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Research Article

Keywords: irritability, youth, ecological momentary assessment, daily stress, affective reactivity, within-person dynamics, dynamic structural equation modeling, transdiagnostic psychopathology

Posted Date: November 5th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11389688/v1

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Additional Declarations: No competing interests reported.

Enhancing Irritability Assessment in Youth: Added Value of Capturing Temporal Dynamics and Daily Stressful Events

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Abstract

Objective: Irritability is a common transdiagnostic symptom in youth that is associated with later psychopathology. Although it may both arise from and contribute to stressful experiences, this dynamic interplay is difficult to capture with retrospective questionnaires. Ecological momentary assessment (EMA) may complement person-level measures by assessing irritability and stressful events as they unfold in daily life. This study examined (1) the correspondence between momentary (EMA-based) and questionnaire-based person-level irritability and (2) bidirectional associations between momentary irritability and daily stressful events.

Methods: A community sample of 294 youth aged 12-21 years (M = 17.5; 58.5% female) completed self- and proxy-report irritability followed by a 14-day EMA protocol with eight daily assessments of irritability and stressful events. Dynamic structural equation modeling was used to examine cross-lagged within-person temporal associations and differences in these dynamics.

Results: Momentary and person-level irritability showed significant but modest correspondence. Most variance in momentary irritability occurred within rather than between individuals. Stressful events were consistently associated with higher irritability at the next timepoint. Youth with higher person-level irritability showed stronger increases in irritability following stressful events and greater within-person variability over time. By contrast, there was limited evidence for irritability being associated with later stressful events.

Conclusions: Irritability in youth appears to reflect both stable individual differences and context-dependent fluctuations in daily life. EMA may complement retrospective questionnaires by capturing stress-related increases and within-person variability, potentially informing more individualized assessment of irritability.

Keywords: irritability; youth; ecological momentary assessment; daily stress; affective reactivity; within-person dynamics; dynamic structural equation modeling; transdiagnostic psychopathology

Background

Irritability is commonly defined as a proneness to anger relative to peers (Brotman, Kircanski, & Leibenluft, 2017) and is conceptualized as a dimensional construct spanning a continuum from normative variations to clinically impairing levels. Population-based studies indicate that approximately 14–23% of youths exhibit elevated levels of irritability, with prevalence estimates varying across age groups (Vidal-Ribas et al., 2025). Irritability is included as an important feature across several diagnostic categories in major psychiatric classification systems (American Psychiatric Association, 2013; World Health Organization, 2019), and is increasingly viewed as a transdiagnostic dimension relevant to a broad range of mental health problems (Stringaris, Zavos, et al., 2012; Vidal-Ribas et al., 2016). Irritability represents one of the most common reasons for referral to youth mental health services (Evans et al., 2023). Particularly at higher levels it is associated with concurrent (Chin et al., 2025; Stoddard et al., 2014) and prospective (Galera et al., 2021; Silver, Sorcher, et al., 2024) psychopathology, functional impairment and poorer social adjustment (Carlson et al., 2023), increased risk-taking behavior (Harty et al., 2017; Silver et al., 2021), as well as increased risk for suicidality and non-suicidal self-injury (Harty et al., 2017; Silver et al., 2021). Despite growing research interest in irritability, challenges remain in its conceptualization and assessment, including variability in definitions and limitations of existing measurement approaches (Evans et al., 2024; Stringaris et al., 2018).

Temporal and contextual variation of irritability

Although irritability is often conceptualized as a dispositional trait, it also varies across time and context as a mood state or affective response. Accordingly, traditional assessment methods relying primarily on retrospective self- or proxy-reports may not adequately capture its temporal variability and situational expression (Carlson & Klein, 2018). This challenge can be addressed using Ecological Momentary Assessment (EMA), which repeatedly captures experiences and behavior in real time and naturalistic settings (e.g., via smartphones),

enhancing ecological validity and reducing retrospective recall bias (Myin-Germeys & Kuppens, 2026). This approach may be particularly relevant for assessing irritability in youth, as young people tend to retrospectively underreport symptoms compared to parent reports (Pan & Yeh, 2019; Stoddard et al., 2014). By capturing within-person dynamics, EMA provides insight into temporal patterns, daily fluctuations, and contextual correlates that can be linked to person-level indices (Brotman, Kircanski, & Leibenluft, 2017; Carlson et al., 2024; Evans, Shaughnessy, et al., 2023).

Initial work supports the feasibility and validity of EMA for assessing irritability in youth. Between-person averages of momentary irritability align closely with established trait and clinician-rated measures and show meaningful associations with laboratory-based frustration paradigms, while EMA measures also demonstrate strong psychometric properties and ecological validity in clinically irritable youths (Hansen et al., 2025; Naim et al., 2021). Higher person-level irritability has further been linked to elevated average momentary irritability, greater affective intensity, variability, and inertia, as well as more negative social interactions and greater engagement in risk-related behaviours in everyday life (Silver, Hawes, et al., 2024). Network analyses have identified frustration as a central process linking irritability with mood and anxiety symptoms (Tseng et al., 2023), and EMA has also proven sensitive to treatment-related change, with reductions in momentary irritability during CBT occurring alongside increases in adaptive parental behaviours (Naim et al., 2024). EMA therefore appears particularly well suited to studying irritability in naturalistic settings, potentially complementing conventional assessments by capturing both stable individual differences and dynamic processes as they unfold in daily life. However, most EMA studies of irritability have focused on clinically enriched or transdiagnostic youth samples, leaving open the question of whether these findings generalize to community samples spanning the full severity spectrum of irritability.

Reciprocal associations between irritability and daily stress

Stress has been proposed as one important mechanism through which irritability is linked to a broad range of emotional, behavioural, and functional outcomes (Harrison et al., 2025). Theoretical and empirical work suggests that irritability often emerges as a reactive response to stressful or frustrating situations (Toohey & DiGiuseppe, 2017; Vidal-Ribas et al., 2016). At the same time, heightened irritability may contribute to the generation of stressful experiences thorugh biases in threat perception and maladaptive interpersonal responses. As such, youths with elevated levels of irritability are more likely to interpret ambiguous social cues as hostile (Stoddard et al., 2016) and tend to perceive stimuli as threatening, even in neutral situations (Brotman, Kircanski, Stringaris, et al., 2017). Responses to perceived threats or provocations may also be excessively aggressive, potentially increasing the likelihood of conflict with peers, parents, and teachers (Leibenluft & Stoddard, 2013). Over time, the accumulation of these stressors may contribute to the emotional, behavioural, and functional difficulties frequently observed among youths with higher irritability.

Despite strong theoretical support for this bidirectional relationship, empirical evidence remains sparse, particularly at fine-grained temporal scales. Existing longitudinal studies suggest bidirectional associations between irritability and both chronic interpersonal stress (Losiewicz et al., 2023) and episodic stressors (Harrison et al., 2025). Yet it remains unclear whether these associations reflect stable, long-term processes or whether they also unfold dynamically, in close temporal proximity to daily stressful events. Examining these processes at finer temporal scales may help clarify whether irritability primarily reflects immediate stress reactivity, contributes to the generation of subsequent stressors, or both. Moreover, it remains largely unknown whether these short-term dynamics differ as a function of person-level irritability.

The present study

The present study aims to address two related research questions. First, we examine the correspondence between EMA-based irritability ratings and established person-level measures of irritability and quantify the extent to which momentary irritability reflects stable between-person differences versus within-person fluctuations over time. Building on prior findings, we expect significant associations, indicating that the momentary ratings capture meaningful variance in the underlying construct.

Establishing this correspondence is a precondition for the second aim: to investigate the dynamic, bidirectional associations between irritability and daily stressful events in youth. Specifically, we test whether daily stressful events predict subsequent increases in irritability (stress reactivity) and whether irritability predicts the subsequent occurrence of stressful events (stress generation), thereby distinguishing short-term contextual dynamics from stable individual differences. Given the broad age range of the sample (12–21 years), we further explore potential developmental differences by examining whether these associations vary as a function of age. Finally, we examine whether youths with higher person-level irritability show stronger stress reactivity and stress generation effects, as well as greater within-person variability in irritability over time.

Methods

Participants and Procedure

Data for the current study was drawn from the Reactivity of Affect in the Daily Lives of Youth Study (READY; OSF project page: https://osf.io/7a8yf/overview). The READY study is an intensive longitudinal study examining (a) the relationship between personality traits and affective regulation following stressful events, and (b) the role of these factors in the onset and maintenance of mental health disorders. Authors involved in prior manuscripts using READY data did not examine irritability specifically or conducted any analyses, beyond descriptive analyses, that would have provided knowledge relevant to the present study. Only the second and second-to-last authors had access to the data prior to preregistration (https://osf.io/e57sm/files/76mak).

