



Grumpy or depressed? Disentangling typically developing adolescent mood from prodromal depression using experience sampling methods

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ABSTRACT

Introduction: This study aimed at differentiating normative developmental turmoil from prodromal depressive symptoms in adolescence.

Method: Negative and positive mood (daily) in different contexts (friends, home, school), and (subsequent) depressive symptoms were assessed in Dutch adolescents.

Results & conclusion: Mixture modeling on one cross-sectional study, using a newly developed questionnaire (CSEQ; subsample 1a; n = 571; girls 55.9%; Mage = 14.17) and two longitudinal datasets with Experience Sampling Methods data (subsample 1b: n = 241; Mage = 13.81; 62.2% girls, sample 2: n = 286; 59.7% girls; Mage = 14.19) revealed three mood profiles: 18–24% "happy", 43–53% "typically developing", and 27–38% "at-risk". Of the "at-risk" profile between 12.5% and 25% of the adolescents scored above the clinical cut-off for depression. These mood profiles predicted later depressive symptoms, while controlling for earlier symptoms. In subsample 1b, parents were not always aware of the mental health status of their adolescent.

1. Introduction

About 17% of adolescents suffer from a depressive disorder during adolescence (Ormel et al., 2015). Currently, there is a paucity of theoretical knowledge regarding prodromal symptoms of depression in adolescence (Iacoviello, Alloy, Abramson, & Choi, 2010; Kovacs & Lopez-Duran, 2010). Both a developmentally normative pattern, here labeled 'typical adolescent behavior', and adolescent depressive disorders may be characterized by heightened irritability and negative mood (Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; DSM-5; American Psychiatric Association, 2013). Because of their phenomenological overlap, identifying the group of adolescents who are at risk for depression may be challenging. This hinders early identification of depression, which is crucial for timely treatment and strongly improves the prognosis (Thapar, Collishaw, Pine, & Thapar, 2012).

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One possible new avenue to differentiate the two groups of adolescents is to examine whether their mood is context-dependent (e.g., Kuppens et al., 2015; Silk et al., 2011). This study aimed to (1) identify hidden groups of adolescents based on the mood they experience in different contexts and (2) link these profiles to (the onset) of depressive symptoms.

1.1. The role of negative mood in depression

Adolescence is characterized by profound biological, cognitive, and social changes. For some, these developmental changes go hand in hand with “storm and stress”, as for instance, indicated by increased negative mood and increasing mood instability (Arnett, 1999; Maciejewski, van Lier, Branje, Meeus, & Koot, 2017). In the eyes of parents and professionals, this negative mood may be interpreted as a sign of a typically developing adolescent (Maciejewski et al., 2017). For most adolescents this assessment is correct. In line with the theoretical concept of multifinality (Cicchetti & Rogosch, 1996), some adolescents may grow out of their negative mood, whereas for others negative mood could be a precursor of wide range of psychological problems (e.g., peer issues, externalizing problems, and depressive disorder). A recent study indicates that adolescents show more negative mood in early adolescence, but most of them grow out of it in later adolescence. However, a subsample of 12% showed increasing, escalating negative mood trajectories, which were predictive of later depressive symptoms (Maciejewski et al., 2019).

Depressed mood, most of the day, nearly every day, is also one of the two core symptoms of depressive disorders (DSM-5; American Psychiatric Association, 2013). In adolescence, this first key feature may be expressed in terms of irritable mood (DSM-5; American Psychiatric Association, 2013). In line with that, previous studies have indeed shown that adolescents with more depressive symptoms, experience more negative and lower positive mood on a daily basis compared to adolescents without psychological problems (Bylsma, Morris, & Rottenberg, 2008; Houben, Van Den Noortgate, & Kuppens, 2015). However, these daily signals seem to be missed, as currently, it may take several years for adolescents with a depressive disorder to be diagnosed correctly and receive treatment (Raven, Jörg, Visser, Oldehinkel, & Schoevers, 2017).

1.2. Different moods in different contexts?

Adolescent mood may be quite volatile and dependent on the social context. In adolescence, pronounced changes take place in social contexts. A handful of studies have specifically examined how mood depends on the social context. For instance, one of the earliest ESM (Experience Sampling Methods) studies in a community sample of American adolescents indicated that adolescents experienced elevated positive mood when among friends, and felt more unhappy and depressed in the company of their parents (Larson & Richards, 1991), a finding that has been replicated in more recent studies (Kendall et al., 2014; van Roekel et al., 2013). Together, theories on normative developmental patterns combined with some empirical studies suggest mood context-dependency among typically developing adolescents. In daily life, typically developing adolescents might experience a more positive mood with friends, and a more negative mood at home and at school (Stage-environment fit theory (Eccles et al., 1997)). However, sub-groups of adolescents may experience context-independent mood. There might also be a group of adolescents that is happy most of the day, almost every day, quite independent of the activities. Hence, they may feel happy across different contexts and generally do not experience much negative mood (i.e., generally happy adolescents). For instance, a subset of children report high quality relationships with parents and almost no conflict (Hafen & Laursen, 2009). Moreover, some youths may in fact like school, and experience a positive mood (Stevens et al., 2018).

