the different emotions consistently loaded on one factor, there were several other reasons for using an overall mood variability score. First, our previous study on the developmental trajectories of mood variability showed that all emotions developed in a similar manner across adolescence, suggesting nonspecificity of developmental changes in mood variability (Maciejewski et al., 2015). Moreover, previous studies have shown that mood variability scores of different emotions contribute in rather nonspecific ways to psychopathology (Neumann, van Lier, Frijns, Meeus, & Koot, 2011; Silk et al., 2003). For instance, using the same dataset Neumann and colleagues (2011) showed that variability of happiness, sadness, anger, and anxiety all contributed with similar effect sizes to internalizing problems. Similarly, Silk et al. (2003) showed that sadness, anger, and anxiety variability contributed in equal ways to depressive symptoms and problem behaviors. The latter were measured using the externalizing subscale of the Youth-Self-Report (Achenbach, 1991), which includes rule-breaking, including delinquency and substance use, as well as aggressive behavior. The 15 overall mood variability scores per person were used in the analyses. These scores represent the within-person variability of mood (i.e., changes in day-to-day mood within weeks).

Depressive symptoms. Depressive symptoms were measured using the following subscales of the Reynolds Adolescent Depression Scale – 2nd Edition (RADS-2; Reynolds, 2002): Dysphoric Mood (eight items; e.g., "I feel like crying"), Negative Self-Evaluation (eight items; e.g., "I feel I am bad"), and Somatic Complaints (seven items; e.g., "I am tired"). Items were rated on a 4-point Likert scale with response options ranging from 0 (*almost never*) to 3 (*most of the time*). The items were summed into a total depression score with higher scores indicating higher depressive symptoms (total possible range: 0–69). Cronbach's αs ranged from .93 to .95 across the seven waves of assessment. The RADS-2 shows significant correlations with other self-report on depressive symptoms and clinical interview ratings, supporting its validity (Reynolds, 2002).

Delinquency. Delinquency was measured with a 30-item scale that targeted minor and major delinquent behaviors in the past year, such as stealing, vandalism, selling drugs, and threatening or injuring others (based on Junger-Tas & Terlouw, 1994). We used a variety scale because they outperform frequency scales in terms of reliability and validity (Bendixen, Endresen, & Olweus, 2003), summing all 30 dichotomized items (0 = *no*, 1 = *yes;* total possible range: 0–30). Cronbach's alphas ranged from .75 to .93 across the seven waves of assessment. Because the scale was extremely skewed (M = 4.06, range = 2.77–6.80), it was log-10 transformed. After that, skewness fell into acceptable ranges (M = 1.39, range = 0.78–2.07). Self-reports on delinquent behaviors are most valid to target minor offenses that do not appear in official records (Junger-Tas & Marshall, 1999).

Alcohol consumption. Frequency of alcohol consumption was measured with the question "How often did you drink alcohol in the past four weeks?" Response options were: *did not drink any alcohol* (0), *1–3 days in 4 weeks* (1), *1–2 days per week* (2), *3–4 days per week* (3), *5–6 days per week* (4), or *every day* (5). Previous studies indicate that self-reports on substance use provide reliable and valid estimates if self-administered questionnaires are used, confidentiality is secured, and reference periods are short, which is the case in the present study (Brener, Billy, & Grady, 2003).

Items of all study variables can be found in online supplemental material 1.

Covariates

Mood level. Adolescent mood level (i.e., the average emotional tone) was included as a covariate in the analysis, because variability and level are conceptually and statistically related (for further discussion see Ebner-Priemer, Eid, Kleindienst, Stabenow, & Trull, 2009; Trull et al., 2015). Concurrent correlations were also high in this study, ranging from .42 to .64 (all $ps < .001$) per wave. Adolescent mood level was calculated as the mean of the emotion ratings across the week, provided there were a minimum four days per week or three days in a row. After reverse coding happiness, the different emotions were averaged per week into a general negative mood level score, which was then averaged across 15 assessment weeks, to obtain an overall score (total possible range: 3–27).

Demographics. Next to mood level, we also controlled for a number of demographic variables, namely sex (0 = *male*; 1 = *female*), SES (0 = *low SES*; 1 = *medium/high SES* according to parents' employment), and externalizing behavior risk status (0 = *average risk*; 1 = *high risk* according to TRF screening, as explained before).

Missing Data

In the present study, few data-points were missing. The majority were still participating in the last year of the annual home visit (T7.1; 78.6%) and the last year of the Internet assessments (T5.2-T5.4; 78.9%). Across all participants and assessments, valid data were available for 90.1% of the seven annual home visits and 76.0% of the 15 Internet assessments.[1] On average, adolescents had 6.30 valid home assessments (SD = 1.30) and 11.39 valid Internet assessments

[1] Total number of possible observations (Sample size × Number of waves) was 482 × 7 = 3,347 for home assessments (3,039 valid assessments) and 482 × 15 = 7,230 for internet assessments (5,492 valid assessments).