Youth from the community between the ages of 12 and 21 years were recruited through university outpatient clinics, universities, schools, sports clubs, mailing lists, as well as social media/WhatsApp groups. The wide age range was chosen to capture developmental transitions in personality and interpersonal processes (Kaurin et al., 2026). Exclusion criteria comprised acute suicidality, a diagnosis of bipolar disorder or psychotic disorder, and substance or alcohol dependence within the preceding six months. Data collection took place between January 2024 and July 2024. Participants provided written informed consent. All study procedures were approved by the Ethics Committee of the University of Wuppertal (SK/AE 230616).

Procedures

In an introductory assessment, participants and a close other completed a battery of questionnaires. Depending on participants' age, this informant was either a parent (participants younger than 16 years) or a peer (16 years and older). Participants were instructed to download the m-Path smartphone app (https://m-path.io) on their own smartphone, which was used for the EMA part of the study, and were then guided through a demonstration survey. The day after the introductory assessment, participants began a 14-day EMA protocol consisting of eight

surveys per day at fixed two-hour intervals including during school hours. On Sundays, participants received seven surveys (110 prompts in total). The surveys comprised between 19 and 39 items, depending on the time of day, participants' social context, and whether they reported a stressful event. Surveys took between 2 and 4 minutes to complete. Once participants received a prompt, they had 55 minutes to complete the survey (60 minutes for the morning survey) before it expired. To maximize compliance, reminders were delivered after 30 minutes. To addres address potential technical difficulties, primary researchers remained in contact with participants throughout the EMA period and conducted two standardized check-ins: the first after 3–4 days and the second after 10–11 days of participation. These check-ins were used to provide technical assistance, answer questions, and reinforce engagement with the study protocol. Participants received €25 for completing the introductory assessment and up to €100 for participation in the EMA protocol, with compensation depending on overall response compliance and the reporting of stressful events that triggered additional follow-up assessments. A complete list of all measures is available at the OSF project page (https://osf.io/7a8yf/overview).

Measures

Person-level irritability

Person-level irritability was measured using the German versions of the Child Behavior Checklist and the Youth Self-Report (CBCL / YSR/11-18R; Döpfner et al., 2014). The YSR was completed by the youth via self-report, whereas the CBCL was completed by a proxy informant, typically a parent or close friend. For both proxy- and self-report, a total irritability score was calculated by summing three items (range = 0–6): (1) irritable mood, (2) sudden changes in mood, and (3) temper outbursts, rated from 0 (not true) to 2 (very true or often true). Internal consistency was $\alpha = .57$ for the three YSR irritability items and $\alpha = .62$ for the CBCL items. These values should be interpreted in light of the small number of items and the skewed distributions, both of which can attenuate Cronbach's alpha (Tavakol & Dennick, 2011). We

did not combine CBCL and YSR irritability items into one joint irritability factor. To retain the informant-specific variance, CBCL and YSR irritability scores were analyzed separately. This decision also aligns with recent work on multi-informant assessment showing that differences between parent and youth reports can contain meaningful contextual information rather than merely measurement noise (De Los Reyes et al., 2023). n addition, each scale included only three items, rendering a one-factor CFA necessarily just-identified (df = 0) and precluding meaningful interpretation of global fit indices. For the two irritability factors, standardized factor loadings ranged from .50 to .67 for the YSR items and from .45 to .83 for the CBCL items, supporting a coherent unidimensional structure for both scales.

Ecological momentary assessment

Momentary irritability was assessed at each EMA prompt by asking participants to rate how irritable they felt "right now" on a Likert-type slider ranging from 0 (not at all) to 10 (very much).

Daily stressful events were also assessed at the same EMA prompts. Participants reported whether they had experienced anything stressful during the past 30 minutes. If multiple events had occurred, they were instructed to select the one they experienced as most stressful or unpleasant. When participants indicated that a stressful event had occured, they selected the type of stressor from 13 predefined categories (see **Table 1**).

Table 1

Predefined EMA Stressor Categories

Category	Stressor Category
1	I had an argument with friends or my romantic partner
2	I had an argument with my parents or one parent
3	I was excluded or ignored
4	I suffered from the distress of others
5	I was under (time) pressure

6	I did something wrong
7	I received negative feedback
8	I got into trouble
9	I received bad news
10	I experienced physical discomfort or pain
11	I had to perform a boring or tedious task
12	I worried about something upcoming
13	Other stressful event (open text response)

Note. When participants indicated that a stressful event had occurred within the past 30 minutes, they selected the type of stressor from one of these 13 predefined categories. If multiple events had occurred, participants were instructed to select the event they perceived as most stressful or unpleasant.

Analysis plan

Analyses were conducted using R Version 2025.09.1 (R Core Team, 2025) for data preprocessing and visualization, and Mplus 8.11 (Muthén & Muthén, 2021) for multilevel and dynamic structural equation models.

Data preprocessing in R

The EMA dataset was first structured in long format and adjusted to ensure that autocorrelations across the night gap could be computed with the correct temporal spacing. To achieve this, an additional time variable was created that, for each prompt, represented the number of hours elapsed since the first EMA prompt of the study period. Prior to model estimation, variables were visually inspected for distributional properties, within-person trajectories, outliers, and systematic patterns of missingness. To ensure data quality, survey responses with extremely short response times, defined as response times more than three standard deviations below the mean, were excluded.

Model estimation in Mplus

Dynamic structural equation models were estimated using Bayesian Markov Chain Monte Carlo (MCMC) in Mplus using default prior distributions and 95% credible intervals for

interpretation[1]. DSEM integrates principles of multilevel modeling, time-series analysis, and structural equation modeling, enabling the simultaneous estimation of within-person temporal dynamics and between-person differences in these dynamics. This approach is particularly suited for intensive longitudinal data such as EMA, where repeated assessments are nested within individuals and measurements may be unequally spaced in time. Time intervals varied substantially due to the night gap (8h) and shorter daytime intervals (2h). These unequal intervals were explicitly modeled through the TINTERVAL option in Mplus to ensure accurate estimation of autocorrelations and cross-lagged effects.

All participants who initiated the EMA protocol were included in the analyses. Missing data were handled within Bayesian estimation as is implemented in the Mplus DSEM module. Cases showing no within-person variability or unstable posterior draws in specific models were excluded from the respective model (maximum exclusion across models: N = 23).

Association between person-level and momentary irritability

To address the first study aim and examine whether established person-level measures of irritability correspond to momentary irritability experienced in daily life, two random-intercept multilevel models were estimated with momentary irritability as the outcome. One model included self-reported person-level irritability and the other proxy-reported person-level irritability as Level-2 predictors of the random intercept. These models partitioned the variance in momentary irritability into within-person variance (temporal fluctuations across assessments) and between-person variance (average differences between individuals), from which the intraclass correlation coefficient (ICC) was calculated. The multilevel approach accounted for the nested data structure, and provided an estimate of the between-person association. The resulting regression coefficient, thus, quantified the extent to which higher

[1] Prior sensitivity analyses using alternative prior specifications yielded substantively identical parameter estimates.

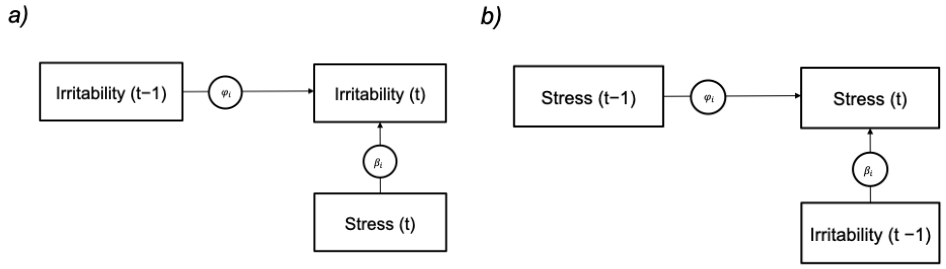
self- or proxy-reported irritability was associated with higher momentary irritability across the EMA period. Compared to a simple correlation between aggregated EMA and person-level scores, this approach appropriately accounts for the dependency of repeated observations and distinguishes stable between-person differences in average momentary irritability from within-person fluctuations around these individual means, thereby providing a more accurate estimate of the association between person-level irritability and everyday experiences of irritability.

Bidirectional associations between irritability and daily stressful events

To examine the bidirectional temporal associations between momentary irritability and daily stressful events, a series of two-level dynamic structural equation models (DSEM; McNeish & Hamaker, 2020) were estimated in a stepwise, cumulative fashion with each model building on the previous one.