In addition, adolescents at risk for depression may be characterized by context-independent mood profiles. One essential feature of depressive disorders, such as major depressive disorder is that the key symptoms (i.e., depressed or irritable mood and/or loss of interest) are present most of the day, in nearly all activities (DSM-5; American Psychiatric Association, 2013). Hence, whether they are with parents, at school, or with friends, their negative mood is present. In fact, the emotion context insensitivity hypothesis poses that adolescents who are depressed show context-independent low positive and high negative mood (Rottenberg, Gross, & Gotlib, 2005). Indeed, clinical studies among depressed adolescents (Kendall et al., 2014; Larson, Raffaelli, Richards, Ham, & Jewell, 1990; Rottenberg et al., 2005; Schneiders et al., 2006; Silk et al., 2011), suggest that depressed adolescents, compared to their peers, feel not only more sad and or irritable with parents, but also at school and with their peers.

1.3. Parents' knowledge of adolescents' depressive symptoms

Additionally, we studied parent's knowledge of adolescent depressive symptoms. Parents may be more often unaware of the internalizing problems of their adolescents (Hodges, Gordon, & Lennon, 1990; Kashani, Orvaschel, Burk, & Reid, 1985). Moreover, with age, adolescents consider an increasing number of topics to fall in the personal domain, and thus beyond the legitimate control and right to know of parents (Smetana, Metzger, Gettman, & Campione-Barr, 2006; Lionetti et al., 2019). Therefore, an additional aim of this study was to map whether poor mental health of adolescents at risk for depression was also recognized as such by their parents.

1.4. The present study

In sum, to facilitate early identification of depressive symptoms, we need theoretical knowledge on how adolescents who experience negative mood as part of normative turmoil, differ from adolescents with early non-specific symptoms that may mark the potential onset of a later depression. The purpose of this study was to test hypotheses regarding (1) distinct context- (in)dependent mood profiles of adolescents and (2) to assess whether these mood profiles would predict (the development of) depressive symptoms in

adolescence. Because mood fluctuates across time and contexts (Kuppens, 2015) and to test whether ESM data can identify the onset of depression earlier, we used ESM to test subtle fluctuations in daily mood in three contexts.

Firstly, we expected three distinct profiles of daily mood patterns: (1) *typically developing profile* (high positive mood and low negative mood with friends, low positive mood and high negative mood at school and at home); (2) *happy profile* (high positive mood and low negative mood, across all contexts, i.e. context-independent); (3) *at-risk profile* (high negative mood and low positive mood across all contexts; i.e. context-independent). We hypothesized that the happy adolescents would show the highest average levels of positive mood and the lowest levels of negative mood, followed by the typically developing, and the at-risk group. Secondly, we expected that adolescents who would be classified with the at-risk profile would report the highest level of self-reported depressive symptoms compared to the other two groups. Specifically, we predicted that at risk and typically developing adolescents in terms of their daily mood would differ in concurrent and later depressive symptoms. These hypotheses were tested using a novel cross-sectional questionnaire and ESM data. Finally, we tested, without a priori hypotheses, whether poor mental health of adolescents at-risk for depression would be recognized as such by their parents and whether adolescents received treatment for their mental health.

2. Method

In the present study, three samples from two different studies were used. For details on differences between the samples, the procedure (including the ESM protocols) consult [Appendix A1](#).

2.1. Participants

[Table 1](#) shows the baseline sample characteristics of subsample 1a (N = 571, girls 55.9%), subsample 1b (N = 241, 62.2% girls) and sample 2 (N = 286, 59.7% girls). Handling of missing data is described in [Appendix A2](#).

2.2. Measures

Context-specific emotion questionnaire. In subsample 1a, adolescents filled out the Context-Specific Emotion Questionnaire (CSEQ, developed by authors [blinded] see also [Appendix A4](#)). This online questionnaire measured positive mood (relaxed, satisfied, confident, happy, energetic, excited) and negative mood (sad, unhappy, disappointed, angry, nervous, irritated) in three different contexts (i.e., friends, home, school). Emotions were scored on a 7-point Likert scale ranging from (1) *never* to (7) *always* ([Riediger, Wrzus, & Wagner, 2014](#)). Cronbach's alpha for positive mood with friends, family, and school were respectively, .85, .89, and .88 and for negative mood with friends, family, and school was .85, .86, and .83. Additional confirmatory factor analysis was performed on the

Table 1
Baseline characteristics.

