

# Adolescents' Daily Perception of Internalizing Emotional States by Means of Smartphone-based Ecological Momentary Assessment

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**Abstract.** This study uses ecological momentary assessment (EMA) with smartphone devices to examine community adolescents' perceptions regarding both the intensity of and variability in their daily sadness/depression, anxiety, and somatic problems over the period of one week. Participants were 90 high-school students ( $M_{\text{age}} = 14.61$ ,  $SD = 1.64$ ; range 12–18). The sample was divided according to gender (61.1% girls), migratory status (68.5% Spanish nationals and 31.5% Latin American immigrants), and level of psychological symptoms (17% risk group). Sadness/depression, anxiety, and somatic problems were examined using a smartphone app, five times per day, semi-randomly, for seven days (35 possible moments). A high proportion of adolescents did not report feelings of sadness (80.0%) or worry (79.3%) or physical symptoms on a daily basis (84.9%). Girls and the risk group reported greater intensity levels for the three analyzed problems than did boys and the normal group, respectively ( $p < .001$  in all cases). Migratory status was not associated with any significant differences in the analyzed problems over the one-week period ( $p > .05$  in all cases). Day-to-day fluctuations in mood during the week were statistically significant but not meaningful ( $b = 0.0004$ , 95% CI [0.0001, 0.0008],  $p = .001$ ).

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Studying the intensity of and temporal variability in emotional states is especially relevant in research involving adolescents, since they are at a developmental stage characterized by numerous internal and external changes that may produce fluctuations in mood states (Hardy, Bukowski, & Sippola 2002). This instability in relation to dynamic psychological processes may play an important role in some forms of psychopathology especially with regard to internalizing problems (Helbig-Lang, Lang, Petermann, & Hoyer, 2012). Fluctuations in mood states have been associated with negative life outcomes (Salum, Desousa, do Rosário, Pine, &

Manfro, 2013), drug use (Comulada, Lightfoot, Swendeman, Grella, & Wu, 2015), and stress (Walsh, Basu, & Monk, 2015). The intensity of negative mood states has also been linked to alcohol (Ahonen, Nebot, & Giménez, 2017; Martínez-Hernández, Marí-Klose, Julià, Escapa, & Marí-Klose, 2012) and tobacco use (Martínez-Hernández, Marí-Klose, Julià, Escapa, Marí-Klose, & DiGiacomo, 2012).

However, despite the importance of reliably assessing the intensity of and temporal variability in mood states, the latter are not always well captured by traditional retrospective assessment methods, which tend to be the most commonly used. Regarding the *intensity* of psychological symptoms, most self-report surveys require respondents to consider their previous mood state after varying lengths of time have elapsed. This kind of retrospective appraisal is subject to potential

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bias, since it may be influenced by both the quality of memory and the impact of recent life events (Ebner-Priemer & Trull, 2009; Raselli & Broderick, 2007; Trull & Ebner-Priemer, 2009). Thus, adolescents may overestimate their problems and this would lead them to report higher levels of psychological symptoms when assessed using conventional questionnaires. Margraf, Taylor, Ehlers, Roth, and Agras (1987) noted three decades ago that the number of symptoms reported in questionnaire surveys was higher than in diaries, suggesting that symptom reports tend to be exaggerated retrospectively. A study by Mokros (1993) showed a clear discrepancy between the reporting of psychological symptoms during a week and the recall of these symptoms at the end of the week.

As regards emotional *variability* over time, it is argued that psychopathology is best seen as a dynamic and constantly changing construct (DeVries, 1992). However, the dynamics of psychological symptoms “has been neglected for some time, likely because of the inability of cross-sectional and retrospective reports to uncover the ebb and flow of symptoms” (Ebner-Priemer, Eid, Kleindienst, Stabenow, & Trull, 2009, p. 195), and this seriously limits the ability to accurately characterize, understand, and change behavior in real-world settings.

Ecological momentary assessment (EMA) offers a way of overcoming these problems, since it involves the repeated assessment of mood and behavior in the here and now, in both natural settings and real-time, thus allowing the dynamics of and fluctuations in psychological states to be observed over a certain period of time (Shiffman, Stone, & Hufford, 2008). Indeed, one of the most promising applications of EMA lies in the possibility of detecting fluctuations over time (Wenze & Miller, 2010). EMA methods were developed partly in response to the limitations of retrospective recall, which is hampered by the fact that our recollections are not simply inaccurate but may often be systematically biased (Shiffman et al., 2008). For example, people are more likely to retrieve negatively valenced information when they are in a negative mood (Clark & Teasdale, 1982). This implies that there will be discrepancies between EMA-based and recall-based assessments of the same period (Shiffman et al., 2008).

