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Adverse childhood experiences and emotion dynamics in daily life: a two sample study*

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ABSTRACT

Research suggests that adverse childhood experiences (ACEs) can have life-long consequences on emotional functioning. However, it is unclear how ACEs shape the dynamic features of everyday emotions. In the current preregistered study with two adult ecological momentary assessment samples ($Ns = 122$ and 121), we examined the linear and curvilinear associations of ACEs with daily emotion dynamic features. We expected ACEs to show linear associations with a higher baseline level, variability, and inertia of negative emotions, as well as a lower baseline level of positive emotions. Moreover, we expected ACEs to show U-shaped curvilinear associations with the variability of negative and positive emotions. The results did not support our hypotheses. Instead, ACEs showed an inverted U-shaped association with the baseline level and variability of negative emotions. Furthermore, ACEs also showed a U-shaped association with the baseline level of positive emotions and a linear association with higher variability of positive emotions. However, all associations were present in only one of the two samples. Our study underscores the critical need to incorporate a broad spectrum of ACEs in research samples to adequately capture their developmental consequences and the role of ACEs in contributing to the baseline level and variability of daily emotions.

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Adverse childhood experiences; emotions; ecological momentary assessment; variability; inertia

Adverse childhood experiences (ACEs), such as physical and psychological abuse and neglect, can have detrimental consequences on people's somatic and mental health (Asmussen et al., 2020; Hughes et al., 2017). One mechanism through which ACEs may influence people's health is by modifying their emotional functioning which in turn is modified by developmental alterations of their regulatory systems Indeed, research has shown that ACEs are related to heightened emotional responsivity and dysregulation (McLaughlin et al., 2019; Miu et al., 2022). However, most studies have utilised one-occasion self-reports or laboratory assessments of emotions, which have only limited ecological validity. Therefore, it remains unclear whether and how ACEs link with more dynamic features that reflect the time-evolving flow of people's everyday emotions (Kuppens et al., 2010). Ecologically valid assessment of such emotion dynamics is possible using Ecological Momentary Assessment (EMA), in which participants report their emotions multiple times per day amidst everyday life. Further, while most research has

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focused on linear associations between ACEs and emotional development, evolutionary models suggest that some of these associations may be non-linear, reflecting developmental adaptations to one's specific environment (Del Giudice et al., 2011; Ellis & Boyce, 2008). In the current study, we use two adult EMA samples to examine both linear and curvilinear (U-shaped) associations of retrospectively assessed ACEs with basic dynamic features of negative and positive emotions in daily life.

Adverse childhood experiences and alterations in stress responses

Two broad-level stress-response frameworks are crucial in understanding the associations between ACEs and regulatory development. First, according to the allostatic load framework, adversities cause alterations in children's stress response system, which include sympathetic and parasympathetic autonomic nervous systems and the hypothalamus pituitary adrenal axis (Danese & McEwen, 2012; Finlay et al., 2022; Shonkoff et al., 2012). While such adjustments can be protective for children's coping and survival in the short term, prolonged exposure to intense adversities can lead to allostatic overload. Allostatic load implies a pattern of multi-system dysregulation that hinders a child's neurobiological and emotional development (Danese & McEwen, 2012; Finlay et al., 2022; Shonkoff et al., 2012). This framework has robust empirical support as ACEs have been linked to emotional dysregulation (Miu et al., 2022) and disorders (Gardner et al., 2019; Tan & Mao, 2023).

Second, the adaptive calibration framework offers an evolutionary-developmental perspective on the genesis of individual differences in stress responsivity. The main models are the Biological Sensitivity to Context (Ellis & Boyce, 2008) and the Adaptive Calibration Model of Stress Responsivity (Del Giudice et al., 2011). Both posit that the characteristics of one's developmental environment guide the developmental balance between heightened and blunted responsivity (Del Giudice et al., 2011; Ellis & Boyce, 2008; Ellis & Del Giudice, 2014, 2019). More specifically, both safe and threatening environments may lead to high stress responsivity, reflecting conditional adaptations to one's environment that follow the U-shaped curve. In safe environments, elevated stress responsivity allows children to spot and capitalise on positive opportunities. This sensitivity can foster collaboration and well-being, especially in stable socio-ecological contexts. In threatening environments, high stress responsivity aids in threat detection, facilitating defensive behaviours, such as fight and flight responses. This vigilance helps children cope with threats in the present and anticipated harsh and unpredictable environments. Finally, exposure to a moderate number of ACEs may regulate development toward reduced stress responsivity, as the costs of high responsivity may outweigh its benefits in moderately stressful environments (Del Giudice et al., 2011; Ellis & Boyce, 2008; Ellis & Del Giudice, 2014, 2019).

Different from the Biological Sensitivity to Context, the Adaptive Calibration Model posits that very high number of ACEs may lead to blunted stress responsivity, facilitating risk-taking and ruthless competition (Del Giudice et al., 2011). This constitutes an S – rather than a U-curve relationship between ACEs and stress responsivity (Del Giudice et al., 2011). However, empirical studies suggest that such extreme strategies are rare in normative samples, and indicate U-shaped relationships between early adversities and children's physiological stress responses (Li et al., 2021; Shakiba et al., 2020).

Collectively, the allostatic load and adaptive calibration frameworks shed light on the developmental nuances of stress responsivity. While both frameworks emphasise the malleability of regulatory processes in response to ACEs, they differ in predicting whether the long-term effects on later development are linear or curvilinear. It is also noteworthy that while both frameworks have explicit focus on psychobiological regulation, we deem them applicable to generate hypotheses about emotional development as well.

Adverse childhood experiences and emotion dynamic features

The dynamic approach to emotions provides novel possibilities to understand emotional processes and regulation in the context of daily life (Kuppens et al., 2010). Within this framework, the emotional flow is characterised by three basic dynamic features: (a) baseline level, referring to a long-run equilibrium of a person's mean emotional state, (b) variability, denoting the degree of moment-to-moment oscillation in a person's emotions from their baseline level, and (c) inertia, indicating the extent to which emotions carry over from one moment to the next (Kuppens et al., 2010). Together, these features capture the main regulatory and responsivity processes in the dynamics of everyday emotions, allowing to extrapolate the theoretical predictions from the allostatic load and adaptive calibration frameworks to tangible, daily emotional experiences.

According to the allostatic load framework, exposure to ACEs amplify the risk for later emotional dysregulation (Finlay et al., 2022). EMA research on mental health has already characterised how emotional dysregulation may be manifested in certain emotion dynamic features. Specifically, a high baseline of negative emotions and a low baseline of positive emotions are robust predictors of low emotional well-being (Dejonckheere et al., 2019). Further, meta-analytical evidence shows that high variability and inertia, especially in the case of negative emotions, are linked with emotional disorders, such as depression and borderline personality (Houben et al., 2015). Thus, drawing from the allostatic load framework, emotional dysregulation stemming from exposure to multiple ACEs may manifest in the four emotion dynamic features in daily life: (a) a high baseline of negative emotions, denoting a heightened tendency to experience negative emotions; (b) high variability of negative emotions, implying heightened stress responses to unfavourable external events and internal states; (c) high inertia of negative emotions, implying a delayed emotional recovery after encountering distressing situations and (d) a low baseline of positive emotions, indicating reduced positive emotional reactions.

In turn, the adaptive calibration framework posits a curvilinear U-shaped relationship between ACEs and people's stress responses to situational cues of unpredictability and novelty (Del Giudice et al., 2011; Ellis & Boyce, 2008). In terms of emotion dynamic features, such responsivity may be captured by high variability of both negative and positive emotions as they both reflect a low response threshold to external events and internal states (Hamaker et al., 2018; Kuppens et al., 2010). Hence, drawing from the adaptive calibration framework, emotional responsivity stemming from exposure to low and high ACEs may manifest through the two emotion dynamic features of the high variability of negative and positive emotions.

Available studies on ACEs and emotion dynamic features are relatively rare and have focused on their linear associations. ACEs have shown associations with a higher baseline level of negative emotions and a lower baseline of positive emotions (Holl et al., 2017; Ion et al., 2023; Kautz et al., 2020; Myroniuk et al., 2024; Pries et al., 2020; Wonderlich et al., 2007). Some of these associations have been detected at the level of specific negative emotions, such as shame and sadness (Holl et al., 2017; Kautz et al., 2020). Studies have also linked ACEs to higher inertia of negative emotions (Myroniuk et al., 2024; Teicher et al., 2015). Regarding the variability of emotions, the results are more mixed. Studies suggest that some adversities, such as sexual abuse, associate with higher variability of negative emotions (Brick et al., 2021; Myroniuk et al., 2024), whereas others, such as physical abuse, associate with lower variability of negative emotions (Myroniuk et al., 2024). Finally, one study found no association between ACEs and the variability of negative emotions (Teicher et al., 2015).