	Subsample 1a (N = 571)	Subsample 1b (adolescent: N = 241; parent: N = 236)	Sample 2 (N = 286)	Test statistic	P
Gender adolescents Girls	55.9%	62.2%	59.7%	$\chi^2(2,3) = 1.51$	0.47
Age adolescent (mean (SD))	14.17 (1.03)	13.81 (0.92)	14.19 (0.55)	$T(810) = 4.69$	0.08
Ethnicity adolescent Dutch	97.9%	98.4%	91.6%		
Educational level adolescent ^a	–	–	25.7%	$\chi^2(1) = 10.135$	0.00*
Low/Middle/High	57.4% 42.6%	45.2% 54.8%	35.0% 39.3%	$\chi^2(1) = 10.135$	0.00*
Positive mood friends (mean (SD))	6.19 (0.70) 1.71 (0.75)	5.89 (0.96) 1.36 (0.53)	5.42 (0.79) 1.49 (0.55)		
Negative mood friends (mean (SD))					
Positive mood home (mean (SD))	6.19 (0.78)	5.92 (0.90)	5.21 (0.78)		
Negative mood home (mean (SD))	2.03 (0.87)	1.36 (0.57)	1.48 (0.55)		
Positive mood school (mean (SD))	4.91 (1.04)	5.60 (0.98)	5.03 (0.81)		
Negative mood school (mean (SD))	2.10 (0.91)	1.40 (0.60)	1.61 (0.57)		
Social context ^b (% time)	n.a.	15.1%	18.5%		
Peers	n.a.	57.5%	36.7%		
Home	n.a.	26.1%	40.9%		
School	n.a.	1.3%	3.9%		
Other					
Depression baseline (mean (SD))	6.68 (5.09)	5.10 (5.03)	10.54 (8.70) ^c	$T(810) = 4.06$	0.39
Depression follow-up (mean (SD))	–	5.13 (5.13)	9.86 (7.97) ^c		

Note. ^a Low = preparatory school for technical and vocational training, Middle = preparatory school for professional education, High = preparatory school for university; ^b positive/negative mood and social context are based on ESM data (subsample 1b: 6,240; sample 2: 11,056). ^c depression scores differ because different measures were used across samples: in subsample 1a/b CDI-I ([Kovacs, 1985](#); range 0–54), in sample 2 CES-D ([Radloff, 1977](#); range 0–60). Values are percentages unless stated otherwise.

self-developed Context-Specific Emotion Questionnaire (CSEQ; Model fit CFI = .87 and RMSEA = .08). See also Appendix A8–A11.

Experience sampling measures of context. In subsample 1b and sample 2, adolescents recorded context-dependent mood using ESM. Specifically, at each beep they indicated whether they were alone or with company. After this question, they could choose from different options in subsample 1b (i.e., father, mother, sibling, friends, classmates, teachers, other adults I know, peers I know, strangers, boy or girlfriend) or answer an open-ended question in sample 2. We coded all answers into four social domains: family (e.g., parents, siblings), friends, classmates, and others. Because of the small percentage in the category others (subsample 1b: 1.3%; sample 2: 3.9%) this category was disregarded.

ESM of mood. In subsample 1b, positive mood was measured by the items relaxed, satisfied, confident, happy, energetic, and excited. Negative mood was measured by the items sad, unhappy, disappointed, angry, nervous, and irritated (PANAS; Crawford & Henry, 2004). In sample 2, positive mood was measured by the items joyful, satisfied, happy, energetic, relaxed, and cheerful and negative mood was measured by insecure, anxious, irritated, worried, sad and guilty. Items were selected based on previous ESM studies (Peeters, Berkhof, Delespaul, Rottenberg, & Nicolson, 2006; Wichers et al., 2007). In both samples mood was scored on a 7-point scale (subsample 1b ranging from (1) never to (7) always; sample 2 ranging from (1) not at all to (7) very much). Cronbach's alphas calculated over all measurements for negative mood and positive mood were 0.89 and 0.91 in subsample 1b and 0.82 and 0.82 in sample 2 respectively. As measure of within-person reliability of R1F coefficients were calculated following the method of Cranford et al. (2006). For negative and positive mood, within-person reliability was sufficient to high (0.77 and 0.86 in subsample 1b and 0.63 and 0.69 in sample 2 respectively). Per person a mean score for negative and positive mood per social context was calculated in which higher scores reflect higher levels of negative and positive mood. An overview of the items across samples are reported in Appendix A8.

Depressive symptoms. In sample 1 (subsample 1a and subsample 1b), depressive symptoms were measured with the 27-item Children's Depression Inventory questionnaire (CDI- I; Kovacs, 1985). Total scores ranged from 0 to 54. A clinical cut-off of 16 was used (Roelofs et al., 2010). Cronbach's alphas were .83 for subsample 1a, 0.87 for the baseline of subsample 1b, and 0.86 at three months follow-up of subsample 1b. In sample 2, depressive symptoms were measured with the 20-item Center for Epidemiology-Depression-scale (CES-D; Radloff, 1977). Participants rated their symptoms on a four point scale ranging from (0) seldom to (3) most of the time or always. Total scores ranged from 0 to 60, and a clinical cut off of 22 was used (Cuijpers, Boluijt, & Van Straten, 2008). Cronbach's alphas were .91 for the baseline, and 0.89 at the follow-up.

Parental report of mental health of adolescent and treatment. In subsample 1b, as part of the online questionnaire for parents, the participating parent reported adolescent mental health using a four point scale ranging from (1) bad to (4) excellent. For treatment, parents answered an open question if their adolescent had treatment or used medication for mental health issues in general.

2.3. Statistical analyses

To identify different mood profiles per sample, we used Mixture Modeling (Muthén & Muthén, 2000) separately for each sample on the measures for positive and negative mood per social context (i.e., friends, home, school). Mixture models are suitable for detecting underlying latent patterns in data, using the combined information from statistics and conceptual rationales. Highlighted by methodologists, the number of classes can only be determined based on a combination of decision criteria, which includes, the question at stake, parsimony of the class solution, theoretical justification, and interpretability (Jung & Wickrama, 2007). The purpose of the application of mixture models here, therefore is, to see if the 3 hypothesized (hence theoretical meaningful and interpretable) classes can be found in different datasets.