In adolescent samples, EMA has been used to evaluate a wide variety of problematic behaviors associated with everyday life, including drug use (Comulada et al., 2015), smoking relapse (Shiffman et al., 2007), and binge eating (Wegner et al., 2002). Silk, Steinberg, and Sheffield Morris (2003) found that the intensity and lability of levels of emotion in everyday life were associated with elevated depressive symptoms and poor adjustment in adolescents. Accordingly, children and youth with major depressive disorder reported both

more intense and labile negative affect than did a control group (Silk et al., 2011). A study by Tan et al. (2012) found that in real contexts and during everyday life anxious youth do not experience more intense momentary negative emotions than do control youths. However, the variability of emotions has been reported to predict the development of anxiety disorder symptoms (Neumann, van Lier, Frijns, Meeus, & Koot (2011)) and emotional distress (Aldinger et al., 2014). The systematic review by Waltz, Nauta, and Aan Het Rot (2014) of 34 studies using EMA highlighted its benefits for the study of anxiety disorders, including generating insight into the temporal variability of symptoms.

These research findings underline the importance of early detection in relation to the intensity of and temporal variability in the mood states of adolescents, especially given their propensity to experience internalizing problems (McLaughlin, Hilt, & Nole-Hoeksema (2007). While there are important differences in the prevalence of such problems by country (Austin & Chorpita, 2004) some multinational studies indicate that Spanish community adolescents show the highest rate of internalizing problems (Rescorla et al., 2007). Ahonen et al. (2017) stated that around 13% of Spanish boys and 21% of Spanish girls reported negative mood states.

In light of the above, the current study uses smartphone-based EMA to assess in a community sample of Spanish adolescents both the *intensity* of and *variability* in three kinds of internalizing psychological problem. In a previous study that examined the use of EMA with more or less the same sample as used here, we showed that it is a feasible method with community adolescents (Magallon-Neri, Kirchner-Nebot, Forn-Santacana, Calderon, & Planellas, 2016). Our aim here is to explore some of our earlier data in greater depth, specifically as regards the role of migratory status, the level of psychological problems, and temporal variability in psychological problems. The overall objective was to analyze adolescents’ daily perceptions about sadness/depression, anxiety, and somatic problems in real-time and in an ecological setting so as gain greater insight into their day-to-day emotional experiences. This general objective was broken down into two specific aims. The first was to examine the perceived day-to-day *intensity* of the three kinds of internalizing symptom (i.e., sadness/depression, anxiety, and somatic problems), as reported using smartphone-based EMA, and second, to analyze the reported levels according to gender, migratory status (Spanish nationals vs. Latin American immigrants), and level of psychological problems (normal vs. risk groups). Our hypothesis was that the immigrant population, the at-risk population, and girls would report higher levels of these

internalizing emotional states. As regards the immigrant population, adapting to a new culture and to the changes that follow from having left one's country of origin are factors that may impact on the emotional states of adolescents, heightening their experience of psychological problems, especially those of the internalizing kind (Janssen et al., 2004) such as depression (Fandrem, Sam, & Roland, 2009) and somatizations (Vieno, Santinello, Lenzi, Baldassari, & Mirandola, 2009). We also expected to find an association between the sadness/depression, anxiety, and somatic states recorded using EMA and the internalizing symptoms reported via conventional paper-and-pencil questionnaires such as the Youth Self Report (YSR) (Achenbach & Rescorla, 2001). More specifically, we hypothesized that participants with high levels of symptoms according to the YSR would also report higher levels of problems via EMA, as compared with those participants who showed a low level of symptoms on the conventional measure. However, we also expected to find that the EMA method would indicate lower overall levels of problems than would the conventional paper-and-pencil questionnaire, due to the fact that the bias effect associated with the former will be lower (Shiffman et al., 2008).

With respect to gender, previous research using traditional methodology indicates that males and females differ in their levels of specific types of psychological problems, with females reporting higher levels of internalizing symptoms (Ahonen et al., 2007; Forns et al., 2015; Zahn-Waxler, Shirtcliff, & Marceau, 2008). In our previous aforementioned study (Magallon-Neri et al., 2016) we observed a higher level of sadness/depression, anxiety, and somatic concerns among girls. As the present sample is almost the same, similar results are expected.

The second aim was to examine via EMA the *variability* in sadness/depression, anxiety, and somatic states across a one-week period. Once again, we sought to analyze the results in relation to gender, migratory status, and level of psychological problem. The hypothesis here was that females, the immigrant population, and adolescents in the risk group would show greater variability in their sadness, anxiety, and somatic states over the period of one week. Previous studies using EMA have reported that males and females differ in the mean level and variability of internalizing problems (Rusby, Westling, Crowley, & Light, 2013; Silk et al., 2003), with girls tending to show greater day-to-day fluctuations in problems of this kind. Likewise, adolescents at risk of psychological problems are more sensitive to everyday stressors (Palmier-Claus et al., 2011), and they show greater lability of negative emotions, especially sadness (Silk et al., 2011).

