



BASIC RESEARCH ARTICLE



Using explainable machine learning to investigate the relationship between childhood maltreatment, positive psychological traits, and CPTSD symptoms

Xiaoxiao Zhou^{a,b}, Zongbao Liang^{b,c} and Guangzhen Zhang^{b,c}

^aDepartment of Medical Humanities, School of Humanities, Southeast University, Nanjing, People's Republic of China; ^bKey Laboratory of Child Development and Learning Science, School of Biological Science & Medical Engineering, Southeast University, Nanjing, People's Republic of China; ^cNational Experimental Base of Intelligent Society Governance (Education), School of Biological Science & Medical Engineering, Southeast University, Nanjing, People's Republic of China

ABSTRACT

Background: The functional impairment resulting from CPTSD symptoms is enduring and far-reaching. Existing research has found that CPTSD symptoms are closely associated with childhood maltreatment; however, researchers debate whether CPTSD symptoms are predominantly influenced by a specific type of childhood maltreatment or the combined influence of multiple maltreatment types.

Objective: (1) Examines the impact of childhood maltreatment on CPTSD symptoms, specifically exploring whether specific types of maltreatment or the cumulative exposure to multiple types of maltreatment play a predominant role. (2) Investigates the role of positive psychological traits in this relationship, assessing whether these traits serve as protective factors or are outcomes of the negative psychological consequences of maltreatment.

Methods: A sample of 1894 adolescents ($M_{age}=13.88$; $SD=1.00$) from a chronically impoverished rural area in China completed the International Trauma Questionnaire – Child and Adolescent Version for CPTSD symptoms, the Childhood Trauma Questionnaire – Short Form for childhood maltreatment types. Positive psychological traits, including mindfulness, self-compassion, and gratitude, were measured using the Mindful Attention Awareness Scale (MAAS), the Self-Compassion Scale – Short Form, and the Gratitude Questionnaire. We addressed the research question using explainable machine learning methods, with SHAP enhancing model interpretability.

Results: The findings indicate that emotional abuse is the most effective predictor of CPTSD symptoms, with individuals who experienced emotional abuse showing higher rates of other forms of maltreatment. Among positive psychological traits, mindfulness contributes the most, followed by self-compassion, while gratitude shows no significant association with CPTSD symptoms. Additionally, individuals with poor positive psychological traits are more likely to have experienced maltreatment, whereas those with higher positive traits are less exposed to abuse.

Conclusions: Emotional abuse and low levels of positive psychological traits are strongly associated with CPTSD symptoms in adolescents from impoverished areas, with positive traits showing limited buffering effects against maltreatment.

Uso del aprendizaje automático explicable para investigar la relación entre el maltrato infantil, los rasgos psicológicos positivos y los síntomas del TEPTC

Antecedentes: El deterioro funcional resultante de los síntomas del TEPT complejo (TEPTC) es duradero y de gran alcance. La investigación existente ha encontrado que los síntomas del TEPTC están estrechamente asociados con el maltrato infantil; sin embargo, los investigadores debaten si los síntomas del TEPTC están predominantemente influenciados por un tipo específico de maltrato infantil o por la influencia combinada de múltiples tipos de maltrato.

Objetivo: (1) Examinar el impacto del maltrato infantil en los síntomas del TEPTC, explorando específicamente si los tipos específicos de maltrato o la exposición acumulativa a múltiples tipos de maltrato juegan un papel predominante; (2) investigar el papel de los rasgos psicológicos positivos en esta relación, evaluando si estos rasgos sirven como factores protectores o son resultados de las consecuencias psicológicas negativas del maltrato.

Método: Una muestra de 1.894 adolescentes ($M_{edad}=13.88$; $DE=1.00$) de una zona rural crónicamente empobrecida de China completaron el Cuestionario Internacional de Trauma – Versión para niños y adolescentes para los síntomas de TEPT, el Cuestionario de Trauma Infantil – Formulario corto para los tipos de maltrato infantil. Los rasgos psicológicos

ARTICLE HISTORY

Received 11 July 2024
Revised 15 November 2024
Accepted 6 January 2025

KEYWORDS

Explainable machine learning; SHAP; CPTSD; childhood maltreatment; positive psychological traits

PALABRAS CLAVE

TEPTC; maltrato infantil; rasgos psicológicos positivos; aprendizaje automático explicable

HIGHLIGHTS

- Emotional abuse is the strongest predictor of CPTSD symptoms.
- Individuals who have experienced high levels of emotional abuse are more likely to suffer from other forms of maltreatment and exhibit lower levels of positive psychological traits compared to those with low levels of emotional abuse.
- Positive psychological traits did not show a significant buffering role between childhood maltreatment and CPTSD symptoms.

positivos, incluyendo la atención plena, la autocompasión y la gratitud, se midieron utilizando la Escala de Conciencia de Atención Plena (MAAS por sus siglas en inglés), la Escala de Autocompasión – Versión Corta, y el Cuestionario de Gratitud. Abordamos la pregunta de investigación utilizando métodos de aprendizaje automático explicable, con SHAP para mejorar la interpretabilidad del modelo.

Resultados: Los hallazgos indican que el maltrato emocional es el factor predictivo más eficaz de síntomas del TEPTC, y que las personas que sufrieron maltrato emocional presentan tasas más elevadas de otras formas de maltrato. Entre los rasgos psicológicos positivos, el mindfulness es el que más contribuye, seguido de la autocompasión, mientras que la gratitud no muestra una asociación significativa con los síntomas del TEPTC. Además, los individuos con rasgos psicológicos positivos deficientes tienen más probabilidades de haber sufrido maltrato, mientras que aquellos con rasgos positivos más elevados están menos expuestos al abuso.

Conclusiones: El abuso emocional y los bajos niveles de rasgos psicológicos positivos están fuertemente asociados con síntomas de TEPTC en adolescentes de zonas empobrecidas, mientras que los rasgos positivos muestran efectos amortiguadores limitados contra el maltrato.

1. Introduction

Complex Post-Traumatic Stress Disorder (CPTSD) was incorporated into the ICD-11 in 2018. This diagnosis integrates the fundamental symptom clusters found in Post-Traumatic Stress Disorder (PTSD) with three additional clusters related to disturbances in self-organization (DSO): affective dysregulation, a negative self-concept, and difficulties in interpersonal relationships (WHO, 2019).

Individuals diagnosed with CPTSD typically endure more prolonged trauma and exhibit lower mental health statuses compared to those with PTSD (Cloitre et al., 2019; Jannini et al., 2023; Shin et al., 2021). Moreover, they are likely to have a higher incidence of comorbid conditions (Haselgruber et al., 2021; Hyland et al., 2018; Møller et al., 2021) and more significant functional impairments (Brewin et al., 2017; Haselgruber et al., 2020a; Karatzias et al., 2017b; Karatzias et al., 2019a). Research consistently demonstrates that CPTSD is more prevalent than PTSD. Cross-cultural studies conducted in various regions, including North America (USA), Europe (UK, Germany, Lithuania), Africa (Ghana, Kenya, Nigeria), and East Asia (China, Korea, Japan), indicate that the incidence of CPTSD is generally two to three times higher than that of PTSD (Charak et al., 2022; Ho et al., 2020; Karatzias et al., 2017a; Kazlauskas et al., 2022). This pattern is evident in both adult and adolescent populations (Fung et al., 2023; Tian et al., 2020, 2022).

