Friendship stress buffering in young people with childhood adversity

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Chapter 4

The Stress-Buffering Role of Friendships in Young People with Childhood Threat Experiences: A Preliminary Report

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Abstract

Background: High-quality friendships have a positive impact on the mental health of young people with childhood adversity (CA). Social stress buffering, the phenomenon of a social partner attenuating acute stress responses, is a potential yet unexplored mechanism that may underlie this relationship. **Objective:** This study examined whether perceived friendship quality was related to better mental health and lower neural stress response in young people with CA. **Method:** A total of N = 102 young people (aged 16-26) with low to moderate CA were included in the study. We first investigated associations between friendship quality, mental health, and CA. In a representative subset (n = 62), we assessed neural stress responses using the Montreal Imaging Stress Task. In our sample, CA was best described along two dimensions resembling threat or deprivation like experiences. Hence, we investigated both cumulative and dimensional effects of CA. **Results:** We found no support for social thinning after CA, meaning that the severity of CA (cumulative or dimensional) did not differentially impact friendship quality. High-quality friendships, on the other hand, were strongly associated with better mental health. Furthermore, acute stress increased state anxiety and enhanced neural activity in five frontolimbic brain regions, including the left hippocampus. We found weak support that threat experiences interacted with friendship quality to predict left hippocampal reactivity to stress. However, this effect did not survive multiple comparison correction. **Conclusion:** The absence of social thinning in our sample may suggest that the risk of developing impoverished social networks is low for rather well-functioning young people with low to moderate CA. Regardless, our findings align with prior research, consistently showing a strong association between high-quality friendships and better mental health in young people with CA. Future research is needed to examine whether friendships aid neural stress responses in young people with childhood threat experiences.

Keywords: childhood adversity, threat experiences, hippocampus, neural stress mechanisms, friendship quality, young people

Highlights

- Young people with childhood adversity underwent acute stress induction, eliciting frontolimbic reactivity.
- High-quality friendships were strongly associated with better mental health.
- Weak support for friendship stress buffering did not survive multiple comparison correction.

Introduction

Up to half of children and adolescents worldwide experience at least one form of childhood adversity (CA), such as abuse, neglect, bullying, or poverty (Bellis et al., 2014). Exposure to CA represents a deviation from the "expectable" environment, which requires young people to adapt their psychological, social, and neurobiological functioning, ultimately putting them at greater risk for prolonged mental health problems (Cicchetti & Valentino, 2006; Clark et al., 2010; Kessler et al., 2010; McLaughlin, 2016). In fact, around a third of lifetime mood, anxiety, and substance use disorders can be attributed to CA (Green et al., 2010). Hence, investigating neurodevelopmental mechanisms that underlie mental health vulnerability and identifying protective factors that buffer these risk pathways is crucial for informing the development of effective psychosocial interventions.

Chronic or repeated exposure to CA has programming effects on key stress response systems, which can increase later-life mental health vulnerability (Lupien et al., 2009). For example, repeated activation of the hypothalamic-pituitary-adrenal (HPA) axis leads to elevated levels of stress hormones (glucocorticoids) in the body (McEwen, 2017). This neuroendocrine response to prolonged psychosocial stress may promote adaptive functioning (e.g., increased alertness) in the short-term to support survival in stressful environments. However, over time, sustained activation of this stress response system may be detrimental to the structure and function of stress-sensitive brain regions (Arnsten, 2009; Y. Chen & Baram, 2016; Danese & McEwen, 2012). Frontolimbic brain regions, including the hippocampus, amygdala, and prefrontal cortex (PFC), may be particularly sensitive to stress in the context of chronic CA exposure due to their dense innervation with glucocorticoid receptors (Cohodes et al., 2021; Ioannidis et al., 2020; Tottenham & Sheridan, 2010).

Given the importance of the frontolimbic system for social information and emotional processing (Humphreys et al., 2016; McLaughlin et al., 2020), alterations to that system following CA may increase mental health vulnerability, as suggested by McCrory et al. (2022). Their social transactional model of mental health vulnerability posits that through neurocognitive adaptations to high stress environments, young people with CA might become more likely to subsequently experience (interpersonal) stress (i.e., "stress generation"; McCrory et al. (2019)) and attenuation in their support networks (i.e., "social thinning"; Nevard et al. (2021); Sheikh et al. (2016)), contributing to greater mental health vulnerability.

Critically, social support is a key protective factor against the emergence of mental health problems in young people with CA (Li et al., 2022; Trickey et al., 2012). However, little is known about the underlying mechanisms of this relationship. Social stress buffering models suggest that the presence of a social partner can reduce physiological responses to acute psychosocial stress, measured by glucocorticoid blood levels (Gunnar, 2017; R. M. Sullivan & Perry, 2015). During childhood, caregiver support suppresses cortisol secretion to acute psychosocial stress (Hostinar et al., 2015), dampens amygdala reactivity, and promotes emotion regulation (Gee et al., 2014) in children without CA. In addition, previously institutionalized children with greater self-reported feelings of caregiver security exhibited reduced amygdala reactivity to caregiver cues, which was also predictive of a greater decrease in future anxiety symptoms (Callaghan et al., 2019). During adolescence, a unique time of social reorientation and increased sensitivity to peers (Cosme et al., 2022), friendship support takes on a more potent stress buffering role, capable of protecting against the emergence and progression of mental health problems following CA (van Harmelen et al., 2016, 2021). Preliminary evidence for friendship stress buffering has shown that the more time spent interacting with supportive friends was associated with diminished neurobiological stress responses (i.e., reduced cortisol, dorsal anterior cingulate cortex (dACC), and anterior insula reactivity) in young people without CA (Eisenberger et al., 2007; C. L. Masten et al., 2012). To date, only two studies have examined friendship stress buffering in young people with CA and reporting mixed results, for a systematic review see (Scheuplein & van Harmelen, 2022). Tang et al. (2021) showed that high-quality friendships were associated with improved sympathetic nervous system reactivity to social rejection feedback at age 12 and reduced peer problems at age 16 in early institutionalized young people. In contrast, no support for friendship stress buffering was found in a small community sample of well-functioning adolescents with low to moderate CA (Fritz, Stretton, et al., 2020). Therefore, it remains unclear whether high-quality friendships aid mental health and well-being in young people with CA through dampening neurobiological stress responses.

To investigate friendship stress buffering in young people with CA, it is crucial to clearly quantify CA experiences, whilst accounting for the fact that different types of CA often co-occur (Brown et al., 2019; Dong et al., 2004). On the one hand, the cumulative-risk approach assumes that discrete forms of CA have additive, but not distinct, effects on neurocognitive functioning, with more CA being associated with stronger effects. Hence, this prevailing approach combines the number of distinct types of adverse experiences into a cumulative risk score (Evans et al., 2013). This approach has been highly influential in public policy and clinical practice (Lacey & Minnis, 2020). On the other hand, dimensional models of adversity differentiate between experiences of *threat/harshness* (involving harm or threat of harm to oneself and others), *deprivation* (involving absence of expected cognitive and social stimulation), and *unpredictability* (involving spatial-temporal variation in threat) to identify mechanisms linking these partially distinct experiences of CA with unique neurodevelopmental and psychopathological consequences (B. J. Ellis et al., 2009; Humphreys & Zeanah, 2015; McLaughlin et al., 2021; Sheridan & McLaughlin, 2014). In line with this framework, Puetz et al. (2020) showed that different forms of childhood maltreatment (abuse, neglect, and their combination) were associated with differential neural processing of threat-related cues. Specifically, childhood abuse was associated with increased localized ventral amygdala reactivity to threat, whereas childhood neglect was associated with heightened reactivity in the dorsal amygdala and across spatially distributed frontoparietal brain networks. Notably, cumulative experiences of abuse and neglect were associated with hypoactivation in various higher- order cortical regions, in addition to the amygdala. Furthermore, a systematic review by McLaughlin, Weissman, et al. (2019) investigated differential associations between threat and deprivation experiences and neural development. To summarize their key findings, threat experiences were found to influence frontolimbic neural networks involved in threat detection and emotion regulation (amygdala and medial prefrontal cortex (mPFC)), salience processing (insula, ACC), and various forms of learning and memory (hippocampus). Deprivation experiences, on the other hand, were found to influence frontoparietal circuits (dorsolateral prefrontal cortex (dlPFC) and superior parietal cortex) contributing to working memory and cognitive control. However, these neural patterns were not consistently observed across studies, highlighting the need for more neuroimaging research to establish consistent and replicable associations between brain alterations and different dimensions of CA.

The main goal of this study was to investigate whether perceived friendship quality was related to reduced neural stress responses in a sample of adolescents and young adults (aged 16-26) with low to moderate CA. In addition, we examined relations between CA, friendship quality, and mental health and well-being. To challenge neural stress responses affected by CA, we utilized the Montreal Imaging Stress Task (MIST) (Dedovic et al., 2005). The MIST is a well-validate acute psychosocial stress paradigm combining the stress-eliciting effects of high cognitive demands (solving math problems under time pressure) with negative social feedback (on screen and verbally via the experimenter), see review by Noack et al. (2019). Previous studies that utilized the MIST reported stress-related activation in frontolimbic regions, including the hippocampus, amygdala, insula, mPFC, ACC, nucleus accumbens (NAc), and thalamus (Chung et al., 2016; Noack et al., 2019; Voges et al., 2022; Wheelock et al., 2016). Hence, we examined the neural correlates of friendship stress buffering in these regions of interest (ROIs).

Specifically, we examined three hypotheses. First, we hypothesized that more severe CA experiences would be associated with lower levels of perceived friendship quality (McCrory et al., 2022) and that reduced friendship quality would be associated with worse mental health functioning (Fritz, Stretton, et al., 2020; van Harmelen et al., 2016, 2021) (hypothesis 1). Second, we expected that acute psychosocial stress would increase state anxiety (Chung et al., 2016; Zschucke et al., 2015) and increase neural activity in our ROIs (Noack et al., 2019) (hypothesis 2). Third, we expected that friendship quality would moderate the relationship between CA and neural stress responses. Specifically, we investigated whether higher friendship quality would be associated with reduced frontolimbic ROI reactivity to stress (Scheuplein & van Harmelen, 2022; Tang et al., 2021) (hypothesis 3). Finally, we examined these hypotheses with both a cumulative-risk approach and a dimensional approach. We expected that more CA experiences, or more severe threat experiences, would be associated with greater frontolimbic ROI reactivity to stress (McLaughlin, Weissman, et al., 2019).

Method

Resilience after Individual Stress Exposure (RAISE) Study

Data were drawn from the Resilience after Individual Stress Exposure (RAISE) study, a multilevel study of N = 102 young people aged 16-26 (Moreno-López et al., 2021). All RAISE participants retrospectively self-reported a history of CA, which was defined as exposure to any adverse life event experienced within the family environment before the age of 16. This included childhood maltreatment (e.g., emotional, sexual, or physical abuse, emotional or physical neglect) or intrafamily adversity (e.g., marital distress or conflict, parental mental health problems or parental alcohol dependence, violence, or aggressive behavior) (Figure 1). Participants were recruited across Cambridgeshire, UK from the general population through flyers and via social media as well as from previous studies conducted at the Department of Psychiatry, University of Cambridge (NSPN 2400 Cohort; Kiddle et al. (2018)). The RAISE study has received funding from the Royal Society in January 2018, ethical approval from the National Research Ethics Service and the NRES Committee East of England-Cambridge Central (REC reference: 18/EE/0388, IRAS project ID: 241765) in February 2019, and commenced in August 2019.

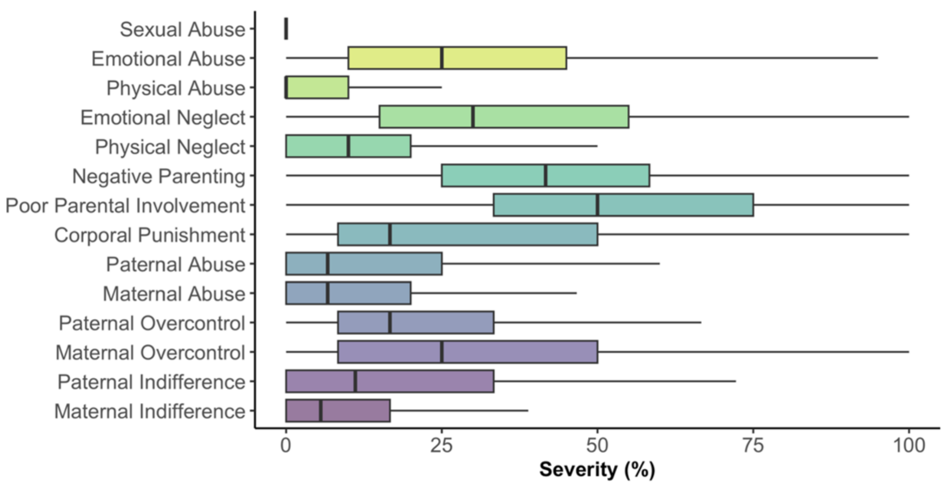

Figure 1. Severity of childhood adversities in the baseline sample. Severity (in percent; x-axis) of individual childhood adversities (y-axis) retrospectively self-reported by all $N = 102$ young people, who participated during the first assessment timepoint (T1) of the RAISE study. Each boxplot displays the median severity (solid vertical line) and interquartile range. Based on established cut-off scores for the CTQ (Bernstein et al., 1994), this baseline sample can be characterized reporting low to moderate levels of CA. Summary statistics are provided in the supplementary Table A.1.1.