## Method

### Participants

The convenience sample comprised 90 students (61.1% girls) recruited from two high schools in Barcelona and ranging in age from 12 to 18 years ( $M = 14.61$ ,  $SD = 1.64$ ). In terms of their migratory status, 68.5% were Spanish nationals and 31.5% were first-generation immigrants from Latin America (6.9% from Argentina, 13.8% from Bolivia, 3.5% from Chile, 10.3% from Colombia, 34.5% from Ecuador, 3.5% from Paraguay, 10.3% from Peru, and 17.2% from the Dominican Republic). From among the immigrant school population we selected exclusively those from Spanish-speaking Latin America so as to ensure that they shared a common language with their Spanish peers. This sample was used in order to address the first aim. For the analysis underpinning the second aim, and in line with the recommendations of various authors (Chen, Bundy, Cordier, Chien, & Einfield, 2015; Palmier-Claus, Dunn, & Lewis, 2012), we excluded from this sample those students whose response rate using the smartphone device was less than 33% of the overall response rate, which in this study equated to  $\leq 13$  assessment moments (range 1–35). After applying this criterion, the sample for this final analysis comprised 86 adolescents (58.8% girls) with an age range between 12 and 18 years ( $M = 14.52$ ,  $SD = 1.64$ ). In terms of their migratory status, 67.1% were Spanish nationals and 32.9% were first-generation immigrants from Latin America. Attrition analysis revealed no significant differences between excluded and included participants on the main independent study variables: gender,  $\chi^2(1, N = 90) = .340$ ,  $p > .05$ ; migratory status,  $\chi^2(1, N = 90) = 3.43$ ,  $p > .05$ ; level of psychological symptoms,  $\chi^2(1, N = 90) = .149$ ,  $p > .05$ .

### Measures

*Sociodemographic data and covariates.* A survey sheet was created to gather basic data on age, gender, school year, and migratory status.

*Smartphone app based on EMA.* Using EMA in conjunction with a smartphone app (Acer Liquid Z-200 based on Android 4.0) we assessed three kinds of problems associated with the internalizing spectrum: sadness/depression (*Right now, do you feel sad or depressed?*), anxiety (*Right now, do you feel nervous or worried?*), and somatic problems (*Right now, do you have a headache or feel sick?*). These items were chosen to reflect the content of the items with the highest factor loading on the corresponding DSM-Oriented scales of the YSR (all above 0.74). Each item was scored on a 5-point Likert-type scale, ranging from 1 (*not at all*) to 5 (*very much*). The assessment schedule was five times

per day (between 9 a.m. and 9 p.m.), semi-randomly, for seven days (35 possible moments for each participant). Participants were required to respond within three minutes of hearing the reminder alarm from the app. If the user did not begin to answer within this period of time the app stopped the alarm and blocked the unit. Regarding reliability of the EMA in this study, the overall Cronbach's coefficient for the three items related to internalizing problems (sadness/depression, anxiety, and somatic problems) was ( $\alpha = .61$ ). If only the sadness/depression and anxiety items were considered, the alpha was .70 (for more details, see Magallón-Neri et al., 2016). Figure 1 shows app screenshots for the smartphone app used in the current study.

*Internalizing problems.* The traditional paper-and-pencil instrument used to establish the normal and at-risk groups was the Spanish version (Abad, Forn, & Gómez, 2002) of the Youth Self-Report (YSR) (Achenbach, & Rescorla, 2001, 2007). This questionnaire measures psychological distress in children and adolescents between 11 and 18 years old through a list of 112 items that represent emotional and behavioral problems. Each item is scored on a 3-point scale: 0 (*not true*), 1 (*somewhat or sometimes true*), or 2 (*very or often true*). For the present study we used only the Internalizing scale, and we segmented the initial sample ( $n = 88$ ) into two groups according to the T scores obtained, labeling the two groups as *normal group* (T score  $\leq 59$ ) and *at-risk group* (T score  $\geq 60$ ), following the criteria of Achenbach

and Rescorla (2001). Cronbach's alpha for the Internalizing scale in the present sample was .86.