As a first step, separate multilevel autoregressive lag-1 [AR(1)] models were estimated to characterize the temporal stability of irritability and stressful events prior to examining bidirectional associations between the two constructs. Momentary irritability at time *t* was regressed on its lagged value (*t*–1), and in a corresponding model, daily stressful events at time *t* were regressed on stressful events at *t*–1. These models captured within-person carry-over effects, while accounting for individual differences in the intercepts and autoregressive slopes. **Figure 1a** illustrates the autoregressive model for irritability, whereas **Figure 1b** illustrates the corresponding model for stressful events.

Figure 1

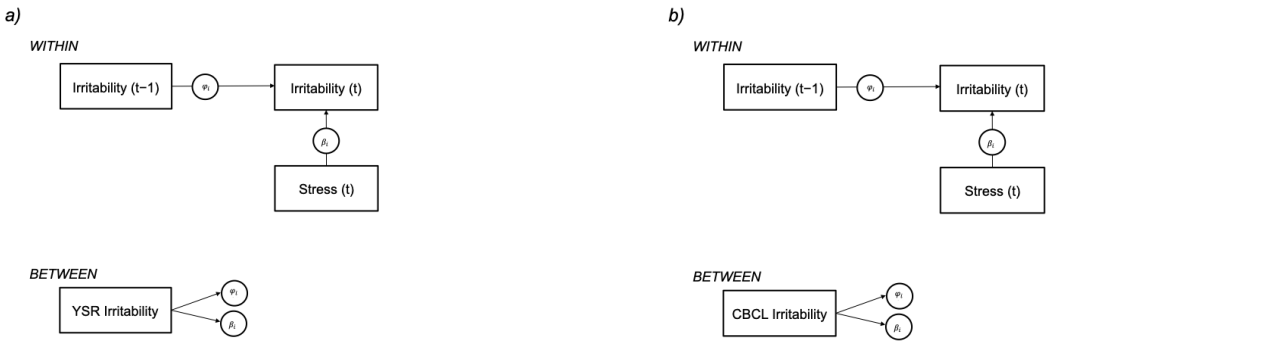


Autoregressive Lag-1 Models

Note. The diagram illustrates the multilevel autoregressive lag-1 [AR(1)] models used to assess temporal stability in momentary irritability and daily stressful events. Each construct at time t is predicted by its value at the previous measurement occasion (t–1). Random intercepts and random autoregressive slopes were estimated to account for between-person variability. The AR(1) Model in Figure 1a additionally estimated the effect of the occurrence of a stressful event reported for the period immediately preceding the prompt (i.e., within the last 30 minutes), although assessed at the same measurement occasion. The AR(1) Model in Figure 1b additionally estimated the effect of irritability measured at the prior time point.

In a second step, person-level irritability was included as a time-invariant Level-2 predictor to examine whether youths with higher person-level irritability differed in their average levels and temporal persistence of momentary irritability and stressful events, providing a first indication of whether everyday emotional dynamics differ as a function of person-level irritability. Separate models were estimated for self- and proxy-reported irritability to account for potential informant-specific effects. **Figure 2a** illustrates the model including self-reported irritability, whereas **Figure 2b** illustrates the corresponding model including proxy-reported irritability.

Figure 2

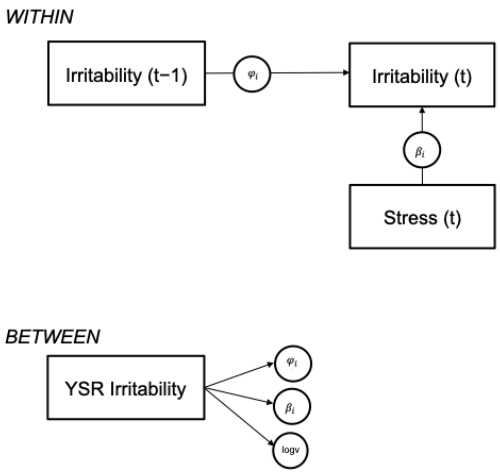


Multilevel Model Including Person-Level Irritability as a Level-2 Predictor

Note. The diagram illustrates the multilevel autoregressive models including person-level irritability as a time-invariant Level-2 predictor. Person-level irritability explains between-person differences in the intercepts and autoregressive effects of momentary irritability across time. Separate models were estimated for self-reported and proxy-reported irritability (in total four models).

As an exploratory extension, multilevel location scale models (Hedeker et al., 2008, 2012) were estimated to examine whether youths with higher person-level irritability also exhibited greater within-person variability in momentary irritability over time extending previous work linking irritability to increased affective variability in daily life (Silver et al., 2024). In line with McNeish and Hamaker (2020), we allowed variability in irritability to differ systematically across individuals (i.e., person-specific residual variance) and used time-invariant Level-2 covariates as predictor variables for these within-person fluctuations in irritability. **Figure 3** illustrates the multilevel location scale model used to examine whether within-person variability in irritability varied as a function of person-level irritability.

Figure 3



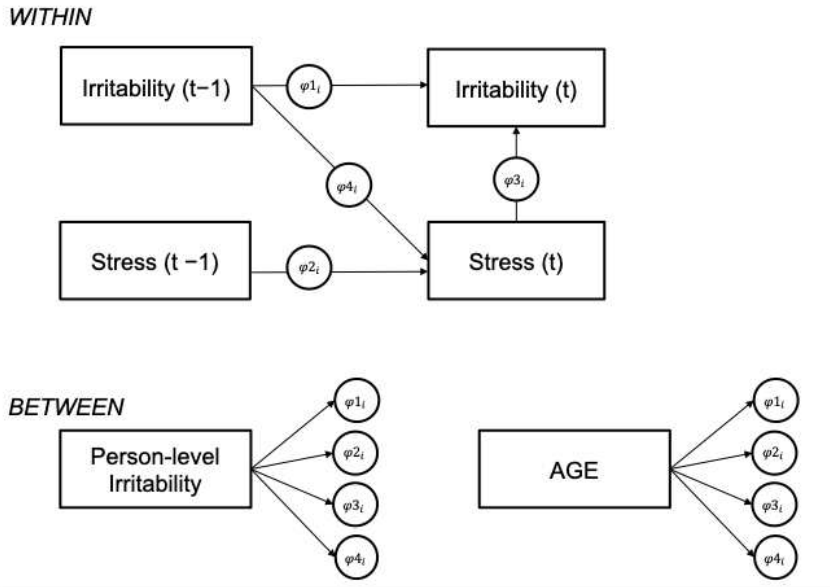
Multilevel Location Scale Model of Momentary Irritability

Note. The multilevel location–scale model was used to examine whether within-person variability in momentary irritability depends on person-level irritability. The location component models the mean level of irritability across measurement occasions, whereas the scale component models the residual within-person variance. Following McNeish and Hamaker (2020), the residual variance is represented as a latent within-person variable and predicted by time-invariant Level-2 covariates in a log-linear form. This specification allows individuals to differ systematically in the predictability (i.e., residual variability) of momentary irritability. Two separate models were estimated for self-reported and proxy-reported irritability.

Finally, to address the second study aim of the study, a multilevel vector autoregressive model with a lag of one [VAR(1)] was estimated to test the fully cross-lagged structure between irritability and stressful events. Specifically, the model examined whether stressful events predicted subsequent increases in irritability (stress reactivity) and whether irritability predicted the occurrence of subsequent stressful events (stress generation). In this model, irritability at time t was predicted by both irritability and stressful events at t–1, and stressful events at time t were analogously predicted by their own lag and by lagged irritability. The model simultaneously estimated autoregressive effects, bidirectional cross-lagged effects, and the concurrent within-person association between irritability and stressful events. In addition, person-level irritability and age were included as between-person predictors of individual

differences in these within-person dynamics to examine whether stress reactivity and stress generation processes varied as a function of stable individual differences and developmental stage. **Figure 4** provides a schematic overview of the final multilevel VAR(1) model including both autoregressive and cross-lagged effects.

Figure 4



Cross-Lagged Multilevel VAR(1) Model of Irritability and Stressful Event

Note. The figure depicts the multilevel vector autoregressive model with a lag of one. Both constructs are predicted by their own previous values (autoregressive paths) and by the lagged values of the other construct (cross-lagged paths). Person-level irritability and age are included as Level-2 moderators of the temporal associations, allowing between-person differences in the dynamic coupling between stressful events and irritability. Two separate models were estimated for self-reported and proxy-reported irritability.

Effect sizes were interpreted using conventional benchmarks for standardized effect sizes, with values around .10, .30, and .50 indicating small, medium, and large effects, respectively (Cohen, 1988, 1992). Given that standardized regression coefficients (β) are expressed in standard deviation units, these guidelines were applied analogously.

Results

The sample consisted of 294 youths aged 12-21 years (mean [SD] age = 17.5 [2.6] years) who were recruited from the community to participate in research at the University of Wuppertal, Germany. The majority of participants were female (58.5%), still attending school (52.4%), and from families reporting a good or very good financial situation (74.7%). Most participants were born in Western or Southern Europe (89.1%), with smaller proportions born in West Asia or North Africa (4.8%), Eastern Europe (3.4%), East or South Asia (1.4%), and Sub-Saharan Africa (1.0%). Full demographic characteristics are presented in **Table 2**.