No EMA studies have tested the curvilinear associations of ACEs with the emotion dynamic features. Yet, the existence of curvilinear associations might account for the discrepancies in previous studies concerning the variability of negative emotions (Brick et al., 2021; Myroniuk et al., 2024; Teicher et al., 2015). Similar cues of curvilinear associations can be discerned from studies examining the variability of positive emotions. Some research has linked ACEs with higher variability (Teicher et al., 2015), while others suggest a link between ACEs and lower variability of positive emotions (Brick et al., 2021; Myroniuk et al., 2024). From the perspective of the adaptive calibration framework, the mixed results of single studies may be attributable to the range of ACEs, that is, the portion of the nonlinear association, captured within the sample (Boyce & Ellis, 2005; Del Giudice et al., 2011).

Current study

In this preregistered EMA study, we applied two prominent stress regulation theories to investigate emotional experiences in natural, ecologically valid settings. Specifically, using two EMA samples, we posited novel hypotheses concerning the associations between individuals' ACEs and the dynamic characteristics of their negative and positive emotions in daily life. First, drawing from the allostatic load framework of childhood adversities (Danese & McEwen, 2012; Finlay et al., 2022; Shonkoff et al., 2012), we test the linear associations of ACEs with the baseline level, variability, and inertia of negative and positive emotions. Second, drawing from the adaptive calibration framework (Del Giudice et al., 2011; Ellis & Boyce, 2008; Ellis & Del Giudice, 2014, 2019), we test the curvilinear (U-shaped) associations of ACEs with the baseline, variability, and inertia of negative and positive emotions. Finally, we also explore the associations of ACEs with dynamic features of specific negative emotions (i.e. anxiety, sadness, anger, and shame), as ACEs may have a specific impact on them (Holl et al., 2017). The allostatic load – and adaptive calibration frameworks were chosen to construct hypotheses concerning emotional dynamics with a solid foundation in evolutionary-developmental theory of individual differences.

Figure 1 depicts our study framework and the hypotheses extrapolated from (a) allostatic load (Figure 1(a)) and (b) adaptive calibration frameworks (Figure 1(b)). Our main prediction regarding the linear associations of ACEs is that people with a high number of ACEs show higher levels of emotional dysregulation. Thus, we expect that high ACEs show a linear association with a higher baseline level of negative emotions, higher variability of negative emotions, higher inertia of negative emotions, and a lower baseline level of positive emotions. Our main prediction regarding the curvilinear associations of ACEs is that ACEs show a U-shaped association with emotional responsivity. Specifically, we expect that ACEs show a U-shaped association with the variability of negative and positive emotions.

Finally, when considering the links between ACEs and emotion dynamic features, it is noteworthy that several recent findings indicate potential confounding between the baseline level of negative emotions and its inertia and variability (Dejonckheere et al., 2019; Tammilehto, Kuppens, et al., 2023; Wendt et al., 2020). These findings emphasise the importance of controlling for baseline level to evaluate it as a more parsimonious explanation. Consequently, we also consider the possibility that if observed, the associations of ACEs with variability and inertia might be entirely accounted for by the relationships between ACEs and emotion baseline level.

Materials and methods

Procedure and sample

We used two independent EMA samples on adults. Sample I came from the Daily Emotions research project (see Tammilehto et al., 2022) and Sample II was from the Miracles of Development research project (https://projects.tuni.fi/kehi/). All hypotheses and the analysis plan were preregistered before conducting the analyses.[1]

Sample I

Regarding Sample I, 125 participants were initially recruited via Tampere University email lists and paper flyers distributed in the campus areas. The inclusion criteria were (a) age over 18 years old, (b) the possibility to use a smartphone, and (c) being fluent in Finnish. The Ethics Committee for Humanities of Tampere region approved the study.

The data collection consisted of two phases: an online questionnaire and an EMA phase. The online questionnaire phase included the questionnaire on ACEs. In the EMA two weeks later, the participants received questionnaires on their smartphones seven times a day for one week. The sending times of the EMA-questionnaires were randomly assigned within seven blocks between 10:00 AM and 10:00 PM. One participant failed to fill the first phase questionnaire, and two participants had the same EMA identity number due to a technical error. These participants were excluded from the analyses. The final sample was 122 participants ($M_{age} = 26.43$ years, $SD = 8.33$, range: 19–52; 88.5% women), comprising 65 university students, 49 open university students, five other students, and three non-students. Of the participants, 82 were in a romantic relationship. The EMA observations totalled 4628, with an average of 38 observations per participant.

Sample II

Sample II was an EMA subsample of the larger Miracles of Development research project that has followed Finnish families from the second trimester of pregnancy to children's young adulthood. The original sample consisted of (a) naturally conceiving couples ($n = 469$) recruited at the Helsinki University Central Hospital during a routine ultrasonographic examination and (b) couples with infertility history who had conceived with assisted reproductive treatment ($n = 484$) recruited from five infertility clinics in Finland. The ethical board of the Helsinki University Hospital had approved all phases of data collection. For more detailed information about the original sample, see (Tammilehto et al., 2021).

The ACE data were collected on late adolescents in families aged 17–19 years. The adolescents were approached by mailed letters and asked to sign and return the informed consent if interested in participating. After that, the participating adolescents answered

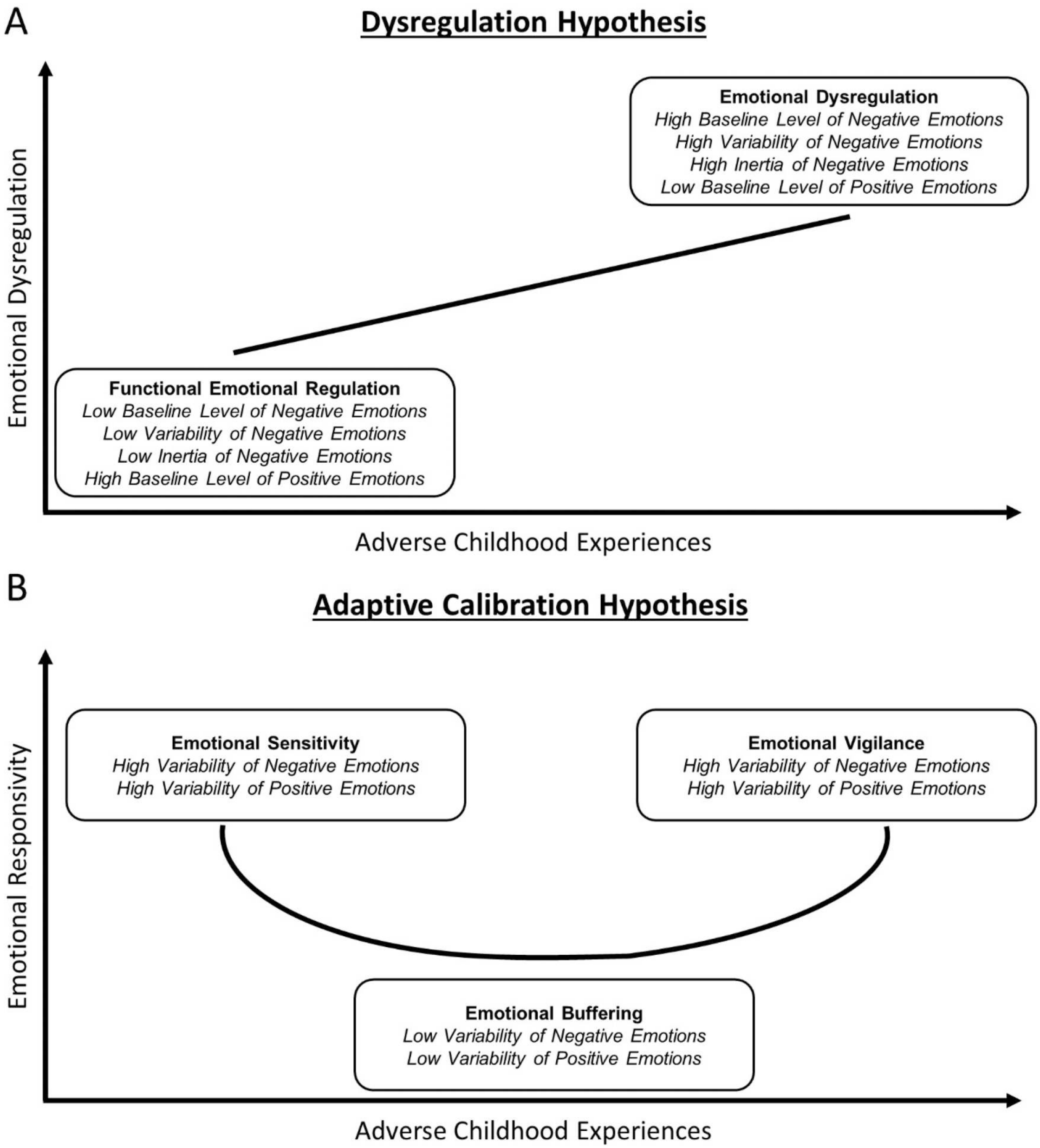

Figure 1. Conceptual framework of current study consisting of (a) allostatic load hypothesis and (b) adaptive calibration hypothesis.

the online questionnaire on ACEs. Overall, 449 late adolescents participated in this data collection. For more information about late adolescent data collection, see Flykt et al. (2021).