The repercussions of childhood maltreatment on individual growth and development are profound, and this early maltreatment is a well-documented risk factor for a spectrum of psychiatric conditions, including depression, schizophrenia, and bipolar disorder (Agnew-Blais & Danese, 2016; Baldwin et al., 2023; Fusar-Poli et al., 2017; Humphreys et al., 2020; Mandelli et al., 2015; Marques-Feixa et al., 2023; Radua et al., 2018). Furthermore, childhood

maltreatment serves as a critical risk factor for CPTSD (Gallagher et al., 2023; Kira et al., 2022). Current research on childhood maltreatment and CPTSD symptoms can be broadly categorized into two types. Variable-centred studies typically focus on the impact of specific types of abuse on CPTSD symptoms. For instance, some studies identify emotional abuse during childhood as a primary predictor of CPTSD symptoms (Gallagher et al., 2023; Lortye et al., 2024), while others highlight sexual and physical abuse by caregivers as significant risk factors (Cloitre et al., 2019). In contrast, person-centred studies examine how childhood maltreatment impacts CPTSD symptoms through the cumulative exposure to multiple types of maltreatment or different subtypes. These studies suggest that the more types of maltreatment an individual experiences, the more severe the CPTSD symptoms tend to be (Brown et al., 2019; Cloitre et al., 2019; Frost et al., 2019; Sölva et al., 2020; Tian et al., 2022). However, due to limitations in data analysis methods, variable-centred studies typically rely on multiple regression analysis or structural equation modelling, which are unable to account for the cumulative impact of the five types of childhood maltreatment on individuals. Although person-centred studies address this issue more effectively, they often use methods that quantify traumatic events by tallying their occurrences or by categorizing continuous variables into binary classifications based on scale threshold values, along with various clustering techniques. These approaches often lead to substantial information loss, making it challenging to conduct an in-depth analysis of relationships among variables. Given these limitations in current research methodologies, more refined approaches are clearly needed to effectively explore the relationship between childhood maltreatment and CPTSD symptoms.

Previous studies have suggested that self-compassion, mindfulness, and gratitude may serve as protective factors in coping with abuse or trauma,

potentially helping individuals alleviate the negative impacts of trauma-related symptoms (Karatzias et al., 2019a, 2019b; Lassri et al., 2023; Richardson & Gallagher, 2021; Zhang et al., 2021). Some studies have treated these positive psychological traits as moderating or mediating variables in models, assuming that significant path effects indicate protective properties (McQuillan et al., 2022; Wu et al., 2022). However, significant moderation or mediation effects do not necessarily equate to protective functions, as these analyses often assume sample homogeneity, which may not be accurate in practice (Howard & Hoffman, 2018). Research has shown that these positive psychological traits may be impaired by adverse early experiences (Huang et al., 2021, 2024; Lavelock et al., 2016; Zhang et al., 2023), potentially leading to systematic differences across groups with varying levels of abuse, thus impacting model results and leading to spurious moderation or mediation effects. Some intervention studies have indeed found that trauma symptoms significantly improve following interventions aimed at enhancing these traits (Dumarkaite et al., 2021; Salvesen et al., 2023), suggesting that they may serve as effective intervention targets. However, this does not necessarily mean that these traits function as protective factors in naturalistic settings; rather, they may simply reflect psychological characteristics that are impacted by trauma, similar to the symptoms associated with CPTSD. Therefore, it is essential to further investigate the relationship between these positive psychological traits, childhood abuse, and CPTSD symptoms to determine whether these traits genuinely serve as protective factors or if they are primarily trauma-related psychological outcomes.

Addressing the limitations of traditional analytical techniques, researchers are increasingly advocating for the application of machine learning in the study of childhood maltreatment (Danese, 2020). Machine learning addresses this by prioritizing the prediction of outcomes on unobserved data – that is, ‘out-of-sample’ data not used in the model fitting process. It constructs models based on the complex, nonlinear relationships between predictive factors and outcome variables, while incorporating regularization and cross-validation to avert overfitting and enhance model robustness. The ‘black box’ properties of machine learning can be interpreted and visualized through SHapley Additive exPlanations (SHAP). SHAP, as one of the most comprehensive and reliable post-hoc explanation methods, provides a global perspective on variable significance and direction of influence. It identifies key predictors and whether they positively or negatively impact the outcome, while also offering insights into interdependencies between variables (Lundberg & Lee, 2017; Yarkoni & Westfall, 2017). Although machine learning’s interpretability has greatly enhanced its application across various

fields (Injadat et al., 2021), its use in psychology and psychiatry is still in the early stages. Nevertheless, the features of interpretability, high-level visualization, and the capability to analyze individual samples are expected to drive person-centred research in psychology and psychiatry.

In this study, applying interpretability methods allows for analyzing the contribution of different maltreatment types to CPTSD symptoms while directly observing interdependencies among maltreatment types. Previous abuse research has often used cumulative scores on the CTQ scale to represent maltreatment severity or pre-defined cutoffs to classify abused and non-abused groups. While such thresholds are commonly used in epidemiological studies, they may vary by culture and age (Xu et al., 2023), potentially leading to information loss and limiting analysis depth. The highly visual nature of explainable machine learning allows for analyzing the relationship between cumulative maltreatment scores and CPTSD symptoms, while also enabling post-hoc threshold analysis directly within result visualizations, as scale scores can be observed directly in the output. Additionally, this approach can consider multiple positive psychological traits simultaneously, identifying the most influential features and examining their roles in the relationship between abuse and CPTSD symptoms.

Current research on the relationship between childhood maltreatment and CPTSD symptoms remains contentious, with limited studies examining the interplay between childhood maltreatment, positive psychological traits, and CPTSD symptoms. Additionally, many research samples in this area are derived from adult populations in economically average or affluent regions, with relatively few studies focusing on adolescents from low-income areas who often face increased risks of abuse and neglect (Cai, 2022; Kim & Drake, 2023). These adolescents are at a higher risk of developing CPTSD (Rink & Lipinska, 2020). Yet psychological support resources are limited in low-income regions. It is essential to investigate the relationship between childhood maltreatment and CPTSD symptoms, especially examining the role of positive psychological traits that are often assumed to serve as protective factors. A deeper understanding of these factors may enable more efficient use of the limited mental health resources in these areas, directing aid where it can be most impactful. To address these gaps, the present study employs explainable machine learning techniques to explore the relationships between childhood maltreatment, positive psychological traits, and CPTSD symptoms among adolescents from low-income rural families. This research aims to address two primary limitations of current studies:

RQ1: How does childhood maltreatment predict CPTSD symptoms? Does the specific type of

maltreatment or the cumulative exposure to multiple types of maltreatment have the most significant impact?

RQ2: What role do positive psychological traits play in the relationship between childhood maltreatment and CPTSD symptoms? Are these traits protective factors, or do they represent negative psychological outcomes associated with childhood maltreatment?

2. Methods

2.1. Participants

This study was conducted at a semi-boarding public junior high school in a chronically impoverished rural area of China. Out of 1999 initially invited students, 1920 completed the survey, resulting in a 96% response rate. Data for 79 students were missing and 26 students were excluded for failing attention checks. The final sample included 1894 Chinese adolescents (94.7% response rate), comprising 975 males and 919 females, with an average age of 13.88 years ($SD = 0.995$). Participants provided information on demographic, social characteristics and study variables.

2.2. Materials

2.2.1. CPTSD

The International Trauma Questionnaire (ITQ) is a reliable and effective instrument for assessing CPTSD, particularly its version for children and adolescents (ITQ-CA). This variant effectively measures CPTSD in younger populations and has been validated within a Chinese adolescent cohort (Haselgruber et al., 2020b; Ho et al., 2022; Kazlauskas et al., 2020). It comprises 12 items and employs a 5-point Likert scale for responses, ranging from 0 (not at all) to 4 (extremely). Higher cumulative scores on this scale indicate greater severity of symptoms. In this study, the Cronbach's α for the ITQ-CA was 0.903.