(SD = 4.08). The number of valid measurement waves was not associated with adolescent sex, $t(464) = -1.11$, $p = .27$, mood variability, average mood level, or depressive symptoms in year 1, all ps $> .50$, but with high SES, $t(52) = 2.52$, $p = .02$, low risk status, $t(351) = 4.15$, $p < .001$, and lower delinquency, $r = -.16$, $p < .001$, and alcohol use, $r = -.10$, $p = .03$, in year 1. The missing data pattern resembled a completely-at-random pattern (Little's MCAR test on all variables in this study: $\chi^2 = 10{,}136.49$, $df = 9390$, χ^2/df ratio = 1.08). Therefore, we used Full Information Maximum Likelihood estimation with robust standard errors (MLR) to account for missing data and non-normal distributions.

Strategy of Analyses

Analyses were conducted in M*plus* 7 (Muthén & Muthén, 1998–2012). Our hypotheses were tested in two parts. First, we tested whether there were distinct subgroups of adolescents with different mood variability trajectories from ages 13 to 18. Second, we tested for differences between members of the latent classes with respect to their trajectories of depressive symptoms, delinquency, and alcohol consumption from ages 13 to 20.

Distinct profiles of mood variability. As a basis for the first part of the analyses, we determined the shape of mood variability using univariate latent growth models. The intercept was centered at T3.3 (age between 15 and 16) to avoid multicollinearity between the growth factors (Wainer, 2000), and because we expected the greatest differences between latent mood variability groups in middle adolescence. The daily mood assessment took place in June, September, and December in each year. Thus, the 15 mood variability weeks were not equally spaced. To take this into account, we specified the slope factor loadings in the latent growth curve model as −0.9, −0.8, −0.7, −0.5, −0.4, −0.3, −0.1, 0, 0.1, 0.3, 0.4, 0.5, 0.7, 0.8, 0.9. We then conducted Growth Mixture Modeling analyses (Muthén & Muthén, 2000), a statistical technique which aims at finding the smallest number of distinct classes in which members have similar trajectories. Before deciding on the optimal number of classes, we first determined the best modeling strategy by increasingly adding complexity to the models. We started with models in which all (co)variances of growth factors were constrained to be zero within the classes (strategy one), and then freed the variances of the intercept and the slopes as well as related covariances one at a time (i.e., strategy two: additionally free the intercept variance; strategy three: additionally free the linear slope variance and related covariance; strategy four: additionally free the quadratic slope variance and related covariances). For each of these four strategies, we ran one to four classes and chose the modeling strategy that yielded the lowest overall Bayesian information criterion (BIC) and Akaike information criterion (AIC).

After having chosen the best modeling strategy, we decided on the optimal number of classes *within* the best modeling strategy. We chose the final number of classes based on the following criteria (see also Jung & Wickrama, 2008): First, the optimal number of classes should have the lowest BIC and a significant Lo-Mendel-Rubin adjusted likelihood ratio test (LMR-LRT), indicating that adding a class significantly improved model fit. We chose the LMR-LRT test, because unlike the bootstrapped log likelihood test, it is robust under many different model and distributional assumptions and can accommodate complex survey data, and may therefore provide more accurate p values (Nylund, Asparouhov, & Muthén, 2007). Second, to assess the quality of the solution, we only considered solutions with good entropy (>.80; Clark & Muthén, 2009). Third, the chosen solution needed to be stable, which was tested by running the models with 200 random starts and 40 final stage optimizations (as well as 400 and 80, respectively) to check whether the same best log-likelihoods were obtained and replicated (Asparouhov & Muthén, 2012). Fourth, the class solution needed to be theoretically meaningful and parsimonious (Jung & Wickrama, 2008). We saved the class-probabilities of the final solution for the second part of the analysis (see below).

Class differences in depression, delinquency, and alcohol. In the second part, we tested for differences between members of the mood variability classes regarding the trajectories of depression, delinquency, and alcohol consumption from ages 13 to 20. To get a more detailed view on whether there was a sensitive period in which mood variability might have the greatest risk for co-occurring adjustment problems, we specified piecewise models, with the first slope from ages 13 to 16 (early to middle adolescence) and the second slope from ages 16 to 20 (early to middle adolescence). The intercept was again centered in the middle. In the Netherlands, the legal drinking age was 16 at the time of the study, which could be related to a sudden increase in alcohol consumption at age 16. Thus, we also tested whether a model with a second intercept factor would describe the alcohol data better (i.e., two sequential processes with each their own intercept and slope; one from ages 13 to 15 for the illegal period, one from ages 16 to 20 for the legal period). We ran three different models for the three different adjustment outcomes. Model fit was evaluated using the confirmatory fit index (CFI), the Tucker-Lewis index (TLI), the root mean squared error of approximation (RMSEA), and the root mean squared residual (SRMR). Hu and Bentler (1999) suggest values close to .95 for TLI and CFI, values close to .08 for SRMR, and values close to .06 for RMSEA.