Two to three years later, the EMA subsample on these same participants was collected at 20–22 years old. The inclusion criteria were (a) a lack of severe developmental disorders, (b) the availability of address information in the Finnish digital and population data services agency, and (c) not having expressed a wish to stop participating the study during the previous data collections. Of all 710 young adults approached via mailed letters, 130 expressed their willingness to participate in the study and were thus included in this subsample. In the EMA, participants completed short questionnaires sent to their smartphones ten times daily for seven days. Each day, the sending time for each questionnaire was randomised within ten blocks between 08:00 and 22:00. Two participants had less than three EMA answers (< 3%), and one participated in neither study phase. Moreover, six participants had not participated in late adolescence data collection when the information was collected about ACEs. Thus, the final sample was 121 participants (M_{age} = 20.97, *SD* = 0.45, range: 20–22; 68.6% women). Of the participants, two had the highest education level of the undergraduate degree, 103 matriculation examination, 12 vocational education and training, and four comprehensive school. Moreover, 63 were in a romantic relationship. The EMA observations totalled 5091, with an average of 42 observations per participant. The attrition analyses are provided in Supplemental Material 1.

Measures

Adverse childhood experiences

Sample I. In the first questionnaire phase, ACEs were assessed using the revised inventory of Adverse Childhood Experiences, comprising 22 items (Finkelhor et al., 2015) and four additional items (Ellonen et al., 2008). All items, their response scales, and frequencies can be found in Supplemental Material 2 (Table S2A). We slightly modified the revised inventory of Adverse Childhood Experiences by replacing some of the binary (0 = no, 2 = yes) answer scales with three-point Likert scales (0 = never, 1 = sometimes, 2 = often). Two items assessed each domain of Emotional abuse, Physical abuse, Emotional neglect, and Physical neglect. Three items assessed the domain of Parent treated violently. Two items assessed each domain of Sexual abuse and Family mental illness.[2] One item assessed each domain of Peer victimisation and Peer isolation or rejection. Finally, one-item questions assessed each domain of Family alcohol and drug problem, Incarcerated household member, Low socioeconomic status, Exposure to community violence, and Parental loss.

Moreover, four items were adapted from Ellonen et al. (2008) to capture other common ACEs that can occur in family contexts. Two additional items assessed interparental psychological violence, and one-item questions assessed each domain of physical and psychological disciplinary violence. In the analyses, we used the total unweighted sum score of the ACE measure. This allowed us to maximise variance in our relatively low-risk sample.

Sample II. ACEs were assessed using ten items from the revised inventory of Adverse Childhood Experiences (Finkelhor et al., 2015) and four additional items at participants ages 17–19 years. All items, their response scales, and frequencies can be found in Supplemental Material 2 (Table S2B). Regarding the revised inventory of Adverse Childhood Experiences, two items assessed each domain of Emotional abuse, Physical abuse, Emotional neglect, and Parent treated violently. One-item questions assessed each domain of Family alcohol and drug problem and Family mental illness. Moreover, two items assessed interparental psychological violence (Ellonen et al., 2008), and one-item question assessed peer victimisation in terms of school bullying. Finally, we used one open-question item "Have you experienced other adversities, such as accidents, victimisation, or natural catastrophes?" to gather additional ACEs. Specifically, we focused on recognising the ACEs corresponding to the items in Sample I but not in Sample II. If the answer belonged to some of these categories, we scored them with a value of "2". Two authors coded these answers independently, after which the answers were reviewed in the research group. We recognised four additional ACEs, three concerned parental loss and one peer isolation. In the analyses, we used the total unweighted sum score of the ACE measure.

Negative and positive emotions

In the EMA of both samples, the participants were asked to report how strongly they experienced four negative (i.e. anger, anxiety, shame, and sadness) and four positive (i.e. joy, pride, satisfaction, and excitement) emotions at the present moment. In Sample I (seven times a day for a week), participants reported their emotions using a 5-point Likert scale (1 = *not at all* to 5 = *very much*). In Sample II (ten times a day for a week), participants reported their emotions using a continuous slider scale (0 = *not at all* to 100 = *very much*).

Previously, we have assessed the psychometric structure of negative and positive emotions using multilevel confirmatory factor analyses (Tammilehto, Kuppens, et al., 2023). In Sample I, the measurement model with two factors of negative and positive emotions at both within – and between-person levels showed good fit, χ^2 [38] = 235.67 $p < .001$, CFI = .973, RMSEA = .041, SRMR within/between = .029/.077. The omega reliabilities at the within – and between-person levels were .65 and .83 for negative emotions and .83 and .89 for positive emotions, respectively. Similarly, in Sample II, the same model showed good fit, χ^2 [38] = 209.75, $p < .001$, CFI = .977, RMSEA = .038, SRMR within/between = .031/.070. The omega reliabilities at the within – and between-person levels were .67 and .90 for negative emotions and .83 and .95 for positive emotions, respectively. In our main analyses, we modelled baseline level, variability, and inertia using the average negative and positive emotion scores.

Sociodemographic covariates

In both Sample I and Sample II, we considered covarying age in years and gender (0 = *female*, 1 = *male*). Moreover, in Sample II, we also considered controlling for the infertility history of the family (0 = *no*, 1 = *yes*) to ensure that the sample distribution did not play a role in the associations we were interested in. To minimise complexity in our analyses, we preregistered only to include covariates correlated with ACEs in either of our samples using an alpha level of .050. Only age met this criterion and was thus included in the analyses.

Analytic strategy

We analysed our data with dynamic structural equation models (DSEM; Asparouhov et al., 2018). These analyses were conducted in Mplus 8.8 (Muthen & Muthen, 2017). In R software, we conducted data preparations, calculated descriptive statistics and correlations, and visualised the results.

DSEM is a novel analytical integration of time-series, multilevel, and structural equation modelling (Asparouhov et al., 2018). It uses latent centreing to decompose the total variance of variables into the within-person and between-person components that are modelled simultaneously (Asparouhov et al., 2018). We chose to use DSEM as it allowed us to model all predictive effects of ACEs on the baseline level, variability, and inertia of emotions within the same model (yet, separately for negative and positive emotions). Overall, we built six primary models for both our samples (i.e. three for negative emotions and three for positive emotions) to examine the associations of ACEs with emotion dynamic features.

Figure 2 summarises our modelling strategy that was conducted for both samples. In all models, baseline level was modelled by estimating the random intercept of emotions, variability by estimating the random innovation variance of emotions, and inertia by estimating the random first-order autoregressive effect of emotions. In the first two models (i.e. one for negative emotions and one for positive emotions), ACEs were specified to predict individual differences in baseline level, variability, and inertia of emotions. Age was also added as a predictor of the emotion dynamic features. Both variables of ACEs and age were grand-mean-centred. Emotion variables were first grand-mean-centred to facilitate interpretations and then latent-mean-centred. Moreover, baseline level, variability, and inertia were specified to correlate with each other. These models enabled us to test whether ACEs show linear effects on the three emotion dynamic features beyond the participants' age.

In the following two models, we added the quadratic term of ACEs to predict the three emotion dynamic features. These models enabled us to test whether the ACEs show curvilinear predictive associations with the emotion dynamic features. In the next two models, the baseline level was additionally specified to predict variability and inertia. These models enabled us to test whether the ACEs show unique predictive linear and/or curvilinear associations with the more complex emotion dynamic features over and above the linear associations of baseline level with variability and inertia. The quadratic term of ACEs was included in these models only if it previously showed links with emotion dynamic features. In our preregistered supplemental analyses, we explored the linear and quadratic associations of ACEs with emotion dynamic features for four specific negative emotions (i.e. anxiety, sadness, anger, and shame). The aim of these analyses was to complement our main results. (Supplemental Material 5)

In all DSEM models, two unthinned chains with 50.000 iterations were used in estimation, and convergence was checked via the Gelman-Rubin Proportional Scale Reduction (PSR) and trace plots. The median was used as a point estimate to summarise posterior distributions. In both Sample I and Sample II, the TINTERVAL command of Mplus was used to specify a 1-hr interval for lag interpretation. An effect was considered as detected when the 95% CrI of its posterior distribution excludes zero. We also reported two-tailed Bayesian *p*-values of the detected effects.