2.2.2. Childhood maltreatment

The Childhood Trauma Questionnaire-Short Form (CTQ-SF) assesses five types of childhood maltreatment: emotional neglect, emotional abuse, physical neglect, physical abuse, and sexual abuse (Bernstein et al., 2003). Each subscale consists of five core items and three items for validity testing, with its efficacy validated among Chinese youth (Li et al., 2014). The scores from each subscale are cumulative, with higher scores indicating more severe maltreatment of that specific type. In this study, the overall scale reported a Cronbach's α of 0.839. The subscale values were as follows: 0.746 for sexual abuse, 0.701 for emotional abuse, 0.792 for emotional neglect, and 0.652 for physical abuse. An exception was noted with the physical neglect scale, which showed a low

Cronbach's α of 0.441 – a pattern similarly observed in multiple studies (Badenes-Ribera et al., 2024; Sölva et al., 2020). Although this value falls below typical reliability thresholds, the cumulative score is still considered indicative of a certain level of physical neglect. Therefore, results involving this scale will be interpreted with caution. Additionally, the robustness of the machine learning model helps mitigate potential adverse effects of low reliability on the overall analysis. A sensitivity analysis was conducted for the physical neglect variable, and findings indicate that this low reliability does not compromise the model's stability.

2.2.3. Self-compassion

The Short Form of the Self-Compassion Scale (SCS-SF) is recognized as an effective tool for assessment (Neff, 2016, 2023; Raes et al., 2011), with the Chinese version also exhibiting favourable measurement characteristics (Chen et al., 2011; Huang et al., 2023). This scale comprises six dimensions: self-kindness, self-judgment, common humanity, isolation, mindfulness, and over-identification, with a total of 12 items. It employs a 5-point Likert scale (1 = almost never, 5 = almost always). Scores are calculated by reverse-scoring specific items and summing to obtain the overall scale score, where higher scores signify greater self-compassion. The Cronbach's α for this scale is 0.708.

2.2.4. Mindfulness

The Mindful Attention Awareness Scale (MAAS) is recognized as a valid instrument for assessing trait mindfulness (Brown & Ryan, 2003), and it also demonstrates robust measurement properties in studies involving Chinese adolescents (Black et al., 2012). This scale includes 15 items, scored on a 6-point Likert scale (1 = almost always, 6 = almost never). The overall score is derived by totalling the item scores, where higher totals reflect greater mindfulness. The Cronbach's α for the scale is 0.872.

2.2.5. Gratitude

The Gratitude Questionnaire-6 (GQ-6) exhibits good measurement characteristics in adolescents (Froh et al., 2011). The GQ-6 consists of six items, each scored on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree). The total score of the six items is calculated, with higher scores indicating greater levels of gratitude. The Cronbach's α for this questionnaire is 0.689.

2.3. Measurement procedure

Data were collected via group testing in the school computer lab, with sessions comprising 40 students each, supervised by one researcher and three

assistants. Ethical approval for this study was obtained from the ethics committee of the corresponding author's institution. All participants and their legal guardians signed an informed consent form. Prior to data collection, the researcher read the instructions aloud to the class, encouraging participants to answer according to their true feelings and experiences, noting that there were no 'right' or 'wrong' answers. Participants were assured that all responses would remain confidential and would not be shared with parents, teachers, or anyone else, and that their data would be anonymized for research purposes. They were also informed that they could withdraw from the study at any time.

2.4. Data analysis

Data entry and management were conducted using SPSS 23.0. During data cleaning, each variable was assessed for missing values, with none exceeding 0.3%. Given the minimal amount of missing data, we chose to impute values based on each variable's mean. Demographic variables were standardized to ensure uniform input formats compatible with machine learning algorithms.

To analyze linear relationships among variables, we calculated Pearson correlation coefficients, which allowed us to examine potential multicollinearity issues. To further identify features with significant explanatory power for the dependent variable, we employed Elastic Net for feature selection. Elastic Net, which combines L1 and L2 regularization, is particularly effective in handling multicollinearity while isolating features with strong associations to the outcome variable. Through cross-validation, we optimized the Elastic Net parameters to identify features that enhance interpretability while minimizing model complexity.

Following feature selection, we constructed three machine learning models using LightGBM, Random Forest, and Decision Tree algorithms. For RQ1, Model 1 utilized five types of maltreatment and key demographic variables as predictors, with CPTSD symptoms as the outcome variable. For RQ2, we incorporated positive psychological traits as an additional variable in Model 2 to explore their relationship with maltreatment and CPTSD symptoms.

The dataset was split into training and testing sets at an 8:2 ratio, with 5-fold cross-validation employed to assess model performance, ensuring robustness and generalizability. We utilized the SHAP library to generate various visualizations, including summary plots, SHAP dependency plots, and scatter plots, which facilitated a deeper understanding of the contribution and relationships of each type of maltreatment and positive psychological traits in predicting CPTSD symptoms.

Model performance was evaluated using R^2 , MAE, MSE, and RMSE. These metrics provided a comprehensive assessment of prediction accuracy and error magnitude, offering valuable insights for model optimization and interpretation of results.

3. Results

3.1. Participant characteristics

The study included 1894 participants aged between 12 and 17 years. Among these, 51.5% were male and 48.5% were female. Predominantly, 83.9% of participants were from rural households, 93.2% were not single children, and 75% were identified as left-behind children. Detailed demographic data are presented in Table 1.

3.2. Correlation analysis

The means, *SD*, and Pearson correlation coefficients for the variables are presented in Table 2. Among

Table 1. Demographic and social characteristics of participants.

	<i>N (%)</i>
<i>Age</i>	
12 years old	7.1%
13 years old	29.2%
14 years old	37.2%
15 years old	21.5%
16 years old	4.7%
17 years old	0.3%
<i>Gender</i>	
Male	51.5
Female	48.5
<i>Household Registration</i>	
Rural	83.9
Urban	16.1
<i>Only Child</i>	
Yes	6.8
No	93.2
<i>Marital Status of Parents</i>	
Normal	89.6
Divorced	7.7
Other	2.7
<i>Father's Educational Level</i>	
Junior high school and below	65.0
High school, vocational school	26.9
College and above	8.1
<i>Mother's Educational Level</i>	
Junior high school and below	69.4
High school, vocational school	21.9
College and above	8.7
<i>Parental Employment</i>	
Father works away from home alone	46.1
Mother works away from home alone	3.2
Both parents work away from home	17.6
Neither parent works away from home	29.1
Other situations	4.0
<i>Annual Time Spent with Father by Left-Behind Children</i>	
1–3 months	49.2
3–6 months	10.7
6–9 months	3.4
9–12 months	3.5
Not left behind	33.1
<i>Annual Time Spent with Mother by Left-Behind Children</i>	
1–3 months	18.2
3–6 months	5.2
6–9 months	4
9–12 months	39.5
Not left behind	33.1

Table 2. Descriptive statistics and Pearson correlations of variables.

Variables	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9
1. Emotional Abuse	7.58	3.04	1								
2. Emotional Neglect	10.51	4.20	0.50**	1							
3. Physical Abuse	5.95	1.87	0.48**	0.32**	1						
4. Physical Neglect	9.12	2.95	0.41**	0.51**	0.27**	1					
5. Sexual Abuse	5.51	1.50	0.32**	0.14**	0.42**	0.20**	1				
6. Self-Compassion	3.10	0.56	−0.44**	−0.42**	−0.14**	−0.30**	−0.11**	1			
7. Mindfulness	64.32	12.27	−0.45**	−0.27**	−0.21**	−0.25**	−0.17**	0.47**	1		
8. Gratitude	23.81	5.29	−0.32**	−0.49**	−0.16**	−0.33**	−0.12**	0.39**	0.24**	1	
9. CPTSD symptoms	13.83	9.29	0.53**	0.39**	0.29**	0.33**	0.19**	−0.55**	−0.65**	−0.31**	1

Note: $N = 1894$, * $p < .05$, ** $p < .01$.

the positive psychological traits, self-compassion and gratitude show a moderately strong positive correlation ($r = 0.39$), while both exhibit a higher correlation with mindfulness ($r = 0.47$), suggesting some degree of interrelation among these variables. However, the correlation coefficients among all variables are less than or equal to 0.8 (Shrestha, 2020), indicating that significant multicollinearity is unlikely within the model.