Table 2

Sociodemographics, Irritability Measures, and EMA Characteristics

Variable	**N(%) / Mean (SD)**
Sample size (*N*)	294
Age, M (*SD*)	17.5 (2.6)
Gender	
Female	172 (58.5)
Male	121 (41.2)
No answer	No answer: 1 (0.3)
Main activity: School	154 (52.4)
Parental financial situation (0 = very bad – 4 = very good)	3 (Median); 3 (Mode)
Region of birth	
Western & Southern Europe	262 (89.1)
West Asia & North Africa	14 (14.8)
Eastern Europe	10 (3.4)
East & South Asia	4 (1.4)
Sub-Saharan Africa	3 (1.0)
Missing	1 (0.3)
EMA compliance	85.05% (27,503 / 32,336), Range = 10–99%
Stressful events (total)	15% of responded EMA prompts
Stressful events per person	10.9 (11.1)

Irritability (person-level; range = 0 – 6;)	
Self-reported (YSR)	1.73 (1.43)
Proxy-report (CBCL	0.90 (1.18)

Note. YSR = Youth Self-Report; CBCL = Child Behavior Checklist. Irritability scores are based on mean item scores, with higher values indicating greater irritability. EMA compliance refers to the proportion of completed EMA prompts across the EMA protocol.

All 294 participants contributed data to assess the correspondence between person level and momentary irritability. The EMA protocol comprised 110 prompts per participant. Mean compliance was high (M = 85.1%, median = 87.5%, range = 10-99%), corresponding to approximately 93.6 completed assessments per participant. Sixteen participants showed comparatively low compliance rates (10–59%). Consistent with previous analyses of the dataset, compliance declined only minimally over the course of the study period. Across all completed EMA prompts, stressful events were reported in 15% of assessments. Participants reported an average of 10.9 stressful events (SD = 11.1, median = 7.5), reflecting a positively skewed distribution with a minority reporting high frequencies of stressful events.

Correspondence between person-level and momentary irritability

Model indices for the correspondence between irritability assessed by person-level measures and EMA ratings are reported in **Table 3**. Both self-reported and proxy-reported person-level irritability were significantly associated with higher levels of momentary irritability across the EMA period. The standardized between-person effect was small for both self-reported irritability ($\beta = .23$, $p < .001$) and proxy-reported irritability ($\beta = .13$, $p = .034$).

Self-reported person-level irritability explained a small proportion of the between-person variance in momentary irritability ($R2 = .06$, $p = .039$), whereas there was no such evidence for proxy-reported irritability ($R2 = .02$, $p = .280$). The intraclass correlation coefficient indicated that 33% of the variance in momentary irritability was attributable to between-person differences, while 67% reflected within-person variability (see **Table 3**).

Table 3

Between-Person Associations of Person-Level Irritability and Momentary Irritability (EMA)

Predictor (Between)	*b*	*SE*	95% CI	β (STDYX)	*p*	R^2 (Between)	*p* (R^2)
Self-reported irritability (YSR)	0.22	0.06	[0.13, 0.33]	.23	< .001	.06	.039*
proxy-reported irritability (CBCL)	0.15	0.07	[0.03, 0.28]	.13	.034	.02	.280
Variance	—	—	—	—	—	ICC = .33	

Note. *b* = unstandardized regression coefficient; *SE* = standard error; CI = 95% credible interval; β (STDYX) = standardized coefficient; R^2 refers to the proportion of explained between-person variance in momentary irritability; ICC = intraclass correlation coefficient indicating the proportion of variance attributable to between-person differences. * indicates credible intervals excluding zero.

Bidirectional associations between irritability and daily stressful events

To address our second research question regarding bidirectional associations between momentary irritability and daily stressful events, we estimated a series of multilevel autoregressive [AR(1)] models of increasing complexity.

Basic models of temporal stability and cross-lagged associations

Two separate AR(1) models were used to examine temporal stability within each construct while simultaneously testing the time-lagged effect of the respective other variable. Higher irritability at the previous assessment was associated with a small increase in the likelihood of reporting a stressful event at the subsequent assessment (β = .05, p < .001) whereas the occurrence of a stressful event within the 30 minutes preceding the prompt showed a substantially stronger association with subsequent increases in momentary irritability (β = .22,

p < .001). Both outcome variables exhibited significant temporal stability across assessments (see **Table 4**).

Table 4

Set of basic AR(1) Models

Figure	Predictor	Outcome	β (STDYX)	95% CI	*p*
1a	Irritability (t−1)	EMA Irritability (t)	.21	[.20, .23]	< .001*
1a	Stress (t)	EMA Irritability (t)	.22	[.21, .24]	< .001*
1a	R^2 (Irritability)	Within	.16	[.15,.17]	—
1b	Stress (t−1)	Stress (t)	.16	[.12, .21]	< .001*
1b	Irritability (t−1)	Stress (t)	.05	[.02, .07]	<.001*
1b	R^2 (Stress)	Within	.14	[.12, .16]	—

Note: Figure 1a presents the autoregressive AR(1) model predicting momentary irritability from prior irritability and current stressful events. Figure 1b presents the corresponding AR(1) model predicting stressful events from prior stress and prior irritability. β (STDYX) = standardized regression coefficient; CI = 95% credible interval. R^2 refers to within-person explained variance. Stress was modeled as a binary outcome. * indicates effects with credible intervals excluding zero.

Role of stable individual differences in irritability

Building on the previous models, we examined whether the temporal associations between stressful events and irritability varied as a function of stable individual differences in irritability. Therefore, time-invariant person-level irritability (self- and proxy-reported) was added as a Level-2 predictor of the intercepts and temporal associations, while retaining the within-person structure as specified in the previous models. The associations observed in the preceding models remained significant after including person-level irritability as a Level-2 predictor.

Consistent with our hypothesis that stress reactivity may be stronger among youths with higher levels of irritability, self-reported person-level irritability moderated the association

between stressful events and momentary irritability (β = .19, p = .002), such that the association between stressful events and momentary irritability was stronger among youths with higher self-reported person-level irritability. In contrast, no corresponding moderation effect emerged for proxy-reported person-level irritability. Neither self- nor proxy-reported person-level irritability moderated the association between prior irritability and subsequent stressful events, providing no evidence that stress generation processes differed as a function of stable individual differences in irritability (see Table 5).

Table 5

Multilevel AR(1) Models With Time-Invariant Irritability

Figure	Predictor	Outcome	β (STDYX)	95% CI	*p*
2a	Irritability (t−1)	EMA Irritability (t)	.214	[.199, .229]	< .001*
2a	Stress (t)	EMA Irritability (t)	.224	[.210, .238]	< .001*
2a	Self-reported irritability (YSR)	EMA Irritability	.225	[.119, .332]	< .001*
2a	Self-reported irritability (YSR)	AR(1) EMA Irritability	.066	[-.080, .209]	.176
2a	Self-reported irritability (YSR)	Stress→ EMA Irritability moderation	.187	[.052, .309]	.002*
2a	R^2 (Irritability)	Within	.155	[.146, .164]	—
2a	R^2 (Irritability)	Between	.102	[.046, .173]	—
2a	Irritability (t−1)	EMA Irritability (t)	.215	[.201, .229]	< .001*
2a	Stress (t)	EMA Irritability (t)	.223	[.210, .238]	< .001*
2a	proxy-reported irritability (CBCL)	EMA Irritability	.124	[.011, .232]	.014*
2a	proxy-reported irritability (CBCL)	AR(1) EMA Irritability	.008	[-.140, .154]	.458
2a	proxy-reported irritability (CBCL)	Stress → EMA Irritability moderation	.052	[-.080, .185]	.222
2a	R^2 (Irritability)	Within	.155	[.147, .165]	—

2a	R^2 (Irritability)	Between	.068	[.023, .132]	—
2b	Stress (t−1)	Stress (t)	.166	[.122, .206]	< .001*
2b	Irritability (t−1)	Stress (t)	.042	[.019, .064]	< .001*
2b	Self-reported irritability (YSR)	Stress	.059	[.075, .192]	.192
2b	Self-reported irritability (YSR)	AR(1) Stress	.079	[-.078, .235]	.160
2b	Self-reported irritability (YSR)	EMA Irritability → Stress	.009	[-.300, .331]	.471
2b	R^2 (Stress)	Within	.152	[.133, .170]	—
2b	R^2 (Stress)	Between	.004	[.00, .037]	—
2b	Stress (t−1)	Stress (t)	.155	[.111, .200]	< .001*
2b	Irritability (t−1)	Stress (t)	.046	[.018, .069]	< .001*
2b	proxy-reported irritability (CBCL)	Stress	.040	[-.094, .172]	.274
2b	proxy-reported irritability (CBCL)	AR(1) Stress	.089	[-.070, .245]	.134
2b	proxy-reported irritability (CBCL)	EMA Irritability → Stress	-.069	[-.382, .261]	.337
2b	R^2 (Stress)	Within	.152	[.133, .175]	—
2b	R^2 (Stress)	Between	.003	[.000, .030]	—

Note. Figure 2a presents multilevel AR(1) models predicting momentary irritability from prior irritability and current stressful events, including self-reported (YSR) and proxy-reported (CBCL) person-level irritability as between-person predictors in separate models. Figure 2b presents corresponding models predicting stressful events from prior stress and prior irritability. β (STDYX) = standardized regression coefficient; CI = 95% credible interval; AR(1) = autoregressive lag-1 effect. Moderation effects indicate whether person-level irritability moderates within-person associations between stressful events and momentary irritability or between irritability and subsequent stress. R^2 refers to explained within- and between-person variance. * indicates effects with credible intervals excluding zero.