Results

Preliminary analyses

Table 1 presents the descriptive statistics of the study variables. ACE distributions in Sample I and Sample II

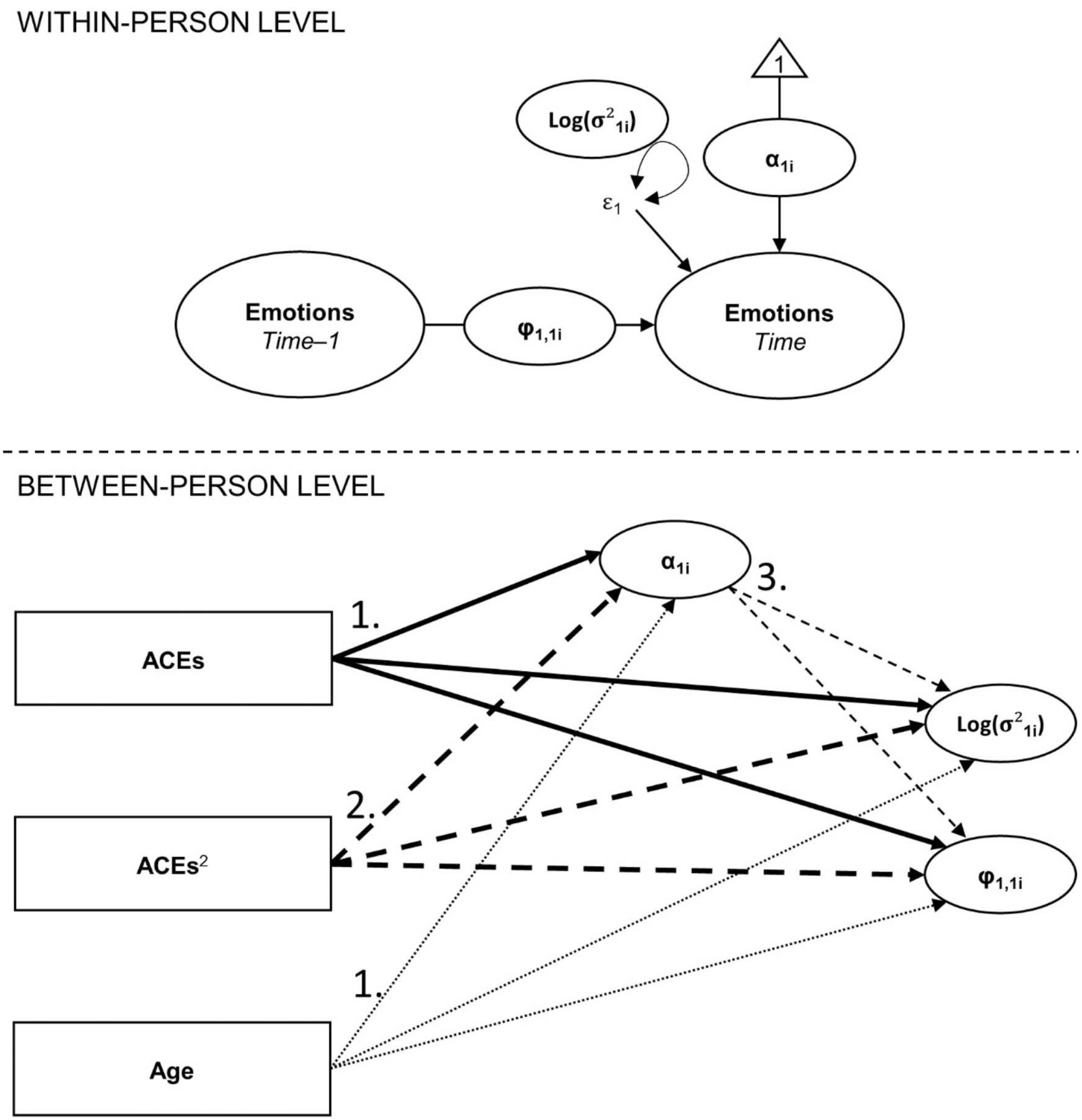

Figure 2. The associations of adverse childhood experiences with emotion dynamic features: dynamic structural equation model. Notes: This strategy was applied to negative and positive emotions. The sequence of our models is presented with the numbers 1, 2, and 3 (we added/estimated more associations in this order). At the between-person level, the unbroken bolded arrows refer to the predictive associations of ACEs with baseline level (α_{1i}), variability ($\log(\sigma^2_{1i})$), and inertia ($\varphi_{1,1i}$) of emotions included in the first and other models. The dashed bolded arrows refer to the predictive associations of the quadratic term of adverse childhood experiences (i.e. ACE^2) with the emotion dynamic features that was included in the following models. Finally, the dashed arrows refer to the predictive associations of baseline level that were controlled in the final models. The round dotted arrows refer to the predictive associations of age that was controlled in all models. The estimated between-level correlations of the emotion dynamic features are not shown. Variability was estimated using the log transformation to guarantee all individual variances to be positive, which is a standard approach in dynamic structural modelling (Asparouhov et al., 2018). At the within-person level, ε1 and the related circle with bidirectional arrows indicate the fixed effect of innovation variance (with the random effect, $\log(\sigma^2)$). ACEs = Adverse Childhood Experiences.

are presented in Figure 3, illustrating the greater number and more comprehensive assessments of reported ACEs in Sample I compared to Sample II. Supplemental Material 3 presents the correlations between the study variables at the within – and between-person level.

Table 1. Descriptive statistics in Sample I and Sample II.

Variables	*n*	*M*	*SD*	Skewness	Kurtosis	*ICC*
Sample I						
Within-Person Level						
Negative Emotions	4628	1.42	0.49	1.89	5.18	.31
Positive Emotions	4628	2.45	0.83	0.33	−0.34	.34
Between-Person Level						
Adverse Childhood Experiences	122	9.64	7.39	0.98	0.45	
Negative Emotions	122	1.42	0.29	1.73	4.45	
Positive Emotions	122	2.46	0.50	0.37	0.79	
Age in years	122	26.43	8.33	1.46	1.20	
Sex[a]	122	0.11	0.32	2.39	3.73	
Sample II						
Within-Person Level						
Negative Emotions	5091	15.06	17.32	1.68	2.97	.58
Positive Emotions	5091	49.28	23.30	−0.15	−0.75	.51
Between-Person Level						
Adverse Childhood Experiences	121	3.57	3.53	1.28	1.12	
Negative Emotions	121	15.37	13.52	1.87	4.82	
Positive Emotions	121	49.55	16.86	−0.08	−0.43	
Age in years	121	20.97	0.45	−0.15	1.94	
Sex[a]	121	0.31	0.47	0.79	−1.38	
Infertility History of Family [b]	121	0.57	0.50	−0.28	−1.94	

Note: ICC = Intraclass correlation.
[a]0 = *female*, 1 = *male*.
[b]0 = *no*, 1 = *yes*.

Main analyses

Associations of adverse childhood experiences with dynamics of negative emotions

Table 2 presents the standardised estimates for the linear and curvilinear associations of ACEs with baseline level, variability, and inertia of negative emotions. The corresponding unstandardised estimates are presented in Supplemental Material 4 (Table S4A). Table 4 provides a summary of our main findings.

Sample I. In the first model testing the linear associations, ACEs predicted a higher baseline level ($p = .020$) and variability ($p = .018$) of negative emotions. Both associations were aligned with our allostatic load hypothesis. However, against our allostatic load hypothesis, ACEs showed no linear associations with the inertia of negative emotions.

In the second model testing the curvilinear associations, the quadratic term of ACEs predicted the baseline level and variability (*ps* < .001). In other words, the associations of ACEs with a baseline level (see Figure 4(a)) and variability (see Figure 4(b)) of negative emotions followed an *inverted* U-shape form: Participants with fewer and higher number of ACEs showed a lower baseline level and variability of negative emotions compared to those with a moderate number of ACEs. It is worth noticing that these results deviated from our adaptation calibration hypothesis suggesting the *noninverted* U-shaped association between ACEs and variability of negative emotions.

In the third model controlling for the associations of the baseline level with other dynamic features of negative emotions, the quadratic association between ACEs and the baseline of negative emotions remained robust ($p < .001$). However, the associations of ACEs with variability diminished and were no longer detected. Surprisingly, in this third model, a curvilinear association between ACEs and inertia of negative emotions emerged ($p = .020$). This suppressor effect is puzzling, requiring further replications to exclude their possibility of being random findings.