3.3. Feature selection outcomes

Given the potential impact of multicollinearity, we applied Elastic Net to screen demographic variables (Age, Gender, Household Registration, Only Child Status, Parental Marital Status, Father's Educational Level, Mother's Educational Level, and Parental Employment), types of maltreatment (Emotional Neglect, Emotional Abuse, Physical Neglect, Physical Abuse, and Sexual Abuse), and positive psychological traits (Mindfulness, Self-Compassion, and Gratitude) prior to training the machine learning models. This approach was chosen to reduce redundant information and enhance model stability. Elastic Net combines L1 and L2 regularization, making it particularly suitable for handling multicollinearity while identifying features with stronger associations to the outcome variable.

Based on the results from Elastic Net selection, further details are provided in Table 3.

Mindfulness and self-compassion were retained in the model through Elastic Net selection, indicating that both contribute significantly to the model, with their contributions to the target variable not entirely overlapping. Each feature provides distinct and crucial information deemed essential for the model. Although some multicollinearity is unavoidable, it remains within an

acceptable range. Among the various demographic variables, only gender and parental marital status were retained, while other less important variables were excluded.

Although the coefficient for sexual abuse is relatively low, it has been retained in the model due to its theoretical and practical significance, as underscored in prior research. This inclusion allows for further investigation into its potential relationship with CPTSD symptoms.

3.4. Machine learning model evaluation and interpretation

Models 1 and 2 were constructed using LightGBM, Random Forest, and Decision Tree algorithms and subsequently evaluated. Detailed performance metrics are provided in Table 4.

In Model 1, only maltreatment types and key demographic variables were included. The R^2 values for each algorithm ranged from 0.30 to 0.36, with Random Forest achieving the highest R^2 (0.36), followed by LightGBM ($R^2 = 0.31$) and Decision Tree ($R^2 = 0.30$). In terms of RMSE and MAE, Random Forest outperformed the other algorithms, with an RMSE of 7.75 and an MAE of 6.02, indicating relatively better error control for this model.

In Model 2, the addition of positive psychological traits led to improved performance across all algorithms. The R^2 for Random Forest increased to 0.58, while LightGBM and Decision Tree achieved R^2 values of 0.45 and 0.51, respectively. Notably, with the inclusion of positive psychological traits, the Random Forest algorithm was able to explain 58% of the variance in CPTSD symptoms. Regarding error metrics, Model 2 showed reductions in both RMSE and MAE. Specifically, the RMSE for Random Forest decreased to 6.26,

Table 3. Key features and corresponding coefficients.

Variable	Coefficient
Mindfulness	−3.66
Self-Compassion	−2.07
Gratitude	−0.14
Emotional Abuse	1.35
Emotional Neglect	0.43
Physical Abuse	0.67
Physical Neglect	0.21
Marital Status of Parents	0.43
Gender	0.39

Table 4. Model performance metrics for different algorithms.

	Variables	R^2	MAE	MSE	RMSE
Model 1	LightGBM	0.31	6.32	64.42	8.03
	Random forest	0.36	6.22	60.02	7.75
	Decision Tree	0.30	6.38	65.31	8.08
Model 2	LightGBM	0.46	5.48	50.77	7.13
	Random forest	0.58	4.89	39.19	6.26
	Decision Tree	0.51	5.25	46.06	6.79

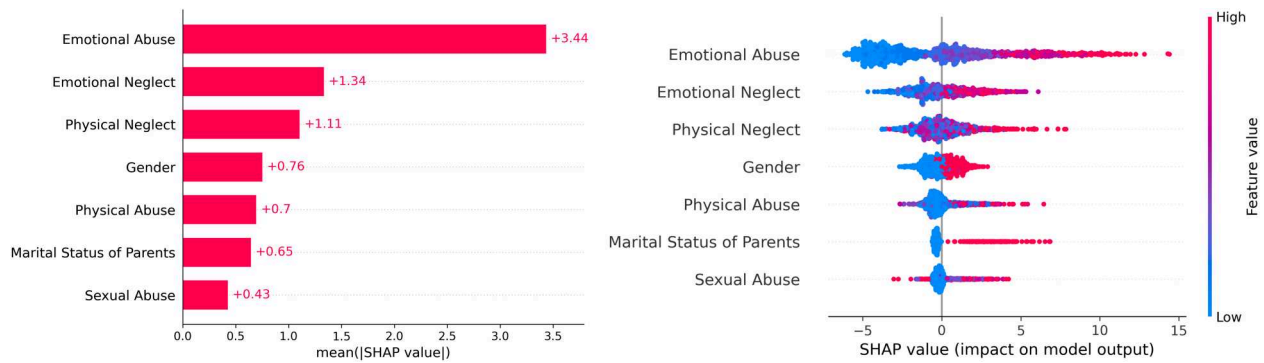


Figure 1. SHAP value analysis of predictors for CPTSD symptoms.

and the MAE to 4.89, further demonstrating that incorporating positive psychological traits significantly enhanced model fit, reduced error, and improved predictive accuracy.

3.5. Machine learning model interpretation

To address RQ1, we built Model 1 with predictors including five types of childhood maltreatment, gender, and parental marital status. The results are presented in Figure 1. The left panel presents a histogram of absolute SHAP values, while the right panel displays the distribution of SHAP values for each factor.

The left panel of Figure 1 displays the mean absolute SHAP values for the five types of maltreatment across sample points, where higher values indicate greater importance to the dependent variable. This analysis reveals that emotional abuse is the most significant predictor of CPTSD symptoms, with a SHAP value of 3.44, followed by emotional neglect at 1.34 and physical neglect at 1.11.

The right panel of Figure 1 shows the distribution of these maltreatment types, enabling a visual assessment of how predictive features contribute to and influence the outcome variable. The horizontal axis, labelled with SHAP values, represents the magnitude of each feature's contribution to the outcome, with 0 at the centre. Values to the left (SHAP value < 0) indicate a negative influence on the outcome variable, whereas values to the right (SHAP value > 0) suggest a positive influence. The vertical axis represents the feature values, with red indicating higher and blue indicating lower values for each variable. In this model, female gender is coded as 1, male as 0, divorced parental status as 1, and intact parental status as 0. Each dot on this axis corresponds to an individual participant's data point for each feature.

The observations show that high scores for emotional abuse and emotional neglect are predominantly located to the right of the centre axis, generally associated with higher predicted levels of CPTSD symptoms. This pattern suggests that increases in these features are likely related to higher CPTSD

symptom levels. In contrast, the influence of the other three types of maltreatment appears less pronounced. Additionally, findings regarding gender and parental marital status suggest that female participants and those with divorced parents may be associated with higher CPTSD symptom levels.

To further investigate how various types of maltreatment predict CPTSD symptoms and explore their interactions, scatter plots of SHAP values were generated for each type of maltreatment, with locally weighted regression (LOESS) fit curves applied. See Figures 2 and 3 below.

In the left panel, based on the criteria of Bernstein et al. (2003), a threshold score of 13 is used to define emotional abuse, where scores of 13 or higher indicate a history of emotional abuse, and scores below 13 indicate the absence of such experiences. The plot shows that samples with a history of emotional abuse have significantly higher SHAP values than those without, with most SHAP values being positive. This suggests that a history of emotional abuse is associated with higher predicted CPTSD symptom levels. The trend further indicates that as emotional abuse scores increase, SHAP values exhibit a noticeable upward trend, implying a stronger association between higher levels of emotional abuse and CPTSD symptoms. Notably, within the lower range of abuse scores, SHAP values increase more rapidly, suggesting that each additional unit increase in emotional abuse within this range has a larger contribution to the predicted CPTSD symptom levels.