Subsequently, we tested how adolescents from the different mood variability classes differed on the growth parameters (i.e., intercept and slope) of these three trajectories. We used class probabilities as a grouping variable, because this takes into account the uncertainty in latent mood variability class formation by allowing participants fractional class membership (Muthén & Muthén, 1998–2012; training data option in Mplus). In these models, we also included the covariates (sex, SES, risk status, mood level), which were grand-mean centered for interpretation purposes. When covariates are included in a growth curve model, not mean growth parameters, but intercepts of growth parameters are estimated (i.e., growth parameters conditional on the covariates). Centering the covariates produces growth parameters for average values of the covariates and thus makes growth parameters easier to interpret (for more information see Singer & Willett, 2003, pp. 113–116). Moreover, the effects of the covariates on the growth parameters were constrained to be equal between the latent classes, because otherwise the interpretation of the growth parameters is not equal across different values of the covariates (comparable to the homogeneity of slope assumption in an ANCOVA). To test whether the growth parameters of depression, delinquency, and alcohol use trajectories differed between the mood variability classes, differences in growth parameters were tested using the Satorra-Bentler chi-square difference test.

Results

Descriptive statistics for the 15 mood variability scores and the seven annual scores of depression, delinquency, and alcohol use can be found in Tables 1 and 2, respectively. Correlations between the study variables can be found in online supplemental material 2.

Distinct Trajectories of Mood Variability

The overall mood variability trajectory was best described by a quadratic growth model (model fit: $\chi^2[111] = 118.78$, CFI = 0.99, TLI = 0.99, RMSEA = 0.01, SRMR = 0.05; intercept = 2.12, SE = 0.07, $p < .001$, linear slope = −0.30, SE = 0.05, $p < .001$, quadratic slope = 0.05, SE = 0.09, $p = .58$, with significant variation around the growth factors, all ps $< .05$). This model was the basis for the growth mixture analyses. Here we first compared the different modeling strategies to test whether we needed to free the variances of the growth parameters within the classes. The modeling strategy with free intercept and linear slope variances (but with quadratic slope variances constrained at zero) was deemed optimal, because it yielded the overall lowest AIC and BIC (see online supplemental material 3 for fit indices).

Within this series of GMM, the two-class solution was chosen as the optimal number of classes (see Table 3). First, although the BIC continuously decreased with an increasing number of classes, the LMR-LRT was only significant for the two-class solution, but not for the three- or four-class solution, indicating that adding three or four classes did not convincingly improve model fit. Second, the two-class model had high entropy values (.82) and high average latent class probabilities (.96 for class 1, .88 for class 2), indicating good classification accuracy. Third, the same best log-likelihood was replicated with different numbers of random starts, indicating a stable solution. Fourth, the two-class solution was theoretically more parsimonious than a three-class solution and the trajectories could be meaningfully interpreted. The third- and fourth-class solutions included classes with sample sizes smaller than 20, which not only complicates stable and meaningful parameters for the growth curve model but also leads to power issues when testing for differences in psychopathology in Step 2. The largest class of adolescents (n = 423; 87.8%) showed a decline in mood variability across adolescence, which slowed down gradually toward late adolescence (see Table 4 and Figure 1). A smaller class (n = 59, 12.2%) showed increases in mood variability throughout adolescence, followed by a slight decrease toward late adolescence. The first class was labeled "decreasing mood variability," and the second class was labeled "increasing mood variability." We additionally calculated effect sizes (i.e., Cohen's d) for all time points for differences between these two classes (see Table 5).

Table 1
Descriptive Statistics of Mood Variability

Age	T	*M*	*SD*	Range
13–14	T1.2	2.70	2.41	0–15.50
	T1.3	2.19	1.98	0–10.31
	T1.4	2.16	2.07	0–14.00
14–15	T2.2	2.37	2.20	0–11.88
	T2.3	2.11	1.98	0–11.81
	T2.4	2.50	2.42	0–16.00
15–16	T3.2	2.15	1.96	0–13.00
	T3.3	2.02	1.95	0–11.67
	T3.4	2.04	1.85	0–9.33
16–17	T4.2	2.11	2.14	0–14.33
	T4.3	1.93	1.92	0–11.75
	T4.4	1.85	1.80	0–9.81
17–18	T5.2	1.77	1.67	0–10.19
	T5.3	1.93	1.87	0–10.92
	T5.4	1.86	1.95	0–11.50

Note. T = Time point.

Adolescent Mood Variability Trajectories and the Trajectories of Depression, Delinquency, and Alcohol Use

In the second part of the analyses, we compared youths with distinct developmental trajectories of mood variability on their trajectories of depression, delinquency, and alcohol consumption across ages 13 to 20. We first built latent growth models for each of the outcomes. For depression and delinquency, piecewise models with the intercept at age 16 and two slopes (one from age 13 to 16 to represent early to middle adolescence and one from age 16 to 20 to represent middle to late adolescence) fitted the sample well (see Table 6). This was not the case for alcohol consumption, $\chi^2(19) = 85.64$, CFI = 0.86, TLI = 0.85, RMSEA = 0.09, SRMR = 0.06. An alternative sequential model with two separate growth processes, one for the illegal (ages 13–15) and one for the legal drinking period (ages 16–20) each with their own intercepts and slopes, showed a good fit and was thus chosen (see Table 5).