To explore further the shrinkage of the effect on variability in the third model, we conducted an additional preregistered model in which we switched the places of the variability and baseline terms (i.e. the variability was specified to predict the baseline level and inertia). The aim was to check whether the associations with baseline level remained robust when controlling for the variability. The quadratic association between ACEs and the baseline level remained robust ($p = .030$). Hence, these analyses supported the interpretation that the baseline level explained the association between ACEs and variability rather than that the variability explained the association between ACEs and the baseline level.

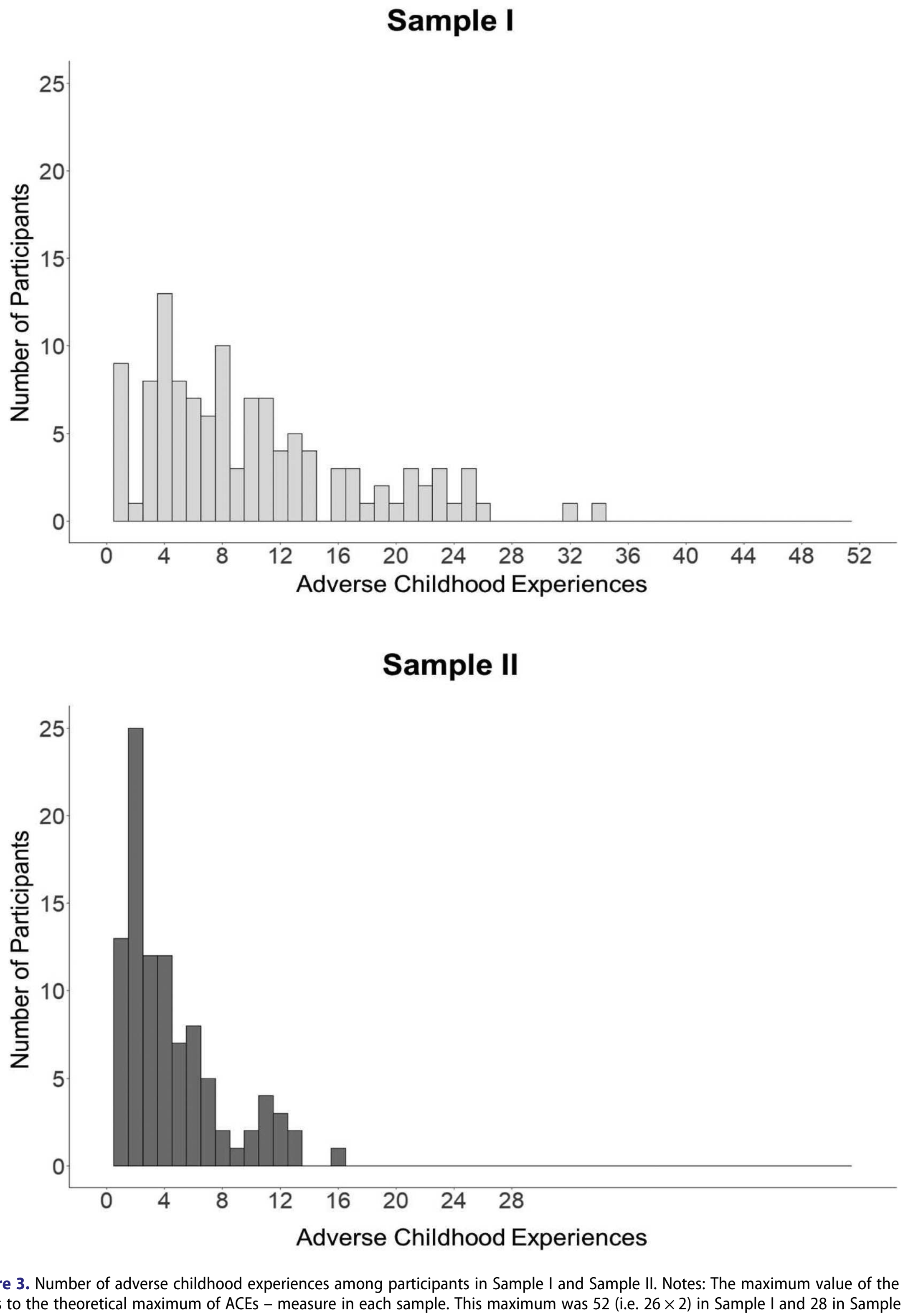

Figure 3. Number of adverse childhood experiences among participants in Sample I and Sample II. Notes: The maximum value of the x-axis refers to the theoretical maximum of ACEs – measure in each sample. This maximum was 52 (i.e. 26×2) in Sample I and 28 in Sample II (i.e. 14×2).

Table 2. Standardised linear and curvilinear associations of adverse childhood experiences with dynamic features of negative emotions.

	Baseline Level of Negative Emotions		Variability of Negative Emotions		Inertia of Negative Emotions	
Predictor	Sample I Posterior *Mdn* β* [95% CrI]	Sample II Posterior *Mdn* β* [95% CrI]	Sample I Posterior *Mdn* β* [95% CrI]	Sample II Posterior *Mdn* β* [95% CrI]	Sample I Posterior *Mdn* β* [95% CrI]	Sample II Posterior *Mdn* β* [95% CrI]
Model 1: Linear Associations						
ACEs	**0.167 [0.026, 0.296]**	0.051 [−0.082, 0.184]	**0.164 [0.027, 0.291]**	0.074 [−0.054, 0.199]	−0.035 [−0.201, 0.134]	0.093 [−0.064, 0.244]
Age	−0.122 [−0.256, 0.019]	0.045 [−0.085, 0.175]	−0.087 [−0.216, 0.049]	0.046 [−0.081, 0.173]	**0.180 [0.014, 0.331]**	−0.009 [−0.165, 0.145]
R^2	.047	.010	.038	.013	.040	.016
Model 2: Curvilinear Associations						
ACEs	**0.367 [0.221, 0.482]**	0.077 [−0.107, 0.253]	**0.342 [0.195, 0.461]**	0.110 [−0.073, 0.277]	−0.125 [−0.316, 0.090]	0.116 [−0.103, 0.314]
$ACEs^2$	**−0.332 [−0.451, −0.187]**	−0.038 [−0.221, 0.155]	**−0.296 [−0.417, −0.149]**	−0.051 [−0.225, 0.133]	0.135 [−0.061, 0.310]	−0.042 [−0.258, 0.188]
Age	**−0.135 [−0.252, −0.010]**	0.049 [−0.086, 0.181]	−0.090 [−0.207, 0.033]	0.052 [−0.077, 0.180]	**0.184 [0.021, 0.332]**	−0.005 [−0.157, 0.145]
R^2	.271	.023	.220	.028	.081	.033
Model 3: Covarying Associations with Baseline Level of Negative Emotions						
ACEs	**0.376 [0.230, 0.488]**	0.054 [−0.080, 0.188]	0.109 [−0.045, 0.254]	0.047 [−0.068, 0.160]	**−0.261 [−0.461, −0.025]**	0.080 [−0.076, 0.230]
$ACEs^2$	**−0.341 [−0.457, −0.195]**	–	−0.085 [−0.225, 0.064]	–	**0.257 [0.044, 0.442]**	–
Age	**−0.138 [−0.256, −0.015]**	0.046 [−0.086, 0.176]	−0.003 [−0.111, 0.107]	0.024 [−0.089, 0.137]	**0.236 [0.073, 0.382]**	−0.019 [−0.170, 0.133]
Baseline Level of Negative Emotions	–	–	**0.628 [0.454, 0.776]**	**0.497 [0.340, 0.632]**	**0.367 [0.069, 0.632]**	0.210 [−0.035, 0.433]
R^2	.283	.011	.511	.260	.192	.066
Model 4: Covarying Associations with Variability of Negative Emotions						
ACEs	**0.167 [0.019, 0.303]**	–	**0.348 [0.200, 0.465]**	–	−0.124 [−0.337, 0.109]	–
$ACEs^2$	**−0.159 [−0.290, −0.017]**	–	**−0.301 [−0.421, −0.155]**	–	0.133 [−0.080, 0.331]	–
Age	−0.083 [−0.188, 0.025]	–	−0.092 [−0.208, 0.032]	–	**0.186 [0.023, 0.336]**	–
Variability of Negative Emotions	**0.583 [0.422, 0.724]**	–	–	–	−0.001 [−0.276, 0.281]	–
R^2	.542	–	.226	–	.098	–

Notes: In Sample I, $N_{participants} = 122$, $N_{observations} = 4628$. In Sample II, $N_{participants} = 121$, $N_{observations} = 5091$. In bolded values, the 95% credible interval (95% CrI) does not contain zero. The results were summarised in R using the MplusAutomation package (Hallquist & Wiley, 2018). ACEs = Adverse Childhood Experiences.

Sample II. In Sample II, ACEs did not predict the dynamic features of negative emotions. Thus, none of the associations in Sample I were replicated in Sample II.