Individual differences in variability of momentary irritability

As an exploratory extension beyond the preregistered analyses, multilevel location-scale models were estimated to examine whether youths with higher person-level irritability also exhibited greater within-person variability in momentary irritability over time. Both self-

reported and proxy-reported irritability were associated with greater moment-to-moment variability in irritability (self: β = .23, p < .001; proxy: β = .13, p = .014). Thus, youths with higher person-level irritability differed not only in their average levels of momentary irritability but also in the extent to which irritability fluctuated over time (see **Table 6**).

Table 6

Location-Scale Models

Figure	Predictor	Outcome	β (STDYX)	95% CI	*p*
3	Irritability (t−1)	EMA Irritability (t)	.21	[.20, .23]	< .001*
3	Stress (t)	EMA Irritability (t)	.23	[.21, .24]	< .001*
3	Self-reported irritability (YSR)	EMA Irritability	.23	[.12, .34]	< .001*
3	Self-reported irritability (YSR)	AR(1) EMA Irritability	.03	[-.10, .16]	.324
3	Self-reported irritability (YSR)	Stress → EMA Irritability moderation	.16	[.03, .29]	.009*
3	Self-reported irritability (YSR)	Log residual variance (logv)	.23	[.12, .34]	< .001*
3	R^2 (Irritability)	Within	.18	[.17, .19]	—
3	R^2 (Irritability)	Between	.11	[.05, .18]	—
3	Irritability (t−1)	EMA Irritability (t)	.21	[.20, .23]	< .001*
3	Stress (t)	EMA Irritability (t)	.23	[.21, .24]	< .001*
3	Proxy-reported irritability (CBCL)	EMA Irritability	.12	[.01, .24]	.016*
3	Proxy-reported irritability (CBCL)	AR(1) EMA Irritability	.02	[-.12, .15]	.395
3	Proxy-reported irritability (CBCL)	Stress → EMA Irritability moderation	.01	[-.12, .14]	.448

3	Proxy-reported irritability (CBCL)	Log residual variance (logv)	.13	[.02, .25]	.014*
3	R^2 (Irritability)	Within	.18	[.17, .19]	—
3	R^2 (Irritability)	Between	.07	[.02, .14]	—

Note. Figure 3 presents multilevel location-scale models examining whether within-person variability in momentary irritability differed as a function of person-level irritability. Separate models were estimated for self-reported (YSR) and proxy-reported (CBCL) irritability. β (STDYX) = standardized regression coefficient; CI = 95% credible interval; AR(1) = autoregressive lag-1 effect; logv = log residual variance parameter reflecting within-person variability in momentary irritability. Higher logv values indicate greater moment-to-moment variability in irritability. R^2 refers to explained within- and between-person variance. * indicates effects with credible intervals excluding zero.

Comprehensive models of dynamic interplay between irritability and stress

Finally, we estimated two DSEM VAR(1) cross-lagged panel models with random slopes to capture the dynamic within-person interplay between irritability and stressful events. The models simultaneously included bidirectional lagged and concurrent associations and incorporated irritability (self-reported vs. proxy-reported, modeled in separate models) and age as between-person predictors.

Across both models, the autoregressive effects and the concurrent associations between stressful events and momentary irritability closely mirrored the patterns observed in the earlier AR(1) analyses. Only irritability at the previous measurement point was no longer associated with the occurrence of a stressful event in both self-reported and proxy-reported models (self: $\beta = .00$, $p = .479$; proxy: $\beta = .00$, $p = .453$). Again, at the between-person level, higher person-level irritability was associated with higher momentary irritability in both models (self: $\beta = .23$, $p < .001$; proxy: $\beta = .12$, $p = .022$). Further, person-level irritability moderated the concurrent association between stress and irritability in both models. Specifically, higher self-reported person-level irritability was associated with a stronger link between the occurrence of a stressful event and higher momentary irritability ($\beta = .21$, $p < .001$). A comparable moderation effect was observed for proxy-reported irritability ($\beta = .12$, $p = .022$) (see **Table 7**).

Table 7

VAR (1)

Figure	Predictor	Outcome	β (STDYX)	95% CI	p
4	Stress (t)	EMA Irritability (t)	.32	[.31, .34]	< .001*
4	EMA Irritability (t−1)	EMA Irritability (t)	.19	[.18, .21]	< .001*
4	Self-reported irritability (YSR)	EMA Irritability	.23	[.12, .34]	< .001*
4	Age	EMA Irritabiliy	-.01	[-.12, .10]	.422
4	Self-reported irritability (YSR)	AR(1) EMA Irritability	.00	[-.14, .14]	.489
4	Age	AR(1) EMA Irritability	.07	[-.07, .22]	.162
4	Self-reported irritability (YSR)	Stress → EMA Irritability moderation	.21	[.09, .32]	< .001*
4	Age	Stress → EMA Irritability moderation	-.02	[-.14, .10]	.371
4	Irritability (t−1)	Stress (t)	.00	[-.03, .03]	.479
4	Stress (t−1)	Stress (t)	.15	[.11, .19]	< .001*
4	Self-reported irritability (YSR)	Stress	.05	[-.08, .17]	.237
4	Age	Stress	.06	[-.07, .18]	.170
4	Self-reported irritability (YSR)	AR(1) Stress	.10	[-.06, .26]	.109
4	Age	AR(1) Stress	-.08	[-.24, .08]	.164
4	Self-reported irritability (YSR)	Irritabiliy → Stress moderation	-.17	[-.48, .11]	.119
4	Age	Irritabiliy → Stress moderation	.23	[-.09, .57]	.077
4	R^2 (Irritability)	Within	.31	[.29, .32]	—
4	R^2 (Stress)	Within	.13	[.11, .14]	—
4	Stress (t)	EMA Irritability (t)	.33	[.31, .35]	< .001*
4	EMA Irritability (t−1)	EMA Irritability (t)	.19	[.18, .21]	< .001*

4	Proxy-reported irritability (CBCL)	EMA Irritability	.12	[.00, .23]	.022*
4	Age	EMA Irritability	-.01	[-.13, .10]	.413
4	Proxy-reported irritability (CBCL)	AR(1) EMA Irritability	-.01	[-.15, .14]	.475
4	Age	AR(1) EMA Irritability	.07	[-.08, .21]	.188
4	Proxy-reported irritability (CBCL)	Stress → EMA Irritability moderation	.12	[.00, .23]	.022*
4	Irritability (t−1)	Stress (t)	.00	[-.03, .02]	.453
4	Stress (t−1)	Stress (t)	.15	[.12, .19]	< .001*
4	Proxy-reported irritability (CBCL)	Stress	.05	[-.08, .18]	.240
4	Age	Stress	.05	[-.08, .18]	.224
4	Proxy-reported irritability (CBCL)	AR(1) Stress	.02	[-.14, .18]	.397
4	Age	AR(1) Stress	-.07	[-.24, .09]	.192
4	Proxy-reported irritability (CBCL)	Irritabiliy → Stress moderation	.03	[-.31, .35]	.429
4	Age	Irritabiliy → Stress moderation	.22	[-.13, .56]	.115
4	R^2 (Irritability)	Within	.31	[.29, .32]	—
4	R^2 (Stress)	Within	.13	[.12, .15]	—

Note. Figure 4 presents multilevel VAR(1) models simultaneously estimating autoregressive and cross-lagged associations between momentary irritability and stressful events. Separate models were estimated for self-reported (YSR) and proxy-reported (CBCL) irritability. β (STDYX) = standardized regression coefficient; CI = 95% credible interval; VAR(1) = vector autoregressive model with lag-1 effects. Moderation effects indicate whether person-level irritability moderates within-person associations between stressful events and momentary irritability. R^2 refers to explained within-person variance. * indicates effects with credible intervals excluding zero.