Participants

This study utilized data from the first two RAISE assessment timepoints. At timepoint 1, participants completed online questionnaires ($N = 102$; “Baseline sample”). Timepoint 2 was completed on average 1 month later and consisted of an in-unit visit at Addenbrooke’s Hospital in Cambridge, UK during which, among other measures, functional magnetic resonance imaging (fMRI) data was acquired ($n = 62$; “Neuroimaging sample”). At each timepoint, informed consent was obtained from the participant. A comprehensive description of the full study procedure as well as the inclusion and exclusion criteria has been previously published by Moreno-López et al. (2021). To summarize, individuals were eligible to participate if they were aged between 16-26 years, able to speak, write, and understand English, had a body mass index (BMI) between 18.5 and 29.9 kg/m^2, did not currently take medication (e.g., corticosteroids) likely to compromise the interpretation of our data, had no MRI contraindications, and self-reported CA experienced before the age of 16. All inclusion and exclusion criteria were assessed via telephone by a trained member of the study team to ensure that interested participants were eligible. Medication use and BMI were re-assessed by a trained research nurse at the day of scanning. Participants received a total of £150 upon completing all three study phases (please note that data from the third study phase was not included in the analysis for this study). If participants chose not to proceed after the first or second phase, they were partially reimbursed. The payment was distributed as follows: £10 for the initial completion of online questionnaires and three cognitive tasks, £100 for their attendance at Addenbrooke's Hospital, and £40 for completing the second set of online questionnaires. This study commenced in August 2019 and was terminated prematurely in March 2020, prompted by a University-wide closure of laboratory research activities and the redirection of clinical research facilities toward COVID-19 related studies. Hence, $n = 42$ participants who completed the baseline assessment could not be assessed at timepoint 2. However, key characteristics (e.g., age, gender, CA experiences, or friendship quality) are comparable between the neuroimaging sample and baseline and the participants who could not complete the study as a consequence of the COVID-19 pandemic (Table A.1.1).

Baseline Assessments (T1)

At baseline, participants received an email containing an online link to remotely complete self-report questionnaires assessing past CA experiences as well as current (past two to four weeks) mental health, well-being, and friendship quality. Specifically, *CA* was assessed with the Short-Form of the Childhood Trauma Questionnaire (CTQ-SF; Bernstein et al. (2003)), the Measure of Parental Style Questionnaire (MOPS; Parker et al. (1997)), and the Alabama Parenting Questionnaire (APQ; Frick (1991)). *Mental health and well-being* (in the following referred to as psychosocial functioning) was assessed with the Mood and Feelings Questionnaire (MFQ; Angold & Costello (1987)), Revised Children's Manifest Anxiety Scale (RCMAS; Reynolds & Richmond (1978)), the Leyton Obsessional Inventory-Child Version (LOI-CV; Bamber et al. (2002)), the Behavioral Checklist (BCL; van Harmelen et al. (2017)), the Rosenberg Self-Esteem Scale (SES; Rosenberg (1965)), the Kessler Psychological Distress Scale (K10; Kessler et al. (2002)), the Warwick-Edinburgh Mental Well-Being Scale (WEMWBS; Tennant et al. (2007)), and the Drugs and Self Injury Questionnaire (DASI; Wilkinson et al. (2018)). *Friendship quality* was assessed with the Cambridge Friendship Questionnaire (CFQ; van Harmelen et al. (2017)). Across all questionnaires, higher scores reflect more severe CA experiences, better psychosocial functioning, and greater perceived friendship quality. A detailed description of all questionnaires is provided in the supplementary information (section B). Given that we recruited adolescents and young adults aged 16-26 (M_{age} = 22.24 at baseline), we chose these measures to ensure that all questionnaires (incl. instructions and items) were accessible and age-appropriate for the entire sample (Demkowicz et al., 2020), which is also in line with similar approaches utilized in previous large-scale longitudinal cohort studies assessing young people aged 14-24 (Goodyer et al., 2010; Kiddle et al., 2018).

In-Unit Assessments (T2)

During the in-unit visit, participants completed the vocabulary and matrix reasoning subtests of the *Wechsler Abbreviated Scale of Intelligence* (WASI-II; Wechsler (2018)) from which age-normed IQ scores were derived. IQ scores ranged from 78 to 138 (M_{IQ} = 116.09, *SD* = 10.18). Furthermore, the *Edinburgh Handedness Inventory* (EHI; Oldfield (1971)) indicated that 91% of participants preferred using the right hand for more complex manual tasks. Furthermore, state anxiety was assessed with the *State-Trait Anxiety Inventory* (STAI; Spielberger & Vagg (1984)) before and after participants completed the MIST in the MRI scanner.

fMRI Stress Paradigm

The *Montreal Imaging Stress Task (MIST)* is a well-validated and widely used acute psychosocial stress paradigm for fMRI (Berretz et al., 2021; Chung et al., 2016; Corr et al., 2021; Dedovic et al., 2005, 2009; Noack et al., 2019; Pruessner et al., 2008). This computerized mental arithmetic task with an artificially induced failure component was presented as a block design across two imaging runs. Each run lasted 11 min and consisted of a stress, control, and rest condition (Figure 2). The order of these conditions was counterbalanced across participants to avoid order effects.

During the 5 min *stress condition* (Figure 2A), participants were asked to answer math problems of varying difficulty under time constraints whilst receiving trial-by-trial on screen performance feedback ("correct" in green, "error" in red, or "timeout" in yellow). To answer, participants were provided a button box and instructed to navigate left or right on a rotary-dial to the correct digit (between 0 and 9). In addition, a performance bar at the top of the screen continuously displayed the "average" performance of previous participants (artificially set to 80%) as well as the participant's current performance. Participants were instructed to attain or surpass the average performance of their peers. To induce a high failure rate, the participant's response time limit got adjusted throughout the task to enforce a range of approximately 20% to 45% correct responses (Dedovic et al., 2005). Specifically, participants were given 10% less time after three consecutive correct responses and 10% more time after three consecutive incorrect or timeout responses. To further induce psychosocial stress, participants were presented with a 5 sec on screen summary of their current performance and were reminded that their "performance should be close to or better than the average performance". This summary was presented at five timepoints during the stress condition. In addition, participants received scripted negative verbal feedback in between runs from a member of the study team saying: "Your performance is below average. In order for your data to be used, your performance should be close to or better than the average performance. Please try as hard as you can next round".

During the 5 min *control condition* (Figure 2B), participants answered math problems of the same difficulty level and received trial-by-trial performance feedback ("correct" in green, "error" in red). However, no time constraints were enforced, the performance bar (including the "average" peer performance) was not displayed, and participants were instructed that their performance would not be recorded.

During the 1 min *rest condition* (Figure 2C), participants were presented with the empty task interface and asked to keep their eyes open and not press buttons until the next math problem would appear.

The MIST took approximately 35 min to complete including approximately 5 min of practice outside the MRI scanner to familiarize participants with each condition. For this study, we used an adapted version of the MIST originally programmed by Borchert (2019) for Millisecond Software, LLC (openly available at: https://www.millisecond.com/download/library/montrealstresstest).

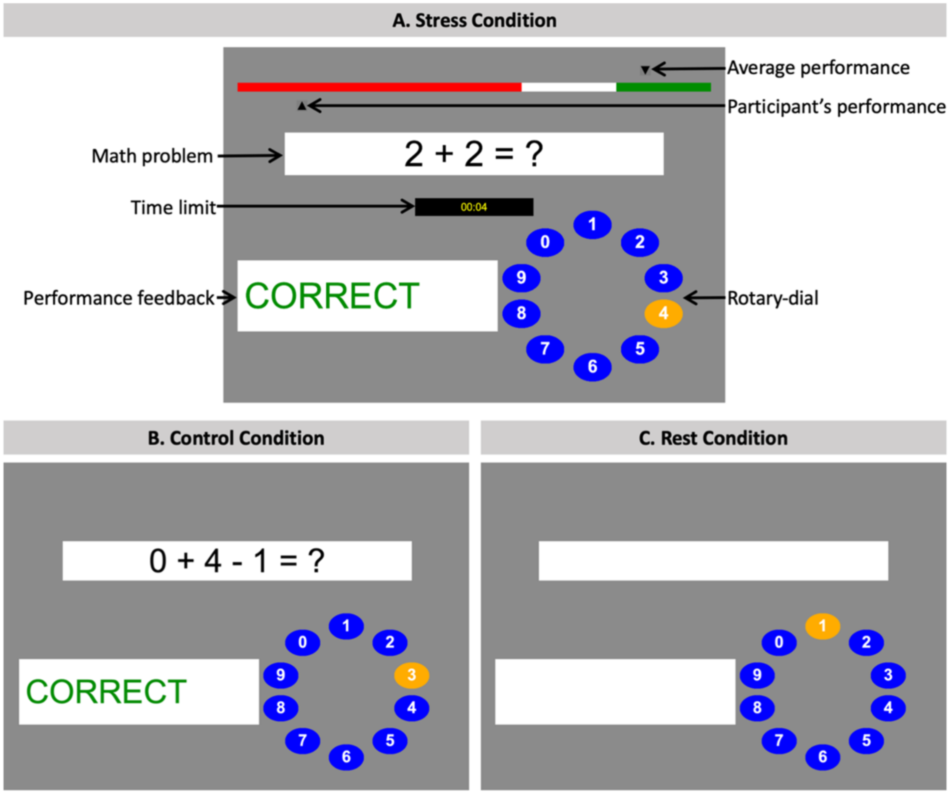

Figure 2. Graphical user interfaces of the Montreal Imaging Stress Task. **(A)** Stress condition: from top to bottom, the figure shows the performance bar displaying the average performance of previous participants (artificially set to 80%) as well as the participant's current performance. Below, participants were presented with math problems of varying difficulty whilst being shown the titrated time limit, they had to provide a response. A response was submitted via the rotary-dial (answer choices between 0 and 9). Finally, participants received trial-by-trial on screen performance feedback ("correct" in green, "error" in red, or "timeout" in yellow). **(B)** Control condition: participants answered math problems of the same difficulty level and received trial-by-trial performance feedback ("correct", "error"). However, no time constraints were enforced, the performance bar was not displayed, and participants were instructed that their performance would not be recorded. **(C)** Rest condition: participants were presented with the empty task interface and asked to keep their eyes open and not press buttons until the next math problem would appear.

Imaging Procedures

fMRI Data Acquisition

fMRI was conducted on a Siemens 3T Magnetom Prisma Fit whole body MRI scanner (Siemens Healthcare GmbH, Erlangen, Germany) with a 32-channel head coil. Blood oxygen level-dependent (BOLD) data were collected using a T2*-weighted transversal echo planar imaging (EPI) sequence with interleaved slice acquisition, covering the entire brain (repetition time (TR) = 2000ms, echo time (TE) = 30ms, flip angle = 78°, number of slices = 34, slice thickness = 3mm, slice gap = 0.3mm, voxel size = 3 x 3 x 3mm^3, field of view (FOV) = 192 x 192mm^2, in-plane resolution = 64 x 64). To obtain a 3D structural scan, high-resolution sagittal T1-weighted images were acquired using a magnetization prepared-rapid gradient echo (MPRAGE) sequence (TR = 2000ms, TE = 2.98ms, , flip angle = 9°, number of slices = 176, slice thickness = 1mm, slice gap = 0.5mm, voxel size = 1 x 1 x 1mm^3, FOV = 256 x 256mm^2, in-plane resolution = 256 x 256).

fMRI Preprocessing and Data Analysis

Preprocessing of the imaging data was performed using SPM12 (https://www.fil.ion.ucl.ac.uk/spm/) implemented in MATLAB (version R2020a; MathWorks) following standard procedures. To summarize, images were realigned to the mean image of the scan run using a 6-parameter rigid body spatial transformation, spatially normalized to the standard stereotactic space of the Montreal Neurological Institute (MNI) template, resampled to 3 mm isotropic voxels, and smoothed with an 8mm full-width at half-maximum (FWHM) Gaussian kernel. In addition, framewise displacement (FD) was computed based on the head motion parameter and used as quality checks (Power et al., 2012). As recommended by Schwarz et al. (2020), participants with a M_{FD} > 0.5mm or more than 20% volumes with FD > 0.5mm in any of the two runs were excluded from subsequent analyses. Based on this rule and through visual inspection, n = 2 participants were excluded, leaving a total neuroimaging sample of n = 60 (Table A.1.1).