Associations of adverse childhood experiences with dynamics of positive emotions

Table 3 presents the standardised estimates for the linear and curvilinear associations of ACEs with baseline level, variability, and inertia of positive emotions. The corresponding unstandardised estimates can be found in Supplemental Material 4 (Table S4B).

Sample I. In the first model testing linear associations, no association of ACEs was found with the baseline level of positive emotions. This was against our allostatic load hypothesis, positing a linear association of ACEs with a lower baseline level of positive emotions. Instead, ACEs predicted higher variability of positive emotions ($p = .028$).

In the second model testing the curvilinear associations, the quadratic term of ACEs did not predict the variability of positive emotions, which was against our adaptive calibration hypothesis. Instead, the quadratic term predicted the baseline level of positive emotions ($p = .038$). This result indicated that the association of ACEs with the baseline level of positive emotions followed a curvilinear U-shaped form (see Figure 4(c)): Participants with fewer and higher number of ACEs showed a higher baseline level of positive emotions compared to those with a moderate number of ACEs. Some differences from the first model, including only the linear term of ACEs, emerged. First, there was a linear association between ACEs and lower inertia ($p = .044$). Second, the 95% CrI of the association of linear term of ACEs with higher variability slightly included zero ($p = .052$).

In the third model controlling for the associations of the baseline level with other dynamic features of positive emotions, the quadratic associations between ACEs and the baseline of positive emotions remained robust ($p = .034$). Moreover, the linear term of ACEs was associated with higher variability ($p = .026$) and lower inertia ($p = .046$).

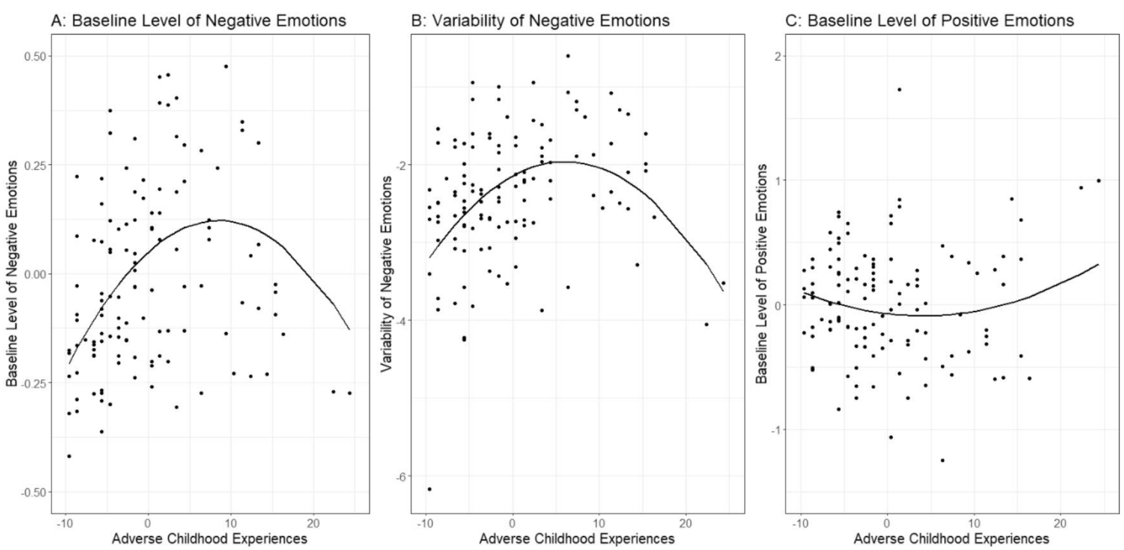

Figure 4. Curvilinear Associations of adverse childhood experiences with (a) baseline level and (b) variability of negative emotions and (c) baseline level of positive emotions in Sample I. Notes: The curvilinear regression lines follow the equation $\hat{Y} = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 z$, where x is the centred variable of ACEs and z = 0 (i.e. centred age variable). Specifically, the equation of the curvilinear regression line of Panel A is $\hat{Y} = 0.050 + 0.017x + (-0.001)x^2$. The equation of the curvilinear regression line of Panel B is $\hat{Y} = -2.145 + 0.061x^2 + (-0.005)x^2$. Finally, the equation of the curvilinear regression line of Panel C is $\hat{Y} = -0.072 + (-0.008)x + 0.001x^2$. In these equations, the used estimates for the intercepts (i.e. β_0 and regression coefficients (i.e. β_i) are the unstandardised estimates from Model 2 (see Table S4A and Table S4B). The data points on the x-axis refer to the grand-mean centred variable of ACEs. The data points on the y-axis regarding the baseline level (Figure 4(a)) and variability (Figure 4(b)) of negative emotions and the baseline level of positive emotions (Figure 4(c)) are their Bayesian plausible value factor scores estimated based on the conducted dynamic structural equation models. Five hundred imputations were used to estimate the factor scores. ACEs = Adverse Childhood Experiences.

Table 3. Standardised linear and curvilinear associations of adverse childhood experiences with dynamic features of positive emotions.

Predictor	Baseline Level of Positive Emotions		Variability of Positive Emotions		Inertia of Positive Emotions	
	Sample I Posterior *Mdn* β* [95% CrI]	Sample II Posterior *Mdn* β* [95% CrI]	Sample I Posterior *Mdn* β* [95% CrI]	Sample II Posterior *Mdn* β* [95% CrI]	Sample I Posterior *Mdn* β* [95% CrI]	Sample II Posterior *Mdn* β* [95% CrI]
Model 1: Linear Associations						
ACEs	0.026 [−0.112, 0.161]	−0.020 [−0.147, 0.110]	**0.164 [0.018, 0.302]**	0.002 [−0.131, 0.135]	−0.200 [−0.402, 0.014]	−0.086 [−0.269, 0.100]
Age	0.034 [−0.103, 0.166]	0.026 [−0.104, 0.156]	−0.082 [−0.220, 0.066]	0.115 [−0.019, 0.245]	0.143 [−0.056, 0.327]	−0.047 [−0.218, 0.126]
R^2	.008	.007	.038	.018	.068	.020
Model 2: Curvilinear Associations						
ACEs	−0.087 [−0.244, 0.085]	0.004 [−0.178, 0.183]	0.182 [−0.002, 0.347]	0.067 [−0.122, 0.243]	**−0.270 [−0.483, −0.008]**	−0.010 [−0.247, 0.220]
$ACEs^2$	**0.179 [0.011, 0.327]**	−0.033 [−0.214, 0.154]	−0.032 [−0.200, 0.148]	−0.093 [−0.271, 0.098]	0.117 [−0.146, 0.338]	−0.143 [−0.397, 0.135]
Age	0.036 [−0.097, 0.166]	0.031 [−0.104, 0.162]	−0.081 [−0.220, 0.064]	0.125 [−0.010, 0.254]	0.141 [−0.052, 0.321]	−0.031 [−0.201, 0.135]
R^2	.049	.017	.052	.041	.126	.047
Model 3: Covarying Associations with Baseline Level of Positive Emotions						
ACEs	−0.089 [−0.246, 0.085]	−0.020 [−0.147, 0.110]	**0.204 [0.023, 0.364]**	−0.003 [−0.132, 0.128]	**−0.264 [−0.476, −0.006]**	−0.087 [−0.270, 0.098]
$ACEs^2$	**0.182 [0.013, 0.332]**	–	−0.077 [−0.245, 0.104]	–	0.107 [−0.161, 0.340]	–
Age	0.038 [−0.098, 0.167]	0.027 [−0.104, 0.157]	−0.090 [−0.224, 0.052]	0.120 [−0.011, 0.247]	0.140 [−0.052, 0.316]	−0.044 [−0.214, 0.127]
Baseline Level of Positive Emotions	–	–	**0.252 [0.039, 0.445]**	**−0.211 [−0.391, −0.017]**	0.051 [−0.244, 0.335]	−0.079 [−0.337, 0.185]
R^2	.050	.007	.122	.067	.149	.040

Notes: In Sample I, $N_{participants} = 122$, $N_{observations} = 4628$. In Sample II, $N_{participants} = 121$, $N_{observations} = 5091$. In bolded values, the 95% credible interval (95% CrI) does not contain zero. The results were summarised in R using the MplusAutomation package (Hallquist & Wiley, 2018). ACEs = Adverse Childhood Experiences.

Sample II. ACEs did not predict the dynamic features of positive emotions in Sample II. Thus, again, none of the associations in Sample I were replicated in Sample II.