We then compared intercepts and slopes for the three adjustment problems between the two mood variability classes (increasing vs. decreasing), controlling for sex, risk status, SES, and mood level.[2] Table 5 contains the growth parameters and chi-square difference tests, and Figures 2 through 4 show the depicted trajectories of depression, delinquency, and alcohol use, respectively. For depression, adolescents from the two classes differed significantly in slopes between ages 13 to 16. Between ages 13 and 16, adolescents from the decreasing mood variability class showed significant declines in depressive symptoms, whereas depressive symptoms remained stable in adolescents from the increasing mood variability class. Moreover, adolescents from the increasing mood variability class experienced significantly more depressive symptoms at age 16 than adolescents from the decreasing mood variability class (significant intercept difference). After age 16, depressive symptoms increased for the decreasing mood variability group, whereas they stayed stable for the increasing mood variability group. However both group changed at a similar rate, as indicated by the nonsignificant difference in slopes between ages 16 and 20.

For delinquency, results showed a similar pattern. The two classes differed significantly in slopes from ages 13 to 16, as only adolescents from the decreasing mood variability group reported significant decreases in delinquency symptoms from ages 13 to 16, whereas delinquency symptoms remained stable in the increasing mood variability class. Moreover, adolescents from the increasing mood variability

[2] The increasing mood variability classes contained significantly more girls, $\chi^2(1) = 7.36$, $p = .007$, and adolescents at risk for externalizing behavior at age 12, $\chi^2(1) = 4.38$, $p = .04$. Adolescents from this class also reported higher average negative mood levels at all assessments, except T1.2, all ps $< .01$. The classes did not differ on SES, age and number of valid internet and annual assessments, all ps $> .32$.

Table 2
Descriptive Statistics of Depression, Delinquency, and Alcohol Consumption

		Depression			Delinquency[a]			Alcohol consumption		
Age	T	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
13	T1.1	14.49	11.27	0–62	1.86	3.11	0–25	0.18	0.45	0–3
14	T2.1	11.70	11.47	0–57	1.27	2.62	0–20	0.36	0.56	0–3
15	T3.1	12.32	12.08	0–63	1.42	2.69	0–17	0.63	0.75	0–5
16	T4.1	12.91	12.34	0–64	1.28	2.66	0–30	1.10	0.86	0–5
17	T5.1	12.36	11.80	0–63	0.90	1.77	0–12	1.41	0.86	0–4
18	T6.1	13.53	12.56	0–65	0.93	2.90	0–30	1.61	0.96	0–5
20	T7.1	15.69	11.63	0–57	0.89	2.03	0–13	2.00	1.21	0–5

Note. T = Time point.
[a] Raw-scores are presented here. For the analyses, log-10 transformed scores were used.

class reported significantly higher levels of delinquency at age 16 compared with adolescents from the decreasing mood variability class. After age 16, both groups declined in delinquency at a similar rate, as indicated by the nonsignificant difference in slopes between ages 16 and 20.

Concerning alcohol consumption, adolescents from the two classes did not differ in intercepts at ages 13 and 16, nor in the slope from ages 13 to 15. However, adolescents from the decreasing mood variability class experienced steeper increases in alcohol consumption after age 16 than adolescents from the increasing mood variability class.

To further evaluate the differences between the two mood variability classes, we calculated effect sizes (i.e., Cohen's *d*) for the time-points with the greatest absolute differences (age 16 for depressive and delinquency symptoms, age 20 for alcohol consumption). For this purpose, we divided the absolute differences between the estimated means (adjusted for the covariates) at that time-point by the pooled estimated standard deviation at that time-point. Effect sizes were small to moderate ($d = 0.28$ for depressive symptoms at age 16, $d = 0.27$ for delinquency symptoms at age 16, $d = -0.34$ for alcohol use at age 20). When not adjusting estimated means for covariates, the effect sizes were medium to large ($d = 0.69$ for depressive symptoms at age 16, $d = 0.38$ for delinquency symptoms at age 16, $d = -0.35$ for alcohol use at age 20).

Discussion

The aim of this study was to (a) identify distinct developmental trajectories of adolescent mood variability development and (b) compare adolescents in distinct mood variability trajectories on their changes in mean levels of depressive symptoms, delinquency, and alcohol consumption in early to middle (ages 13–16) and middle to late adolescence (ages 16–20). A large majority of adolescents developed more stable moods across adolescence (the decreasing mood variability class; 88%), whereas a small minority showed increasingly unstable moods across adolescence, with a peak around middle adolescence and a slight decline toward late adolescence (the increasing mood variability class; 12%). Moreover, adolescents from the increasing mood variability class stayed stable in their depressive and delinquency symptoms in early to middle adolescence, whereas adolescents from the decreasing mood variability class showed a significant decline. At age 16, there was a significant difference in depressive and delinquency symptoms, which stayed stable from middle to late adolescence. This suggests that low mood variability may be protective against psychopathology by being related to decreasing depressive and delinquency symptoms. High mood variability in turn seems to be a risk factor, as those adolescents with an increasing mood variability trajectory do not experience expected declines in depressive and delinquency symptoms. Although the two groups did not differ concerning their alcohol consumption in early and middle adolescence, the increasing mood variability class exhibited less steep increases in alcohol consumption toward late adolescence compared with the decreasing mood variability class.