By statistically comparing the 1-class and the 2-class solution, we tested whether heterogeneity existed. By comparing the 2- and 3-class solution, we tested the existence of the hypothesized third class of adolescents with typically developing negative mood, above and beyond two classes. To validate a 3-class solution against less parsimonious models, we also explored and provide the results of the 4- and 5- class solutions, on which we did not have a priori hypotheses, but which we fitted merely for controlling purposes and for transparency (Van De Schoot, Sijbrandij, Winter, Depaoli, & Vermunt, 2017). A first set of criteria here applied are the statistically fit indices. First, we fitted mixture models to examine the most optimal number of classes in the datasets. Following guidelines from Van De Schoot et al. (2017), we evaluated this primarily in terms of BIC (Bayesian Information Criterion) and AIC (Akaike's Information Criterion), and secondarily in term of the LMR-LRT (Lo-Mendell-Rubin adjusted Likelihood Ratio Test; e.g., Van De Schoot et al., 2017). Furthermore, to assess the quality of the solution, we only considered solutions with good entropy (0.80; Clark & Muthén, 2009). 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, and 800 and 160 respectively) to check whether the same best log-likelihoods were obtained and replicated (Asparouhov & Muthén, 2012). Variances were freely estimated across classes.

Another set of criteria in mixture models are theoretical, and include the research question, parsimony, theoretical justification, and interpretability (Jung & Wickrama, 2008).

Given that we aimed at comparing the different classes with each other on depressive symptoms, we refrained from class solutions with classes that were too small (smaller than 5% of the total sample) to meaningfully test for differences in depressive symptoms. In a second step, we described the characteristics of the latent profiles by comparing within-class and between-class differences (e.g., negative mood at home vs. friends) using the Wald test.

Thirdly, to test our hypotheses that these profiles predict adolescent scores on well-established depression questionnaires, we use the AUXILIARY (DU3STEP) option in Mplus (Vermunt, 2010), to correct for classification inaccuracy. Depression was treated as a distal outcome with unequal means and variances across latent classes (Asparouhov & Muthén, 2014). Finally, we examined whether parental perception of adolescent mental health differed across the latent mood profiles.

All analyses, except the mixture analyses, were performed in R (R Core team, 2017; Rstudio version 1.0.153). The mixture analyses

were performed in Mplus (version 8.2, [Muthén & Muthén, 2015](#)). To control for type I errors the false discovery rate (FDR) was applied ([Benjamini & Hochberg, 1995](#)).

3. Results

[Table 1](#) shows the descriptive statistics. Appendix A5–A7 show the correlations among all study variables.

3.1. Identifying different mood profiles

A first objective was to find distinct mood profiles. [Table 2](#) shows the fit indices of the mixture models in subsample 1a, subsample 1b and sample 2. The hypotheses, that two classes would be better than one (i.e., there is significant heterogeneity) was supported by all indicators, and three classes would be better than two (i.e., there is an intermediate class between generally “happy” adolescents, and “at-risk” adolescents) received support in 8 out of 9 indicators. More specifically, in each sample, the primary evaluation criteria BIC and the AIC confirmed the hypothesis that a 2-class solution is superior to a 1-class solution and 3-classes were better than 2-classes. In two out of three samples, moreover, the secondary criterion LMR-LRT confirmed that the 3 classes were significantly better than 2 classes. All three-class solutions had a good to excellent entropy (0.88–0.96).

Even though we did not have theoretical hypotheses regarding their existence, we still explored a 4- and 5-class solution following [Van De Schoot et al. \(2017\)](#). This indicated that for two out of three samples only 3 classes were represented in the data. More specifically, in subsample 1a and 1b the 4-class solution did not converge (despite additional specifications which were tested, see [Table 2](#)) and the 5-class solution did not result in a lower BIC compared to the 3-class solution. Sample 2 suggested one or two small additional classes, above and beyond the hypothesized and statistically confirmed three (“happy”, “typically developing”, and “at-risk”). However, sample size of the 4th and 5th class were too small (less than 5% of the sample; resulting in suboptimal power) for follow-up analyses, and there was less distinct theoretical meaningfulness for a 4th or 5th class. Therefore we continued with the three class solution, but still present the follow up analyses for interested readers on the 4 and 5 class solution in [Appendix A15](#). The combined statistical and theoretical argumentation needed to evaluate the number of classes ([Van De Schoot et al., 2017](#)) suggested that the hypothesized 3- class structure was present in each of the datasets. Most adolescents were classified as “typically developing” (53%;

Table 2

Fit measures mixture models.