Preregistered supplemental analyses for anxiety, sadness, anger, and shame

Supplemental Material 5 presents the unstandardised and standardised estimates for the linear and curvilinear associations of ACEs with the baseline level, variability, and inertia of anxiety (Table S5A and S5B), sadness (Table S5C and S5D), anger (Table S5E and S5F), and shame (Table S5G and S5H). In general, the results showed strong similarity with those detected at the level of average negative emotions. Some especially interesting results emerged concerning anxiety in Sample I. In contrast to using the negative emotion sum score, two results were robust against the control of the anxiety baseline level. First, there was a robust linear association between ACEs and higher variability of anxiety. Second, there was a robust linear association between ACEs and low inertia of anxiety.

Non-preregistered sensitivity analyses

While several associations of ACEs with dynamic features of negative and positive emotions were observed in Sample I, no associations emerged in Sample II. One explanation for this difference could be that we used substantially shorter ACE measures in Sample II, which may have left many ACEs unreported, restricting their overall range (see Del Giudice et al., 2011). To further explore the plausibility of this explanation, we reran all our DSEMs in Sample I using the ACE measure based on 13 items comparable to the closed-question items in Sample II. Moreover, we reran these DSEMs for the pooled sample, utilising the 13-item ACE measure in both samples and the within-sample standardised scores for negative and positive emotions.[3]

Supplemental Material 6 presents these findings. For negative emotions (Tables S6A and S6B), the same associations were detected as in our main analyses for Sample I, with one exception: in the pooled sample, the 95% CrI slightly included zero for the curvilinear association between ACEs and the variability of negative emotions ($p = .070$). For positive emotions (Tables S6C and S6D), ACEs showed no linear or curvilinear associations with emotion dynamic features in Sample I. In the pooled sample, high ACEs were related to higher variability and lower inertia of positive emotions, aligning with our main analyses for Sample I. However, the curvilinear association between ACEs and the baseline level was not detected. Overall, these further inspections suggested that while contributing to the null findings, the use of the shorter ACE measure could not solely explain the lack of associations in Sample II. When we compared the number of ACEs between Sample I and Sample II using the same 13-item ACE measure, the average number of ACEs was substantially higher in Sample I than in Sample II, $t(220.02) = 4.95$, $p < .001$, $d = 0.63$. This suggests that the number of ACEs was genuinely lower in Sample II compared to Sample I.

Finally, as shown in Figure 4(a–c), two participants who showed over 30 ACE scores seemed to play a critical role in the detected curvilinear associations. As a result, we conducted the same DSEM models for negative and positive emotions by excluding these two participants from the data. Supplemental Material 7 presents these results. In sum, the curvilinear association of ACEs was replicated with the baseline level of negative emotions (Tables S7A and S7B). However, the curvilinear association of ACEs with the variability of negative emotions was no longer detected. Moreover, the curvilinear association of ACEs with the baseline level of positive emotions was no longer detected (Tables S7C and S7D).

Simulations concerning statistical power

Lastly, we conducted Monte Carlo simulations with 500 replications to assess the smallest effect sizes our study design could detect with at least 80% power. These simulations suggested that in Sample I, the smallest detectable standardised effects for the linear associations of ACEs were |0.29| on baseline level and variability and |0.36|–|0.40| on inertia. In Sample II, these effects were |0.28|–|0.30| on baseline level, |0.28| on variability, and |0.35|–|0.36| on inertia. In turn, in Sample I, the smallest detectable standardised effects for the quadratic associations of ACEs were |0.35| on baseline level, |0.34|–|0.35| on variability, and |0.43|–|0.50| on inertia. In Sample II, these effects were |0.38|–|0.40| on baseline level, |0.39|–|0.40| on variability, and |0.47|–|0.50| on inertia. Thus, in our primary analyses, the power was higher for detecting associations with the baseline level and variability than with inertia. Notably, in general, the statistical power was likely higher in our additional sensitivity analyses for the pooled data.

Discussion

Research suggests that ACEs can have life-long consequences on emotional functioning. However, it has remained unclear whether and how ACEs shape emotion dynamics in everyday life. In the current study, we used two EMA samples to model how exposure to ACEs associate with the dynamic features of emotions. Against our expectations, we found significant results only in another of our samples (see Table 4).

While somewhat inconclusive, our findings did not provide definite support for either allostatic load or adaptive calibration hypotheses. We found both linear and curvilinear associations of emotion dynamic features with ACEs. To further scrutinise these associations, we accounted for the baseline level of the emotions. The analyses suggested that the most robust findings were the linear association of ACEs with the variability of positive emotions, and the curvilinear associations between ACEs and the baselines of negative and positive emotions as well as variability of negative emotions. These findings highlight the importance of considering baseline levels as confounding factors in the analysis of more complex emotion dynamic features (Dejonckheere et al., 2019; Tammilehto, Kuppens, et al., 2023; Wendt et al., 2020).

In Sample II, with evidently lower level of ACEs, there were no associations between ACEs and the emotion dynamic features. Despite their non-replicability across the samples, our results provide indications of the nuanced role of ACEs in shaping daily emotion dynamics.

Curvilinear associations of adverse childhood experiences with emotion dynamics in Sample I

According to the adaptive calibration framework (Del Giudice et al., 2011; Ellis & Boyce, 2008) low responsivity develops as a response to moderate exposure to ACEs (i.e. buffered profile), whereas high responsivity develops from both low (i.e. sensitive profile) and high (i.e. vigilant profile) ACE exposure. On this premise, we hypothesised U-shaped association between ACEs and the variability of both negative and positive emotions. To our surprise, the results opposed our hypotheses: Participants with *moderate* ACEs experienced *higher* variability of negative emotions compared to those with both low and high ACEs. In addition, there was unexpected U-shaped curve for the baseline level of positive and negative emotions, such that highest positive and lowest negative emotions were experienced at the extreme ends of ACE exposure.

The reason for the unexpected pattern of results is not clear. Yet, it may concern the range of developmental environments within Sample I. First, although our hypotheses concerned the three profiles, the Adaptive Calibration Model (Del Giudice et al., 2011) proposes a fourth profile with blunted emotional responsivity (i.e. unemotional profile). This profile results from excessively high ACE exposure and therefore, we did not anticipate it to emerge in our normative study (see also Li et al., 2021; Shakiba et al., 2020). Second, our operationalisation of the safe environment was based on the absence of ACEs. This approach may have inadvertently sidelined the nuances of positive environments and experiences, such as family cohesion and sensitive care (Lindblom et al., 2017; Tammilehto, Flykt, et al., 2023). Considering that our participants with both low and high ACEs displayed blunted (rather than heightened) emotional responsivity, it seems plausible that we failed to capture the safe environment. Altogether, we deem it possible that the variation in Sample I covered the spectrum from moderately to extremely stressful environments, rather than from safe to highly stressful environments.

Assuming our interpretation of the shifted range is valid, our curvilinear results align well with the Adaptive Calibration Model (Del Giudice et al., 2011). Participants with moderate number of ACEs showed high baseline and high variability of negative emotions. In general, such emotional dynamics associates with emotional problems and poor well-being (Dejonckheere et al., 2019; Houben et al., 2015). More specifically, such dynamics fits well with the vigilant profile, characterised by heightened stress responsivity (Del Giudice et al., 2011). This is expected to result from exposure to highly threatening environments, and, from an evolutionary perspective, is adaptive within such environments. Our findings suggest that heightened negative emotionality may be part of such developmental adaptation, and foster, for example, threat detection and preparation for defensive behaviours.

Table 4. Summary of original hypotheses and actual findings.

Outcome	Allostatic Load Hypothesis	Adaptive Calibration Hypothesis	Sample I: Results of Linear and Curvilinear Model		Sample II: Results of Linear and Curvilinear Model	
	Linear Association of ACEs	Curvilinear Association of ACEs	Model 1: Linear Association of ACEs	Model 2: Curvilinear Association of ACEs	Model 1: Linear Association of ACEs	Model 2: Curvilinear Association of ACEs
Baseline Level of Negative Emotions	Yes (+)	–	Yes (+)	Yes (Inverted U-shape)	No	No
Variability of Negative Emotions	Yes (+)	Yes (U-shape)	Yes (+)	Yes (Inverted U-shape)	No	No
Inertia of Negative Emotions	Yes (+)	–	No	No	No	No
Baseline Level of Positive Emotions	Yes (-)	–	No	Yes (U-shape)	No	No
Variability of Positive Emotions	–	Yes (U-shape)	Yes (+)	No	No	No
Inertia of Positive Emotions	–	–	No	No	No	No

	Sensitivity Analyses for Sample I					
	Controlling for the Baseline Level		With Shortened 13-item ACE measure		Without two participants with a 30 > ACE score	
Outcome	Model 3: Linear Association of ACEs	Model 3: Curvilinear Association of ACEs	Model 1: Linear Association of ACEs	Model 2: Curvilinear Association of ACEs	Model 1: Linear Association of ACEs	Model 2: Curvilinear Association of ACEs
Baseline Level of Negative Emotions	No	Yes (Inverted U-shape)	Yes (+)	Yes (Inverted U-shape)	Yes (+)	Yes (Inverted U-shape)
Variability of Negative Emotions	No	No	Yes (+)	Yes (Inverted U-shape)	Yes (+)	No
Inertia of Negative Emotions	No	Yes (U-shape)	No	No	No	No
Baseline Level of Positive Emotions	No	Yes (U-shape)	No	No	No	No
Variability of Positive Emotions	Yes (+)	No	No	No	Yes	No
Inertia of Positive Emotions	Yes (-)	No	No	No	No	No

Notes: "+" refers to a positive association and "–" a negative association. ACEs = Adverse Childhood Experiences.