Distinct Profiles of Adolescent Mood Variability Development

The results on the distinct mood variability developmental profiles emphasize that most adolescents become more stable in their mood over time, although a minority were identified who struggled with increases in emotional instability. In a previous

Table 3
Fit Indices of GMM for Mood Variability

				Class counts (%)			
Class	BIC	LMR-LRT	$p_{LMR\text{-}LRT}$	Class 1	Class 2	Class 3	Class 4
Class 1	22000.83						
Class 2	**21922.27**	**99.26**	**.02**	**87.76**	**12.24**		
Class 3	21880.19	64.19	.40	89.63	6.43	3.94	
Class 4	21850.59	52.34	.29	81.12	9.75	5.60	3.53

Note. GMM = Growth Mixture Modeling; BIC = Bayesian Information Criterion; LMR-LRT = Lo-Mendell-Rubin Adjusted Likelihood Ratio Test. The two-class solution (in bold) was chosen for subsequent analyses.

Table 4
Mean Growth Parameters of Distinct Mood Variability Trajectories

Trajectory	Intercept (*SE*)	Lin. slope (*SE*)	Quad. slope (*SE*)
Decreasing mood variability class	1.73 (0.07)***	−.47 (0.05)***	0.27 (0.09)**
Increasing mood variability class	4.53 (0.27)***	.77 (0.25)**	−1.33 (0.48)**

Note. *SE* = Standard error; Lin. = Linear; Quadr. = Quadratic.
** $p < .01$. *** $p < .001$.

Table 5
Effect Sizes for Differences in Mood Variability Means for Increasing and Decreasing Mood Variability Class

Age	T	*M* decreasing class	*M* increasing class	Pooled *SD*	Cohen's *d*
13–14	T1.2	2.37	2.76	2.38	0.16
	T1.3	2.28	3.06	2.00	0.39
	T1.4	2.19	3.34	2.07	0.56
14–15	T2.2	2.03	3.81	2.06	0.86
	T2.3	1.96	4.01	1.79	1.15
	T2.4	1.90	4.18	2.23	1.03
15–16	T3.2	1.78	4.44	1.84	1.44
	T3.3	1.73	4.53	1.81	1.55
	T3.4	1.69	4.59	1.70	1.70
16–17	T4.2	1.62	4.64	1.84	1.65
	T4.3	1.59	4.62	1.69	1.79
	T4.4	1.57	4.58	1.54	1.95
17–18	T5.2	1.54	4.41	1.43	2.02
	T5.3	1.53	4.29	1.68	1.64
	T5.4	1.53	4.14	1.68	1.55

Note. T = Time point.

paper (Maciejewski et al., 2015) we have shown that adolescents experience an overall decline in mood variability across adolescence. The current analyses add to these results by identifying a subgroup of adolescents who do not follow this normative declining pattern. Adolescents from the two classes developed mood variability in opposite directions particularly in early to middle adolescence, a period in which adolescents are confronted with many biological and environmental challenges. Toward late adolescence, the increasing mood variability class seemed to become more stable again, which might be explained by the fact that new equilibriums are reached during that time (De Goede et al., 2009; Somerville, Jones, & Casey, 2010). Our findings are in line with studies that suggest youths restructure their emotion regulation repertoire especially during early and middle adolescence (Zimmermann & Iwanski, 2014). This period might thus constitute a sensitive developmental window in which interindividual differences in emotion regulation may become especially pronounced and persist until late adolescence. Most adolescents may come to grips with their emotions, but a minority do not. The results also converge with identity research that shows that about 15% of adolescents are not able to find a stable identity and instead stay in a moratorium-like identity, characterized by uncertain and fluctuating commitments (Meeus, Van De Schoot, Keijsers, Schwartz, & Branje, 2010). To our knowledge, our study was the first to identify adolescents following different trajectories of mood swings, and therefore these findings need replication.

Adjustment Development for Increasing Versus Decreasing Mood Variability Classes

When comparing adolescents from the increasing and decreasing mood variability trajectory, our results indicated developmen-

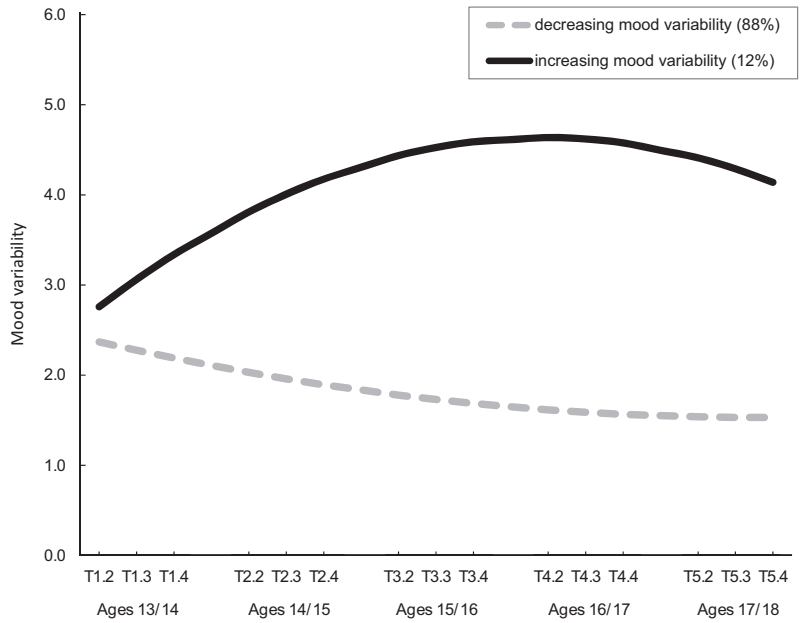

Figure 1. Distinct profiles of mood variability development. The *y* axis goes from the minimum of the scale until 3 *SD*s above the minimum of the scale (*SD* averaged across all time points = 2.01).