# of classes	Primary criteria			Secondary criteria		Number (percentage) per latent class*				
	BIC	AIC	LL (parameters)	LMR-LRT (p)	Entropy	1	2	3	4	5
Subsample 1a (n = 571)										
1	8552.540	8500.372	–4238.19 (12)	–	–	571 (100%)				
2	7257.038	7148.354	–3549.18 (25)	0.0281	0.847	271 (47.46%)	300 (52.54%)			
3	6684.907	6519.706	–3221.85 (38)	0.0035	0.881	305 (53.41%)	111 (19.44%)	155 (27.15%)		
4	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5	6788.159	6509.926	–3190.96 (64)	0.3325	0.917	299 (52.36%)	110 (19.26%)	156 (27.32%)	4(0.7%)	2(0.3%)
Subsample 1b (n = 241)										
1	2870.460	2828.643	–1402.32 (12)	–	–	241(100%)				
2	1710.841	1623.721	–786.86 (25)	0.000	0.929	132 (54.8%)	109 (45.2%)			
3	1405.469	1273.047	–598.52 (38)	0.065	0.920	117 (48.5%)	58(24.1%)	66(27.4%)		
4	NA	NA	NA	NA	NA	NA	NA	NA		
5	1433.382	1210.355	–541.18 (64)	0.147	0.916	79(32.8%)	79(32.8%)	58(24.1%)	4(1.7%)	21 (8.7%)
Sample 2 (n = 286)										
1	3492.712	3448.186	–1712.09(12)	–	–	302(100%)				
2	2704.949	2612.188	–1281.09 (25)	0.0000	0.874	155 (51.0%)	147 (49.0%)			
3	2524.106	2383.110	–1153.56 (38)	0.0017	0.853	130 (43.0%)	56(18.5%)	116 (38.5%)		
4	2459.853	2270.352	–11084.18 (51)	0.0029	0.863	126 (41.7%)	54(17.9%)	80(26.5%)	42 (13.9%)	
5	2426.468	2189.001	–1030.50 (64)	0.0194	0.868	109 (36.1%)	52(17.2%)	76 (25.9%)	42 (13.9%)	21 (6.9%)

Note. Class counts and proportions are based on their most likely latent class membership; Due to the small size of some classes, estimates may be less trustworthy. Stable class solution was tested by 200 and 40 random starts (as well as 400 and 80, 800 and 160). Variance were freely estimated across classes (zero variance within classes was also performed; did not converge).

48%, and 43%, for subsample 1a, 1b, and sample 2, respectively), some as “happy” adolescents (19%, 24%, 18.5%), and some had high levels of negative mood, and were “at-risk” for depression (or “at-risk”; 27% 27%, and 38.5%).

3.2. Describing the mood profiles

To theoretically validate the mood profiles, a more detailed description is provided on the differences between profiles, and the context patterning within classes. Table 3 provides a full overview of the Wald-test comparisons between the latent classes. Results indicate that adolescents in different classes differed in their moods, especially in their negative mood (effect sizes of Cohen’s *d* was on average large ($M = 1.59$; range 0.35–3.2). Adolescents “at-risk” reported the highest negative mood, followed by the adolescents identified as “typically developing” and followed by the “happy” adolescents. When focusing on positive mood, results showed overall that the “at-risk” group reported the lowest positive mood, followed by the adolescents identified as “typically developing” and followed by the adolescents identified as “happy”. Although the described pattern is visible in Fig. 1, Wald tests showed a less consistent pattern across samples in the effects of positive mood compared to negative mood.

In order to examine whether positive or negative mood differed across contexts in the different classes (“happy”, “typically developing”, “at-risk”), Wald-tests were used as well (see Table 4 for results). In line with our expectations, results suggested context-independent mood for adolescents identified as “at-risk”. More specifically, we found (almost) no significant differences between different contexts (i.e., friends, home, school) in all samples. We did, however, find that the adolescents in sample 2 reported higher negative mood when at school compared to when with friends. Furthermore, we hypothesized that the “happy” adolescents would also show a pattern of context-independency. Even though in subsample 1a we found evidence of context-dependency (i.e., adolescents were happier at school and with friends compared to at home), in subsample 1b and sample 2, a less consistent pattern emerged. While in subsample 1b there were differences across contexts in negative emotions, there was almost no difference in sample 2. With regard to the “typically developing” group of adolescents, the results of subsample (1a) indicated significant differences pointing towards context-dependency. In contrast, the ESM samples (subsample 1b and sample 2) did not suggest context-dependency. Thus, although the hypothesized 3 profiles were found, and the “at risk” adolescents reported context-independent mood as expected by the emotion context insensitivity hypothesis, the hypothesized context-independency in the “happy” group and the context-dependency in the “typically developing” group did not receive clear empirical support.

3.3. Linking mood profiles to depressive symptoms

To assess how the mood profiles, which were identified with mixture models in the previous step, would predict depression symptoms, we tested them against validated depression questionnaire outcomes (CDI-I; Kovacs, 1985; or CES-D; Radloff, 1977) both concurrently and at follow-up (Table 5). This led to overall difference tests between the clusters ($df = 2$), as well as pairwise comparisons. In the five overall Chi-square tests (see Table 5), it was confirmed that adolescents in these classes differed in terms of depressive symptoms. More specifically, the adolescents who were categorized as “at-risk” showed the highest depression symptoms scores according to the CDI or CES-D in 9 out of 10 pairwise comparisons. Compared to happy adolescents, “at-risk” adolescents scored

Table 3
Group differences in emotions.