For the first-level analysis, we defined a general linear model (GLM) for each subject and each condition of the MIST (convolved with the canonical hemodynamic response function (HRF) of SPM12). Six head motion parameters from the realignment step were included as covariates. A high-pass filter with a cut-off frequency of 1/262 Hz and an autoregressive model of the first order were applied. To identify regions showing greater activation (i.e., greater mean BOLD signal) during the stress condition compared to the control condition, we computed stress > control first-level contrasts for each participant. This contrast allowed for investigating the effect of acute psychosocial stress on brain activation whilst controlling for activation changes induced by mental arithmetic.

For the second-level analysis, single-subject contrast maps were entered into random effects analyses (one-sample *t*-test). Based on our a-priori hypotheses, ROI analyses were performed using bilateral masks for the hippocampus, amygdala, insula, mPFC, ACC, NAc, and thalamus. ROI analyses were conducted using the pipeline implemented in the Wake Forest University (WFU) PickAtlas SPM12 toolbox (version 3.0.5; Maldjian et al. (2004), (2003); https://www.nitrc.org/projects/wfu_pickatlas/). Specifically, these ROIs were defined using the PickAtlas GUI and resliced to match smoothing. Given that the anatomical region of the mPFC is less well defined, this ROI mask was based on the anatomical location of both dorsal and ventral mPFC (including the ACC; Brodmann areas (BA): 9, 10, 11, 24, 25, 32) (Moreno-López et al., 2020; Passingham & Wise, 2012; van Harmelen et al., 2013). All other ROIs were based on the Automated Anatomical Labeling (AAL) atlas (Tzourio-Mazoyer et al., 2002). ROI results were familywise error (FWE) corrected ($p_{FWE} < .05$) using voxel-level statistics. For all ROIs that showed a significant main effect of task, we extracted individual beta weights by averaging across all activated voxels in the cluster containing the ROI peak (Tong et al., 2016). We applied no restriction for the minimum cluster size. To comprehensively examine neural activation outside our ROIs, we additionally conducted follow-up exploratory whole-brain analyses ($p_{FWE} < .05$) using the same stress > control contrast, k > 25 voxels.

Principal Component Analysis

Principal component analyses (PCAs) with oblique rotation were used to explore differential dimensions of CA experiences and to capture the range of psychosocial outcomes in our sample. Specifically, we computed principal component (PC) scores, weighted by their explained variance for CA and psychosocial functioning, respectively. The PCA for CA revealed a two-component solution so that CA could be delineated along two dimensions resembling *threat* and *deprivation* experiences. Those dimensional scores were subsequently combined into a *cumulative CA index*, with a higher index indicating more severe CA (Figure 3A). Specifically, this PCA was conducted on standardized individual total scores of the Measure of Parental Style Questionnaire (MOPS; measure of maternal and paternal abuse, indifference, and overcontrol), the Short-Form of the Childhood Trauma Questionnaire (CTQ-SF; measure of physical abuse, emotional abuse, physical neglect, and emotional neglect), and the Alabama Parenting Questionnaire (APQ; measure of corporal punishment, poor parental involvement, and negative parenting). The PCA for psychosocial functioning revealed a three-component solution, and we summed the weighted PC1, PC2, and PC3 scores to compute a *cumulative psychosocial functioning index*, with a higher index indicating better mental health and well-being (Figure 3B). This PCA was conducted on standardized individual total scores of the Warwick-Edinburgh Mental Well-Being Scale (WEMWBS; measure of mental well-being), the Revised Children's Manifest Anxiety Scale (RCMAS; measure of physiological anxiety, worry/oversensitivity, and social concerns/concentration), the Mood and Feelings Questionnaire (MFQ; measure of depressive symptoms); the Rosenberg Self-Esteem Scale (SES; measure of self-esteem); the Kessler Psychological Distress Scale (K10; measure of psychological distress); the Leyton Obsessional Inventory-Child Version (LOI-CV; measure of compulsions, obsessions, and cleanliness), and the Behavioral Checklist (BCL; measure of behavioral problems). Please note that all results hold when only using the weighted PC1 score for psychosocial functioning. A similar method has been employed by Anand et al. (2019) and a detailed description of our analyses as well as a summary of the PC scores and their associations can be found in our supplementary information (section E).

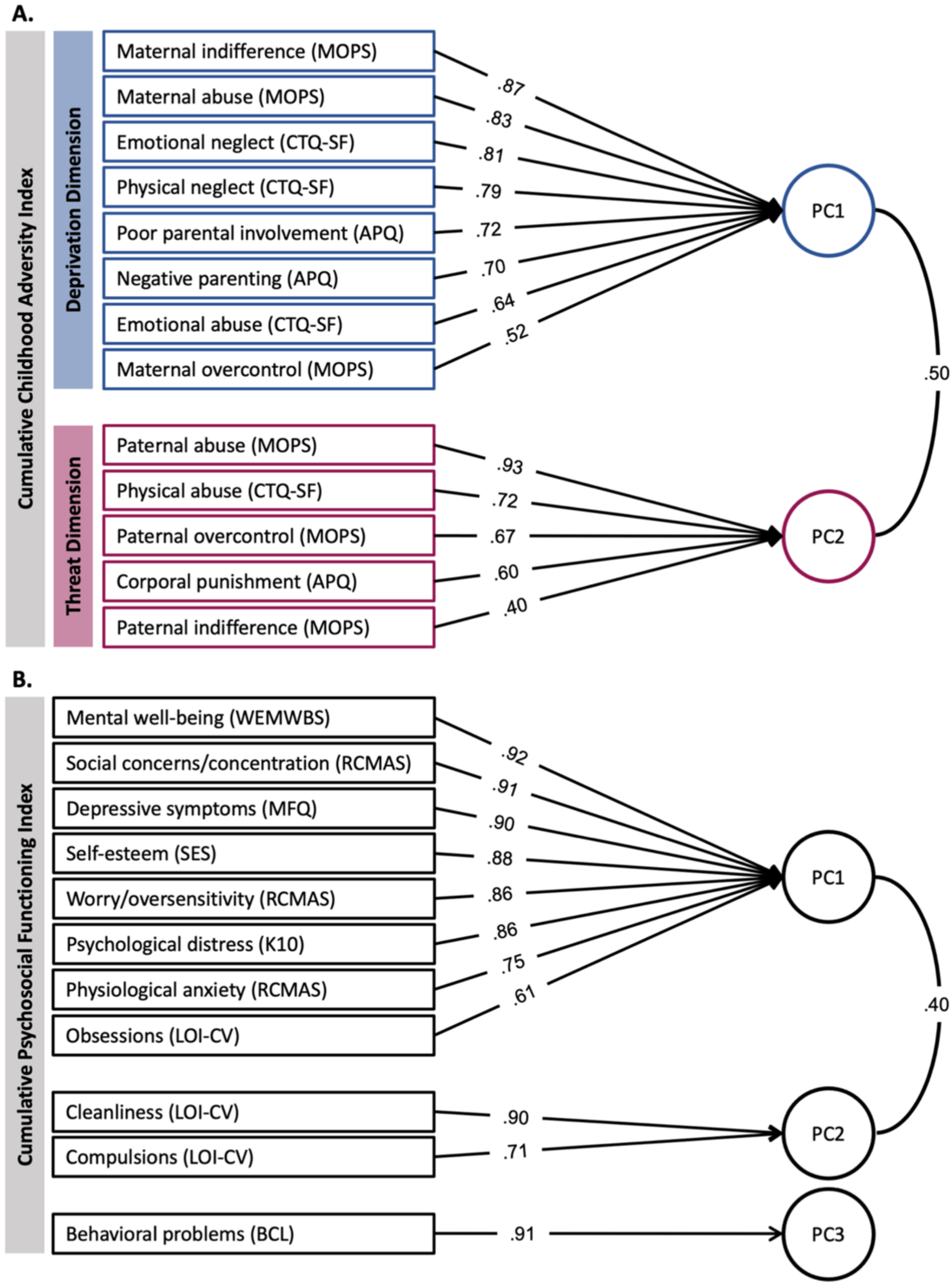

Figure 3. Principal component analysis loading matrices for childhood adversity and psychosocial functioning. Two PCAs with oblique rotation were conducted on individual scores of **(A)** CA measures and **(B)** psychosocial functioning measures. The PCA for CA resulted in two principal components (PCs) which were further divided into a *deprivation dimension* (blue; PC1 explaining 37% of variance) and a *threat dimension* (red; PC2 explaining 21% of variance). To account for the

contributions of both PCs, we weighted the scores for each PC by their explained variance and subsequently summed these scores to compute a single index of total severity experienced (*cumulative CA index*). The PCA for psychosocial functioning resulted in three PCs (PC1 explained 55% of variance; PC2 explained 15%; PC3 explained 10%). To compute a *cumulative psychosocial functioning index*, we summed the weighted PC1, PC2, and PC3 scores. Factor loadings of each measure are displayed on the arrows.

Statistical Analyses

First, we analyzed behavioral data collected at baseline (T1; $N = 102$). Specifically, we examined associations between friendship quality and CA through linear regression models. We ran separate models for the cumulative CA index (derived through summing the weighted PC1 and PC2 scores) as well as the weighted deprivation (PC1) and threat dimensions (PC2). In addition, we examined associations between friendship quality and the cumulative psychosocial functioning index (hypothesis 1). All models included age at the time of assessment and gender identity as covariates. To handle missing questionnaire data, we derived sum scores from scales with ≥15 items if 85% or more of the items were answered. For scales with less than 15 items, a sum score was only derived if 100% of the items were answered. This resulted in 2.45% of missing data.

Second, we analyzed data collected during the in-unit assessment (T2; $n = 60$). We used a paired *t*-test to examine individual mean differences in state anxiety before and after completing the MIST in the MRI scanner. Afterwards, we investigated overall task effects in our predefined ROIs (hypothesis 2) and then examined associations between CA and friendship quality on stress-induced significant ROI reactivity during stress (> control) trials of the MIST (hypothesis 3). We ran separate moderated multiple regression models for the cumulative CA index, the deprivation, and threat dimensions. All multiple regression models included age at the time of scanning and gender identity as covariates. As our stressor comprised of a timed arithmetic test, we further added IQ as a covariate to all models. Furthermore, friendship quality scores were mean centered to align the scaling of the predictor variables and thereby enhance interpretation of the multiple regression results (Iacobucci et al., 2016).

All statistical analyses outlined above were run in R version 3.6.3 (R Core Team, 2022). The PCAs were performed using the psych R package (version 2.2.9; Revelle (2022)) and mean imputations to replace missing values were performed using the mice R package (version 3.15.0; Van Buuren & Groothuis-Oudshoorn (2011)). Regression models were run using the stats R package (version 3.6.3). Partial Cohen's f-squared (f_p^2) and Cohen's d (*d*) effect size estimates are reported for all relevant tests. Significance was set at $p < .05$ throughout all analyses unless stated otherwise and all tests were Bonferroni corrected for multiple comparisons

(# of models tested). In addition, we used the Median Absolute Deviation (MAD) method (i.e., median plus or minus 3 times the MAD; Leys et al. (2013)) in combination with the Rosner's test (EnvStats R package version 2.7.0; Millard (2013)) to detect and exclude potential outliers. Moreover, to visualize significant interactions, we plotted model estimated marginal means using the sjPlot R package (version 2.8.14; Lüdecke (2023)) alongside 95% confidence intervals. Specifically, we explored how the relationship between CA and stress-induced ROI reactivity changed as a function of low and high friendship quality (-1*SD*, +1*SD*). For statistical power considerations, please refer to the supplementary information (section F).

Results

Behavioral Results (T1; N = 102)

First, we did not observe that participants with more severe retrospectively self-reported CA experiences self-reported lower friendship quality, β = -0.19, SE = .01, t_{97} = -1.89, p = .062 (Figure 4A). Next, we observed that models specifying either deprivation or threat experiences as a predictor showed a better model fit compared to a model specifying cumulative CA (see supplementary information for full details). However, none of these dimensional models significantly predicted differences in friendship quality (deprivation experiences: β = -0.16, SE = .01, t_{97} = -1.57, p = .120; threat experiences: β = -0.17, SE = .01, t_{97} = -1.65, p = .103). Second, we found that greater subjectively perceived friendship quality was significantly related to better psychosocial functioning in young people with CA, β = 0.44, SE = .02, t_{97} = 4.87, p < .001, f^2_p = .245, R^2_{adj} = .207 (Figure 4B). Finally, we observed no significant associations between CA (including cumulative index, threat, or deprivation experiences) and psychosocial functioning, p's > .235. Please see our supplementary information for the full model output, descriptive statistics, and correlations between the study variables (sections G-H).

