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Research paper

Stress reactivity moderates the association between stressful life events and depressive symptoms in adolescents: Results from a population-based study

Vilte Baltramonaityte [a], Alexandre A. Lussier [b,c,d], Andrew D.A.C. Smith [e], Andrew J. Simpkin [f], Graeme Fairchild [a], Erin C. Dunn [b,c,d], Esther Walton [a,*]

[a] Department of Psychology, University of Bath, Bath, United Kingdom
[b] Psychiatric and Neurodevelopmental Genetics Unit, Center for Genomic Medicine, Massachusetts General Hospital, Boston, MA, USA
[c] Department of Psychiatry, Harvard Medical School, Boston, MA, USA
[d] Stanley Center for Psychiatric Research, Broad Institute of MIT and Harvard, Cambridge, MA, USA
[e] Mathematics and Statistics Research Group, University of the West of England, Bristol, United Kingdom
[f] School of Mathematical and Statistical Sciences, University of Galway, Galway, Ireland

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ABSTRACT

Background: A large body of evidence links stressful life events with depression. However, little is understood about the role of perceived impact in this association.
Methods: We performed regression analysis to investigate whether self-reported stress reactivity (derived by regressing the impact-weighted life event score on the unweighted score) moderated the association between stressful life events and depressive symptoms in adolescents from the Avon Longitudinal Study of Parents and Children cohort ($n = 4791$), controlling for age at outcome, sex, ethnicity, and maternal education. Depressive symptoms were assessed using the self-report Short Mood and Feelings Questionnaire (score range 0–26) at 16 years of age. Adolescents also reported on their exposure to 23 possible stressful life events since age 12 and their impact, which were used to define stress reactivity groups using a residual regression approach.
Results: We identified a moderating effect of stress reactivity. Adolescents with high stress reactivity showed a stronger association between the number of stressful life events and depressive symptoms than adolescents with low ($b = 0.32$, 95 % CI = 0.13, 0.50, $p < 0.001$) or typical ($b = 0.44$, 95 % CI = 0.28, 0.60, $p < 0.001$) stress reactivity.
Limitations: Limitations include the use of retrospective life event measures and limited generalisability of findings to other population-based, high-risk, or clinical samples.
Conclusions: When resources are limited, interventions should prioritise individuals with high stress reactivity who have experienced multiple stressful life events, as these individuals may be at greater risk for depression.

1. Introduction

Stressful life events, such as becoming seriously ill, moving, or experiencing the death of a loved one, have been shown to be important predictors of depressive symptoms (Gao et al., 2022; Gronewold et al., 2022; Hammen, 2005; Nelson et al., 2020). Most studies in this area employ one of two approaches for assessing the occurrence of these life events: (1) an unweighted measure of life events, which is a simple count of the number of life events experienced over a specific time period; or (2) a weighted measure of life events that accounts for the perceived impact of each event (e.g., "strongly affected" vs. "not affected"). Some empirical studies find little benefit to weighting life events when examining associations with depression (i.e., perception of impact does not appear as important in predicting risk for depression as previously believed), irrespective of the specific weighing approach (Flouri et al., 2020; Ii and Ross, 1980; Rahe and Arthur, 1978; Tibubos et al., 2021; Zimmerman, 1983). However, the lack of benefit from using impact-weighted measures may be driven by the failure to consider the number of stressful life events *together* with their impact.

According to stress sensitisation theory (Hammen et al., 2000; Monroe and Harkness, 2005), exposure to environmental risk factors (such as stressful life events) can alter the stress response system (e.g.,

* Corresponding author at: Department of Psychology, University of Bath, Claverton Down Campus, Bath, Somerset BA2 7AY, United Kingdom.
E-mail address: E.Walton@bath.ac.uk (E. Walton).

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the hypothalamic-pituitary-adrenal [HPA] axis), making individuals more psychologically and physiologically sensitive to subsequent stressors (Rauschenberg et al., 2022). Kendler et al. (2004) showed that women with a history of sexual abuse showed a stronger association between subsequent life events and depression than women without such history. Similar evidence for stress sensitisation by childhood adversity has also been observed in other studies (Espejo et al., 2007; Harkness et al., 2006; Rudolph and Flynn, 2007; Shapero et al., 2014), demonstrating a dose-response relationship (Wichers et al., 2009). Therefore, measuring the perceived impact of stressful life events without accounting for the number of life events already experienced may bias perceived impact ratings and their association with outcomes like depression, as doing so would fail to account for the degree of stress sensitisation.