Discussion

The goal of the study was twofold. First, we examined whether EMA measures of irritability correspond to self- and proxy-reported person-level measures of irritability in youth. Second, we investigated the dynamic interplay between irritability and daily stressful events,

including bidirectional associations, moderation by person-level irritability and age, and individual differences in within-person variability using location-scale modeling. Our findings suggest that irritability in youth is best understood as reflecting both stable individual differences and context-dependent fluctuations in daily life. Rather than representing competing perspectives, these findings indicate that stable individual differences in irritability shape how youths respond to stressful experiences in everyday life.

Correspondence Between Person-Level and Momentary Irritability

Our first preregistered hypothesis assumed positive associations between established person-level measures of irritability and momentary irritability assessed via EMA. Consistent with this hypothesis, momentary irritability assessed via EMA showed small but reliable associations with both self-reported and proxy-reported person-level measures of irritability. Thus, youths who reported higher levels of irritability on person-level measures also tended to report higher average irritability across the EMA assessment period. This finding is in line with prior EMA-based studies demonstrating moderate associations between person-level and momentary irritability (Naim et al., 2021; Silver, Sorcher, et al., 2024; Tseng et al., 2023), and extends this evidence to a community sample, thereby providing further support for the use of EMA-based assessments across the full spectrum of irritability severity.

Moreover, the present study advances prior research by explicitly disentangling within-person and between-person sources of variance in momentary irritability using a multilevel framework. While the observed associations indicate that EMA-based irritability captures meaningful individual differences, effect sizes were small, and only 33% of the variance in momentary irritability was attributable to stable between-person differences. The remaining 67% represented within-person variance across assessments. However, because momentary irritability was assessed with a single item, this proportion cannot be interpreted entirely as meaningful psychological fluctuation, as it is likely to include some degree of measurement error. Nevertheless, the substantial within-person component suggests that momentary

irritability is not adequately represented by stable between-person differences alone. In line with recent calls to advance irritability research through ecologically valid and mechanistically informative methods (Evans, Shaughnessy, et al., 2023), EMA-based approaches may therefore complement person-level measures by capturing changes in irritability across time and situations. Such changes may reflect an interplay of contextual and situational influences, such as daily stressors or social interactions, and intraindividual processes, including emotional reactivity, regulatory capacity, and short-term affective dynamics (Myin-Germeys et al., 2009, 2018).

Associations between momentary and person-level irritability were somewhat stronger for self-reported compared to proxy-reported measures. This finding is consistent with the well-documented phenomenon of informant discrepancies in youth mental health, which reflects meaningful differences in access to information rather than mere measurement error (De Los Reyes & Kazdin, 2005; De Los Reyes, 2011). This pattern may reflect youths' privileged access to their own internal states, whereas proxy reports are based on external observations and broader behavioral patterns. Considering both perspectives may provide a more differentiated account of irritability across internal experience and externally observable behaviour.

Stress as a Predictor of Subsequent Irritability

Our second preregistered hypothesis predicted a bidirectional relationship between irritability and daily stressful events in youths' everyday lives.

Across a series of increasingly complex dynamic structural equation models, we found that the report of a stressful event within the 30 minutes preceding an EMA prompt was consistently associated with subsequent increases in momentary irritability. These findings suggest that stress represents a proximal predictor of irritability in youths ' everyday lives and supports current conceptualizations of irritability as reflecting heightened reactivity to negative affect and frustration (Leibenluft et al., 2024).

Extending prior EMA research that has primarily focused on between-person associations between irritability and affective or social processes (Silver, Hawes, et al., 2024) or longer-term longitudinal associations between irritability and stress across developmental periods (Harrison et al., 2025), the present results further demonstrate temporally ordered within-person processes linking daily stress to fluctuations in irritability and highlight stress as an immediate trigger.

Together with the substantial within-person component of momentary irritability, these findings indicate that irritability varies systematically across everyday contexts and responds to proximal stressful experiences. Short-term stress reactivity may therefore represent one process contributing to changes in irritability within individuals over time.

Findings for the reverse pathway from irritability at the prior measurement timepoint to subsequent reports of daily stressful events were sensitive to model specification. In simpler models, higher irritability predicted a small but significant increase in the likelihood of experiencing a stressful event at the next assessment. However, this association did not persist in the most complex model, when cross-lagged and autoregressive effects were modeled simultaneously. This discrepancy likely arose because, in simpler AR(1) models, irritability and stress are estimated in separate equations, such that shared dynamic variance between the two processes is not fully partitioned. In contrast, the VAR(1) model estimates both processes simultaneously, allowing cross-lagged effects to persist only if they explain unique variance beyond concurrent associations and mutual temporal dependencies.

The fact that the association remained robust from stressful events to subsequent irritability, but not in the reverse direction, may suggest that these processes operate on different time scales. Stressful events may be more directly and immediately associated with subsequent irritability, whereas potential stress-generating effects of irritability may unfold more indirectly through interpersonal interactions or escalating conflicts and therefore may not be detectable within the short intervals captured by the present EMA design. This pattern

586 contrasts with prior longitudinal research, which has reported stress-generating effects of
587 irritability over multi-year developmental intervals (e.g., across ages 12, 15, and 18; Harrison
588 et al., 2025). A further, methodological explanation is that overall irritability levels in the
589 present sample were relatively low, limiting the ability to detect effects on subsequent stress.
590 The present study design does not allow us to determine whether the absence of the reverse
591 pathway reflects a genuine temporal asymmetry or methodological constraints related to
592 restricted range and statistical power.. At the same time, the results do not necessarily imply
593 that irritability is irrelevant for stress generation. Rather, they provide stronger evidence for
594 immediate stress reactivity than for immediate stress generation. Whether irritability
595 contributes to stress generation over longer time scales, or whether such effects are more
596 readily detectable in samples with higher levels of irritability, remains an open question.

597 ***Person-level irritability as a moderator***

598 We further hypothesized that person-level irritability would moderate both directions of
599 the within-person associations between stress and irritability. Consistent with this expectation
600 for stress reactivity, self-reported person-level irritability was associated with stronger increases
601 in momentary irritability following stressful events. No corresponding mmoderation was
602 observed for proxy-reported irritability in the lagged model, and neither self- nor proxy-
603 reported irritability moderated the reverse pathway from irritability to subsequent stressful
604 events. Recent experience-sampling studies indicate that personality traits such as neuroticism
605 shape individual differences in stress reactivity, that is, the within-person associations between
606 momentary stress and negative affect (Lücke et al., 2024; Wrzus et al., 2021). Extending this
607 line of research, the present findings demonstrate that self-reported person-level irritability is
608 likewise associated with stronger stress reactivity, as reflected in a stronger momentary
609 association between stressful events and subsequent irritability.

610 The moderation findings further specify how stable individual differences and
611 momentary processes are related. Youths with higher person-level irritability did not merely

report higher average levels of momentary irritability; they also showed stronger increases in irritability following stressful experiences. Person-level irritability may therefore be reflected not only in average levels of irritability, but also in systematic differences in stress reactivity and, as discussed below, in moment-to-moment variability.

Individual Differences in Moment-to-Moment Variability of Irritability

In addition to the preregistered analyses, we explored whether youths with higher person-level irritability also showed more pronounced fluctuations in momentary irritability using a location-scale modeling approach. Tseng et al. (2023) and Naim et al. (2021) have previously shown that individuals with higher irritability display more complex and unstable affective profiles in daily life. However, these studies have primarily characterized instability descriptively or indirectly, without directly modeling interindividual differences in within-person variability. Extending this work, our location-scale analysis indicated greater moment-to-moment variability among youths with higher person-level irritability. Together with the moderation findings, these results suggest that person-level irritability is reflected not only in higher average levels of momentary irritability, but also in greater moment-to-moment variability and stronger stress-related fluctuations.. This pattern is consistent with a broader literature linking higher levels of psychopathology to greater affective variability in daily life, as captured through EMA approaches (e.g., Thunnissen et al., 2022).

Age Effects in the Association Between Stress and Irritability

Age did not moderate the observed associations between stressful events and momentary irritability. We found no evidence that the association between stress and irritability differed systematically by age within the present sample, despite the substantial psychological and social changes that typically occur between ages 12 and 21. One possible explanation is that momentary stress reactivity reflects a more general affective process that is already established in early youth and is less strongly tied to specific developmental stages. The absence of age effects may also reflect considerable heterogeneity within age groups. Youths of the

same chronological age can differ in pubertal status, social context, emotion regulation capacities, and levels of stress exposure, such that individual differences may outweigh average developmental trends (e.g. Blakemore, 2019; Marceau et al., 2011). Future research may therefore benefit from incorporating more proximal developmental markers, such as pubertal timing, transitions in social roles, or changes in environmental demands, to better characterize potential developmental modulation in the dynamics between stress and irritability.