Participants with both low and high ACEs showed reduced level and variability of negative emotions, alongside of a high level of positive emotions. Low intensity and variability of negative emotions are likely indicators of low responsivity, which is the hallmark of both the buffered and unemotional profiles (Del Giudice et al., 2011). Despite their similarity, they have emerged as an adaptation to very different kind of environments. In moderately safe environments, reduced negative emotionality may help avoid unnecessary and potentially detrimental threat responding. In contrast, in extremely threatening environment, reduced negative emotionality may foster risk-oriented and antagonistic behaviours essential for survival. It is noteworthy that the unemotional profile was relatively rare in our data, and the curvilinear association with variability of negative emotions was primarily driven by only two participants with very high ACE score (above 30).

Furthermore, we explored the associations for specific negative emotions. These analyses yielded an intriguing pattern for anxiety, robust for accounting the baseline level. ACEs associated with high variability and low inertia of daily anxiety. While heightened variability often indicates emotional dysregulation, lower inertia indicates flexible emotion regulation, reflecting rapid return of emotions to a baseline level when stressors dissipate (Houben et al., 2015). Thus, the combination of high variability and low inertia might not suggest emotional dysregulation but rather suddenness in anxiety responses, encompassing marked fluctuations with minimal persistence from one moment to the next. This observation gains prominence considering the functional role of anxiety in amplifying responsiveness and vigilance to threats, particularly when facing uncertainties regarding vital life outcomes (Bateson et al., 2011; Nettle & Bateson, 2012).

Non-replicability across Sample I and Sample II

Two samples provided us a unique opportunity to assess the replicability of our findings. Unexpectedly, while Sample I revealed multiple associations between ACEs and daily emotion dynamic features, no associations were detected in Sample II. One potential explanation is the disparity of ACE measures between the samples. Sample I used a comprehensive ACE measure encompassing a broad range of childhood adversities (Ellonen et al., 2008; Finkelhor et al., 2015), while the ACE measure in Sample II was more abbreviated, roughly half the length. The use of the abbreviated measure likely contributed, in part, to the null findings in Sample II.

However, our more detailed analyses indicated that the majority of the results in Sample I remained even when applying the abbreviated ACE measure. Importantly, a comparison of the samples, focusing exclusively on the overlapping ACE items, showed that participants in Sample I had more ACEs than those in Sample II. Thus, we conclude that the samples were not comparable to each other. Drawing from the principles of the allostatic load (Danese & McEwen, 2012; Finlay et al., 2022; Shonkoff et al., 2012) and adaptive calibration framework (Del Giudice et al., 2011; Ellis & Boyce, 2008), it seems that ACE-related emotion dynamics is highly sensitive to the range of the captured adversity. Whereas our findings from Sample I suggest that the sample variance of ACEs may have captured moderate to extremely stressful environments, the low frequency of ACEs in Sample II suggests that a threshold of sufficient variance for even moderately stressful environments might not have been met, leading to the null findings.

Further research avenues for adverse childhood experiences and daily emotions

Our preregistered two-sample EMA study offered a novel opportunity to test hypotheses derived the allostatic load and adaptive calibration frameworks within the realm of daily emotions. Yet, our findings did not directly mirror the postulations of our guiding frameworks. This disparity sets the stage for further EMA research. Supporting the notion that environmental stress has nonlinear effects on emotional development, our findings underscore the need to identify the threshold points that lead to shifts in adaptive strategies. Clearly defined thresholds, spanning from sensitive environments to extreme stress, would enable better contextualisation and integration of findings across different studies. Future research should aim to cover wide range of experiences and incorporate indicators of both safety and harshness. Insights from other disciplines, such as anthropology and primatology, could be useful, as humans, throughout their evolutionary journey, have encountered a wider array of childhood adversities than is typically acknowledged (Frankenhuis & Amir, 2022). By integrating these perspectives, we can approach a richer understanding of the role of ACEs on people's emotional functioning.

Moving beyond the allostatic load and adaptive calibration models, other theoretical frameworks may also be fruitful in studying ACEs and daily emotional experiences. First, these is increasing evidence that nature of ACEs, characterised as either threat or deprivation, has important role in shaping the developmental consequences (McLaughlin et al., 2019). Future research should test whether these adversity types have specific consequences on emotional dynamics (e.g. threat with high variability of negative emotions). Another potentially fruitful framework is the study of resilience (Mesman et al., 2021; Oshri et al., 2024). Research suggests that the typical trajectory of post-traumatic events is to return to relatively high levels of emotional functioning (Mesman et al., 2021) and small-to-moderate exposure to stress may foster resiliency (Oshri et al., 2024). Future studies should aim to identify the potential emotional processes that underlie these protective processes.

Finally, it is also worth noting that our study contributed on self-reported emotional experiences, whereas the allostatic load and adaptive calibration frameworks emphasise the physiological aspects of regulation (Danese & McEwen, 2012; Del Giudice et al., 2011). We acknowledge that there is only a modest congruence between subjective and physiological indicators of emotions (Hollenstein & Lanteigne, 2014; Mauss & Robinson, 2009). Therefore, further research is needed to clarify how emotions, encompassing their physiological and subjective components (e.g. Van Doren et al., 2021), link with the proposed evolution based adaptive processes and profiles.

Limitations

Our study has several limitations. First, post hoc simulations indicated that our study had limited power to detect small effects, which may account for the absence of certain findings, especially related to inertia. However, our additional sensitivity analyses for the pooled data partially alleviate these concerns. Second, our Western samples were predominantly female, limiting the generalizability of our findings to males and non-Western cultures. Third, one limitation in our modelling strategy was not accounting for measurement error, which may have influenced the detected estimates. There is a call for larger EMA studies allowing for modelling of person-specific measurement errors (Schuurman & Hamaker, 2019). Fourth, our findings relied solely on retrospective reports of ACEs. Although retrospective ACE reports are highly predictive of various psychosocial outcomes (Danese & Widom, 2020), they also carry the risk of common method bias. It would be important in future studies to analyse the prospective associations between childhood adversity and daily emotion features. Finally, we prioritised the most relevant univariate emotion dynamic features at the level of negative and positive emotions, as well as individual negative emotions, while multivariate emotion dynamic features, such as granularity as well as emotion cross-lags (Kuppens & Verduyn, 2015) were out of scope on this study. We emphasise its importance as a research question for future studies.

Conclusions

In the current study, we examined the potential correlates of ACEs and the nuances of daily emotion dynamics. Using two distinct EMA samples, we tested hypotheses derived from the prominent allostatic load and adaptive calibration frameworks. Another of our samples, with higher prevalence of ACEs, provided partial support for our hypotheses concerning the roles of ACEs on daily emotional experiences. Our results included curvilinear associations (e.g. for baseline of negative emotions), underscoring the utility of evolutionary perspective to understand the role of ACEs on emotional functioning. However, our study also raised the need for more comprehensive and theory-driven research to elucidate the impact of ACEs on everyday emotion dynamics. To find the true effects of ACE's in shaping the effects of ACEs on emotional development, we need further to examine the threshold level of ACE's that are capable of producing this effect.

Notes

1. for preregistration, see https://osf.io/c5mbe. All analysis scripts of both samples can be found at https://osf.io/2wstr. The data of Sample I and its codebook can be found at https://osf.io/scjna. The data of Sample II is not shared to protect the privacy of the participants in the ongoing longitudinal study.
2. Regarding Family mental illness, the original item "Was a household member depressed or mentally ill, or did a household member attempt suicide?" was divided into

two separate items: "Was a household member depressed or mentally ill" and "Did a household member attempt suicide?".

3. Additionally, we conducted pooled analyses using an alternative emotion variable, which we adjusted by linearly transforming the scale of Sample I before combining the samples. This transformation set the negative emotion variable to range from 0 to 100, as in Sample II, using the formula: (negative emotion variable − 1) * 25. The results of these analyses strongly aligned with the reported results based on within-sample standardization. The outputs of the analyses are available at https://osf.io/2wstr/.

Disclosure statement

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