Table 6
Model Fit Indices and Growth Parameters for Depression, Delinquency, and Alcohol Consumption Trajectories (Decreasing Versus Increasing Mood Variability Class)

	Model fit indices					
Measure	χ^2	*df*	CFI	TLI	RMSEA	SRMR
Depression	45.87	19	.98	.97	.05	.04
Delinquency[a]	54.80	19	.94	.93	.06	.06
Alcohol	22.08	14	.98	.98	.04	.03

	Depression					
	Int age 16 (*SE*)	$\Delta\chi^2(1)$	Slo age 13–16 (*SE*)	$\Delta\chi^2(1)$	Slo age 16–20 (*SE*)	$\Delta\chi^2(1)$
Decreasing mood variability class	11.70 (0.47)***	5.93*	−0.64 (0.16)***	8.09**	0.85 (0.13)***	1.12
Increasing mood variability class	15.05 (1.33)***		0.80 (0.51)		0.50 (0.32)	

	Delinquency[a]					
	Int age 16 (*SE*)	$\Delta\chi^2(1)$	Slo age 13–16 (*SE*)	$\Delta\chi^2(1)$	Slo age 16–20 (*SE*)	$\Delta\chi^2(1)$
Decreasing mood variability class	0.19 (0.01)***	5.34*	−0.04 (0.01)***	13.59***	−.01 (0.004)**	0.26
Increasing mood variability class	0.27 (0.03)***		0.01 (0.02)		−.02 (0.01)*	

	Alcohol consumption							
	Int age 13 (*SE*)	$\Delta\chi^2(1)$	Slo age 13–15 (*SE*)	$\Delta\chi^2(1)$	Int 16 (*SE*)	$\Delta\chi^2(1)$	Slo age 16–20 (*SE*)	$\Delta\chi^2(1)$
Decreasing mood variability class	0.18 (0.02)***	0.33	0.22 (0.02)***	0.04	1.12 (0.04)***	0.38	0.24 (0.02)***	9.27**
Increasing mood variability class	0.15 (0.05)**		0.23 (0.04)***		1.17 (0.09)***		0.12 (0.04)**	

Note. Covariates were sex, risk, SES, mood level. Int = Intercept; Slo = Linear slope; *SE* = Standard error. The Satorra Bentler chi-square difference test ($\Delta\chi^2$) was used to test for the difference of the growth parameters between the decreasing and increasing mood variability classes.
[a] Delinquency was log-10 transformed.
* $p < .05$. ** $p < .01$. *** $p < .001$.

tal differences between the groups, although this was different for depressive and delinquency symptoms as well as alcohol consumption, both in terms of the time course and the direction.

We will first discuss the results regarding depressive and delinquency symptoms. Our results support the notion that emotional dysregulation is a central feature in psychopathology (Cole & Hall, 2008; Wichers et al., 2015) and that mood variability and adjustment problems are intertwined processes, even after accounting for average negative affect. Although previous studies have shown a link between mood variability and depressive and externalizing symptoms (Silk et al., 2003), the present study adds a person-centered and developmental perspective. We identified a small group of adolescents characterized by escalating emotional turmoil who are at risk for developing depressive and delinquency symptoms. The time course further emphasizes that early to middle adolescence is a time in which trajectories are altered in ways that may lead to ongoing difficulties in late adolescence and young adulthood (Dahl, 2004). The majority of adolescents outgrow adjustment problems in early to middle adolescence, whereas a minority with mood regulation problems have more difficulties catching up and show stable delinquency and depressive symptoms during that time. Notably, both groups reported similar declines in delinquency and similar increases in depressive symptoms toward late adolescence, indicating that, as a whole, adolescents eventually desist from delinquency problems, whereas that does not seem to be the case for depressive symptoms.

Our findings on alcohol consumption were in contrast to our hypotheses and some earlier studies in young adults (e.g., Gottfredson & Hussong, 2013). However, one needs to take into account the cultural background of our sample. In the Netherlands, drinking was legally allowed at age 16 at the time of the study and Dutch people are generally quite tolerant with regard to moderate drinking (Bongers, van de Goor, & Garretsen, 1998). Furthermore, compared with other countries, alcohol is more readily available and not expensive (Brand, Saisana, Rynn, Pennoni, & Lowenfels, 2007). Another thing to keep in mind is that alcohol is often consumed in the peer context, especially during adolescence, and moderate alcohol use has even been associated with higher popularity (Allen, Porter, McFarland, Marsh, & McElhaney, 2005). Adolescents who experience intense mood swings and show high depressive and delinquency symptoms may be less popular and have more peer problems, maybe because this combination makes them unpredictable and hampers social interactions. This would diminish opportunities to consume alcohol in a peer context. Indeed, studies showed that mood fluctuations were associated with more peer conflicts (Flook, 2011) and co-occurring depressive and delinquency symptoms while feeling isolated from the peer group (Brand et al., 2007). Thus, future studies might benefit from also examining the social network of adolescents. For instance, a recent study showed that social anxiety was linked to less frequent cannabis use through less peer involvement (Nelemans et al., 2016).