Strengths and Limitations

A central strength of the present study lies in its intensive longitudinal EMA design. With eight assessments per day across a two-week period and a high compliance rate of approximately 85%, the study provides a highly resolved view of youths' moment-to-moment experiences. This high level of participant engagement provided substantial within-person information for modeling dynamic and context-dependent psychological processes as they unfold in everyday life.

A second major strength is the analytic approach. By applying DSEM, the study was able to simultaneously model multiple high-frequency processes, including autoregressive stability, concurrent associations, and cross-lagged effects, while separating within-person from between-person variance. This approach allowed us to evaluate the temporal ordering of stress and irritability and to identify which effects were robust across increasingly complex model specifications. The use of DSEM further ensured appropriate handling of unequal time intervals and missing data, which are common challenges in EMA designs. Moreover, person-level irritability could be incorporated as a moderator of within-person stress reactivity, a modeling strategy that has rarely been applied in EMA studies of irritability.

Despite these strengths, several limitations of the present study should also be acknowledged. First, the sample was drawn from the community, with relatively few youths exhibiting high levels of irritability. This restricted range may have reduced our ability to detect associations, particularly for the stress-generating effects of irritability. Future research should

replicate these analyses in clinical or high-risk samples, where higher symptom severity and greater interpersonal dysregulation may amplify bidirectional dynamics between irritability and stress.

Second, person-level irritability was assessed with an empirically derived 3-item irritability scale. Although CBCL and YSR are widely implemented questionnaires across large-scale and longitudinal studies in youth mental health, irritability-specific questionnaires could provide a more fine-grained picture of the correspondence and associations examined in this study. Nevertheless, prior research using exploratory, confirmatory, and conceptual approaches has consistently demonstrated that these CBCL/YSR items validly capture the construct of irritability (Evans et al., 2020; Stringaris, Goodman, et al., 2012; Tseng et al., 2017; Wiggins et al., 2014) and this scoring approach is also widely used and particularly suitable for secondary analyses of existing datasets (Evans et al., 2020).

Third, momentary irritability was assessed with a single item. As noted above, this also limits the interpretation of the within-person variance, as this variance reflects both meaningful momentary fluctuations and measurement error. Although this approach is common in EMA research and helps minimize participant burden, future studies may benefit from broader, theory-driven, and psychometrically validated assessments of irritability. A more differentiated measurement strategy (i.e., distinguishing tonic and phasic irritability) with multiple EMA items could provide deeper insight into how these components unfold over time and how they differentially relate to daily stressful events and longer-term psychopathology.

For future irritability research, it is crucial to also investigate the correspondence between momentary irritability and other standard clinical assessments such as the Affective Reactivity Index (ARI; Stringaris et al., 2012) or the Brief Irritability Test (BITe; (Holtzman et al., 2015). Furthermore, assessments that distinguish between tonic and phasic irritability (TAPIS; (Silver et al., 2025) may also show differential associations with EMA-assessed irritability.

Conclusion

The present study shows that irritability in youth reflects both stable individual differences and variation within individuals across daily life. Person-level irritability was associated with average momentary irritability and greater within-person variability, while higher self-reported person-level irritability was also associated with stronger stress-related increases in irritability. Daily stressful events consistently associated with subsequent increases in momentary irritability across model specifications, whereas there was little evidence for an immediate effect of irritability on subsequent stressful events. EMA-based assessments may therefore complement person-level measures by characterizing how irritability changes over time and in association with everyday stress.

Acknowledgements

We would like to thank all participants for their time and commitment to the study.

Funding

The first author was supported by the Swiss National Science Foundation (SNSF) through the UTOPICA project [215660].

Declaration of generative AI use

During the preparation of this manuscript, the authors used ChatGPT (OpenAI, GPT-5.6) for language refinement and coding assistance, including support with R code and Mplus syntax. All AI-assisted text and code were critically reviewed, revised, and validated by the authors. The authors take full responsibility for the accuracy, originality, and integrity of the manuscript, including the analyses, results, and references.

Declaration of interest statements

The authors report no conflicts of interest.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Appendix

Table 1

Predefined EMA Stressor Categories

Category	Stressor Category
1	I had an argument with friends or my romantic partner
2	I had an argument with my parents or one parent
3	I was excluded or ignored
4	I suffered from the distress of others
5	I was under (time) pressure
6	I did something wrong
7	I received negative feedback
8	I got into trouble
9	I received bad news
10	I experienced physical discomfort or pain
11	I had to perform a boring or tedious task
12	I worried about something upcoming
13	Other stressful event (open text response)

Note. When participants indicated that a stressful event had occurred within the past 30 minutes, they selected the type of stressor from one of these 13 predefined categories. If multiple events had occurred, participants were instructed to select the event they perceived as most stressful or unpleasant.

Table 2

Sociodemographics, Irritability Measures, and EMA Characteristics

Variable	N(%) / Mean (SD)
Sample size (*N*)	294
Age, M (*SD*)	17.5 (2.6)
Gender	
Female	172 (58.5)
Male	121 (41.2)
No answer	No answer: 1 (0.3)
Main activity: School	154 (52.4)
Parental financial situation (0 = very bad – 4 = very good)	3 (Median); 3 (Mode)
Region of birth	
Western & Southern Europe	262 (89.1)
West Asia & North Africa	14 (14.8)
Eastern Europe	10 (3.4)
East & South Asia	4 (1.4)
Sub-Saharan Africa	3 (1.0)
Missing	1 (0.3)
EMA compliance	85.05% (27,503 / 32,336), Range = 10–99%
Stressful events (total)	15% of responded EMA prompts
Stressful events per person	10.9 (11.1)
Irritability (person-level; range = 0 – 6;)	
Self-reported (YSR)	1.73 (1.43)
Proxy-report (CBCL	0.90 (1.18)

Note. YSR = Youth Self-Report; CBCL = Child Behavior Checklist. Irritability scores are based on mean item scores, with higher values indicating greater irritability. EMA compliance refers to the proportion of completed EMA prompts across the EMA protocol.

Table 3

Between-Person Associations of Person-Level Irritability and Momentary Irritability (EMA)

Predictor (Between)	***b***	***SE***	**95% CI**	**β (STDYX)**	***p***	***R*²** **(Between)**	***p* (R²)**
Self-reported irritability (YSR)	0.22	0.06	[0.13, 0.33]	.23	< .001	.06	.039*
proxy-reported irritability (CBCL)	0.15	0.07	[0.03, 0.28]	.13	.034	.02	.280
Variance	—	—	—	—	—	ICC = .33	

Note. *b* = unstandardized regression coefficient; *SE* = standard error; CI = 95% credible interval; β (STDYX) = standardized coefficient; R^2 refers to the proportion of explained between-person variance in momentary irritability; ICC = intraclass correlation coefficient indicating the proportion of variance attributable to between-person differences. * indicates credible intervals excluding zero.

Table 4

Set of basic AR(1) Models

Figure	Predictor	Outcome	β (STDYX)	95% CI	*p*
1a	Irritability (t−1)	EMA Irritability (t)	.21	[.20, .23]	< .001*
1a	Stress (t)	EMA Irritability (t)	.22	[.21, .24]	< .001*
1a	R^2 (Irritability)	Within	.16	[.15,.17]	—
1b	Stress (t−1)	Stress (t)	.16	[.12, .21]	< .001*
1b	Irritability (t−1)	Stress (t)	.05	[.02, .07]	<.001*
1b	R^2 (Stress)	Within	.14	[.12, .16]	—

Note: Figure 1a presents the autoregressive AR(1) model predicting momentary irritability from prior irritability and current stressful events. Figure 1b presents the corresponding AR(1) model predicting stressful events from prior stress and prior irritability. β (STDYX) = standardized regression coefficient; CI = 95% credible interval. R^2 refers to within-person explained variance. Stress was modeled as a binary outcome. * indicates effects with credible intervals excluding zero.