### Procedure

We began by contacting six state schools in two districts of the metropolitan area of Barcelona; one of these districts had a large immigrant population, while the other had a typical proportion of immigrants (13.8%). After explaining the nature of the research to the management boards of the schools, two of the six agreed to participate in the study. The low acceptance rate was due to concerns that school heads had about the possible impact that EMA might have on classroom management or on the dynamic between participating and non-participating adolescents, and/or because some parents did not wish to be responsible for their child being in possession of a smartphone for a week. In the two schools that agreed to take part we hosted an information session for adolescent students, encouraging them to participate and giving them an informed consent form to be signed by their parents or legal guardians; the latter were also sent a letter setting out the aims of the study and encouraging them and their children to take part. Once permission had been obtained we administered the paper-and-pencil questionnaire in sessions lasting approximately 90 minutes. In these same sessions the use of the smartphone devices and the nature of EMA were explained. Upon delivery of a device to each participant, he or she was assigned an individual alphanumeric code so as to

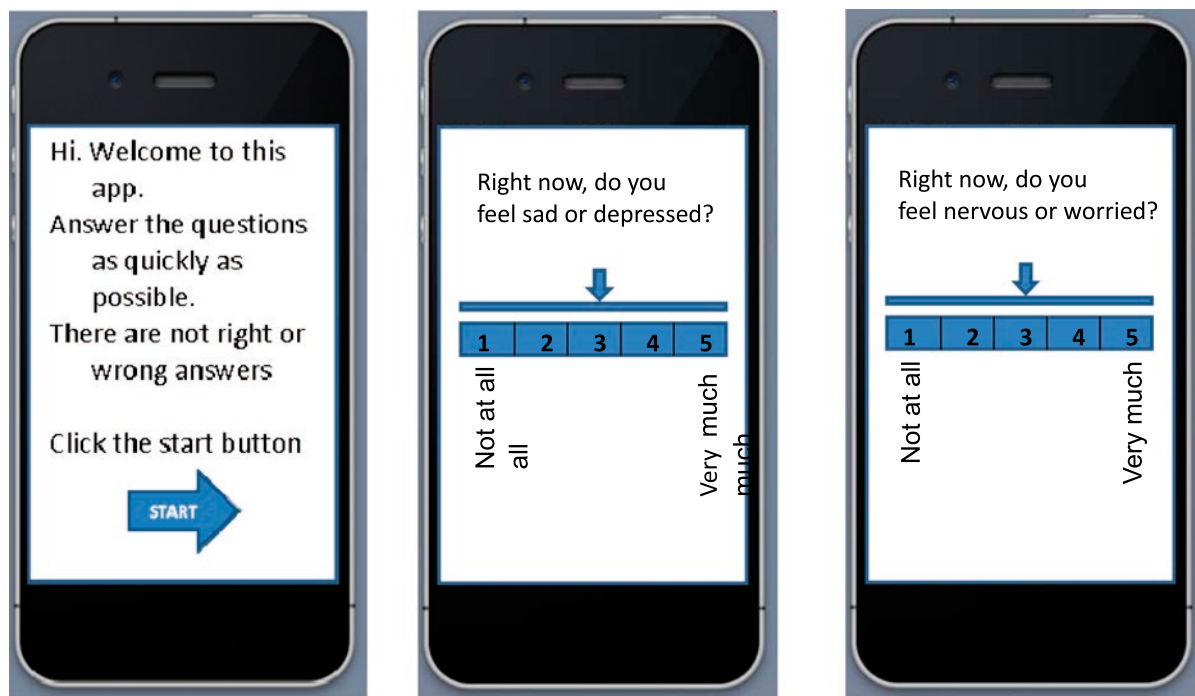


Figure 1. App Screenshots of Smartphone.

protect their identity in case of loss or theft of the device. It was explained to participants that they would have the smartphone for a whole week and that the device would ring five times a day at random times; they were asked to respond on as many occasions as possible each day. Each participant signed an agreement regarding the care and proper use of the smartphone device, and they were given contact details should they encounter any technical problems during the experiment. Technical assistance was requested by 5.6% of participants, mainly due to a malfunction of the device or app.

### Data analysis

The present study fulfills the majority of technical characteristics that must be met by studies using EMA methodology and which are stipulated in the Checklist for Reporting EMA studies (CREMAS) (Liao, Skelton, Dunton, & Bruening, 2016). Data were analyzed using SPSS 23, Mplus 5.1, and STATA 14.2. Regarding the intensity of sadness/depression, anxiety, and somatic problems, significant differences between the groups for each comparison (i.e., by gender, migratory status, and risk level) were examined using the Student's T test for independent samples, after first applying Levene's test for equality of variances. Cohen's *d* was calculated as a measure of the effect size. Differences between the different groups in the percentages of responses for sadness/depression, anxiety, and somatic problems were tested with  $\chi^2$ , applying the Monte Carlo exact test when needed and calculating the standardized adjusted residuals.

Regarding variability, trajectories were estimated with longitudinal growth curve models (Singer & Willett, 2003). Growth models allow for flexible handling of time and account for non-independence from repeated measures on each participant. In addition to the usual linear regression parameters, growth models can have a random intercept, capturing the variability between participants in starting points (in our models, individual differences in baseline affective, anxiety, and somatic symptoms) and random slopes, and capturing the variability between participants in change over time (in our models, the trajectories of affective, anxiety, and somatic symptoms). The models also allow the intercept and slope to be correlated, which indicates the degree of correlation between an individual's starting point and his/her change over time. For example, a strong positive correlation would indicate that the higher a participant's baseline level of affective symptoms, the more this level would increase over time.