Limitations

Results of the present study need to be interpreted in light of several limitations. First, our sample included Dutch adolescents with mostly medium to high SES, and half of these adolescents had

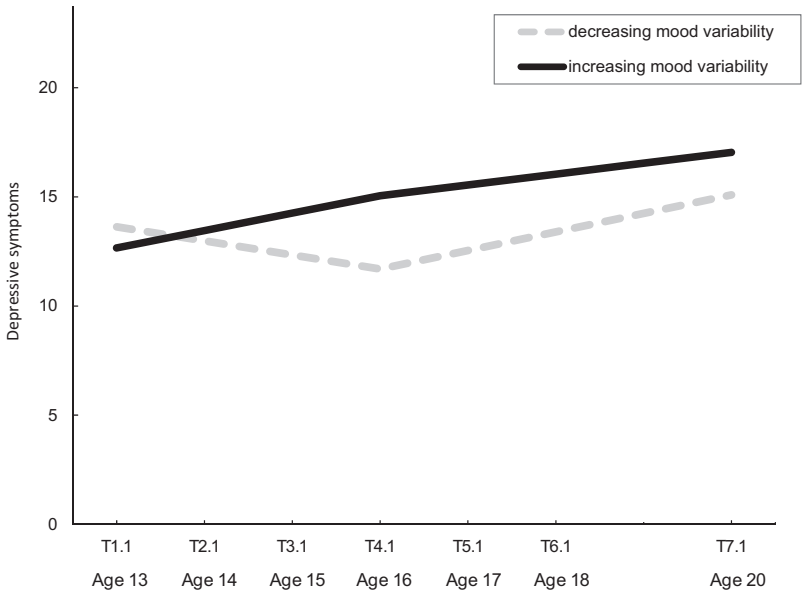

Figure 2. Depressive symptoms from ages 13 to 20 for the increasing and decreasing variability classes. The *y* axis goes from the minimum of the scale until 2 *SD*s above the minimum of the scale (*SD* averaged across all time points = 11.88).

high externalizing problem scores at age 12. Thus, it is not clear whether results would generalize to other samples.

Second, adolescent mood variability was based on daily emotion scores; however, emotions are clearly more dynamic and recall bias can even occur within very short time-frames (Shiffman et al., 2008). However, given that in the present study adolescents were followed over a large time span (five years), within-day assessments would probably be associated with overall low compliance and tolerance rates (Gunthert & Wenze, 2012). Moreover, a recent meta-analysis on microlevel emotion dynamics showed that associations between mood variability and well-being were not dependent on the time-scale that was used for the microlevel mood variability measurement (intervals ranging from seconds, minutes, hours, and up to days; Houben et al., 2015).

Another limitation is that our measurements were based on self-report, and thus associations may have been stronger because of shared method variance. However, mood variability and the adjustment measures were collected in different settings and at

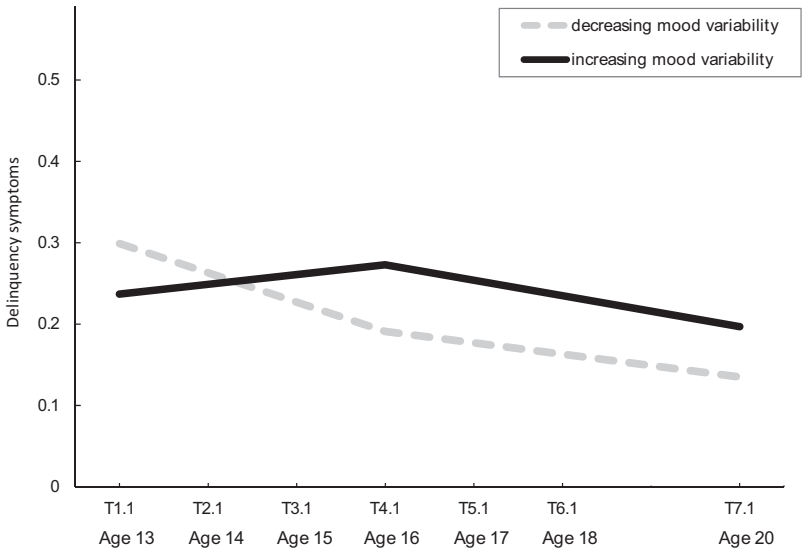

Figure 3. Delinquency symptoms from ages 13 to 20 for the increasing and decreasing variability classes. The *y* axis goes from the minimum of the scale until 2 *SD*s above the minimum of the scale (*SD* averaged across all time points = 0.29).