		Subsample 1a			Subsample 1b			Sample 2		
		χ^2	P	d	χ^2	P	d	χ^2	P	d
Context	Level of negative mood									
Friends	At-risk vs. typically developing	37.53	.00*	1.24	9.83	.00*	0.91	15.88	.00*	0.90
Friends	At-risk vs. Happy	56.87	.00*	2.04	12.77	.00*	1.25	12.18	.00*	1.32
Friends	Typically developing vs. happy	86.55	.00*	1.15	6.69	.01*	0.35	8.32	.00*	0.50
Home	At-risk vs. typically developing	27.97	.00*	1.84	28.87	.00*	1.16	38.80	.00*	1.38
Home	At-risk vs. Happy	40.60	.00*	2.84	32.24	.00*	1.59	14.13	.00*	1.83
Home	Typically developing vs. happy	8.78	.00*	0.98	18.70	.00*	0.47	11.69	.00*	0.57
School	At-risk vs. typically developing	18.14	.00*	1.34	10.14	.00*	1.02	21.28	.00*	1.12
School	At-risk vs. Happy	33.15	.00*	1.93	11.59	.00*	1.31	23.67	.00*	2.04
School	Typically developing vs. happy	7.66	.01*	0.63	7.84	.01*	0.29	13.33	.00*	0.51
Context	Level of positive mood									
Friends	At-risk vs. typically developing	28.19	.00*	0.60	5.40	.02*	2.59	5.89	.02	2.21
Friends	At-risk vs. Happy	48.61	.00*	1.72	8.27	.00*	260	5.50	.02	2.00
Friends	Typically developing vs. happy	52.60	.00*	2.05	0.93	.36	0.84	1.57	.21	0.87
Home	At-risk vs. typically developing	16.69	.00*	1.29	9.57	.00*	2.26	3.29	.07	2.52
Home	At-risk vs. Happy	44.27	.00*	2.58	15.91	.00*	3.08	3.74	.05	2.14
Home	Typically developing vs. happy	90.95	.00*	1.68	6.65	.01	2.58	1.16	.28	1.15
School	At-risk vs. typically developing	3.17	.08	0.87	54.98	.00*	2.41	9.67	.00*	1.92
School	At-risk vs. Happy	1.72	.19	2.17	8.29	.00*	3.20	6.02	.00*	2.48
School	Typically developing vs. happy	31.33	.00*	1.70	2.35	.13	2.72	12.31	.00*	1.22

Note. To test for multiple correction through the FRD method the lowest p-value that was regarded as significant was 0.01, 0.02 and 0.01 for subsample 1a, 1b and sample 2 respectively (for more details and corrected p-values see FRD excel which can be provided on request). *significant at the adjusted p-level. All Wald-tests have a DF of 1. Effect sizes are calculated using Cohen’s *d*.

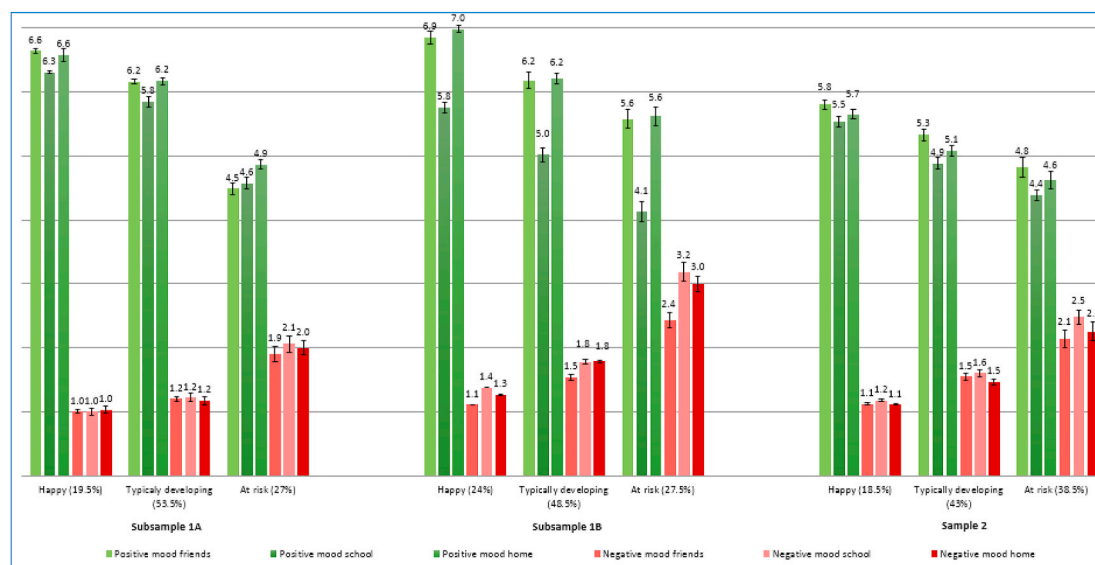


Fig. 1. Fig. 1 Means of positive and negative mood across context in subsample 1a, subsample 1b, and sample 2. *Error bars represent S.E.

Table 4

Within class differences in context.