Several models were tested. First, we estimated an unconditional model to characterize the overall trajectory of affective, anxiety, and somatic symptoms.

All models included a random intercept and time slope that were allowed to correlate. Time was coded as 0, 1, 2, and so on. Second, we ran a conditional model, entering time, gender, migratory status, and level of psychological problems into all models. Finally, we tested whether each covariate interacted with time (time  $\times$  gender, time  $\times$  migratory status, and time  $\times$  level of psychological problems). If the interaction term was not significant, we dropped it and report estimates from the final model without the interaction. Effects were considered statistically significant at  $p < .05$ .

### Results

#### Intensity of Subjective Perceptions of Momentary Sadness/Depression, Anxiety, and Somatic States

Table 1 shows mean raw scores for momentary ratings of sadness/depression, anxiety, and somatic problems according to gender, migratory status (Spanish nationals vs. Latin American immigrants), and level of psychological problems (normal  $T < 60$  on YSR vs. risk groups  $T \geq 60$  on YSR). Girls obtained significantly higher mean raw scores than boys for momentary sadness/depression,  $t = 8.75$ ;  $p < .001$ ,  $d = 0.41$ ; anxiety  $t = 5.06$ ;  $p < .001$ ,  $d = 0.4$ ; and somatic problems,  $t = 6.02$ ;  $p < .001$ ,  $d = 0.28$ . However, Cohen's *d* indicated a small effect size in all cases. Similarly, the risk group obtained significantly higher mean raw scores than the normal group for sadness/depression,  $t = 4.40$ ;  $p < .001$ ,  $d = 0.26$ ; anxiety,  $t = 6.33$ ;  $p < .001$ ,  $d = 0.43$ ; and somatic problems,  $t = 7.14$ ;  $p < .001$ ,  $d = 0.53$ . Here, the effect sizes (Cohen's *d*) were between small and moderate. Migratory status was not associated with any significant differences in sadness/depression,  $t = 1.69$ ;  $p > .05$ ; anxiety,  $t = 1.58$ ;  $p > .05$ ; or somatic problems,  $t = 1.75$ ;  $p > .05$ .

Despite these differences, however, and as shown in Table 1, the mean scores for sadness/depression, anxiety, and somatic problems fall between a minimum value of 1.17 and a maximum of 1.69 (range 1–5; mode = 1), independently of gender, migratory status, and level of psychological problems. At the qualitative level, the percentage of responses with a value of 1 on the Likert scale (i.e., *not at all*) was 80.0% for sadness/depression, 79.3% for anxiety, and 84.9% for somatic problems. The percentage of responses with a value of 2 was 9.6% for sadness/depression, 9.8% for anxiety, and 6.7% for somatic problems. The percentage of responses with a value of 5 (i.e., *very much*) was 1.7%, 1.4%, and 1.7% respectively. The values 3 and 4 in no case exceeded 8% of respondents. These data indicate a low rate of internalizing problems reported over a week by these adolescents.

Notably, the value of 1 (*not at all*) was the most often reported by adolescents classified as *at risk* according

**Table 1.** Frequencies and Descriptive of Momentary Sadness/Depression, Anxiety and Somatic Problems. Counts and Percentages of Momentary Responses, Means and SD of EMA Raw Scores according to Gender, Migratory Status and Level of Psychological Problems according to YSR

	<i>n</i>	Sadness/depression problems		Anxiety problems		Somatic problems	
		EMA Counts (%)	Mean (SD)	EMA Counts (%)	Mean (SD)	EMA Counts (%)	Mean (SD)
<b>Gender</b>							
Boys	35	848 (69) <sup>a</sup>	1.18 (.53)	848 (69) <sup>a</sup>	1.19 (.53)	848 (69) <sup>a</sup>	1.17 (.55)
Girls	55	1091 (56.7) <sup>b</sup>	1.49 (.98)	1091 (56.7) <sup>b</sup>	1.49 (.97)	1091 (56.7) <sup>b</sup>	1.37 (.90)
<b>Migratory status</b>							
Spanish nationals	61	1397 (65.4) <sup>c</sup>	1.38 (.84)	1397 (65.4) <sup>c</sup>	1.38 (.85)	1395 (65.3) <sup>c</sup>	1.30 (.81)
Immigrant	29	542 (53.3) <sup>d</sup>	1.31 (.79)	542 (53.3) <sup>d</sup>	1.33 (.75)	540 (54.8) <sup>d</sup>	1.25 (.65)
<b>YSR</b>							
Normal group T ≤ 59	75	1608 (61.3) <sup>e</sup>	1.32 (.77)	1608 (61.3) <sup>e</sup>	1.30 (.75)	1604 (61.1) <sup>e</sup>	1.20 (.61)
Risk group T ≥ 60	15	331 (63) <sup>f</sup>	1.55 (1.02)	331 (63) <sup>f</sup>	1.69 (1.05)	331 (63) <sup>f</sup>	1.69 (1.23)