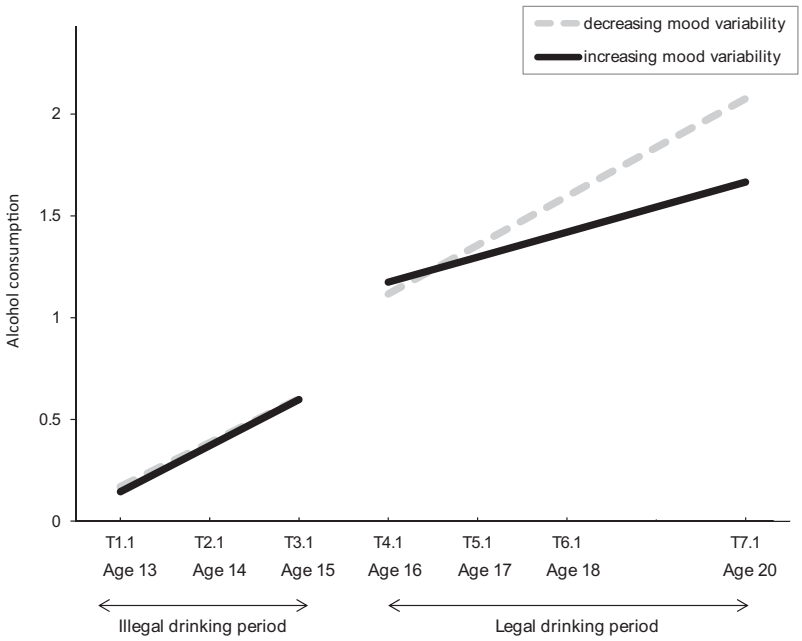

Figure 4. Alcohol consumption from ages 13 to 20 for the increasing and decreasing variability classes. The *y* axis goes from the minimum of the scale until 3 *SD*s above the minimum of the scale (*SD* averaged across all time points = 0.81).

different time-points. Moreover, many internal processes were measured in the present study, which may not have been accurately represented by other measures or proxy reports. Additionally, we used an overall composite of mood variability, which consisted of one positive and three negative emotions. The tripartite model suggests that although negative affect is important for both anxiety and depression, low positive affect is unique to depression (Clark & Watson, 1991). Thus it would be interesting to see whether the different emotions contributed differently to depressive symptoms, delinquency, and alcohol consumption. Although previous research in adolescents has shown that variability and levels of different emotions contribute relatively equally to different forms of psychopathology (Neumann et al., 2011; Silk et al., 2003), future research could examine the effect of distinct developmental trajectories of variability in different emotions and their association with adjustment development across adolescence.

Third, the method of growth mixture modeling is only an approximation of developmental classes, and our results do not imply that there are no other meaningful classes. It is possible that other smaller classes exist (e.g., adolescents with high mood variability before adolescence), but that we did not carve out these classes because of our overall sample size. Indeed, it has been noted that the power to extract different classes is limited if within-sample sizes and class separation are small (Lubke & Neale, 2006).

Directions for Future Research and Conclusion

Our findings raise a number of questions and thus provide directions for future research. First, our analyses do not allow any conclusion on the direction of effects, and thus it is not clear whether increases in mood variability predicted increases in psychopathology or the other way around. However, there are studies emerging that suggest that mood variability may be driving psychopathology, and not vice versa (Parrish et al., 2011). Moreover, a study in depressed patients and controls found that rising mood variability increased the probability of a transition into a depressive state, which suggests a temporal relation and further demonstrates the clinical relevance of mood variability (van de Leemput et al., 2014). In fact, heightened mood variability may represent a prodromal symptom of psychopathology. Our results emphasize that it may be useful to monitor adolescents' emotional experiences using experience sampling techniques to identify who is at greatest risk for psychopathology. In the last several years the use of such measures has gained popularity; for instance, they have been implemented in the context of psychological treatment (see also Wichers et al., 2011).

Second, further research needs to be conducted on the origins of mood variability. We have argued that a minority of adolescents might develop increasing mood variability levels because they are more susceptible prior to adolescence and react more strongly to the pile-up of developmental challenges during early and middle adolescence. Although the hypothesis is plausible and there is evidence for both the influence of developmental stressors on mood variability (e.g., identity formation; Klimstra et al., 2016) and greater susceptibility of some individuals to the effect of stressors with respect to their daily mood (e.g., due to their genetic make-up; Conway et al., 2015), both perspectives need joint critical testing in a developmental framework.

Third, an interesting question is how adolescents with increasingly unstable moods develop beyond adolescence. Our results suggest that their mood became more stable again toward late adolescence, but it is unclear whether this trend persists or whether

this group (or a subgroup) continues to experience heightened emotional turmoil in adulthood. Similarly, it is unclear whether the heightened depressive and delinquency symptoms of the increasing mood variability class are an adolescent-limited phenomenon or whether they stay relatively high beyond adolescence.

In conclusion, most adolescents do not experience a rise in mood variability during this period. Only a minority reported increases in emotional storm and stress. Although these adolescents were protected from increases in alcohol use toward late adolescence, they also developed more depressive and delinquency symptoms in early to middle adolescence (indicated by adolescents showing stable symptoms of depression and delinquency, in contrast to adolescents from the decreasing mood variability class who showed declines in these symptoms), a difference that stayed stable toward late adolescence. Thus, the present study suggests that most adolescents fare well in terms of emotional development, but that a minority with escalating mood swings should be monitored more closely.

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Received July 28, 2017
Revision received September 14, 2018
Accepted September 17, 2018 ■