		Subsample 1a			Subsample 1b			Sample 2		
		χ^2	P	d	χ^2	P	d	χ^2	P	d
Negative mood	Context									
	Happy									
	Happy									
	Happy									
	Typically developing									
	Typically developing									
	Typically developing									
	At-risk									
	At-risk									
Positive mood	Context									
	Happy									
	Happy									
	Happy									
	Typically developing									
	Typically developing									
	Typically developing									
	At-risk									
	At-risk									

Note. To test for multiple correction through the FRD method the lowest p-value that was regarded as significant was 0.01, 0.02 and 0.01 for subsample 1a, 1b and sample 2 respectively (for more details and corrected p-values see OSF project). *significant at the adjusted p-level. All Wald-tests have a DF of 1. Effect sizes are calculated using Cohen's d.

higher than happy adolescents on each comparison, crosssectionally and in the follow-up (see also Table 5). Moreover, “typically developing” and “happy” adolescents were significantly different in subsample 1a and sample 2 (this was not confirmed in subsample 1b). The “at-risk” adolescents scored highest on depression symptoms, followed by the “typically developing” followed by the “happy” adolescents.

Testing one of the key hypotheses in this paper, the “typically developing” versus “at-risk” mood profiles showed significant differences in depressive symptoms in each sample. The “typically developing” and “at-risk” adolescents still significantly differed in their depression scores at the 3-months follow-up in subsample 1b, but not at the 7-month follow-up in sample 2.

Thus, in four out of five tests, the hypothesis was confirmed that “at-risk” vs “typically developing” adolescents reported higher levels of depressive symptoms on validated questionnaires. Effect sizes calculated by means of Cohen's d ranged from small to large (d = 0.23–1.73).

Additionally, we examined differences in terms of clinical depression cut-off scores. Crosssectionally, compared to “happy”

Table 5

Depressive feelings among adolescents with distinct different mood profiles.

	Subsample 1a		Subsample 1b		Sample 2	
	Cross-sectional (n = 571) *		Baseline (n = 241) *	Follow-up (n = 179) *	Baseline (n = 286) *	Follow-up (n = 197) *
Mean (SD) depression per mood profile*						
Happy	3.51 (0.34)		2.57 (0.34)	2.52 (0.47)	5.15 (0.63)	5.80 (0.61)
Typically developing	5.108 (0.22)		3.46 (0.33)	3.72 (0.33)	10.49 (0.72)	11.13 (0.98)
At-risk	11.77 (0.46)		10.94 (0.80)	10.32 (0.98)	19.24 (1.53)	14.81 (1.87)
Percentage of clinical depression range per mood profile*						
Happy	0%		0%	0%	0.86%	0.86%
Typically developing	0%		0%	0.85%	6.15%	7.7%
At-risk	19.2%		12.12%	15.15%	25%	12.5%
Class comparisons of depression						
	df	χ^2, d	χ^2, d	χ^2, d	χ^2, d	χ^2, d
Overall test	2	230.90*	95.49*	51.50*	87.70*	39.96*
At-risk vs. Typically developing	1	169.47*	77.36*	40.56*	25.42*	2.62
Happy vs. Typically developing	1	13.01*	3.31	3.98	23.68*	20.09*
At-risk vs. happy	1	211.48*	93.76*	51.04*	74.19*	21.02*
		1.73	1.69	1.31	1.16	0.62

Note. Sample size can be different because of missing data. * $p < .001$. Effect sizes are calculated using Cohen's.

(max.0.86% clinically depressed in this profile) or “typically developing” adolescents (max.6.15%), “at-risk” adolescents more often reported clinical levels of depression (19.2% in subsample 1a, and 12.12% at baseline 15.15% at follow-up in subsample 1b, 25% at baseline and 12.5% at follow-up in sample 2).

3.4. Parental report of adolescent mental health

To assess how often depression goes unrecognized by parents, we addressed the parental perception of adolescent physical and mental health in subsample 1b. Only 3 parents out of the 21 clinically depressed participants recognized their adolescents' mental health as bad (14%). None of the participants received treatment for mental health problems.

4. Discussion

The present study tested if adolescents “at-risk” for depression could be identified based on different profiles of context-(in) dependent negative and positive moods. To differentiate adolescents whose negative affect is related to a typical developmental pattern from adolescent with an at risk mood-insensitive patterns, we developed a novel questionnaire and we used ESM to measure real-time mood and social context several times per day in two samples. Using data-analytical mixture techniques, three distinct mood profiles were identified: adolescents who were “happy”, “typically developing” and “at-risk for depression”. Even though 3 profiles were found, their mood-context sensitivity was only supported in the questionnaire. In support of the second hypothesis, the “at risk” adolescents, reported elevated levels of depressive symptoms, compared to the other groups. Between 12% and 25% of the adolescents who were identified as “at-risk” reported a clinical level of depressive symptoms. Only 14% of the parents recognized their adolescent's poor mental health status and none of the adolescents received treatment. Below we highlight how these findings may add to theory and clinical practice.

4.1. Describing the mood profiles

First, results suggested that the adolescents “at-risk” showed higher negative moods compared to the “happy” and the “typically developing” groups. With regard to positive mood no significant differences in the three profiles were detected. Secondly, in support of our hypotheses, “typically developing” group of adolescents showed significant differences pointing towards context-dependency (in the cross-sectional subsample 1a). However, in the ESM sample (subsample 1b and sample 2) this hypothesized effect was not detected. For “happy” and “typically developing” adolescents in all samples, positive mood increased with friends and at school, and decreased when at home, comparable with the findings of Larson and colleagues(1998). However, for youths with an “at-risk” profile, levels of negative mood were mostly context-independent, supporting the context-insensitivity hypothesis (e.g. Larson et al., 1990; Rottenberg et al., 2005; Schneiders et al., 2007; Silk et al., 2011). Hence, although we did find three profiles in three datasets, which could be theoretically interpreted, the exact nature of the context mood dependency was different from our hypothesis in ESM data.