In the right panel, the threshold for emotional neglect is set at 15 (Bernstein et al., 2003). When emotional neglect scores approach or exceed this level, SHAP values increase markedly, with more samples displaying SHAP values greater than zero. This indicates that emotional neglect at or above this threshold (i.e. samples considered to have experienced emotional neglect) may be associated with higher predicted CPTSD symptom levels.

The threshold for physical abuse and physical neglect is set at a score of 10 (Bernstein et al., 2003). The plot shows that when the values for these features

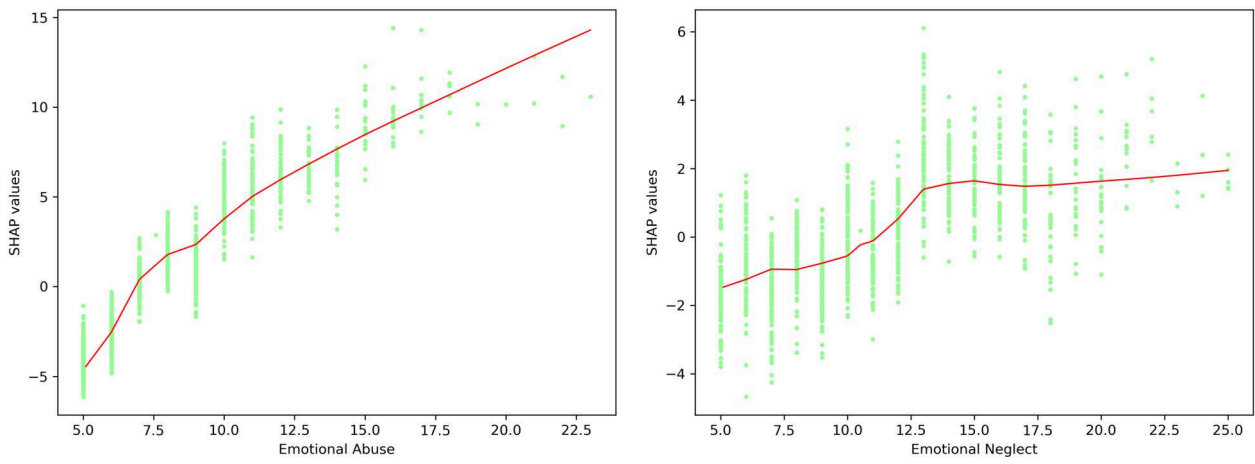


Figure 2. Scatter plots of SHAP values for emotional abuse and emotional neglect.

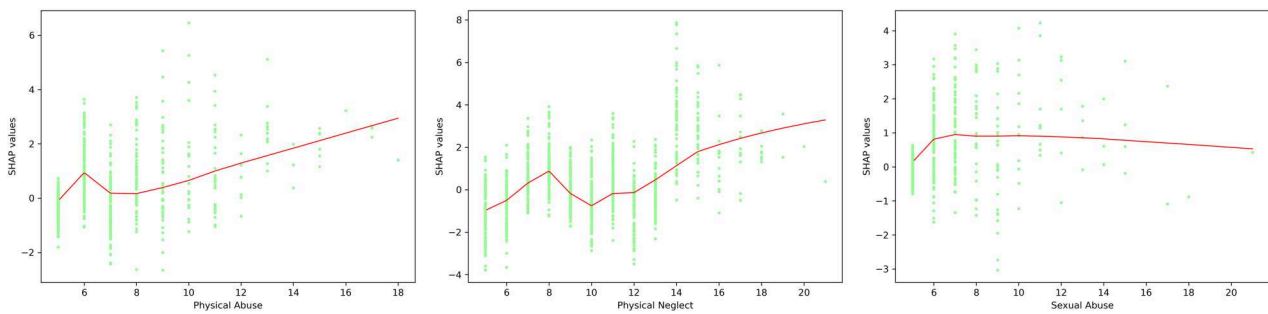


Figure 3. Scatter plots of SHAP values for physical abuse, physical neglect, and sexual abuse.

reach or exceed 10, SHAP values exhibit an upward trend, suggesting that physical abuse and neglect at this level may be associated with higher predicted CPTSD symptom levels.

For sexual abuse, its association with CPTSD symptoms appears weaker. However, this does not imply the absence of a relationship between the two. This finding may be attributed to the relatively small number of participants who experienced sexual abuse in this study, which limits the ability to fully capture their association.

Feature dependence plots for various types of maltreatment are presented in Figure 4. The horizontal axis represents the actual values of the feature, the left vertical axis displays the SHAP values for that feature's contribution to the outcome variable, and the colour bar on the right vertical axis indicates the actual values of another feature.

Analysis of the sample point colours reveals a higher prevalence of high emotional neglect values, followed by physical neglect, while instances of high physical abuse and sexual abuse values are relatively rare. At higher levels of emotional abuse, more samples exhibit high levels of emotional neglect, emotional abuse, and physical neglect compared to samples with lower levels of emotional abuse.

To address the RQ 2, we incorporated positive psychological traits as additional predictive features in the model 2. The results are presented in Figure 5.

Figure 5 presents the SHAP summary plot, where emotional abuse remains the most impactful type of maltreatment (+1.35), followed by emotional neglect and physical neglect. Mindfulness emerges as the most influential feature overall, with a mean SHAP value of +3.76, indicating a strong positive contribution to the model's output. This is followed by self-compassion (+1.9) and gratitude (+1.01), each demonstrating a notable impact. In comparison, demographic variables contribute relatively less, with gender at 0.66 and parental marital status at 0.37.

The right panel illustrates that mindfulness consistently exerts a strong positive effect on the model's output, as shown by the dense clustering of high SHAP values in the positive direction. High feature values for mindfulness produce a particularly pronounced positive influence (Figure 6).

As the level of mindfulness increases, the SHAP values exhibit a gradual downward trend. Higher mindfulness scores are associated with SHAP values leaning toward negative, while lower mindfulness scores correspond with SHAP values that tend to be positive. Similarly, an increase in self-compassion