*Notes:*

- (a) This percentage corresponds to the number of responses/ number maximum of potential responses ( $n = 1225$ )  
 (b) This percentage corresponds to the number of responses/ number maximum of potential responses ( $n = 1925$ )  
 (c) This percentage corresponds to the number of responses/ number maximum of potential responses ( $n = 2135$ )  
 (d) This percentage corresponds to the number of responses/ number maximum of potential responses ( $n = 1015$ )  
 (e) This percentage corresponds to the number of responses/ number maximum of potential responses ( $n = 2625$ )  
 (f) This percentage corresponds to the number of responses/ number maximum of potential responses ( $n = 525$ )

to the YSR (69.9% for sadness/depression, 61.4% for anxiety, and 70.2% for somatic problems), although the proportions were significantly lower than those for their peers in the normal group:  $\chi^2(4, 1936) = 33.83$ ,  $p < .001$  (standardized adjusted residual = 5.0) for sadness/depression;  $\chi^2(4, 1936) = 73.21$ ,  $p < .001$  (standardized adjusted residual = 8.4) for anxiety; and  $\chi^2(4, 1932) = 119.08$ ,  $p < .001$  (standardized adjusted residual = 8.3) for somatic problems. In addition, the risk group gave, in comparison with the normal group, a significantly higher proportion of responses with a value of 5 (*very much*): 3.8% (standardized adjusted residual = 3.3), 3.5% (standardized adjusted residual = 3.37), and 7.1% (standardized adjusted residual = 8.4) for sadness/depression, anxiety, and somatic problems, respectively. The fact that the risk group and the normal group, as classified by means on the Internalizing scale of the YSR, differed significantly in their EMA ratings for sadness/depression, anxiety, and somatic problems supports the convergent validity of the latter method.

**One-Week variability in internalizing problems**

*Model for sadness/depression problems.* First, we tested a growth model with time, but no covariates, in order to characterize the overall trajectory. For this baseline model the estimate for the intercept was  $b = 1.42$  and the random effect was  $\sigma_{\text{intercept}} = .33$ , indicating that the overall mean intercept was 1.42 and the standard

deviation of individual subject variability about that mean was 0.33. The overall time effect was statistically significant,  $b = 0.0004$ , 95% CI [0.0001, 0.0008],  $p = .001$ , but not meaningful.

The random effect for the time slope was  $\sigma_{\text{time}} = .011$ , which is small relative to the mean, suggesting that there is no substantial individual variability in the linear time slope. The estimated correlation between the random intercept and the time slope parameters was  $-.73$ , indicating that subjects who were above the mean at baseline tended to have more negative time slopes.

Next, we tested whether each of the covariates predicted the trajectory of sadness/depression. There was a significant effect of gender,  $b = .21$ , 95% CI [0.19, 0.23],  $p < .001$ , suggesting that girls self-reported more affective symptoms than did boys. Furthermore, participants with psychological problems experienced more affective symptoms over the course of the study period,  $b = .09$ , 95% CI [0.06, 0.11],  $p < .001$ . Although the interactions of time x migratory status and time x level of psychological problems reached statistical significance, the associated effect sizes indicated that they were not meaningful.

*Model for anxiety problems.* For anxiety, we tested an unconditional growth model characterizing the overall trajectory. For this model, the estimate for the intercept was  $b = 1.45$  and the random effect was  $\sigma_{\text{intercept}} = .33$ , indicating that the overall mean intercept was 1.45 and the standard deviation of individual subject variability

**Table 2.** Longitudinal Growth Curve Models for Variability of Sadness/Depression, Anxiety and Somatic Problems

Predictor	Sadness/depression problems		Anxiety problems		Somatic problems	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
Intercept	1.42** [1.41, 1.43]		1.45** [1.44, 1.46]		1.28** [1.27, 1.29]	
Time	0.0004** [0.0001, 0.0008]		-0.001** [-0.001, -0.0006]		0.004** [0.004, 0.005]	
Gender	0.21** [0.19, 0.23]		0.08** [0.06, 0.09]		0.08** [0.06, 0.10]	
Migratory status	-0.008 [-0.02, 0.01]		-0.07** [-0.09, -0.05]		-0.04** [-0.05, -0.02]	
Psychological problems	0.09** [0.06, 0.11]		0.18** [0.16, 0.21]		0.15** [0.12, 0.17]	
Time x Gender	-0.0002 [-0.001, 0.0004]		0.002** [0.002, 0.004]		0.003** [0.002, 0.004]	
Time x Migratory status	0.0012** [0.0004, 0.0020]		0.002** [0.001, 0.003]		-0.002** [-0.002, -0.000]	
Time x Psychological problems	0.002** [0.001, 0.003]		0.002** [0.001, 0.003]		0.007** [0.006, 0.008]	
$\sigma_{\text{intercept}}$	.337		.338		.37	
$\sigma_{\text{time}}$	.011		.012		.014	
$r_{\text{intercept, time}}$	-.73		-.61		-.44	
$\sigma_{\text{residual}}$	.521		.71		.61	