4.2. Linking mood profiles to depressive symptoms

We additionally related the three different mood profiles to depression to assess whether they would have predictive value in

understanding (the onset of) depression. Cross-sectional comparisons demonstrated increased levels of depressive symptoms among adolescents with an “at-risk” profile. The mood profiles also predicted depressive symptoms 3 months later. Even though this study could not yet identify adolescents “at-risk” with 100% accuracy, we suggest that it provides insights relevant for clinical practice and may be an additional instrument in a large toolbox. Specifically mood profiles may help disentangling “at risk” adolescents from “typically developing” teens. Those who were identified as typically developing, had almost no risk (0%–7.7%) to score in the clinical range of depressive symptoms.

ESM is the more ecologically valid method for detecting changes in mood (Moore, Depp, Wetherell, & Lenze, 2016), but the novel questionnaire may be a promising, additional assessment tool to predict the onset of depression. Although the findings were in general terms replicated in two samples, both came from the same country and were quite similar in terms of cultural factors. Future research will need to assess the extent to which emotional dynamics are dependent on demographic characteristics or cultural factors.

4.3. Parental report of adolescent mental health

The present study confirmed an often expressed worry that only few parents recognize their adolescent’s well-being and depressive feelings (i.e., 14% of adolescents with an “at-risk” profile were evaluated as such by their parents; see also Logan & King, 2002; Raven et al., 2017; Dietvorst, Hiemstra, Hillegers, & Keijsers, 2018). More in-depth examination is needed, preferably with more advanced instruments for tapping into parental knowledge of depressive symptoms. Still, our finding that none of the adolescents received treatment, even though they scored in the clinical range of depressive symptomatology, shows that earlier identification and treatment in a community sample is needed. In addition, these results highlight that parent-child communication might be a hindering factor on the route towards early identification.

4.4. Limitations and suggestions for future research

Apart from the fact that this empirical study found similar results in two independent samples, some limitations have to be mentioned. In our ESM studies, not all compliance rates were high. Tips and tricks (based on Sample 1 and Sample 2) on how to improve ESM studies can be found elsewhere (Van Roekel, Keijsers, & Chung, 2019). Moreover, clinical samples should be included to validate the profiles. Furthermore, the self-reported daily emotions in the context of school could be confounded by the fact that they spend time with peers, of which some may be friends. Additionally, as outcomes we relied on self-reported depressive questionnaires. Thus, interviews on psychopathology could give additional insights in clinician-rated depressive symptoms and diagnoses among adolescents. To translate these findings into (clinical) practice, and build a sensitive and specific algorithm to identify depression risk, we consider mood profiles as only one of the predictive variables. Based on this empirical study, classification of a person, in our view, is especially suitable for disentangling the subtle differences between normal developmental turmoil from (sub)clinical levels of depression in terms of context-insensitivity. Alternative approaches, which have shown to be promising highlight predictive power of emotional dynamics over time, such as inertia, or mean levels of negative mood (Dejonckheere, Kuppens, et al., 2019; Bos, de Jonge, & Cox, 2019). Future research would benefit from an integrated approach in which the unique incremental value of each type of predictor is compared (see also Appendix 14 and 15). With regard to the novel questionnaire, developed to assess this context-dependency, we have conducted preliminary validation of the psychometric qualities and tests of predictive validity (Appendix 9), but follow-up studies in independent, larger and clinical samples will be needed to improve it for use in clinical practice. Moreover, this empirical study is a first step in developing novel assessment tools for the onset of depression. User- and professional experiences, the impact of (mis)profiling on clients, and the validity in clinical practice all need to be carefully considered when implementing findings like these.

5. Conclusion

Notwithstanding these limitations and the need for future studies, this study suggests that context-mood insensitivity, and the inability to adapt mood to a different contexts, may be a trait-like risk factor for depressive symptoms in adolescence (Rottenberg et al., 2007). Although the nature of the mood-context sensitivity was not confirmed in each dataset and some indicators hinted that small additional unhypothesized classes could be present, the mood profiles were able to predict depressive symptoms concurrently and 3 and 7 months later. Youth “at-risk” were indeed more often clinically depressed compared to “happy” and “typically developing” adolescents. Thus, combining state-of-the-art statistics, with both real-life or a context-mood questionnaire (CSEQ), might open up possibilities of detecting adolescents “at-risk” in community samples. Confirming the notion that parents and children tend to refrain from communication about more personal issues in adolescence, most parents did not recognize their adolescent as “at-risk” for mental health problems and none of them received medical or psychological treatment. Results of this study, combined with subsequent research and implementations into eHealth may help adolescents to recognize whether they are in need of help, or whether they are just a “typically developing” adolescent, who is sometimes grumpy, but not depressed.

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The Ethical Committee of the Faculty of Social Science University Utrecht approved this study.

Sample 2: This study was approved by the Medical Ethical Committee (CMO Arnhem-Nijmegen, 2009; No. 285).

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.adolescence.2021.01.009>.

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