For example, using a self-weighted life event score in isolation (i.e., an individual's subjective perception of the impact of their life events) would disregard that two individuals with the same weighted score could differ in the number of stressful life events they experienced (compare Persons A and B in the conceptual Fig. 2A in the Results section). This approach contradicts the stress sensitisation theory and empirical evidence (Collip et al., 2007; Hammen, 2005; Hammen et al., 2000; Kendler et al., 2004; Rauschenberg et al., 2022), as it fails to acknowledge that person B – the person who experienced more stressful life events – might be more sensitised to stress and should therefore appraise their experience as more unpleasant. If person B rates their experience as less unpleasant than predicted (based on the unweighted sum of life events, see Fig. 2A), this suggests a lower reactivity to stressful life events, compared to person A who shows increased (higher than predicted, Fig. 2A) stress reactivity.

Consequently, to account for this potential sensitisation to stress, we constructed a measure of stress reactivity that considers the number of life events already experienced. Our measure of stress reactivity is conceptually related to some approaches used in the resilience field. For instance, in the residual regression approach, psychopathology is regressed onto a continuous measure of stress exposure or adversity to determine whether an individual is doing better or worse than would be expected given the normative values of the study's sample (Kalisch et al., 2021; Nishimi et al., 2021). While psychological resilience and stress reactivity may represent partly overlapping constructs (García-León et al., 2019; Lara-Cabrera et al., 2021), resilience is commonly defined as a broader, often long-term ability to adapt well in the face of adversity (Mukherjee and Kumar, 2016), whilst stress reactivity is viewed as a more narrow measure of acute psychological or physiological reactivity to stressful events (Boyce, 2019; Johnson et al., 2019; Kiecolt-Glaser et al., 2020; Nelson et al., 2020; Turner et al., 2020).

Understanding whether stress reactivity modifies the association between life events and depression may have important implications for developing well-targeted prevention strategies and for optimising the allocation of limited resources in many healthcare settings. For instance, reducing exposure to stressful life events may be beyond the scope of most preventions, given the ubiquity of stressors in life. Yet, fostering emotional resilience among people in vulnerable groups (e.g., economically disadvantaged families or communities) could be considerably more feasible. While several studies have identified stress reactivity as a possible mechanism linking stressful life events and depression (Cantave et al., 2019; Harkness et al., 2006; Rauschenberg et al., 2022; Shapero et al., 2014), the majority of these studies either: (1) did not formally test stress reactivity as a moderating/mediating pathway or (2) used a physiological rather than psychological measure of stress reactivity. While physiological measures of stress reactivity can provide important mechanistic insights, their use in most community settings would be practically or economically unfeasible.

To address these gaps, we assessed whether a psychological measure of stress reactivity moderated the association between the number of life events and depressive symptoms in a large population-based sample of adolescents. We hypothesised that individuals with high stress reactivity would demonstrate a stronger relationship between the number of life events and depressive symptoms, compared to those with low or typical stress reactivity.

2. Methods

2.1. Setting and participants

We analysed data from the Avon Longitudinal Study of Parents and Children (ALSPAC; Boyd et al., 2013; Fraser et al., 2013) – a population-based longitudinal study designed to investigate environmental, social and genetic factors impacting the health and development of individuals from birth to adulthood. Pregnant women resident in Avon, UK with expected dates of delivery between 1st April 1991 and 31st December 1992 were invited to take part in the study (see Supplementary Material [SM] section 1.1 for more detail). Out of the available sample (children alive at 1 year of age: $n = 14{,}901$), we restricted our analysis to individuals who responded to at least 50 % of items measuring depressive symptoms and stressful life events at 16 years of age ($n = 5058$). In cases where multiple children from the same family were included in the sample, we included only the eldest child, resulting in a final sample size of 4791 individuals. Missing values were imputed using multiple imputation (see Section 2.3.1 and SM section 1.2 for more details). For a flowchart of participant selection see Fig. S1 in SM.

Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees (see SM section 1.1 for more detail). Please note that the study website contains details of all the data that is available through a fully searchable data dictionary (http://www.bristol.ac.uk/alspac/researchers/our-data/) and variable search tool (https://variables.alspac.bris.ac.uk/).

2.2. Measures

2.2.1. Exposures

We used data on 23 self-reported, potentially stressful life events (e.g., moving house, death of a family member, serious illness or injury; see Table S1 for a complete list of items) collected using a postal questionnaire when the children were approximately 16 years old. The questionnaire was based on earlier work by Coddington (1972) and has been widely applied in previous studies using ALSPAC data (e.g., Araya et al., 2009; Crane et al., 2016; Flouri et al., 2019). The questionnaire focussed on events that occurred since the age of 12. Each item had a dichotomous response category, which indicated whether the event occurred (yes/no), and five weighted response categories, which assessed how the respondent appraised the event (i.e., 'Very pleasant', 'A bit pleasant', 'No Effect', 'A bit unpleasant', and 'Very unpleasant'). Based on available responses, we derived two types of life event scores: an unweighted and an impact-weighted life event score.

2.2.1.1. Unweighted life event score. The unweighted score represented the total number of life events experienced since the child was 12 years old, based on dichotomous (1 = 'yes', 0 = 'no') responses (possible score range: 0–23; Table S1; Fig. 1).

2.2.1.2. Impact-weighted life event score. The weighted score represented the self-perceived impact of life events. To obtain this score, we recoded the weighted response categories so greater numbers indicated more unpleasant appraisal and combined unvalenced and positively-valenced responses (i.e., 'No Effect', 'A bit pleasant' and 'Very pleasant') into the same category (i.e., 'No unpleasant effect'). Accordingly, this resulted in the following four response categories: 0 = 'Didn't happen', 1 = 'No unpleasant effect', 2 = 'A bit unpleasant', and 3 = 'Very unpleasant'. The impact-weighted score was calculated by summing the weighted responses (possible score range: 0–69; Table S1; Fig. 1).