about that mean was 0.33. Though the overall time effect was statistically significant it was unimportant,  $b = -.001$ , 95% CI [0.0001, 0.0006],  $p < .001$ . The random effect for the time slope was  $\sigma_{\text{time}} = .012$ , suggesting a small individual variability in the linear time slope. The estimated correlation between the random intercept and the time slope correlation parameters was  $-.61$ , indicating a more negative slope for subjects who were above the mean at baseline.

A conditional model was then tested, adding covariates into a second model. Here we did find a significant effect of gender,  $b = .08$ , 95% CI [0.06, 0.09],  $p < .001$ ; migratory status,  $b = -.07$ , 95% CI [-0.09, -0.05],  $p < .001$ ; and level of psychological problems,  $b = .18$ , 95% CI [0.16, 0.21],  $p < .001$ . Specifically, girls, Latinos, and participants self-reporting psychological problems experienced more anxiety over the study period. However, although all the interactions tested were statistically significant, the effect sizes indicated that they were not meaningful.

*Model for somatic problems.* An unconditional model with no covariates was tested first. For this model, the estimate for the intercept was  $b = 1.28$  and the random effect was  $\sigma_{\text{intercept}} = .37$ , indicating that the overall mean intercept was 1.28 and the standard deviation of individual subject variability about that mean was 0.37. The overall time effect was not meaningful,  $b = .004$ , 95% CI [0.0004, 0.005],  $p < .001$ . There was a small individual variability in the linear slope ( $\sigma_{\text{time}} = .012$ ). The estimated correlation between the random intercept and the time slope was  $-.44$ , indicating that participants who were above the mean had a more negative slope.

Finally, we used a conditional model to test the contribution of covariates to the prediction of somatic problems. Here we found a significant effect of gender

$b = .08$ , 95% CI [0.06, 0.09],  $p < .001$ ; migratory status,  $b = -.04$ , 95% CI [-0.09, -0.05],  $p < .001$ ; and level of psychological problems,  $b = .15$ , 95% CI [0.12, 0.17],  $p < .001$ . Specifically, girls, Latinos, and participants self-reporting psychological problems experienced more somatic problems over the study period. Although the interactions tested reached statistical significance, the effect sizes indicated that they were not meaningful (see Table 2).

## Discussion

The adolescents in our sample reported low levels of sadness/depression, anxiety, and somatic problems in a range of ecological settings and in real time. In other words, at most of the assessment moments (maximum of 35) over the period of a week they did not feel sad or anxious or experience somatic symptoms. Compared with boys, girls obtained significantly higher mean scores in their responses related to anxiety, depression, and somatic symptoms. However, their scores remained low and were indicative of no or only mild subjective distress. This result suggests that mood states in this sample were generally good and stable.

Although we expected to observe an association between the results obtained through the EMA and paper-and-pencil questionnaire methods, we also hypothesized that the former would indicate a lower intensity of symptoms. The results support these hypotheses. On the one hand, we found that when using EMA, those adolescents classified as *at risk* by the YSR obtained higher mean scores for internalizing states than did their peers assigned to the normal group. This result can be considered an indicator of convergent validity between the two assessment methods. On the other hand, those adolescents who

were assigned to the risk group according to their YSR scores did not, in most of the ecological settings and in real time, report (via EMA) feelings of sadness or worry or the experience of physical symptoms. This suggests that the intensity of symptoms is actually lower, probably due to the bias effect associated with conventional assessment methods (Shiffman et al., 2008). As such, these data provide a more nuanced view of the day-to-day mood states of young people who would be considered by conventional assessment methods to be at risk. It should still be noted, however, that adolescents in the risk group chose the response category *very much* in 3.3% of their responses about sadness/depression, 3.5% of those about anxiety, and 7.1% of those about somatic problems. This underlines the importance of identifying these adolescents so as to implement preventive measures or, if necessary, intervene psychologically.

Contrary to what we hypothesized, no differences were observed in relation to the overall intensity of problems according to migratory status: Both Spanish nationals and Latin American immigrants reported low levels of internalizing problems and the differences were non-significant. This finding could be due to the fact that the two groups have a shared language and a comparable cultural and religious background. This may have minimized the impact of migration and the effects of acculturation that are commonly observed both in adult immigrant populations (Achtogui, 2003; Mirsky et al., 2008; Patiño & Kirchner, 2010) and among adolescent immigrants from different cultural backgrounds (Céspedes & Huey, 2008; Potochnick & Perreira, 2010). It is also possible that adolescents are better able than adults to adapt to changes of this kind and to develop more adaptive coping strategies. This is an aspect that requires further investigation.