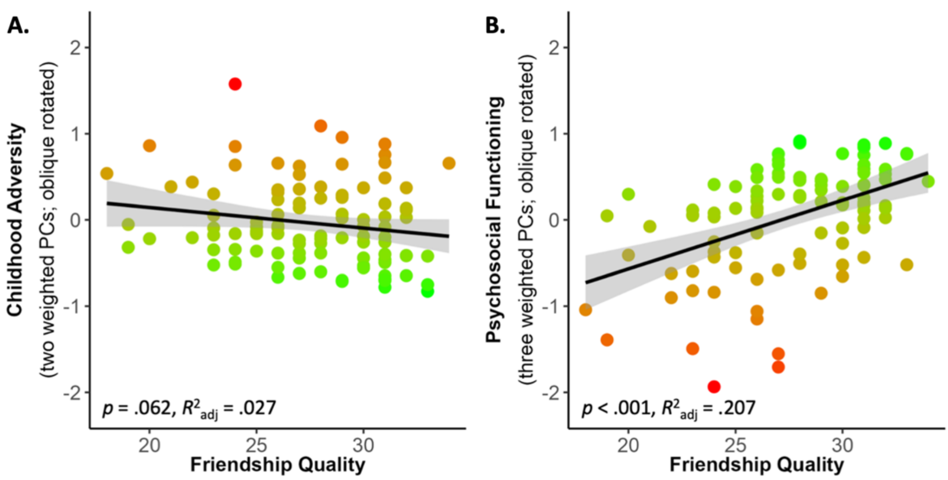

Figure 4. Associations between friendship quality and (A) childhood adversity and (B) psychosocial functioning**.** Participants with greater subjectively perceived friendship quality **(A)** did not retrospectively self-reported less negative CA (p = .062) but **(B)** showed better psychosocial functioning (p < .001). Index scores of CA comprise two weighted principal components (PCs) and index scores of psychosocial functioning comprise three weighted PCs, both oblique rotated. Both y-axes represent factor scores with M = 0 and SD = 1. Brighter shading (green) of individual data points represents (A) less severe CA and (B) better psychosocial functioning on each graph respectively. The black lines show the best-fitting linear regression lines, and the shaded regions around them represent the 95% confidence intervals.

Neuroimaging Results (T2; n = 60)

State Anxiety Before and After Acute Psychosocial Stress

We observed a significant increase in self-reported state anxiety upon completion of the MIST (M_{before} = 29.19, SD = 5.75; M_{after} = 34.88, SD = 11.57), t_{57} = -4.33, p < .001, d = .568, suggesting that our task successfully induced subjective emotional stress (Figure 5).

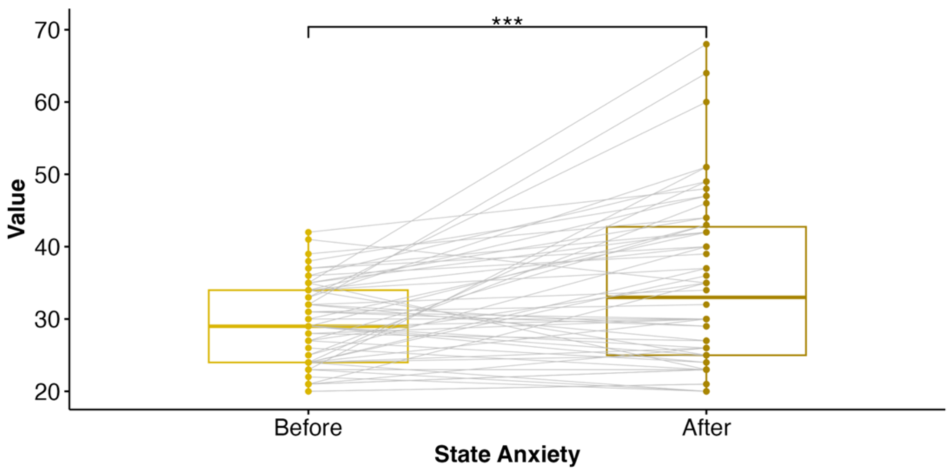

Figure 5. State anxiety increased after acute psychosocial stress. Participants exhibited greater self-reported state anxiety after completing the Montreal Imaging Stress Task (MIST) compared to state anxiety levels before the MIST (p < .001). The boxplot displays the median (Mdn, solid vertical line) and interquartile range (IQR) before (Mdn = 29.00, IQR = 10) and after (Mdn = 33.00, IQR = 17.75) completing the MIST. The points represent individual datapoints with the grey lines connecting paired observations. *** p < .001.

Brain Responses to Acute Psychosocial Stress

First, we investigated the main effect of stress (> control) in our predefined ROIs (hippocampus, amygdala, insula, mPFC (ACC), NAc, and thalamus) using familywise error (FWE) correction (p_{FWE} < .05) at the voxel level. This analysis identified significant activation in the left hippocampus (t_{57} = 4.24, p_{FWE} = .007; MNI coordinates: -27, -37, -4), bilateral insula (t_{57} = 4.07, p_{FWE} = .020; MNI coordinates: -42, 14, 5), left mPFC (ACC) (t_{57} = 4.35, p_{FWE} = .043; MNI coordinates: -3, 16, 38), right NAc (t_{57} = 3.09, p_{FWE} = .016; MNI coordinates: 15, 11, -10), and bilateral thalamus (t_{57} = 5.22, p_{FWE} < .001; MNI coordinates: 12, -10, 14). All significant task-related ROI clusters are summarized in Table 1 and visualized in Figure 6 below. Whole-brain analyses (p_{FWE} < .05) revealed no significant activation outside our predefined ROIs.

Region	Side	MNI Coordinates			Cluster			p_{FWE}
		x	y	z	Size	*t*	*z*	(Peak)
Hippocampus	L	-27	-37	-4	8	4.24	3.93	.007
Insula	L	-42	14	5	2	4.07	3.80	.020
	L	-30	5	14	4	3.98	3.73	.026
	R	45	11	2	1	3.97	3.71	.027
	L	-45	-1	5	4	3.88	3.64	.035
	L	-33	-16	8	1	3.76	3.54	.048
mPFC (ACC)	L	-3	-16	38	1	4.35	4.03	.043
NAc	R	15	11	-10	4	3.09	2.96	.016
Thalamus	R	12	-10	14	195	5.22	4.70	<.001
	L	-9	-19	14		4.80	4.38	.001
	L	-18	-22	14		4.61	4.23	.002

Table 1. ROIs activated during stress (> control) trials of the Montreal Imaging Stress Task. All reported statistics are significant at p_{FWE} < .05, voxel-level corrected for the ROI. All ROIs were bilaterally defined using the WFU PickAtlas Tool (version 3.0.5; Maldjian et al. (2003)) and based on the Automated Anatomical Labeling (AAL) atlas (Tzourio-Mazoyer et al., 2002). Given that the anatomical region of the mPFC is less well defined the ROI mask was based on the anatomical location of both dorsal and ventral mPFC (including the ACC; Brodmann areas (BA): 9, 10, 11, 24, 25, 32) (Moreno-López et al., 2020; Passingham & Wise, 2012; van Harmelen et al., 2013). ACC = anterior cingulate cortex; mPFC = medial prefrontal cortex; NAc = nucleus accumbens. L = left; R = right.

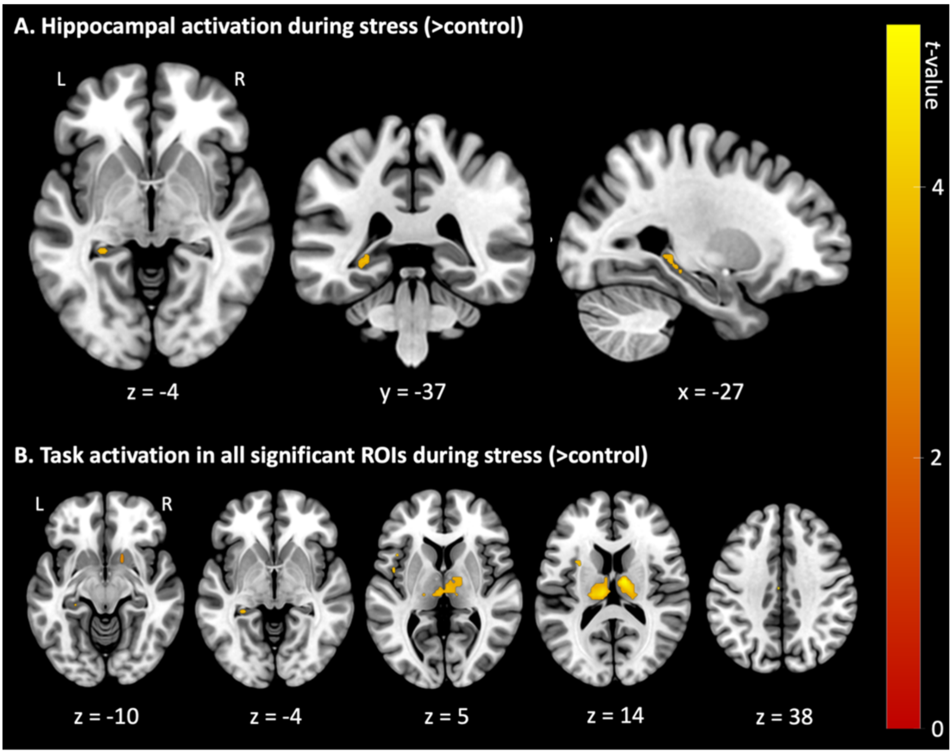

Figure 6. Overview of neural activation during acute psychosocial stress (> control). Displayed are *t*-values of neural activation ($p_{FWE} < .05$) during stress (> control) trials of the Montreal Imaging Stress Task. Results are presented **(A)** centered at the left hippocampus region of interest (MNI coordinates: x = -27, y = -37, z = -4) and **(B)** as axial slices with corresponding z-coordinates. L = left; R = right.

Moderation Effect of Friendship Quality

To examine whether perceived friendship quality was related to lower neural stress responses, we ran three separate linear regression models for each of our five predefined ROIs. Specifically, we examined the interaction between friendship quality and cumulative CA, deprivation, or threat experiences. These analyses revealed only a significant threat experiences x friendship quality interaction on left hippocampal reactivity, $\beta = -0.33$, SE = .26, $t_{46} = -2.26$, $p = .029$, $f^2_p = .111$, $R^2_{adj} = .142$ (Figure 7). However, this effect did not survive correction for multiple comparisons ($p_{Bonf} = .145$; corrected for five ROI comparisons). Age had a significant effect on left hippocampal reactivity across all analyses, with older participants showing increased left hippocampal reactivity. No other main effects or interactions were observed in any of our analyses (*p*'s > .050).

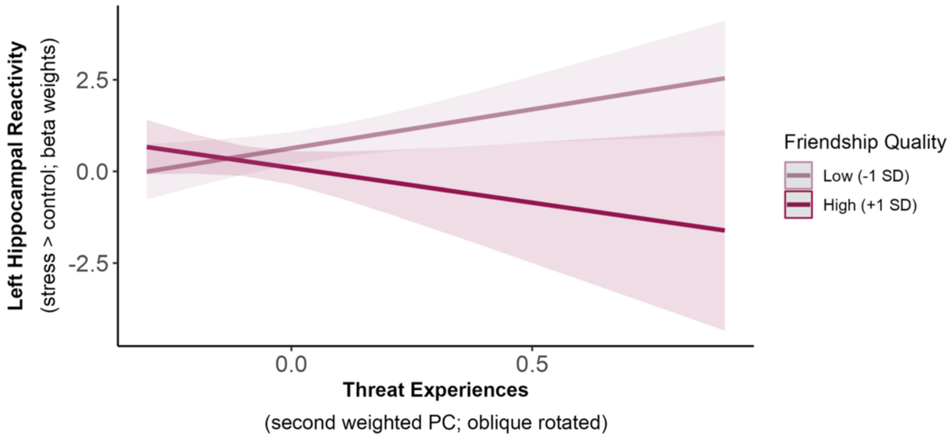

Figure 7. Exploratory average marginal effects in the interaction of threat experiences and friendship quality on left hippocampal reactivity to acute stress. Friendship quality had a weak moderating effect on the relationship between threat experiences and left hippocampal reactivity to acute stress (p = .029), such that hippocampal reactivity increased with more negative threat experiences in participants reporting low friendship quality. However, this effect did not survive correction for multiple comparisons (p_{Bonf} = .145; corrected for five ROI comparisons). The lines show the estimated marginal means of threat experiences (x-axis; second weighted PC) on left hippocampal reactivity (y-axis; beta weights) at different values of friendship quality (-1*SD* = 24.31; +1*SD* = 31.05) with a pointwise 95% confidence interval, derived from a multiple linear regression model.

Discussion

In this study, we examined whether perceived friendship quality was related to better mental health and well-being (*N* = 102) and lower neural stress responses using the Montreal Imaging Stress Task (*n* = 62) in young people (aged 16-26) with low to moderate CA. In addition, we examined the relation between CA and friendship quality. A principal component analysis revealed two dimensions of CA resembling threat or deprivation like experiences. Hence, we investigated both cumulative and dimension specific effects of CA (Evans et al., 2013; Sheridan & McLaughlin, 2014). Contrary to the social transactional model of mental health vulnerability (McCrory et al., 2022), we found no support for social thinning after CA, meaning that the severity of CA (neither cumulative nor dimension specific) did not differentially impact friendship quality. Higher friendship quality, on the other hand, was strongly associated with better psychosocial functioning. Furthermore, we found that experimentally induced acute stress increased state anxiety and enhanced neural activity in five frontolimbic regions (left hippocampus, bilateral insula, left mPFC (ACC), right NAc, and bilateral thalamus). Finally, we found weak support that threat experiences interacted with friendship quality to predict left hippocampal reactivity to acute stress. However, this effect did not survive correction for multiple comparisons. Therefore, future research is needed to examine whether friendships aid neural responses to acute stress in young people with childhood threat experiences.