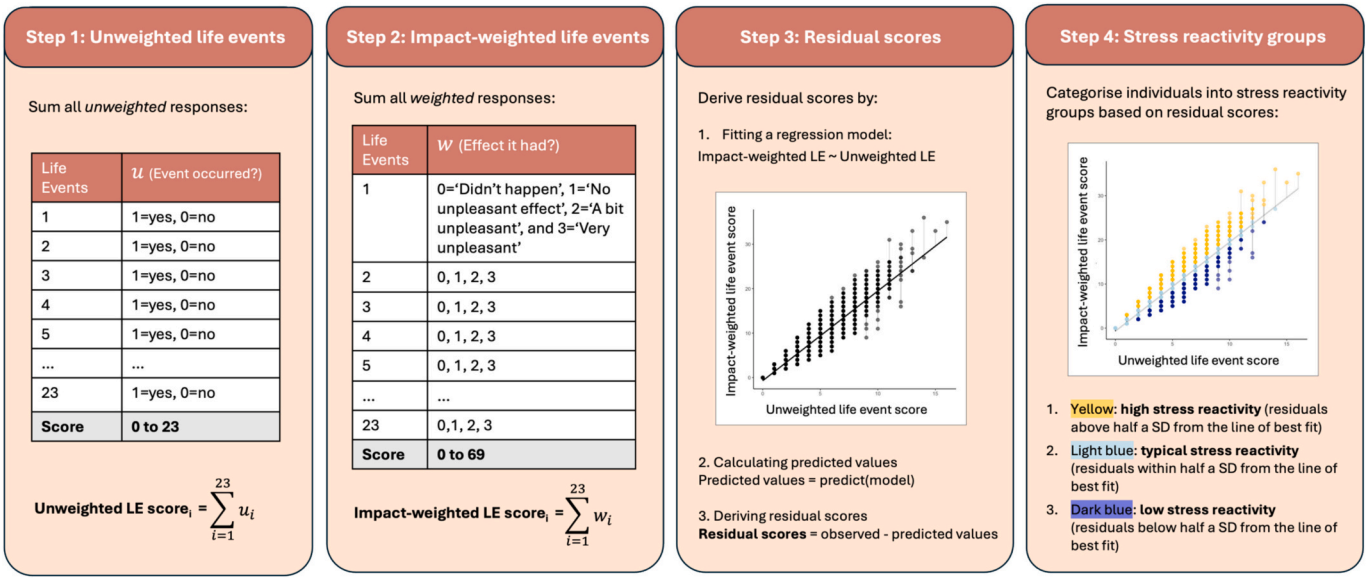

Fig. 1. An overview of the derivation of unweighted life event score, impact-weighted life event score and stress reactivity groups.
Note. Half a standard deviation (SD) of the residuals equals a residual score of −/+ 0.88 (i.e., the cutoff value used to categorise individuals into stress reactivity groups). LE = life events.

2.2.1.3. Stress reactivity groups. We defined low, typical, and high stress reactivity groups using a two-step procedure. First, the impact-weighted life event score was regressed on the unweighted score. Subsequently, individuals were assigned into three distinct groups (high reactivity, low reactivity, and typical reactivity) based on the residuals from the regression model and the standard deviation (SD) of those residuals. Individuals who scored half an SD or more above and below the line of best fit were classified as having a high and low reactivity to stress, respectively (Fig. S2). The high reactivity group included individuals who appraised their experiences as more unpleasant than predicted based on the number of life events experienced (i.e., based on their unweighted score). Conversely, the low reactivity group included individuals who appraised their experiences as less unpleasant than predicted. The typical reactivity group contained individuals who scored within half an SD of the line of best fit (i.e., their appraisal was close to the predicted value based on the unweighted life event score).

For an overview of the derivation of the unweighted life event score, impact-weighted life event score, and stress reactivity groups see Fig. 1. For a plot of stress reactivity groups see Fig. S2.

2.2.2. Outcome

2.2.2.1. Depressive symptoms. Depressive symptoms were assessed using the self-report Short Mood and Feelings Questionnaire (SMFQ; Angold et al., 1995) completed as part of a postal questionnaire when youth were approximately 16 years old. The SMFQ is a 13-item measure that assesses the occurrence of depressive symptoms over the past two weeks using a 3-point Likert scale (0 = 'not true', 1 = 'sometimes true', 2 = 'true'), with higher scores indicating greater depressive symptoms (possible range 0–26). The SMFQ correlates highly with clinical measures of depression in late adolescence and has good construct, content and criterion validity (Turner et al., 2014). Internal reliability at a mean age of 16 years was very high (Cronbach's α = 0.908; Kwong, 2019). See Table S2 for a complete list of SMFQ items.

2.2.3. Covariates

We included age at outcome, sex, ethnicity (White, non-White), and maternal education (university degree, no degree) as potential confounders in our analyses. Maternal education served as a proxy for children's socioeconomic status. The association between these covariates and depressive symptoms is shown in Table S3.

2.3. Statistical analysis

All analyses were conducted in R version 4.2.1. The scripts underlying the analyses can be found at https://github.com/VilteBaltra/LifeEvents.

2.3.1. Multiple imputation

Prior to data analysis, we imputed missing values in our exposure variables, covariates and outcome using multiple imputation by chained equations (van Buuren and Groothuis-Oudshoorn, 2011), using the "mice" package (v. 3.16.0) in R. We specified 60 iterations and 30 imputed datasets. Parameter estimates were pooled following Rubin's Rules (Rubin, 1987). For details on the imputation model see SM section 1.1.

2.3.2. Moderating effect of stress reactivity

To assess whether stress reactivity moderated the relationship between number of life events and depressive symptoms (our primary analysis of interest), we regressed SMFQ score on unweighted life events, stress reactivity (low, typical, high), and their cross-product interaction term, along with covariates. Low (or typical) stress reactivity was used as the reference category since we were primarily interested in assessing whether the hypothesised relationship would be stronger in individuals with higher stress reactivity levels. Lastly, given differences in the experience of objective and subjective stressors across sexes and the greater prevalence of depression in adolescent females than males (Altemus et al., 2014), we stratified the analyses by sex to investigate potential sex-specific patterns.