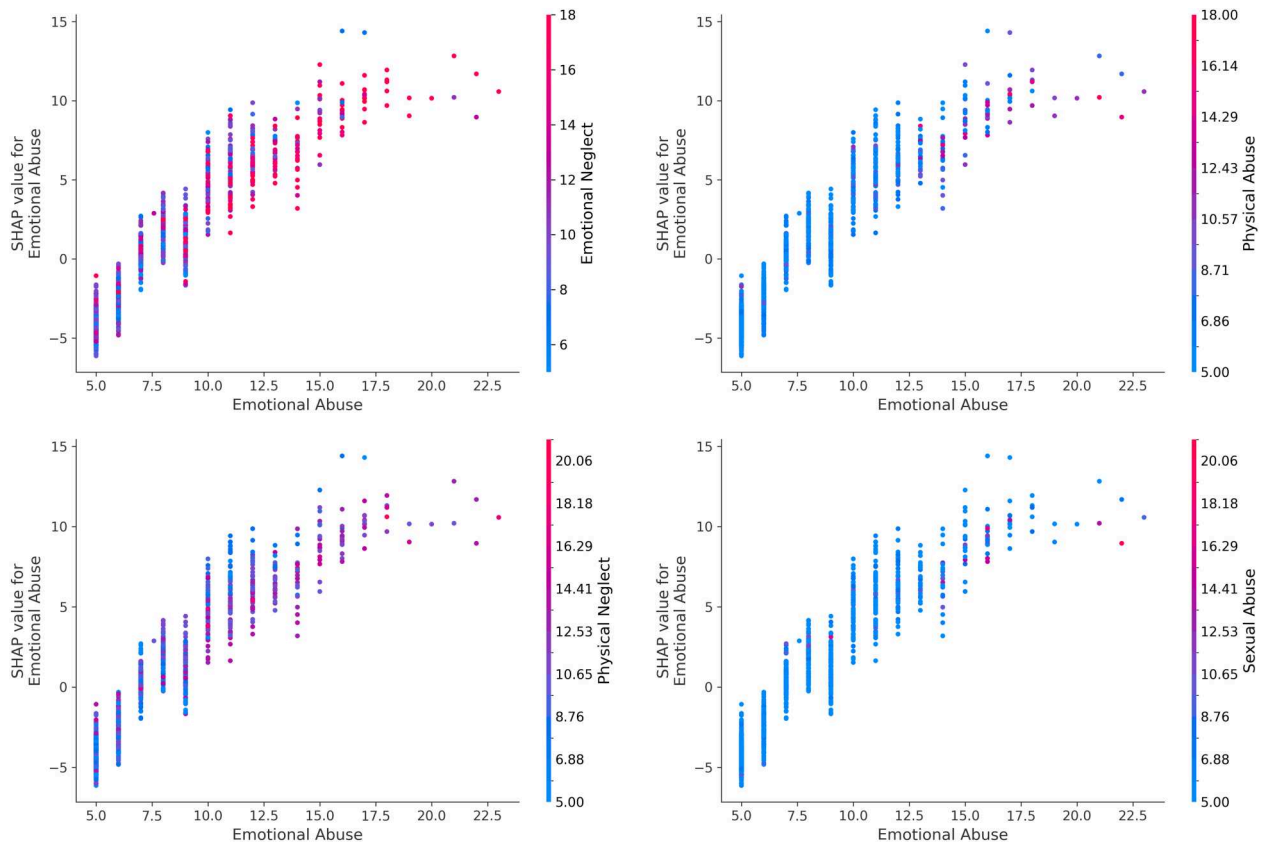


Figure 4. Bivariate feature dependence plot of emotional abuse and other types of maltreatment.

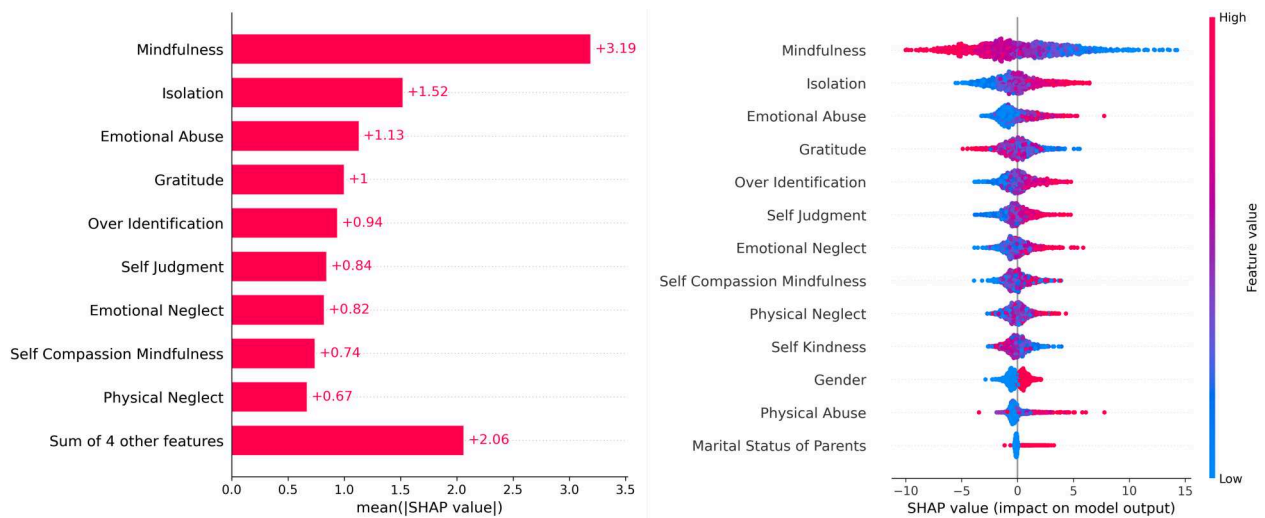


Figure 5. SHAP value analysis of predictors for CPTSD symptoms.

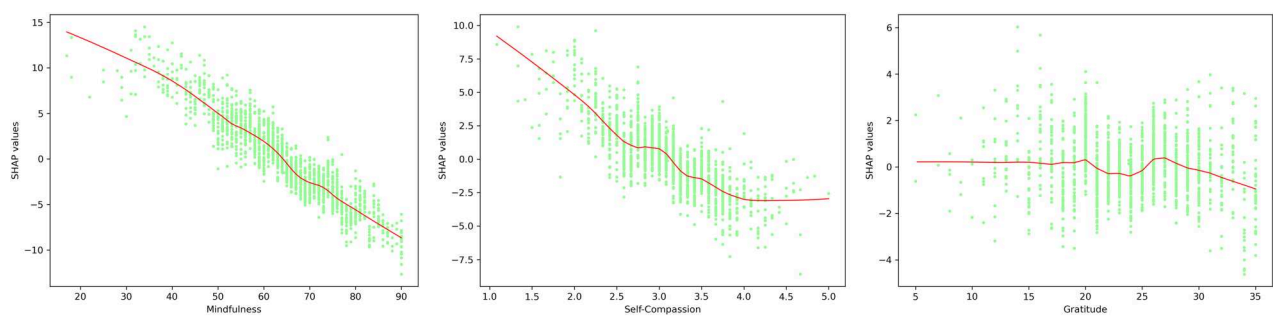


Figure 6. Scatter plots of SHAP values for the three positive psychological traits.