Despite the prominence of research suggesting that CA can lead to impoverished social networks (Horan & Widom, 2015; Nevard et al., 2021; Sperry & Widom, 2013), we observed that neither conceptualization of CA (i.e., cumulative, deprivation, or threat) was associated with lower friendship quality. Our findings are in fact aligned with previous longitudinal studies by A. B. Miller et al. (2014) and van Harmelen et al. (2016) who showed that CA was not directly associated with poor friendships in healthy community samples. In addition, Fritz, Stretton, et al. (2020) even showed that CA predicted higher friendship quality at ages 14 and 18. The absence of social thinning in our sample may suggest that the risk of developing impoverished social networks is low for rather well-functioning young people with low to moderate CA. This assumption is further supported by our finding that neither conceptualization of CA was related to subsequent psychosocial functioning. Furthermore, we showed that higher friendship quality was strongly associated with better psychosocial functioning. This is in line with previous research showing that social support provided by friends, family, or significant others is related to better mental health and well-being in samples with CA (Jaffee, 2017; Lagdon et al., 2021; Salazar et al., 2011; van Harmelen et al., 2016, 2021; Vranceanu et al., 2007).

Next, we found that high-quality friendships aided left hippocampal reactivity to acute stress in young people with childhood threat experiences. While this interaction effect did not survive stringent correction for multiple comparisons, we recognize the value in cautiously aligning our uncorrected findings with previous research. For example, recent work by Tang et al. (2021) showed that low, but not high, levels of friendship quality facilitated blunted sympathetic nervous system reactivity to social rejection feedback, linking early institutionalization (i.e., severe deprivation experiences) with later-life peer problems. In contrast, Fritz, Stretton, et al. (2020) utilized a cumulative-risk approach to quantify CA and found that friendship support at ages 14 or 17 was not associated with neural responses to social rejection at age 18. Consequently, our results align with previous findings that have shown friendship stress buffering through dimensional, but not cumulative, approaches, despite some divergence regarding the specific dimensions investigated. However, it is worth noting that Tang et al. (2021) did not formally examine different dimensions of early experiences in their sample.

Given the established association between past threat experiences and hippocampal neurodevelopment, our uncorrected findings regarding friendship stress buffering on hippocampal functioning are particularly interesting. The hippocampus is a subcortical region which develops mainly in the first two years of life, and is vital for learning, memory, spatial navigation, and emotional processing (Bird & Burgess, 2008; Phelps, 2004). The hippocampus also plays an important role in inhibiting HPA axis activity in response to elevated blood glucocorticoid levels (Lupien et al., 2009). Due to its dense innervation with glucocorticoid receptors, the hippocampus is particularly sensitive to chronic or repeated stress exposure. Both animal and human studies have shown that early onset and increased severity of CA, specifically threat exposure, was associated with structural and functional alterations in the hippocampus, which in turn was identified as a risk factor for later-life psychopathology (Y. Chen et al., 2008; Cohodes et al., 2021). For example, reductions in hippocampal volume were consistently observed in children and adolescents with past threat experiences, which partially mediated the relationship between threat exposure and internalizing (Weissman et al., 2020) and externalizing problems (Hanson, Nacewicz, et al., 2015), whilst also being associated with reduced friendship support (Malhi et al., 2020). Furthermore, hippocampal hyperreactivity to acute stress has been reported in young adults with cumulative CA (Seo et al., 2014) and middle-aged adults with emotional maltreatment (Leicht-Deobald et al., 2018). Interestingly, such hippocampal hyperreactivity to acute stress was associated with greater adverse health symptoms (Seo et al., 2014). In other words, reductions in hippocampal volume and functioning may act as a potential mechanism of stress vulnerability in young people with CA. In line with this claim, CA has been linked with a greater sensitivity towards peer rejection (van Harmelen et al., 2014) and a greater likelihood of experiencing interpersonal stress (Benedini et al., 2016; Handley et al., 2019; van Harmelen et al., 2016; Widom et al., 2014). Through this process, CA experiences are thought to reduce an individual's likelihood to form and maintain long-lasting, high-quality relationships (Labella et al., 2018; McLafferty et al., 2018). Again, an effect we did not observe in the current study, despite other studies reporting impoverished social networks in individuals with CA (Horan & Widom, 2015; Nevard et al., 2021; Sperry & Widom, 2013). Regardless, our findings, as well as those from other studies, consistently demonstrate a strong association between high-quality friendships and better mental health outcomes in young people with CA.

Our findings are considered in the context of important limitations. First, the current study design prohibits causal inferences. Future large-scale, longitudinal, prospective, and genetically sensitive studies are needed to draw conclusions about the causal impact of CA on neurocognitive and social functioning and the relationship to mental health vulnerability (Danese & Lewis, 2022; McCrory et al., 2022). Second, the data collection period of this study was cut short due to re-allocation of the clinical research facilities in Cambridge, UK during the COVID-19 pandemic, resulting in a small neuroimaging sample (n = 62). Although a retrospective power analysis confirmed that the sample size was sufficient to detect large effects, future research is needed to validate and extend our findings. Despite previous research indicating that stress can induce laterality changes in the hippocampus (Riem et al., 2015), we refrained from interpreting our laterality findings as these might be driven by our stringent significance threshold and reduced sample size. Third, the value of dimensional approaches for conceptualizing CA and identifying mechanisms shaping developmental outcomes is actively being debated (McLaughlin et al., 2021; Pollak & Smith, 2021). The current study suggests that continuously assessing the severity of different CA dimensions may be helpful for specifying putative neural mechanisms that potentially increase mental health vulnerability (McLaughlin, Weissman, et al., 2019; Puetz et al., 2020). In addition, future work should consider the developmental timing and chronicity of exposure to holistically understand the detrimental impact CA can have on the developing brain and consequently on neurocognitive and social functioning. Similarly, future work should account for differential friendship dimensions, such as intimacy, loyalty, frequency of engagement, or network size, as well as differences in stress paradigms with regards to type, intensity, and duration of acute stress, to gain a more nuanced mechanistic understanding about friendship stress buffering after CA. It is worth noting that our sample self-reported on average high levels of friendship quality suggesting a well-functioning group of young people. Nevertheless, current individual characteristics, such as mental health vulnerabilities, may have biased the reporting of friendship quality, in that relationships may be perceived as more negative (Baldwin & Degli Esposti, 2021; Colman et al., 2016). However, this concern seems negligible given that we successfully replicated previous longitudinal findings showing a strong link between high-quality friendships and better mental health in samples with low to moderate CA (van Harmelen et al., 2016, 2017, 2021). Furthermore, in our sample, we found no association between CA and psychosocial functioning, which is at odds with robust associations reported in the literature (Humphreys et al., 2016; McCrory et al., 2019; Shackman & Pollak, 2014; Sheikh et al., 2016). It is plausible that the remote assessment of CA and psychosocial functioning in our study may have introduced some limitations to the validity of these measures in our particular sample. However, remote psychosocial functioning assessments have demonstrated adequate psychometric properties (van Ballegooijen et al., 2016) and strong internal consistency (Brock et al., 2012) in previous studies. Furthermore, our remote assessment of the MFQ at T1 exhibited a moderate correlation with the MFQ assessment we conducted in the laboratory at T2 ($r = .69$, $p < .001$). Additionally, all our questionnaires demonstrated acceptable to excellent internal consistency at baseline, and we successfully replicated the above mentioned large-scale longitudinal findings (van Harmelen et al., 2017, 2021). Given these considerations, it is possible that the absence of a relationship between CA and psychosocial functioning in our sample can be attributed to the fact that our sample consisted of relatively well-functioning young people who reported only low to moderate CA.

In conclusion, we showed that young people with more severe CA did not self-report lower friendship quality. However, higher friendship quality was strongly associated with better psychosocial functioning. We found only weak support that threat experiences interacted with friendship quality to predict left hippocampal reactivity to acute stress. However, this effect did not survive correction for multiple comparisons and therefore requires replication in larger ideally longitudinal samples. Hence, future research is needed to examine whether friendships aid neural responses to acute stress in young people with childhood threat experiences.

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Data Availability Statement
For all significant ROIs, group-level statistical maps displaying *t*-values of neural activation (p_{FWE} < .05) during stress (> control) trials of the MIST have been uploaded to NeuroVault (https://neurovault.org/collections/AXXZBAGI/).

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Declaration of Competing Interests
The authors have no competing interests to declare that are relevant to the content of this article. KI receives a stipend for editorial work from Elsevier.

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Characteristics	Baseline Assessment (T1)	Attrition	In-Unit Assessment (T2)	Dropout Analysis	
	Baseline Sample (N = 102)	**Dropouts** (n = 42)	**Neuroimaging Sample** (n = 60)	***t***	***p***
Age	22.24 (2.76)	21.76 (2.84)	22.57 (2.68)	1.46	.148
Gender identity				-0.76	.448
Male	36 (35.3)	13 (31.0)	23 (38.3)		
Female	66 (64.7)	29 (69.0)	37 (61.7)		
Race				-1.80	.075
Asian	18 (17.7)	11 (26.1)	7 (11.7)		
Black	4 (3.9)	2 (4.8)	2 (3.3)		
White	69 (67.6)	25 (59.5)	44 (73.3)		
Others	11 (10.8)	4 (9.6)	7 (11.7)		
Highest education				.075	.127
GCSEs	16 (15.8)	9 (21.4)	7 (11.7)		
A-Levels	29 (28.4)	13 (31.0)	16 (26.7)		
Undergraduate degree	39 (38.2)	14 (33.3)	25 (41.6)		

Postgraduate degree	18 (17.6)	6 (14.3)	12 (20.0)		
Housing				-0.04	.967
Parent(s)	30 (29.4)	12 (28.6)	18 (30.0)		
University housing	33 (32.4)	15 (35.6)	18 (30.0)		
Rented room	8 (7.8)	2 (4.8)	6 (10.0)		
Rented house or flat	27 (26.5)	13 (31.0)	14 (23.3)		
Owned a house or flat	4 (3.9)	0 (0)	4 (6.7)		
Employment				0.65	.517
Full-time	26 (48.1)	9 (45.0)	17 (50.0)		
Part-time	20 (37.0)	9 (45.0)	11 (32.4)		
Self-employed	8 (14.8)	2 (10.0)	6 (17.6)		
Friendship quality	27.47 (3.55)	27.17 (3.82)	27.68 (3.37)	0.72	.473
Childhood adversity					
Sexual abuse	9.60 (22.10)	13.25 (28.36)	7.12 (16.41)	-1.36	.178
Emotional abuse	30.15 (24.12)	33.88 (26.13)	27.67 (22.56)	-1.27	.209
Physical abuse	7.82 (14.41)	9.39 (15.62)	6.75 (13.56)	-0.90	.369

Emotional neglect	36.80 (25.75)	34.25 (22.52	38.50 (27.74)	0.81	.422
Physical neglect	13.45 (15.24)	14.15 (16.65	12.97 (14.30)	-0.38	.705
Negative parenting	40.68 (23.31)	42.89 (25.11	39.17 (22.09)	-0.79	.434
Poor parental involvement	52.50 (24.55)	53.33 (24.08)	51.94 (25.04)	-0.28	.783
Corporal punishment	28.28 (25.86)	30.34 (26.73	26.94 (25.41	-0.64	.526
Paternal abuse	15.71 (23.86)	17.30 (26.38)	14.52 (21.95)	-0.57	.571
Maternal abuse	14.13 (21.13)	16.98 (25.00)	12.09 (17.83)	-1.15	.253
Paternal overcontrol	24.57 (25.39)	25.79 (26.98)	23.66 (24.35)	-0.41	.683
Maternal overcontrol	32.35 (27.03)	34.13 (27.04)	31.11 (27.18)	-0.55	.582
Paternal indifference	20.20 (26.33)	21.56 (29.17	19.14 (24.12)	-0.45	.657
Maternal indifference	13.29 (20.58)	14.55 (21.39)	13.41 (20.13)	-0.52	.607

Table A.1.1. Characteristics of the baseline and neuroimaging sample (including dropout analysis). Age (in years), friendship quality, and severity of CAs (in percent) are reported as *M* (*SD*). All other characteristics are reported as n (%). A dropout analysis was performed using two sample t-tests to compare characteristics between the neuroimaging sample and the dropouts.