2.3.3. Polygenic score (PGS) for neuroticism sensitivity analysis

To determine whether the moderating effect of stress reactivity was influenced by genetic risk for neuroticism–a personality trait that predisposes individuals to emotional distress (Schneider, 2004; Suls, 2001)–we performed sensitivity analyses using a polygenic score (PGS) for neuroticism as an additional covariate. We did not control for the genetic risk of depression, anxiety, or other psychiatric phenotypes to avoid overadjustment. Sensitivity analyses were performed in a subset of our analytic sample with genetic data (n = 3443). A detailed description

of the PGS calculation using PRSice-2 (v.2.3.5; Choi and O'Reilly, 2019) is provided in SM section 1.3 and Figs. S3-S4.

3. Results

Sample characteristics and correlations among study variables are presented in Tables 1 and S4, respectively. Briefly, our sample consisted of 4971 adolescents with a mean age of 16.7 years (range: 16–18). Of these, 59.0 % were female, the majority (96.0 %) were White, and a minority had mothers with a university degree (20.1 %). The mean number of stressful life events experienced by the individuals in our sample since age 12 was 4.0 ($SD = 2.3$). While the low and typical stress reactivity groups were similar in terms of demographic characteristics and polygenic risk, individuals with high stress reactivity were more likely to be female, less likely to have mothers with a university degree, and more likely to have a higher PGS for neuroticism (Table S5). Assessment of missing values per each life event and SMFQ item is included in Tables S1 and S2, respectively. The two life event scores (unweighted and impact-weighed) correlated very highly with each other ($r = 0.94$). The impact-weighted score explained a slightly larger proportion of variance in depressive symptoms than the unweighted measure ($\Delta R^2_{\text{weighted}} = 0.07$ vs. $\Delta R^2_{\text{unweighted}} = 0.05$). See Table S6 for detailed output.

3.1. Moderating effect of stress reactivity

Our primary analysis revealed a moderating effect of stress reactivity on the relationship between unweighted life events and depressive symptoms (Fig. 2B, Table 2). Specifically, adolescents with high stress reactivity showed a stronger association between unweighted life events and depressive symptoms than adolescents with low (interaction coefficient [high vs low] = 0.32, 95 % CI = 0.13, 0.50, $p < 0.001$) or typical (interaction coefficient [high vs typical] = 0.44, 95 % CI = 0.28, 0.60, $p < 0.001$; Table S7) stress reactivity. Sex-stratified analysis revealed a stronger moderating effect of stress reactivity in females (interaction coefficient [high vs typical] = 0.47, 95 % CI = 0.25, 0.69, $p < 0.001$) than in males (interaction coefficient [high vs typical] = 0.31, 95 % CI = 0.07, 0.56, $p < 0.013$; Table S8; Fig. S5). All analyses were adjusted for ethnicity, age at outcome, and maternal education, with sex only adjusted for in the main analysis. Difference test results for these covariates in relation to depressive symptoms is shown in Table S3.

Table 1
Sample characteristics before and after imputation.

Variable	Mean (SD); n (%) before imputation	Missing; n (%)	Mean (SD); n (%) after imputation
Age at outcome	16.68 (0.24)	<5 (<0.1 %)[a]	16.68 (0.24)
Sex			
Male	1964 (41.0 %)	<5 (<0.1 %)[a]	1965 (41.0 %)
Female	2826 (59.0 %)	<5 (<0.1 %)[a]	2826 (59.0 %)
Ethnicity			
White	4379 (96.2 %)	241 (5.0 %)	4600 (96.0 %)
Non-White	171 (3.8 %)		191 (4.0 %)
Maternal education			
University degree	908 (20.1 %)	283 (5.9 %)	963 (20.1 %)
No degree	3600 (79.9 %)		3828 (79.9 %)
Unweighted life events	4.04 (2.34)	171 (3.6 %)	4.04 (2.34)
Impact-weighted life events	7.42 (5.03)	331 (6.9 %)	7.46 (5.03)
Stress reactivity groups			
High reactivity	1056 (23.1 %)	220 (4.6 %)	1098 (22.9 %)
Typical reactivity	2126 (46.5 %)		2246 (46.9 %)
Low reactivity	1389 (30.4 %)		1447 (30.3 %)
SMFQ score	5.93 (5.67)	86 (1.8 %)	5.92 (5.67)

Note. Sample characteristics were pooled across 30 imputed datasets. The above values are presented for our analytic sample ($n = 4791$). Child ethnicity was determined based on self-reported parental ethnicity at birth. Non-White group comprises Black, South Asian, East Asian, and Mixed ethnic backgrounds. SMFQ; Short Mood and Feelings Questionnaire.