As regards our second objective, the study of mood lability, the results indicated that at baseline participants scored low on sadness/depression, anxiety, and somatic symptoms. Relative to the mean the variability of these measures were low. Although the time measure reached statistical significance for each mood indicator, the effect sizes indicated that the differences were not meaningful. Thus, these variables remained stable across the one-week study period. This stability could be due both to the short time period analyzed and, especially, to the fact that the population is drawn from a non-clinical context. All correlations between the intercepts and slopes were negative, suggesting that participants who score high in sadness-depression, anxiety and somatic problems at baseline, tend to have a negative slope.

We did find a significant difference between boys and girls in affective, anxiety, and somatic symptoms and this difference remained unchanged across the one-week

study period. Similarly, girls showed an elevated trajectory for anxiety and somatic symptoms, compared with boys. Migratory status predicted different trajectories in anxiety and somatic symptoms, with Latinos scoring lower on these variables. Finally, participants at risk had an elevated trajectory for affective symptoms, anxiety, and somatic problems.

Although adolescents at risk of psychopathology reported a *greater intensity* of internalizing symptoms on a daily basis, they showed no *variability* in mood over the one-week study period (i.e., these symptoms remained stable). This means that independently of the overall set of situations experienced during one week, these at-risk adolescents manifest an ongoing experience of certain emotional discomfort. Our findings disagree with those of van Roekel et al (2016), who observed greater fluctuations during the week in sadness/depression, anxiety, and somatic states, as measured by EMA, in adolescents classified as *at risk*.

As for the issue of retrospective reports being associated with higher levels of symptoms, Margraf et al. (1987) found that the number of symptoms reported using paper-and-pencil surveys was higher than when the frequency and intensity of symptoms were logged shortly after they occurred. The authors concluded that this illustrated the tendency for symptoms to be overestimated when considered retrospectively. The same pattern can be observed in our results, since a high proportion of EMA moments were associated with no or only minimal internalizing problems, this being the case even among those adolescents who, according to the conventional retrospective test (YSR), were considered to be at risk for problems of this kind. This is not a trivial issue, especially in relation to child and adolescent psychopathology, since 1 in 10 children are considered to have at least one DSM-IV disorder (Ford, Goodman, & Meltzer, 2003). It is worth considering, therefore, whether this high rate reflects an overdiagnosis of mental health disorders. The use of EMA in conjunction with classical tests of psychopathology using longitudinal designs could help to shed light on this issue.

From a developmental perspective, one aspect to emphasize is that adolescence has traditionally been considered a stage of significant emotional fluctuations, especially along the internalizing spectrum (Hardy et al., 2002). Our data indicate relative stability in this regard, although a longer assessment period would be required in order to draw reliable conclusions. In addition, from a clinical perspective, the discrepancies we observed in the reported intensity of symptoms according to the methodology used (EMA vs. traditional) suggests that clinicians should consider using both kinds of measures when examining psychopathology.



Several limitations warrant consideration. First, the results are based on a community sample and cannot be generalized to the clinical population of adolescents. Second, all the data are derived from self-reports. Third, the monitoring period for EMA could, at one week, be considered short in comparison with some other studies. On the plus side, the semi-random sampling schedule for eliciting responses increases the ecological validity of the study. Fourth, the fact that sadness/depression, anxiety, and somatic problems were assessed with just a single item each may be a limitation when it comes to symptom sampling. The items used in the smartphone app were, however, chosen from among those with the highest factor loading on each of the YSR scales. Future studies should seek to replicate these results with larger samples, over longer periods of monitoring, and through a longitudinal design. Fifth, the percentage of omissions was higher in girls, and therefore the data may be biased and provide an underestimation of symptoms in girls. Sixth, the method of data collection could lead to an increase in self-focused attention, which might in turn introduce some error into the assessment of variability.

Despite these limitations, this study is, to the best of our knowledge, one of the first to use EMA to explore internalizing states in community adolescents and to examine differences according to gender, migratory status, and level of psychological problems. Day-to-day variability in behavior is a distinguishing factor that may help professionals to identify those adolescents most at risk of psychopathology. This study suggests that EMA should be considered a promising approach for further research into the internalizing states of community adolescents.

The momentary ecological assessment of internalizing spectrum problems among community adolescents reveals that a high percentage of boys and girls do not report feelings of sadness or worry or the experience of physical symptoms on a daily basis. Day-to-day fluctuations during the week in these affective, anxiety, and somatic symptoms were significant but not meaningful.

The authors have no conflict of interest to declare.

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