Childhood Adversity	Baseline Assessment (T1)	Attrition	In-Unit Assessment (T2)
	Baseline Sample (N = 102)	**Dropouts** (n = 42)	**Neuroimaging Sample** (n = 60)
Deprivation dimension			
Maternal indifference	8.39 (3.70)	8.62 (3.85)	8.23 (3.62)
Maternal abuse	7.12 (3.17)	7.55 (3.75)	6.81 (2.67)
Emotional neglect	12.36 (5.15)	11.85 (4.50)	12.70 (5.55)
Physical neglect	7.69 (3.05)	7.83 (3.33)	7.59 (2.86)
Poor parental involvement	9.30 (2.95)	9.40 (2.89)	9.23 (3.00)
Negative parenting	7.88 (2.80)	8.15 (3.01)	7.70 (2.65)
Emotional abuse	11.03 (4.82)	11.78 (5.23)	10.53 (4.51)
Maternal overcontrol	7.88 (3.24)	8.10 (3.24)	7.73 (3.26)

Threat dimension			
Paternal abuse	7.36 (3.58)	7.60 (3.96)	7.18 (3.29)
Physical abuse	6.56 (2.88)	6.88 (3.12)	6.35 (2.71)
Paternal overcontrol	6.95 (3.05)	7.10 (3.24)	6.84 (2.92)
Corporal punishment	6.39 (3.10)	6.64 (3.21)	6.23 (3.05)
Paternal indifference	9.64 (4.74)	9.88 (5.25)	9.44 (4.34)

Table A.1.2. Severity ratings of childhood adversity measures. Raw severity ratings of CA measures are reported as *M* (*SD*). Based on the principal component analyses for CA, each measure is sorted into a deprivation or threat dimension and ranked according to their factor loading. Based on established cut-off scores for the CTQ (Bernstein et al., 1994), the baseline sample can be characterized reporting low to moderate levels of CA. Specifically, emotional abuse severity ratings between 9-12 can be categorized as low to moderate trauma exposure. Physical abuse ratings between 5-7 can be categorized as none or minimal trauma exposure. Emotional neglect ratings between 10-14 can be categorized as low to moderate trauma exposure. And finally, physical neglect ratings between 5-7 can be categorized as none or minimal trauma exposure. Overall, CTQ scale severity ratings can be categorized into four groups representing none or minimal trauma exposure, low to moderate trauma exposure, moderate to severe trauma exposure, and severe to extreme trauma exposure.

B. Baseline Assessments (T1)

B.1 Childhood Adversity

During the baseline assessment (T1), participants completed three retrospective self-report questionnaires aimed at assessing different types of CA. Across all questionnaires, positive items were reverse coded so that higher scores reflect more severe experiences of CA.

B.1.1 Short-Form of the Childhood Trauma Questionnaire (CTQ-SF)

The CTQ-SF (Bernstein et al., 2003) is a 28-item screening measure for maltreatment experiences within the family environment during childhood or adolescence (up until age 18). On a 5-point Likert scale (1 = never true, 5 = very often true) participants responded to items such as “I didn’t have enough to eat”. The CTQ-SF comprises of five subscales (sexual, physical, and emotional abuse and physical and emotional neglect), which can be combined to estimate the total severity of childhood maltreatment experiences. In this sample, internal consistency was excellent for the total scale (Cronbach’s α = .92) and acceptable to excellent for the five subscales (sexual abuse: α = .94; physical abuse: α = .81; emotional abuse: α = .85; physical neglect: α = .72; emotional neglect: α = .93). In our analyses, we utilized the four CTQ-SF subscales: physical abuse, emotional abuse, physical neglect, and emotional neglect. The sexual abuse subscale was excluded due to low prevalence (*Mdn* = 0, IQR = 0).

B.1.2 Measure of Parental Style Questionnaire (MOPS)

The MOPS (Parker et al., 1997) is a 30-item screening measure for perceived maternal and paternal parenting style experiences respectively. On a 4-point Likert scale (1 = not true at all, 4 = extremely true) participants responded to items such as “My father was physically violent or abusive to me”. The MOPS comprises of six subscales (maternal and paternal abuse, -indifference, and -overcontrol), which can be combined to estimate the total severity of adverse maternal and paternal parenting style experiences. In this sample, internal consistency was excellent for the total maternal scale (α = .91) and paternal scale (α = .90) and acceptable to good for the six subscales (maternal abuse: α = .86, -indifference: α = .88; -overcontrol: α = .78; paternal abuse: α = .77; -indifference: α = .90; -overcontrol: α = .89). In our analyses, we utilized all six MOPS subscales: maternal and paternal abuse, -indifference, and -overcontrol.

B.1.3 Alabama Parenting Questionnaire (APQ)

The APQ (Frick, 1991) is a 42-item screening measure for past parenting experiences. On a 5-point Likert scale (1 = never true, 5 = very often true) participants responded to items such as “Your parents spank you with their hand when you have done something wrong”. The APQ comprises of five subscales (corporal punishment, parental involvement, negative parenting, poor monitoring/supervision, and inconsistent discipline), which can be combined to estimate the total severity of negative parenting experiences. For the current study, a modified 15-item version of the APQ was administered retaining all five subscales (guided by Elgar et al. (2007)). In this sample, internal consistency was poor for two subscales (poor monitoring/supervision: α = .51; inconsistent discipline: α = .57) which led us to exclude these scales from all analyses. Internal consistency was acceptable to good for the remaining three subscales (corporal punishment: α = .86; parental involvement: α = .77; negative parenting: α = .83) and good for the 9-item total scale (α = .85). Hence, in our analyses, we utilized the three APQ subscales: corporal punishment, parental involvement, and negative parenting.

B.2 Psychosocial Functioning

During the baseline assessment (T1), participants also completed eight self-report questionnaires aimed at assessing psychosocial functioning over the past two to four weeks. Across all questionnaires, negative items were reverse coded so that higher scores reflect more healthy psychosocial functioning and reduced symptom frequency.

B.2.1 Mood and Feelings Questionnaire (MFQ)

The MFQ (Angold & Costello, 1987) is a 33-item screening measure for current depressive symptoms. On a 4-point Likert scale (1 = never, 4 = always) participants responded to items such as "I felt miserable or unhappy". In this sample, internal consistency was excellent for the total scale (α = .94), which was utilized in our analyses.

B.2.2 Revised Children's Manifest Anxiety Scale (RCMAS)

The RCMAS (Reynolds & Richmond, 1978) is a 28-item screening measure for current anxiety symptoms. On a 4-point Likert scale (1 = never, 4 = always) participants responded to items such as "I worried a lot of the time". The RCMAS comprises of three subscales (physiological anxiety, worry/oversensitivity, social concerns/concentration), which can be combined to estimate the total severity of anxiety symptoms. In this sample, internal consistency was excellent for the total scale (α = .94) and good for the three subscales (physiological anxiety: α = .80; worry/oversensitivity: α = .89; social concerns/concentration: α = .84). In our analyses, we utilized all three RCMAS subscales: physiological anxiety, worry/oversensitivity, and social concerns/concentration.

B.2.3 Leyton Obsessional Inventory-Child Version (LOI-CV)

The LOI-CV (Bamber et al., 2002) is a 20-item screening measure for current obsessive-compulsive symptoms. On a 4-point Likert scale (1 = never, 4 = always) participants responded to items such as "I worried about being clean enough". The LOI-CV comprises of three subscales (compulsions, obsessions, cleanliness), which can be combined to estimate the total severity of obsessive-compulsive symptoms. In this sample, internal consistency was good for the total scale (α = .87) and acceptable to good for the three subscales (compulsions: α = .85; obsessions: α = .78; cleanliness: α = .83). In our analyses, we utilized all three LOI-CV subscales: compulsions, obsessions, and cleanliness.

B.2.4 Behavioral Checklist (BCL)

The BCL (van Harmelen et al., 2017) is an 11-item screening measure for current antisocial behavior symptoms. On a 4-point Likert scale (1 = never, 4 = always) participants responded to items such as “I stole things”. In this sample, internal consistency was acceptable for the total scale (α = .72), which was utilized in our analyses.

B.2.5 Rosenberg Self-Esteem Scale (SES)

The SES (Rosenberg, 1965) is a 10-item screening measure for current self-esteem. On a 4-point Likert scale (1 = never, 4 = always) participants responded to items such as “At times, I thought I was no good at all”. In this sample, internal consistency was acceptable for the total scale (α = .78), which was utilized in our analyses.

B.2.6 Kessler Psychological Distress Scale (K10)

The K10 (Kessler et al., 2002) is a 10-item screening measure for current psychological distress symptoms. On a 5-point Likert scale (1 = none of the time, 5 = all of the time) participants responded to items such as “How often did you feel nervous?”. In this sample, internal consistency was excellent for the total scale (α = .91), which was utilized in our analyses.

B.2.7 Warwick-Edinburgh Mental Well-Being Scale (WEMWBS)

The WEMWBS (Tennant et al., 2007) is a 14-item screening measure for current mental well-being. On a 5-point Likert scale (1 = none of the time, 5 = all of the time) participants responded to items such as “I've been feeling optimistic about the future”. In this sample, internal consistency was excellent for the total score (α = .93), which was utilized in our analyses.

B.2.8 Drugs and Self Injury Questionnaire (DASI)

The DASI (Wilkinson et al., 2018) is a 10-item screening measure for current risk-taking behavior related to smoking, alcohol, and drug use as well as non-suicidal self-injury (NSSI). On a 4-point Likert scale (1 = never, 4 = every day or nearly every day) participants responded to items such as “How often did you smoke a cigarette/s?”. Due to weak correlations with the total score (r < .30) both items assessing NSSI were excluded. In this sample, internal consistency was acceptable for the 8-item total scale (α = .71), which was utilized in our analyses.

B.3 Friendship Quality

The Cambridge Friendship Questionnaire (CFQ; van Harmelen et al. (2017)) is an 8-item screening measure to assess the self-reported number, availability, and quality of friendships. During the baseline assessment (T1), participants responded to items such as “Do you feel that your friends understand you?”. Higher scores reflect greater perceived friendship quality. An exploratory factor analysis was conducted on the 8-items of the CFQ revealing low factor loadings (< .40; Stevens (2001)) of item 6 (“Do people who aren’t your friends laugh at you or tease you in a hurtful way?”) which led to the exclusion of this item from all analyses. Please see below for a summary of the factor analysis (Table C.1). In this sample, internal consistency was acceptable for the 7-item total scale (α = .72). Across two different samples of young people with CA (van Harmelen et al., 2017, 2021), the CFQ has been successfully utilized to predict mental health functioning.

C. Exploratory Factor Analysis on the Cambridge Friendship Questionnaire

An exploratory factor analysis (FA) was conducted on the 8-items of the Cambridge Friendship Questionnaire (CFQ) with orthogonal rotation (varimax). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis (KMO = . 80; "meritorious" according to Kaiser (1974)) and all KMO values for individual items were above the acceptable limit of .50. Bartlett's test of sphericity, $\chi^2_{28} = 269.77$, $p < .001$, indicated that correlations between items were sufficiently large for a FA. The scree plot and parallel analysis suggested retaining two factors. We performed a principal axes factor analysis using the psych R package (version 2.2.9; Revelle (2022)) with the maximum number of iterations for convergence set to 100. Due to rotated factor loadings of < .40 on both factors, item 6 ("Do people who aren't your friends laugh at you or tease you in a hurtful way?") was excluded from all analyses. Table C.1 below shows the factor loadings after rotation.

	Item	**FA1**	**FA2**	***h*2**	***u*2**
1.	Are you happy with the number of friends you've got at the moment?	**.77**	.01	.59	.41
2.	How often do you arrange to see friends other than at school, college or work?	**.70**	-.19	.52	.48
3.	Do you feel that your friends understand you?	**.74**	.28	.62	.38
4.	Can you confide in your friends?	**.70**	.14	.51	.49
5.	Do your friends ever laugh at you or tease you in a hurtful way?	-.03	**.84**	.71	.29
6.	Do people who aren't your friends laugh at you or tease you in a hurtful way?	.26	.34	.18	.82
7.	Do you have arguments with your friends that upset you?	.01	**.50**	.25	.75
8.	Overall, how happy are you with your friendships?	**.80**	.10	.65	.35
	Eigenvalues	2.81	1.22		
	% of variance	35.2	15.3		

Table C.1. Summary of exploratory factor analysis results for the Cambridge Friendship Questionnaire (*N* = 102). Factor loadings over .39 appear in bold. FA = varimax rotated factor loadings; h2 = communalities (proportion of common variance within a variable); u2 = uniqueness (proportion of unique variance for each variable).

D. In-Unit Assessment (T2)

D.1 State Anxiety

State anxiety was assessed with the State-Trait Anxiety Inventory (STAI; Spielberger & Vagg (1984)) before and after participants completed the MIST in the MRI scanner. As part of the STAI, participants responded to items such as "I feel nervous" on a 4-point Likert scale (1 = not at all, 4 = very much so). Positive items were reverse coded so that higher scores indicate greater state anxiety. In this sample, internal consistency ranged from good (α = .88) before scanning to excellent (α = .96) after scanning.