[a] Cell counts below five are not shown, this may include zero.

3.2. PGS sensitivity analysis

Results from multinomial logistic regression showed that a higher PGS for neuroticism was linked to higher stress reactivity. Specifically, holding all other variables constant, for one SD increase in PGS, the odds of being in the *high* versus *low* reactivity group increased by 14 % (OR = 1.14, 95 % CI = 1.03, 1.25, $p = 0.009$). Similarly, for one SD increase in PGS, the odds of being in *high* versus *typical* reactivity group increased by 14 % (OR = 1.14, 95 % CI = 1.04, 1.24, $p = 0.004$). We therefore repeated our primary (moderation) analysis, including PGS for neuroticism as an additional covariate. While a higher PGS was linked to higher levels of depressive symptoms ($b = 0.51$, 95 % CI = 0.34, 0.69, $p < 0.001$), including PGS in the model did not meaningfully change our main findings (Table S9).

4. Discussion

In this study, we examined whether stress reactivity moderated the relationship between the number of life events and depressive symptoms in a large population-based sample of adolescents. Consistent with our hypothesis, adolescents with high stress reactivity levels demonstrated a stronger relationship between the number of life events and depressive symptoms, compared to adolescents with low and typical stress reactivity. Our study adds to the limited evidence base by illustrating the importance of measuring both the occurrence and perceived impact of stressful life events, as their combination can help identify individuals with high stress reactivity who may be at a greater risk for depression.

Sensitivity analysis revealed an association between higher PGS for neuroticism and greater stress reactivity, which aligns with previous research showing a relationship between higher neuroticism and increased reactivity to stress (Suls, 2001). However, including the PGS for neuroticism in our model did not meaningfully alter our findings, suggesting that the present results were not driven by genetic confounding.

Our results are consistent with previous studies, which have demonstrated an important role of stress reactivity (psychological and physiological) in the relationship between stressful life events and depressive symptoms (Cantave et al., 2019; Daches et al., 2019; Shapero et al., 2014). For example, Cantave et al. (2019) detected an association between childhood maltreatment and a higher risk for depression among individuals with high cortisol responses to stress, but not among those with moderate-to-low responses. Similarly, a study by Shapero et al. (2014) reported greater depressive symptomatology in individuals with a history of childhood emotional abuse when faced with recent stressful life events, indicating heightened stress reactivity as a results of childhood adversity. Deriving a measure of stress reactivity based on the occurrence and perceived impact of life events (as done in the present study) may be particularly advantageous when a dedicated psychological (e.g., Perceived Stress Reactivity Scale; Schlotz et al., 2011) or physiological (e.g., saliva/hair cortisol) measure of stress reactivity is not available.

Interestingly, our results support the stress sensitisation theory (Hammen et al., 2000; Monroe and Harkness, 2005), as individuals who experienced a greater number of stressful life events generally appraised their experiences as more unpleasant. This finding further emphasises the need to consider the occurrence of life events in conjunction with their perceived impact, as using the impact-weighted life event measure