Table 5

Multilevel AR(1) Models With Time-Invariant Irritability

Figure	Predictor	Outcome	β (STDYX)	95% CI	*p*
2a	Irritability (t−1)	EMA Irritability (t)	.214	[.199, .229]	< .001*
2a	Stress (t)	EMA Irritability (t)	.224	[.210, .238]	< .001*
2a	Self-reported irritability (YSR)	EMA Irritability	.225	[.119, .332]	< .001*
2a	Self-reported irritability (YSR)	AR(1) EMA Irritability	.066	[-.080, .209]	.176
2a	Self-reported irritability (YSR)	Stress→ EMA Irritability moderation	.187	[.052, .309]	.002*
2a	R^2 (Irritability)	Within	.155	[.146, .164]	—
2a	R^2 (Irritability)	Between	.102	[.046, .173]	—
2a	Irritability (t−1)	EMA Irritability (t)	.215	[.201, .229]	< .001*
2a	Stress (t)	EMA Irritability (t)	.223	[.210, .238]	< .001*
2a	proxy-reported irritability (CBCL)	EMA Irritability	.124	[.011, .232]	.014*
2a	proxy-reported irritability (CBCL)	AR(1) EMA Irritability	.008	[-.140, .154]	.458
2a	proxy-reported irritability (CBCL)	Stress → EMA Irritability moderation	.052	[-.080, .185]	.222
2a	R^2 (Irritability)	Within	.155	[.147, .165]	—
2a	R^2 (Irritability)	Between	.068	[.023, .132]	—
2b	Stress (t−1)	Stress (t)	.166	[.122, .206]	< .001*
2b	Irritability (t−1)	Stress (t)	.042	[.019, .064]	< .001*
2b	Self-reported irritability (YSR)	Stress	.059	[.075, .192]	.192
2b	Self-reported irritability (YSR)	AR(1) Stress	.079	[-.078, .235]	.160
2b	Self-reported irritability (YSR)	EMA Irritability → Stress	.009	[-.300, .331]	.471
2b	R^2 (Stress)	Within	.152	[.133, .170]	—
2b	R^2 (Stress)	Between	.004	[.00, .037]	—

2b	Stress (t−1)	Stress (t)	.155	[.111, .200]	< .001*
2b	Irritability (t−1)	Stress (t)	.046	[.018, .069]	< .001*
2b	proxy-reported irritability (CBCL)	Stress	.040	[-.094, .172]	.274
2b	proxy-reported irritability (CBCL)	AR(1) Stress	.089	[-.070, .245]	.134
2b	proxy-reported irritability (CBCL)	EMA Irritability → Stress	-.069	[-.382, .261]	.337
2b	R^2 (Stress)	Within	.152	[.133, .175]	—
2b	R^2 (Stress)	Between	.003	[.000, .030]	—

Note. Figure 2a presents multilevel AR(1) models predicting momentary irritability from prior irritability and current stressful events, including self-reported (YSR) and proxy-reported (CBCL) person-level irritability as between-person predictors in separate models. Figure 2b presents corresponding models predicting stressful events from prior stress and prior irritability. β (STDYX) = standardized regression coefficient; CI = 95% credible interval; AR(1) = autoregressive lag-1 effect. Moderation effects indicate whether person-level irritability moderates within-person associations between stressful events and momentary irritability or between irritability and subsequent stress. R^2 refers to explained within- and between-person variance. * indicates effects with credible intervals excluding zero.

Table 6

Location-Scale Models

Figure	Predictor	Outcome	β (STDYX)	95% CI	*p*
3	Irritability (t−1)	EMA Irritability (t)	.21	[.20, .23]	< .001*
3	Stress (t)	EMA Irritability (t)	.23	[.21, .24]	< .001*
3	Self-reported irritability (YSR)	EMA Irritability	.23	[.12, .34]	< .001*
3	Self-reported irritability (YSR)	AR(1) EMA Irritability	.03	[-.10, .16]	.324
3	Self-reported irritability (YSR)	Stress → EMA Irritability moderation	.16	[.03, .29]	.009*
3	Self-reported irritability (YSR)	Log residual variance (logv)	.23	[.12, .34]	< .001*
3	R^2 (Irritability)	Within	.18	[.17, .19]	—
3	R^2 (Irritability)	Between	.11	[.05, .18]	—
3	Irritability (t−1)	EMA Irritability (t)	.21	[.20, .23]	< .001*
3	Stress (t)	EMA Irritability (t)	.23	[.21, .24]	< .001*
3	Proxy-reported irritability (CBCL)	EMA Irritability	.12	[.01, .24]	.016*
3	Proxy-reported irritability (CBCL)	AR(1) EMA Irritability	.02	[-.12, .15]	.395
3	Proxy-reported irritability (CBCL)	Stress → EMA Irritability moderation	.01	[-.12, .14]	.448
3	Proxy-reported irritability (CBCL)	Log residual variance (logv)	.13	[.02, .25]	.014*
3	R^2 (Irritability)	Within	.18	[.17, .19]	—
3	R^2 (Irritability)	Between	.07	[.02, .14]	—

Note. Figure 3 presents multilevel location-scale models examining whether within-person variability in momentary irritability differed as a function of person-level irritability. Separate models were estimated for self-reported (YSR) and proxy-reported (CBCL) irritability. β (STDYX) = standardized regression coefficient; CI = 95% credible interval; AR(1) = autoregressive lag-1 effect; logv = log residual variance parameter reflecting within-person variability in momentary

irritability. Higher logv values indicate greater moment-to-moment variability in irritability. R^2 refers to explained within- and between-person variance. * indicates effects with credible intervals excluding zero.

Table 7

VAR (1)

Figure	Predictor	Outcome	β (STDYX)	95% CI	p
4	Stress (t)	EMA Irritability (t)	.32	[.31, .34]	< .001*
4	EMA Irritability (t−1)	EMA Irritability (t)	.19	[.18, .21]	< .001*
4	Self-reported irritability (YSR)	EMA Irritability	.23	[.12, .34]	< .001*
4	Age	EMA Irritabiliy	-.01	[-.12, .10]	.422
4	Self-reported irritability (YSR)	AR(1) EMA Irritability	.00	[-.14, .14]	.489
4	Age	AR(1) EMA Irritability	.07	[-.07, .22]	.162
4	Self-reported irritability (YSR)	Stress → EMA Irritability moderation	.21	[.09, .32]	< .001*
4	Age	Stress → EMA Irritability moderation	-.02	[-.14, .10]	.371
4	Irritability (t−1)	Stress (t)	.00	[-.03, .03]	.479
4	Stress (t−1)	Stress (t)	.15	[.11, .19]	< .001*
4	Self-reported irritability (YSR)	Stress	.05	[-.08, .17]	.237
4	Age	Stress	.06	[-.07, .18]	.170
4	Self-reported irritability (YSR)	AR(1) Stress	.10	[-.06, .26]	.109
4	Age	AR(1) Stress	-.08	[-.24, .08]	.164
4	Self-reported irritability (YSR)	Irritabiliy → Stress moderation	-.17	[-.48, .11]	.119
4	Age	Irritabiliy → Stress moderation	.23	[-.09, .57]	.077
4	R^2 (Irritability)	Within	.31	[.29, .32]	—
4	R^2 (Stress)	Within	.13	[.11, .14]	—
4	Stress (t)	EMA Irritability (t)	.33	[.31, .35]	< .001*
4	EMA Irritability (t−1)	EMA Irritability (t)	.19	[.18, .21]	< .001*
4	Proxy-reported irritability (CBCL)	EMA Irritability	.12	[.00, .23]	.022*

4	Age	EMA Irritability	-.01	[-.13, .10]	.413
4	Proxy-reported irritability (CBCL)	AR(1) EMA Irritability	-.01	[-.15, .14]	.475
4	Age	AR(1) EMA Irritability	.07	[-.08, .21]	.188
4	Proxy-reported irritability (CBCL)	Stress → EMA Irritability moderation	.12	[.00, .23]	.022*
4	Irritability (t−1)	Stress (t)	.00	[-.03, .02]	.453
4	Stress (t−1)	Stress (t)	.15	[.12, .19]	< .001*
4	Proxy-reported irritability (CBCL)	Stress	.05	[-.08, .18]	.240
4	Age	Stress	.05	[-.08, .18]	.224
4	Proxy-reported irritability (CBCL)	AR(1) Stress	.02	[-.14, .18]	.397
4	Age	AR(1) Stress	-.07	[-.24, .09]	.192
4	Proxy-reported irritability (CBCL)	Irritabiliy → Stress moderation	.03	[-.31, .35]	.429
4	Age	Irritabiliy → Stress moderation	.22	[-.13, .56]	.115
4	R^2 (Irritability)	Within	.31	[.29, .32]	—
4	R^2 (Stress)	Within	.13	[.12, .15]	—

Note. Figure 4 presents multilevel VAR(1) models simultaneously estimating autoregressive and cross-lagged associations between momentary irritability and stressful events. Separate models were estimated for self-reported (YSR) and proxy-reported (CBCL) irritability. β (STDYX) = standardized regression coefficient; CI = 95% credible interval; VAR(1) = vector autoregressive model with lag-1 effects. Moderation effects indicate whether person-level irritability moderates within-person associations between stressful events and momentary irritability. R^2 refers to explained within-person variance. * indicates effects with credible intervals excluding zero.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1.docx
- Table5.docx
- Table4.docx
- Table2.docx
- Table7.docx
- Table6.docx
- Table3.docx