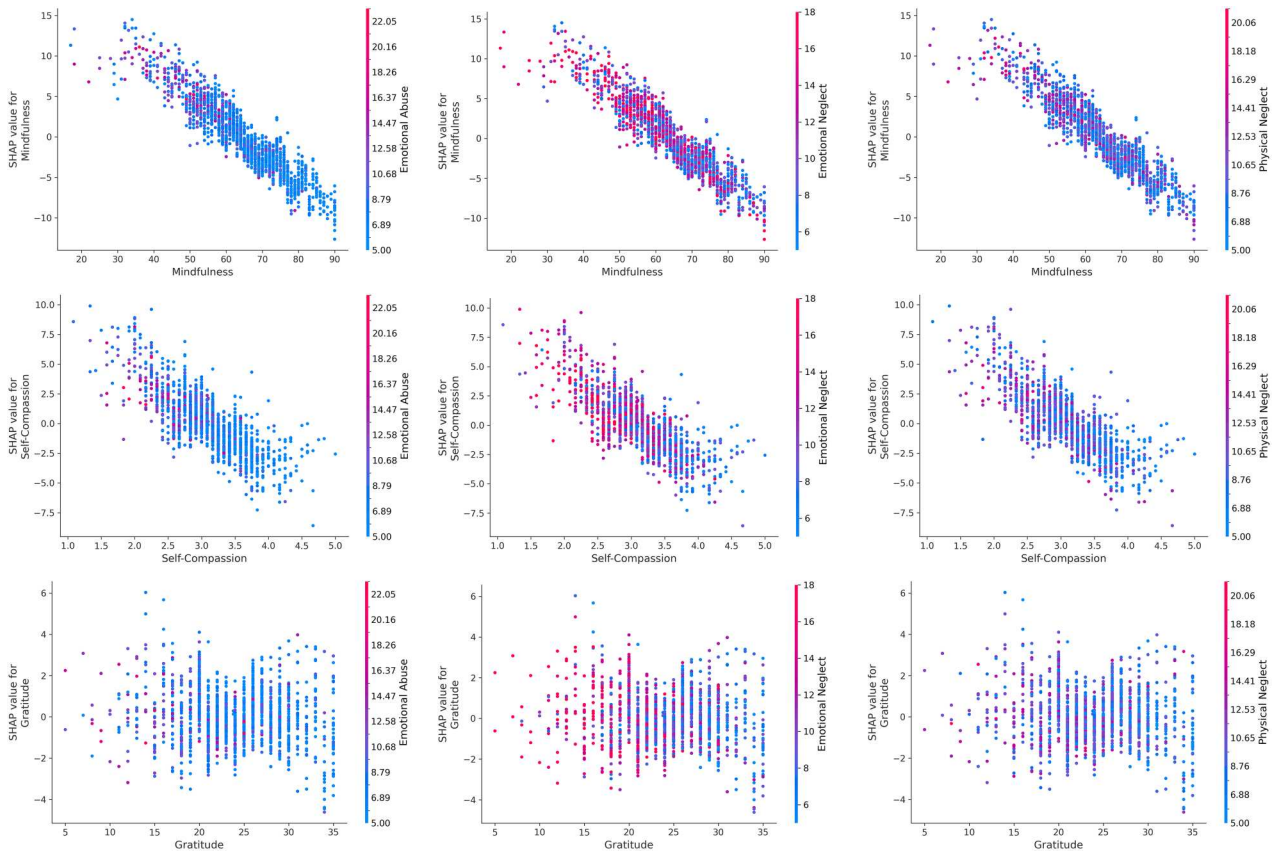


Figure 7. Bivariate feature dependence plot of positive psychological traits and types of maltreatment.

levels is accompanied by a decrease in SHAP values. In regions of low self-compassion, SHAP values are relatively high; however, as self-compassion scores increase, the SHAP values progressively shift toward negative. In contrast, the relationship between gratitude and SHAP values appears relatively stable, with no distinct linear trend overall (Figure 7).

In the mindfulness plot, samples with higher levels of adverse experiences are primarily concentrated in the lower mindfulness range and correspond to higher SHAP values. Conversely, as mindfulness levels increase, the number of samples with high levels of maltreatment gradually decreases. This pattern is particularly evident in the feature dependence plot of mindfulness and emotional abuse (left panel), where positive SHAP values are associated with most samples exhibiting high levels of emotional abuse. This suggests that individuals with low mindfulness and high emotional abuse contribute positively to the predicted CPTSD symptom scores.

A similar co-occurrence is observed in the self-compassion plot, where samples with lower self-compassion tend to have higher levels of maltreatment. As self-compassion increases, the presence of samples with high levels of maltreatment significantly declines. Although SHAP values for gratitude do not display a marked trend, a similar pattern is still noticeable, with fewer high-maltreatment samples as gratitude levels increase.

4. Discussion

The relationship between childhood maltreatment and CPTSD symptoms has long been a significant topic in CPTSD research. This study provides new insights into the relationship among childhood maltreatment, positive psychological traits, and CPTSD symptoms in adolescents from impoverished areas. It explores how childhood maltreatment predicts CPTSD symptoms and the role of positive psychological traits in this process, aiming to inform targeted interventions for CPTSD symptoms.

The results of RQ1 indicate that emotional abuse is the most significant associated factor of CPTSD symptoms, supporting previous variable-centred research findings (Gallagher et al., 2023; Tian et al., 2022). Additionally, the results reveal that individuals who have experienced emotional abuse are more likely to endure emotional neglect and physical neglect. In contrast, those who have not experienced emotional abuse are less likely to encounter other types of maltreatment. This finding aligns with prior person-centred research, which suggests that childhood maltreatment often occurs in cumulative forms or specific combinations of subtypes (Cloitre et al., 2019; Frost et al., 2019; Grasso et al., 2016; Sölva et al., 2020). Furthermore, the results indicate that the effects of maltreatment types and doses are not mutually exclusive.

Notably, even when emotional abuse does not meet the threshold defined by the CTQ, it still demonstrates a significant association with CPTSD symptoms, with stronger correlations observed at sub-threshold levels. This suggests that even mild emotional abuse can have measurable impacts.

According to the Conservation of Resources Theory, particularly its principles of the loss spiral and despair, childhood maltreatment can result in a lack of essential resources needed for growth. The greater the severity and variety of maltreatment, the more likely resources will be lost, and this resource loss can accelerate further losses (Hobfoll, 2001). When resources are depleted or nearly depleted, individuals may enter a negative and irrational defensive mode to protect themselves (Hobfoll et al., 2018), consistent with the symptoms of self-organization disruption in CPTSD. Resource depletion leaves individuals unable to regulate emotions positively, leading to emotional dysregulation. Integrating Early Maladaptive Schema (EMS) theory and attachment theory, emotional abuse reflects a disconnection or rejection by parents, leaving children's core emotional needs – such as love, care, safety, acceptance, and respect – unmet. This often leads to feelings of shame, instability and distrust in interpersonal relationships, and self-isolation (Young et al., 2003), corresponding to the negative self-concept and interpersonal difficulties observed in self-organization disruption symptoms.

RQ2 results indicate that mindfulness shows the strongest negative association with CPTSD symptoms, followed by self-compassion. Gratitude appears to have a weaker association and may be more closely related to PTSD symptoms (Kumar et al., 2022) rather than CPTSD symptoms. In this study, all three positive psychological traits exhibited a similar sample distribution: individuals with low levels of positive psychological traits were more likely to have experienced high levels of maltreatment, while those with stronger positive traits were typically less exposed to maltreatment. This reflects a substantial difference between individuals who experienced abuse and those who did not. However, previous variable-centred studies often operate under the homogeneity assumption, which may not hold true when the sample includes both abused and non-abused individuals. Such biases may contribute to spurious moderation or mediation effects when examining childhood maltreatment. For instance, prior research has frequently identified positive psychological traits such as mindfulness and self-compassion as mediatory or moderating factors (Huang et al., 2021; McQuillan et al., 2022; Wu et al., 2018; Zhang et al., 2023) and considered them protective factors against the adverse effects of childhood maltreatment. However, these conclusions may be insufficiently robust due to underlying biases in sample comparisons and methodological limitations. This

study also revealed a high level of variable dependency between maltreatment and positive psychological traits, with no significant interaction trends observed. Moreover, there were few cases of individuals with high levels of maltreatment who also exhibited strong positive psychological traits.

Therefore, positive psychological traits may not function as protective factors against childhood maltreatment or CPTSD. A more plausible explanation could be that the positive psychological traits of individuals who have experienced maltreatment are in an impaired state. Numerous studies support the notion that childhood adversity is associated with the development of adaptive traits (Kerker et al., 2015; Sciaraffa et al., 2018). While most research focuses on the relationship between childhood maltreatment and poor mental health or psychopathology, some studies examining physiological changes associated with childhood maltreatment have revealed long-term effects, such as HPA axis dysregulation, autonomic dysfunction, and reduced cortical volume (Kalmakis et al., 2015; McLaughlin et al., 2014; van Harmelen et al., 2010). These physiological mechanisms are closely linked to emotional regulation, attention, and stress-adaptive responses (Kemp et al., 2017), suggesting that maltreatment may disrupt the physiological foundations of many positive psychological traits. The classical Sensitization Theory also describes the Fight-Flight-Freeze System (FFFS), which explicitly outlines potential behavioural responses individuals may exhibit when faced with threats (McNaughton & Gray, 2000). When individuals experience maltreatment, they may exhibit fight, flight, or freeze responses, prioritizing their limited psychological resources to deal with the threat rather than developing positive psychological traits or seeking emotional fulfilment. Prolonged exposure to such states restricts the development of positive psychological traits.