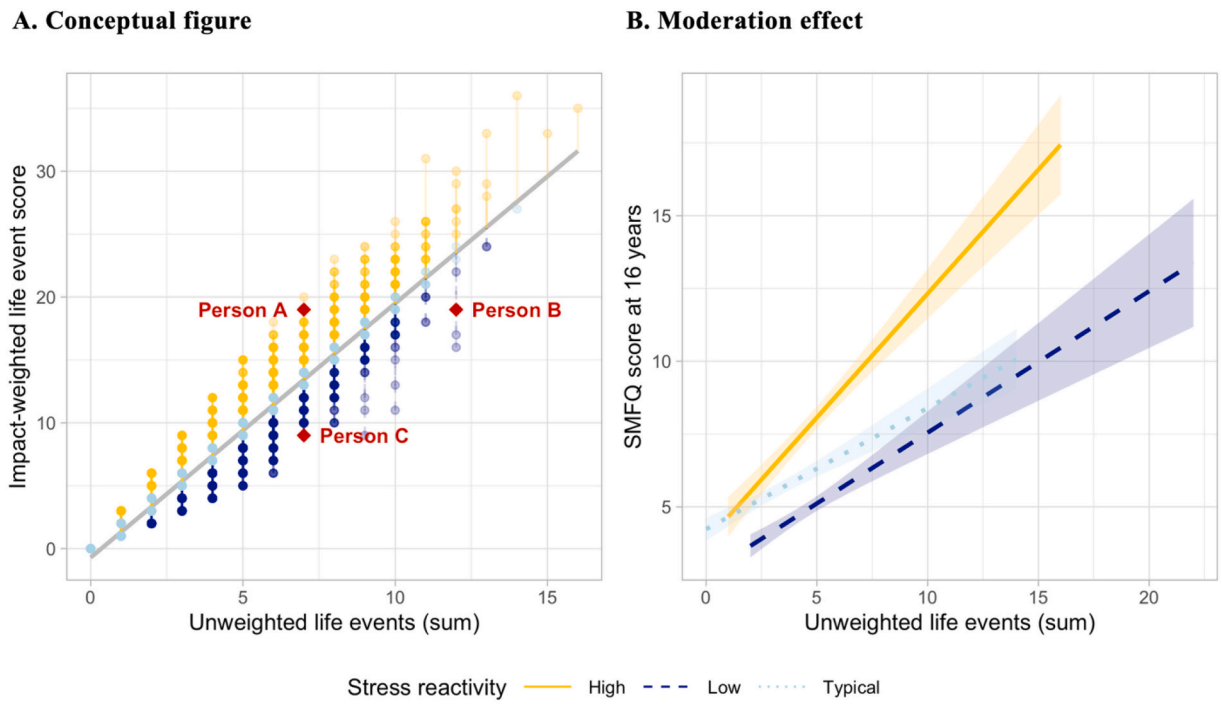

Fig. 2. Conceptual diagram depicting the A) hypothesised relationship and B) empirical results showing the moderating effect of stress reactivity on the association between unweighted life events and depressive symptoms.
Note. (A) Conceptual diagram based on observed data demonstrating the association between number of stressful life events (i.e., an unweighted life event measure) and impact-weighted life event score. Person A and B denote two individuals who experienced different numbers of stressful life events but had identical perceived ratings. Person A and C denote two individuals who experienced the same number of life events but had different perceived ratings, indicating variability in appraisals. (B) Interaction between unweighted life events and stress reactivity on depressive symptoms. High stress reactivity (yellow; solid line), typical (light blue; dotted line), low (dark blue; dashed line). Shading corresponds to the standard error of the fitted values. SMFQ; Short Mood and Feelings Questionnaire. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 2
Moderating effect of stress reactivity on the association between unweighted life events and depressive symptoms.

	Effect (95 % CI)	*p*-Value
SMFQ score change per stress reactivity group (main effect[a])		
Low stress reactivity (reference category)	0.00	
Typical stress reactivity	1.03 (0.67, 1.40)	<0.001
High stress reactivity	2.16 (1.72, 2.60)	<0.001
SMFQ score change with unit increase in unweighted life events (main effect[b])		
Low stress reactivity	0.48 (0.34, 0.62)	<0.001
Typical stress reactivity	0.36 (0.26, 0.46)	<0.001
High stress reactivity	0.80 (0.67, 0.92)	<0.001
Moderating effect[c]		
Low stress reactivity (reference category)	0.00	
Typical stress reactivity	−0.12 (−0.29, 0.05)	0.170
High stress reactivity	0.32 (0.13, 0.50)	<0.001

Unstandardised effect estimates in units of SMFQ are presented, pooled across 30 imputed datasets. Estimates are adjusted for age at outcome, sex, ethnicity, and maternal education. The sample size is $n = 4791$. Adjusted model $R^2 = 0.126$. SMFQ; Short Mood and Feelings Questionnaire.
[a] Main effect of stress reactivity at the mean level of unweighted life events.
[b] Main effect of unweighted life events at each stress reactivity group.
[c] Coefficients depict the strength and direction of the relationship between unweighted life events and depressive symptoms in typical and high stress reactivity groups relative to the reference category (low).

alone may under- or overestimate the importance of participant's appraisal. In terms of clinical implications, our study suggests that, in settings of limited resources, interventions should prioritise people with higher stress reactivity levels, as these individuals may be at greater risk for depression.