E. Principal Component Analysis

E.1 Childhood Adversity

Principal component analysis (PCA) was used to explore differential dimensions of CA experiences in our sample, which were subsequently combined into a cumulative CA index. Specifically, we computed weighted multi-modal composite scores for CA using a PCA with non-orthogonal (oblique) rotation on individual scores of the three APQ subscales (corporal punishment, parental involvement, and negative parenting), the four CTQ-SF subscales (physical abuse, emotional abuse, physical neglect, and emotional neglect), and the six MOPS subscales (maternal and paternal abuse, indifference, and overcontrol). Two of the APQ subscales (poor monitoring/supervision and inconsistent discipline) were excluded due to poor internal consistency (α's < .58) and the sexual abuse subscale of the CTQ-SF was excluded due to low prevalence of sexual abuse (*Mdn* = 0, IQR = 0). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis (KMO = .85; "meritorious" according to Kaiser (1974)) and all KMO values for individual items were ≥ .70, which is well above the acceptable limit of .50. Bartlett's test of sphericity, χ^2_{78} = 722.86, $p < .001$, indicated that correlations between items were sufficiently large for a PCA. The scree plot was slightly ambiguous and showed inflexions that would justify retaining both two and three components. Given the small sample size, and because the more parsimonious option is always preferred, we retained a two-component solution for the final analyses. The principal component (PC) scores and their associations are visualized in Figure 3A and further summarized in Table E.1. The figure shows that negative parenting (APQ), parental involvement (APQ), emotional abuse (CTQ-SF), emotional neglect (CTQ-SF), physical neglect (CTQ-SF), maternal indifference (MOPS), maternal overcontrol (MOPS), and maternal abuse (MOPS) all loaded onto PC1, which explained 37% of variance. Given that most items, except for maternal and emotional abuse, capture experiences involving an absence of expected inputs from the environment, we referred to PC1 as the *deprivation dimension* in all analyses. Furthermore, PC2 explained 21% of variance across the subscales: corporal punishment (APQ), physical abuse (CTQ-SF), paternal indifference (MOPS), paternal overcontrol (MOPS), and paternal abuse (MOPS). Given that most of these subscales capture experiences involving harm or threat of harm, except for paternal indifference which only had a weak loading (.40), we referred to PC2 as the *threat dimension* in all analyses. To calculate a cumulative-risk score, we summed both dimensional scores. Specifically, to account for the contributions of both PCs, we weighted the scores for each PC by their explained variance and subsequently summed these scores to compute a single index of total severity experienced, which in all analyses we refer to as the *cumulative CA index*. A similar method has been employed by Anand et al. (2019).

Items	**PC1**	**PC2**	***h2***	***u2***
Maternal indifference (MOPS)	**.87**	-.11	.68	.32
Maternal abuse (MOPS)	**.83**	-.05	.65	.35
Emotional neglect (CTQ-SF)	**.81**	.09	.73	.27
Physical neglect (CTQ-SF)	**.79**	-.05	.59	.41
Parental involvement (APQ)	**.72**	-.01	.51	.49
Negative parenting (APQ)	**.70**	.05	.53	.47
Emotional abuse (CTQ-SF)	**.64**	.30	.68	.32
Maternal overcontrol (MOPS)	**.52**	.20	.41	.59
Paternal abuse (MOPS)	-.11	**.93**	.78	.22
Physical abuse (CTQ-SF)	.07	**.72**	.56	.44
Paternal overcontrol (MOPS)	.08	**.67**	.50	.50
Corporal punishment (APQ)	.27	**.60**	.59	.41
Paternal indifference (MOPS)	.26	**.40**	.32	.68
Eigenvalues	4.82	2.73		
% of variance	37.0	21.0		

Table E.1. Summary of principal component analysis on childhood adversity measures (N = 102). Factor loadings over .39 appear in bold. PC = oblique rotated principal component loadings; $h2$ = communalities (proportion of common variance within a variable); $u2$ = uniqueness (proportion of unique variance for each variable). APQ = Alabama Parenting Questionnaire; CTQ-SF = Short-Form of the Childhood Trauma Questionnaire; MOPS = Measure of Parental Style Questionnaire.

E.2 Psychosocial Functioning

To capture the range of psychosocial outcomes, we computed weighted multi-modal composite scores for psychosocial functioning using a PCA with oblique rotation on individual total scores of the MFQ, the three RCMAS subscales (physiological anxiety, worry/oversensitivity, and social concerns/concentration), the three LOI-CV subscales (compulsions, obsessions, and cleanliness), the BCL, the SES, the K10, the WEMWBS, and the DASI. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis (KMO = .91; “marvelous” according to Kaiser (1974)). All but one KMO values for individual items were ≥ .78. Only the DASI had a KMO value of .44 ("unacceptable" according to Kaiser (1974)) which led to its exclusion from all analyses. Bartlett's test of sphericity, χ^2_{55} = 897.97, p < .001, indicated that correlations between items were sufficiently large for a PCA. The scree plot showed inflexions that justified retaining three components. The PC scores and their associations are visualized in Figure 3B and further summarized in Table E.2. The figure shows that the total scores of the MFQ, SES, K10, and WEMWBS as well as the subscales: physiological anxiety (RCMAS), worry/oversensitivity (RCMAS), social concerns/concentration (RCMAS), and obsessions (LOI-CV) all loaded onto PC1, which explained 55% of variance. Furthermore, PC2 explained 15% of variance across the subscales: compulsions (LOI-CV), obsessions (LOI-CV), and cleanliness (LOI-CV) whereas BCL was the only scale loading onto PC3, which explained 10% of variance. To compute a *cumulative psychosocial functioning index*, we summed the weighted PC1, PC2, and PC3 scores.

Items	**PC1**	**PC2**	**PC3**	***h*2**	***u*2**
Mental well-being (WEMWBS)	**.92**	-.13	-.09	.75	.25
Social concerns/concentration (RCMAS)	**.91**	-.07	.06	.80	.20
Depressive symptoms (MFQ)	**.90**	-.02	.14	.88	.12
Self-esteem (SES)	**.88**	-.01	-.11	.74	.26
Worry/oversensitivity (RCMAS)	**.86**	.07	-.03	.78	.22
Psychological distress (K10)	**.86**	.06	.07	.80	.20
Physiological anxiety (RMCAS)	**.75**	.14	.29	.84	.16
Obsessions (LOI-CV)	**.61**	**.44**	-.03	.76	.24
Cleanliness (LOI-CV)	-.14	**.90**	.20	.81	.20
Compulsions (LOI-CV)	.32	**.71**	-.32	.77	.23
Behavioral problems (BCL)	.14	.04	**.91**	.92	.08
Eigenvalues	6.00	1.69	1.15		
% of variance	55.0	15.0	10.0		

Table E.2. Summary of principal component analysis on psychosocial functioning measures (N = 102). Factor loadings over .39 appear in bold. PC = oblique rotated principal component loadings; *h*2 = communalities (proportion of common variance within a variable); *u*2 = uniqueness (proportion of unique variance for each variable). MFQ = Mood and Feelings Questionnaire; RCMAS = Revised Children's Manifest Anxiety Scale; LOI-CV = Leyton Obsessional Inventory-Child Version; BCL = Behavioral Checklist; SES = Rosenberg Self-Esteem Scale; K10 = Kessler Psychological Distress Scale; WEMWBS = Warwick-Edinburgh Mental Well-Being Scale.

F. Power Analysis

A power analysis was performed using G*Power (version 3.1.9.6; Faul et al. (2007)) to determine the minimum sample size required to examine associations between CA (measured by weighted composite scores), friendship quality (measured by total CFQ scores), and stress-induced ROI reactivity. The following parameters were used to calculate the total sample size: effect size (f^2) = .40, α error probability = .05, power (1- β error probability) = .95, number of predictors = 5 (main predictors: CA, friendship support; covariates: age, gender, IQ). Results indicated that the required sample size to achieve 95% power for detecting a large effect was *N* = 56 for linear regression analyses. Thus, our obtained neuroimaging sample of *n* = 60 is adequate for the current research.

G. Descriptive Statistics and Correlations between Study Variables

	Variable	*M*	*SD*	1	2	3	4	5	6
1.	Age	22.57	2.68	-					
2.	Gender	1.62	0.49	-.09	-				
3.	Friendship quality	27.68	3.37	.03	.07	-			
4.	Deprivation experiences	-0.04	0.31	.06	-.01	-.22	-		
5.	Threat experiences	-0.02	0.19	.09	.12	-.21	.51	-	
6.	Cumulative CA	-0.06	0.49	.08	.04	-.25	.94	.77	-
7.	Psychosocial functioning	0.03	0.60	.09	-.03	.42	.05	.03	.05

Table G.1. Descriptive statistics and correlations between study variables. *N* = 102; Gender: 1 = male, 2 = female; CA = childhood adversity.

H. Behavioral Results (T1; *N* = 102): Full Model Output

	β	SE	t_{97}	*p*
Intercept		0.53	0.02	.987
Friendship quality	-0.19	0.01	-1.89	.062
Age	0.16	0.02	1.60	.113
Gender	0.03	0.10	0.26	.798

Table H.1. More severe cumulative childhood adversity was not associated with lower friendship quality. The cumulative CA index was derived through summing the weighted PC1 and PC2 scores. Age at assessment and gender identity were added as covariates. One outlier was excluded.

	β	SE	t_{97}	p
Intercept		0.40	-0.20	.840
Friendship quality	-0.16	0.01	-1.57	.120
Age	0.16	0.01	1.59	.116
Gender	0.03	0.08	0.31	.760

Table H.2. Deprivation experiences were not associated with friendship quality. The deprivation dimension was derived through the weighted PC1 scores. Age at assessment and gender identity were added as covariates. One outlier was excluded.

	β	SE	t_{97}	p
Intercept		0.23	0.40	.692
Friendship quality	-0.17	0.01	-1.65	.103
Age	0.09	0.01	0.94	.350
Gender	0.01	0.04	0.06	.954

Table H.3. Threat experiences were not associated with friendship quality. The threat dimension was derived through the weighted PC2 scores. Age at assessment and gender identity were added as covariates. One outlier was excluded.

	β	SE	t_{97}	p
Intercept		0.62	-4.41	<.001
Friendship quality	**0.44**	**0.02**	**4.87**	**<.001**
Age	0.08	0.02	0.87	.386
Gender	0.13	0.12	1.48	.141

Table H.4. Higher friendship quality was associated with improved psychosocial functioning. The cumulative psychosocial functioning index was derived through summing the weighted PC1, PC2, and PC3 scores. Age at assessment and gender identity were added as covariates. One outlier was excluded. f^2_p = .245, R^2_{adj} = .207.

	β	SE	t_{96}	p
Intercept		0.43	-1.61	.111
Psychosocial functioning	-0.09	0.08	-0.86	.393
Age	0.16	0.02	1.59	.116
Gender	0.02	0.10	0.24	.809

Table H.5. Cumulative childhood adversity was not associated with psychosocial functioning. The cumulative CA index was derived through summing the weighted PC1 and PC2 scores. The cumulative psychosocial functioning index was derived through summing the weighted PC1, PC2, and PC3 scores. Age at assessment and gender identity were added as covariates. Two outliers were excluded.

	β	SE	t_{96}	p
Intercept		0.33	-1.56	.123
Psychosocial functioning	-0.05	0.06	-0.47	.637
Age	0.16	0.01	1.53	.130
Gender	0.02	0.08	0.24	.808

Table H.6. Deprivation experiences were not associated with psychosocial functioning. The deprivation dimension was derived through the weighted PC1 scores. The cumulative psychosocial functioning index was derived through summing the weighted PC1, PC2, and PC3 scores. Age at assessment and gender identity were added as covariates. Two outliers were excluded.

	β	SE	t_{96}	p
Intercept		0.18	-1.04	.301
Psychosocial functioning	-0.12	0.03	-1.19	.236
Age	0.10	0.01	1.03	.306
Gender	0.01	0.04	0.14	.890

Table H.7. Threat experiences were not associated with psychosocial functioning. The threat dimension was derived through the weighted PC2 scores. The cumulative psychosocial functioning index was derived through summing the weighted PC1, PC2, and PC3 scores. Age at assessment and gender identity were added as covariates. Two outliers were excluded.

	Dependent variable	Independent variable	Covariates
Model 1	Friendship quality	Cumulative CA	Age, Gender
Model 2	Friendship quality	Deprivation + Threat experiences	Age, Gender
Model 3	Friendship quality	Deprivation experiences	Age, Gender
Model 4	Friendship quality	Threat experiences	Age, Gender

Table H8.1. Likelihood ratio tests. Models using different approaches to conceptualize CA whilst predicting friendship quality.

	BIC	AIC
Model 1	560.15	547.07
Model 2	564.58	548.89
Model 3	561.25	548.18
Model 4	561.00	547.92

Table H8.2

	χ^2	p
Model 1 vs. Model 2	0.18	.671
Model 1 vs. Model 3	1.10	**<.001**
Model 1 vs. Model 4	0.86	**<.001**
Model 3 vs. Model 4	0.25	**<.001**

Table H8.3

I. Neuroimaging Results (T2; *n* = 60): Full Model Output

	β	SE	t_{46}	*p*
Intercept		2.24	0.31	.756
Cumulative CA	0.14	0.35	0.92	.361
Friendship quality	-0.11	0.06	-0.72	.474
Age	0.12	0.07	0.80	.430
Gender	-0.20	0.35	-1.37	.176
IQ	-0.04	0.02	-0.25	.805
Cumulative CA x Friendship quality	-0.15	0.10	-1.04	.306

Table I.1. Bilateral insula reactivity was not related to cumulative childhood adversity and friendship quality.