Our results should be interpreted considering the following limitations. First, while our life event measure covered a range of life events, it did not account for their frequency (i.e., how many times the same type of life event occurred), developmental timing, or the chronicity of life events (i.e., duration of exposure over time) (Dunn et al., 2017; Nelson et al., 2020). In other words, a person who experienced one intense chronic life event that lasted several years, such as going through a severe illness, would have a lower unweighted life event score than someone who experienced two or more low-intensity life events, such as moving house and the death of a pet. These limitations are analogous to those documented for measures of exposure to Adverse Childhood Experiences (Anda et al., 2020). However, we think the impact-weighting of life events used in our study partly circumvented some of these issues, since it captured how individuals appraised their experiences, allowing us to derive a more comprehensive, adjunct measure of stress reactivity. Second, the categorisation of individuals into stress reactivity groups was based on the variability of residuals specific to our sample and may not generalise well to other populations. Third, it is unclear whether individuals identified as belonging to the high stress reactivity group would also be identified as such using alternative, validated measures of stress reactivity, such as the Perceived Stress Reactivity Scale (Schlotz et al., 2011), salivary cortisol (Bozovic et al., 2013), or heart rate variability (Hamilton and Alloy, 2016). Nonetheless, the fact that the PGS for neuroticism was greater in the high stress reactivity group compared to the low and typical groups points to the validity of the residual regression approach applied in our study.

Lastly, as life events were measured retrospectively, it is possible that individuals with depressive symptoms were more likely to recall negative life events (or appraise them more negatively) than individuals without depression. This tendency may be attributed to negative

memory bias commonly observed in depression (Gotlib and Joormann, 2010; Hitchcock et al., 2020; Marchetti et al., 2018). To overcome this bias, stressful life events should ideally be measured across several time points in childhood and adolescence before the emergence of symptoms. While such measures are available in ALSPAC, they are limited to childhood and are mother-reported. As such, self-reports of the perceived impact of life events are not available at earlier time points. It is worth noting, however, that the bias due to retrospective reports in this study is likely smaller than in many adult studies where the interval between stressful life events and their measurement can be many decades. Furthermore, even though we controlled for genetic propensity for neuroticism, future studies could consider including more direct measures of personality traits (e.g., the Big-5 personality scale; Goldberg, 1992) as covariates in analytical models, as these variables may help to control for the personal tendency to focus on either positive or negative life events. Similarly, to have a more comprehensive understanding of how stressful life events impact depression, future studies could triangulate findings using subjective (e.g., perceived impact) and objective (e.g., salivary/hair cortisol) measures of stress.

5. Conclusions

In conclusion, we identified a moderating effect of stress reactivity on the relationship between stressful life events and depressive symptoms. Specifically, experiencing multiple life events was associated with greater depressive symptomatology in adolescents with high stress reactivity levels than in adolescents with low or typical stress reactivity. Our findings suggest that, when resources are limited, preventative interventions may prioritise focusing on individuals with high stress reactivity, as they may be at greater risk for depression. To this end, individuals with high stress reactivity levels could benefit from stress management interventions, such as Mindfulness-Based Stress Reduction (Hofmann et al., 2010; Kabat-Zinn, 2013), which can reduce depression levels in the general population (Khoury et al., 2013) as well as in individuals high in neuroticism (Nyklíček and Irrmischer, 2017). Future studies should also assess the generalisability of these findings to other population-based, high-risk, or clinical samples.

CRediT authorship contribution statement

Vilte Baltramonaityte: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Alexandre A. Lussier:** Writing – review & editing, Conceptualization. **Andrew D.A.C. Smith:** Writing – review & editing, Methodology, Conceptualization. **Andrew J. Simpkin:** Writing – review & editing, Methodology, Conceptualization. **Graeme Fairchild:** Writing – review & editing, Supervision, Conceptualization. **Erin C. Dunn:** Writing – review & editing, Conceptualization. **Esther Walton:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization.

Role of the funding source

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Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2024.12.068.

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