	β	SE	t_{46}	*p*
Intercept		2.88	-0.67	.509
Cumulative CA	-0.08	0.45	-0.51	.611
Friendship quality	-0.03	0.07	-0.17	.866
Age	0.26	0.09	1.71	.095
Gender	-0.09	0.46	-0.65	.519
IQ	-0.01	0.02	-0.07	.947
Cumulative CA x Friendship quality	-0.08	0.13	-0.56	.576

Table I.2. Left medial prefrontal cortex reactivity was not related to cumulative childhood adversity and friendship quality.

	β	SE	t_{46}	*p*
Intercept		2.54	1.19	.241
Cumulative CA	0.15	0.39	0.99	.327
Friendship quality	0.16	0.06	1.09	.280
Age	0.07	0.08	0.46	.648
Gender	-0.13	0.40	-0.92	.364
IQ	-0.18	0.02	-1.16	.252
Cumulative CA x Friendship quality	-0.04	0.11	-0.24	.811

Table I.3. Right nucleus accumbens reactivity was not related to cumulative childhood adversity and friendship quality.

	β	SE	t_{46}	p
Intercept		2.20	-0.80	.428
Cumulative CA	-0.04	0.34	-0.28	.778
Friendship quality	-0.15	0.05	-1.04	.304
Age	**0.42**	**0.07**	**2.96**	**.005**
Gender	-0.14	0.35	-1.00	.323
IQ	-0.10	0.02	-0.72	.473
Cumulative CA x Friendship quality	-0.10	0.10	-0.71	.483

Table I.4. Bilateral thalamus reactivity was not related to cumulative childhood adversity and friendship quality.

	β	SE	t_{46}	p
Intercept		1.85	0.41	.681
Cumulative CA	-0.002	0.29	-0.02	.984
Friendship quality	-0.23	0.04	-1.65	.106
Age	**0.31**	**0.06**	**2.09**	**.042**
Gender	-0.09	0.29	-0.63	.531
IQ	-0.23	0.01	-1.56	.125
Cumulative CA x Friendship quality	-0.22	0.08	-1.62	.112

Table I.5. Left hippocampus reactivity was not related to cumulative childhood adversity and friendship quality.

	β	SE	t_{46}	p
Intercept		2.24	0.26	.800
Deprivation experiences	0.15	0.47	1.03	.310
Friendship quality	-0.10	0.05	-0.70	.488
Age	0.12	0.07	0.82	.418
Gender	-0.19	0.35	-1.30	.200
IQ	-0.03	0.02	-0.21	.832
Deprivation experiences x Friendship quality	-0.14	0.13	-0.98	.330

Table I.6. Bilateral insula reactivity was not related to deprivation experiences and friendship quality.

	β	SE	t_{46}	p
Intercept		2.86	-0.60	.550
Deprivation experiences	-0.12	0.60	-0.84	.404
Friendship quality	-0.03	0.06	-0.20	.844
Age	0.26	0.08	1.73	.091
Gender	-0.10	0.45	-0.71	.481
IQ	-0.02	0.02	-0.14	.893
Deprivation experiences x Friendship quality	-0.11	0.16	-0.78	.441

Table I.7. Left medial prefrontal cortex reactivity was not related to deprivation experiences and friendship quality.

	β	SE	t_{46}	p
Intercept		2.56	1.15	.257
Deprivation experiences	0.09	0.54	0.58	.563
Friendship quality	0.15	0.06	0.98	.331
Age	0.08	0.08	0.53	.598
Gender	-0.12	0.40	-0.83	.413
IQ	-0.19	0.02	-1.20	.237
Deprivation experiences x Friendship quality	-0.04	0.14	-0.25	.802

Table I.8. Right nucleus accumbens reactivity was not related to deprivation experiences and friendship quality.

	β	SE	t_{46}	p
Intercept		2.20	-0.79	.433
Deprivation experiences	-0.08	0.46	-0.56	.579
Friendship quality	-0.14	0.05	-1.06	.296
Age	**0.43**	**0.07**	**2.99**	**.004**
Gender	-0.13	0.34	-0.99	.326
IQ	-0.11	0.02	-0.76	.453
Deprivation experiences x Friendship quality	-0.09	0.12	-0.64	.527

Table I.9. Bilateral thalamus reactivity was not related to deprivation experiences and friendship quality.

	β	SE	t_{46}	*p*
Intercept		1.87	0.33	.743
Deprivation experiences	-0.08	0.40	-0.59	.561
Friendship quality	-0.23	0.04	-1.64	.108
Age	**0.31**	**0.06**	**2.16**	**.036**
Gender	-0.07	0.29	-0.48	.635
IQ	-0.23	0.01	-1.56	.127
Deprivation experiences x Friendship quality	-0.14	0.11	-0.99	.328

Table I.10. Left hippocampus reactivity was not related to deprivation experiences and friendship quality.

	β	SE	t_{46}	*p*
Intercept		2.25	0.25	.805
Threat experiences	0.03	0.97	0.21	.839
Friendship quality	-0.14	0.05	-0.90	.372
Age	0.14	0.07	0.92	.363
Gender	-0.18	0.36	-1.24	.220
IQ	-0.05	0.02	-0.32	.752
Threat experiences x Friendship quality	-0.13	0.34	-0.80	.426

Table I.11. Bilateral insula reactivity was not related to threat experiences and friendship quality.

	β	SE	t_{46}	*p*
Intercept		2.88	-0.74	.461
Threat experiences	0.08	1.24	0.51	.614
Friendship quality	0.04	0.07	0.28	.782
Age	0.24	0.09	1.59	.120
Gender	-0.09	0.46	-0.65	.522
IQ	0.02	0.02	0.14	.891
Threat experiences x Friendship quality	0.07	0.43	0.46	.647

Table I.12. Left medial prefrontal cortex reactivity was not related to threat experiences and friendship quality.

	β	SE	t_{46}	p
Intercept		2.49	1.28	.205
Threat experiences	0.25	1.08	1.53	.134
Friendship quality	0.21	0.06	1.35	.185
Age	0.06	0.07	0.37	.717
Gender	-0.15	0.40	-1.05	.297
IQ	-0.17	0.02	-1.14	.262
Threat experiences x Friendship quality	0.06	0.37	0.37	.712

Table I.13. Right nucleus accumbens reactivity was not related to threat experiences and friendship quality.

	β	SE	t_{46}	p
Intercept		2.20	-0.84	.407
Threat experiences	0.03	0.95	0.22	.825
Friendship quality	-0.13	0.05	-0.86	.395
Age	**0.42**	**0.07**	**2.90**	**.006**
Gender	-0.14	0.35	-1.02	.315
IQ	-0.09	0.02	-0.64	.529
Threat experiences x Friendship quality	-0.06	0.33	-0.42	.679

Table I.14. Bilateral thalamus reactivity was not related to threat experiences and friendship quality.

	β	SE	t_{46}	p
Intercept		1.77	0.46	.648
Threat experiences	0.05	0.76	0.31	.756
Friendship quality	-0.26	0.04	-1.84	.072
Age	**0.30**	**0.05**	**2.16**	**.036**
Gender	-0.11	0.28	-0.80	.431
IQ	-0.23	0.01	-1.63	.110
Threat experiences x Friendship quality	**-0.33**	**0.26**	**-2.26**	**.029**

Table I.15. Left hippocampus reactivity was related to threat experiences and friendship quality. This effect did not survive correction for multiple comparisons (p_{Bonf} = .145; corrected for five ROI comparisons).

J. Exploratory Analyses (T2; *n* = 60): Full Model Output

	β	SE	t_{48}	*p*
Intercept		2.17	0.24	.809
Cumulative CA	0.16	0.33	1.11	.273
Age	0.12	0.07	0.79	.433
Gender	-0.19	0.34	-1.27	.212
IQ	-0.03	0.02	-0.17	.866

Table J.1. Bilateral insula reactivity was not related to cumulative childhood adversity.

	β	SE	t_{48}	*p*
Intercept		2.76	-0.77	.444
Cumulative CA	-0.07	0.42	-0.52	.605
Age	0.26	0.08	1.78	.082
Gender	-0.08	0.44	-0.58	.567
IQ	-0.002	0.02	-0.02	.988

Table J.2. Left medial prefrontal cortex reactivity was not related to cumulative childhood.

	β	SE	t_{48}	*p*
Intercept		2.46	1.01	.316
Cumulative CA	0.10	0.38	0.72	.473
Age	0.10	0.07	0.65	.521
Gender	-0.11	0.39	-0.80	.426
IQ	-0.17	0.02	-1.11	.274

Table J.3. Right nucleus accumbens reactivity was not related to cumulative childhood adversity.

	β	SE	t_{48}	*p*
Intercept		2.14	-0.80	.430
Cumulative CA	-0.01	0.33	-0.05	.963
Age	**0.41**	**0.06**	**2.92**	**.005**
Gender	-0.13	0.34	-0.97	.337
IQ	-0.10	0.02	-0.70	.488

Table J.4. Bilateral thalamus reactivity was not related to cumulative childhood adversity.

	β	SE	t_{48}	p
Intercept		1.85	0.37	.714
Cumulative CA	0.05	0.28	0.34	.738
Age	0.29	0.06	1.95	.057
Gender	-0.06	0.29	-0.45	.656
IQ	-0.21	0.01	-1.42	.161

Table J.5. Left hippocampus reactivity was not related to cumulative childhood adversity.

	β	SE	t_{48}	p
Intercept		2.17	0.20	.756
Deprivation experiences	0.16	0.46	0.92	.361
Age	0.12	0.07	0.80	.430
Gender	-0.17	0.34	-1.37	.176
IQ	-0.02	0.02	-1.56	.125

Table J.6. Bilateral insula reactivity was not related to deprivation experiences.

	β	SE	t_{48}	p
Intercept		2.88	-0.67	.509
Deprivation experiences	-0.08	0.45	-0.51	.611
Age	0.26	0.09	1.71	.095
Gender	-0.09	0.46	-0.65	.519
IQ	-0.23	0.01	-1.56	.125

Table J.7. Left medial prefrontal cortex reactivity was not related to deprivation experiences.

	β	SE	t_{48}	p
Intercept		2.48	1.00	.322
Deprivation experiences	0.05	0.52	0.37	.716
Age	0.10	0.07	0.69	.491
Gender	-0.11	0.39	-0.74	.461
IQ	-0.18	0.02	-1.15	.256

Table J.8. Right nucleus accumbens reactivity was not related to deprivation experiences.

	β	SE	t_{48}	p
Intercept		2.14	-0.77	.445
Deprivation experiences	-0.05	0.45	-0.41	.684
Age	**0.41**	**0.06**	**2.96**	**.005**
Gender	-0.13	0.34	-0.97	.338
IQ	-0.11	0.02	-0.76	.453

Table J.9. Bilateral thalamus reactivity was not related to deprivation experiences.

	β	SE	t_{48}	*p*
Intercept		1.86	0.40	.693
Deprivation experiences	-0.05	0.39	-0.34	.738
Age	**0.30**	**0.06**	**2.02**	**.049**
Gender	-0.06	0.29	-0.41	.688
IQ	-0.23	0.01	-1.53	.134

Table J.10. Left hippocampus reactivity was not related to deprivation experiences.

	β	SE	t_{48}	*p*
Intercept		2.19	0.31	.755
Threat experiences	0.11	0.86	0.76	.453
Age	0.12	0.07	0.81	.425
Gender	-0.18	0.35	-1.28	.208
IQ	-0.04	0.02	-0.26	.793

Table J.11. Bilateral insula reactivity was not related to threat experiences.

	β	SE	t_{48}	*p*
Intercept		2.77	-0.76	.451
Threat experiences	0.05	1.09	0.35	.730
Age	0.25	0.08	1.67	.101
Gender	-0.10	0.45	-0.69	.496
IQ	0.01	0.02	0.09	.925

Table J.12. Left medial prefrontal cortex reactivity was not related to threat experiences.

	β	SE	t_{48}	*p*
Intercept		2.44	1.11	.272
Threat experiences	0.17	0.96	1.18	.242
Age	0.09	0.07	0.58	.565
Gender	-0.14	0.39	-0.95	.345
IQ	-0.18	0.02	-1.12	.267

Table J.13. Right nucleus accumbens reactivity was not related to threat experiences.

	β	SE	t_{48}	*p*
Intercept		2.13	-0.76	.451
Threat experiences	-0.09	0.84	0.65	.522
Age	**0.40**	**0.06**	**2.84**	**.007**
Gender	-0.15	0.34	-1.09	.281
IQ	-0.09	0.02	-0.64	.525

Table J.14. Bilateral thalamus reactivity was not related to threat experiences.

	β	SE	t_{48}	p
Intercept		1.81	0.48	.635
Threat experiences	0.21	0.71	1.53	.133
Age	0.26	0.05	1.84	.072
Gender	-0.10	0.29	-0.71	.479
IQ	-0.20	0.01	-1.38	.175

Table J.15. Left hippocampus reactivity was not related to threat experiences.