The finding that mindfulness and self-compassion surpass emotional abuse as the two strongest predictors does not diminish the importance of emotional abuse. On the one hand, retrospective memory biases may influence reports of childhood maltreatment. On the other hand, while childhood maltreatment is a distal factor, positive psychological traits represent more proximal psychological states and may therefore serve as better predictors of current CPTSD symptoms. This underscores the complex and far-reaching impact of childhood maltreatment. Early Maladaptive Schema theory highlights that individuals with adverse experiences often fail to develop a healthy functioning self that can connect with others and continuously meet core needs in adulthood (Bach et al., 2018). Even after escaping abusive environments, individuals who have suffered maltreatment continue to experience the long-term effects of resource depletion and impaired positive psychological traits, increasing their vulnerability to psychological health risks.

5. Conclusion

The co-occurrence of emotional abuse with other types of maltreatment, along with low levels of positive psychological traits, is closely associated with CPTSD symptoms in adolescents from impoverished areas. Among individuals with low positive psychological traits, most have experienced high levels of maltreatment, whereas those with stronger positive traits are generally less exposed to abuse. This may indicate that positive psychological traits have a limited buffering effect for those subjected to maltreatment. These findings suggest that key positive psychological traits could be incorporated into adolescent mental health screenings, with low levels of these traits considered as risk factors to help identify at-risk populations. In low-income regions with limited access to psychological support resources, prioritizing interventions focused on maltreatment may be more effective in alleviating CPTSD symptoms in adolescents than emphasizing a single positive psychological trait.

6. Limitations

This study has several limitations that warrant consideration. First, the cross-sectional design restricts the ability to infer causal relationships. Future research should employ longitudinal designs to gain a deeper understanding of the relationship between positive psychological traits and CPTSD symptoms. Second, the sample was drawn exclusively from adolescents in a specific low-income region in China. Due to the unique social and cultural context of this population, caution should be exercised when generalizing the findings to other populations or regions. Third, the study included a relatively small number of participants who had experienced sexual abuse, which may have limited the ability to fully assess its significance. This does not diminish the importance of sexual abuse as a factor but underscores the need for future studies with more representative and balanced samples to better evaluate its impact on CPTSD symptoms.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by National Social Science Foundation of China for Education (BBA240046).

CRedit authorship contribution statement

Xiaoxiao Zhou: conceptualization, methodology, project administration, resources, validation, visualization, writing – review & editing. Guangzhen Zhang: writing – review & editing. Zongbao Liang: writing – review & editing.

Ethics declarations

This study was approved by the Institutional Ethics Committee for Clinical Research of Zhongda Hospital, affiliated to Southeast University (Ethics Approval Number: 2021Z0SYLL166-P01).

Data availability statement

The data that has been used is confidential.

References

- Agnew-Blais, J., & Danese, A. (2016). Childhood maltreatment and unfavourable clinical outcomes in bipolar disorder: A systematic review and meta-analysis. *The Lancet Psychiatry*, 3(4), 342–349. [https://doi.org/10.1016/S2215-0366\(15\)00544-1](https://doi.org/10.1016/S2215-0366(15)00544-1)
- Bach, B., Lockwood, G., & Young, J. E. (2018). A new look at the schema therapy model: Organization and role of early maladaptive schemas. *Cognitive Behaviour Therapy*, 47(4), 328–349. <https://doi.org/10.1080/16506073.2017.1410566>
- Badenes-Ribera, L., Georgieva, S., Tomás, J. M., & Navarro-Pérez, J. J. (2024). Internal consistency and test-retest reliability: A reliability generalization meta-analysis of the Childhood Trauma Questionnaire - Short Form (CTQ-SF). *Child Abuse & Neglect*, 154, 106941. <https://doi.org/10.1016/j.chiabu.2024.106941>
- Baldwin, J. R., Wang, B., Karwatowska, L., Schoeler, T., Tsaligopoulou, A., Munafo, M. R., & Pingault, J.-B. (2023). Childhood maltreatment and mental health problems: A systematic review and meta-analysis of quasi-experimental studies. *American Journal of Psychiatry*, 180(2), 117–126. <https://doi.org/10.1176/appi.ajp.20220174>
- Bernstein, D. P., Stein, J. A., Newcomb, M. D., Walker, E., Pogge, D., Ahluvalia, T., Stokes, J., Handelsman, L., Medrano, M., Desmond, D., & Zule, W. (2003). Development and validation of a brief screening version of the Childhood Trauma Questionnaire. *Child Abuse & Neglect*, 27(2), 169–190. [https://doi.org/10.1016/S0145-2134\(02\)00541-0](https://doi.org/10.1016/S0145-2134(02)00541-0)
- Black, D. S., Sussman, S., Johnson, C. A., & Milam, J. (2012). Psychometric assessment of the Mindful Attention Awareness Scale (MAAS) among Chinese adolescents. *Assessment*, 19(1), 42–52. <https://doi.org/10.1177/1073191111415365>
- Brewin, C. R., Cloitre, M., Hyland, P., Shevlin, M., Maercker, A., Bryant, R. A., Humayun, A., Jones, L. M., Kagee, A., Rousseau, C., Somasundaram, D., Suzuki, Y., Wessely, S., van Ommeren, M., & Reed, G. M. (2017). A review of current evidence regarding the ICD-11 proposals for diagnosing PTSD and complex PTSD. *Clinical Psychology Review*, 58, 1–15. <https://doi.org/10.1016/j.cpr.2017.09.001>
- Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, 84(4), 822. <https://doi.org/10.1037/0022-3514.84.4.822>
- Brown, S. M., Rienks, S., McCrae, J. S., & Watamura, S. E. (2019). The co-occurrence of adverse childhood experiences among children investigated for child maltreatment: A latent class analysis. *Child Abuse & Neglect*, 87, 18–27. <https://doi.org/10.1016/j.chiabu.2017.11.010>
- Cai, J. Y. (2022). Economic instability and child maltreatment risk: Evidence from state administrative data. *Child Abuse & Neglect*, 130(Pt 4), 105213. <https://doi.org/10.1016/j.chiabu.2021.105213>

- Charak, R., Cano-Gonzalez, I., Shevlin, M., Ben-Ezra, M., Karatzias, T., & Hyland, P. (2022). Dimensional latent structure of ICD-11 posttraumatic stress disorder, complex PTSD, and adjustment disorder: Evidence from Ghana, Kenya, and Nigeria. *Traumatology*, 28(2), 223. <https://doi.org/10.1037/trm0000311>
- Chen, J., Yan, L. S., & Zhou, L. H. (2011). Reliability and validity of Chinese version of self-compassion scale. *Chinese Journal of Clinical Psychology* 19(6), 734–736.
- Cloitre, M., Hyland, P., Bisson, J. I., Brewin, C. R., Roberts, N. P., Karatzias, T., & Shevlin, M. (2019). ICD-11 Posttraumatic stress disorder and complex posttraumatic stress disorder in the United States: A population-based study. *Journal of Traumatic Stress*, 32(6), 833–842. <https://doi.org/10.1002/jts.22454>
- Danese, A. (2020). Annual research review: Rethinking childhood trauma-new research directions for measurement, study design and analytical strategies. *Journal of Child Psychology and Psychiatry*, 61(3), 236–250. <https://doi.org/10.1111/jcpp.13160>
- Dumarkaite, A., Truskauskaitė-Kuneviciene, I., Andersson, G., Mingaudaite, J., & Kazlauskas, E. (2021). Effects of mindfulness-based internet intervention on ICD-11 post-traumatic stress disorder and complex posttraumatic stress disorder symptoms: A pilot randomized controlled trial. *Mindfulness*, 12(11), 2754–2766. <https://doi.org/10.1007/s12671-021-01739-w>
- Froh, J. J., Fan, J., Emmons, R. A., Bono, G., Huebner, E. S., & Watkins, P. (2011). Measuring gratitude in youth: Assessing the psychometric properties of adult gratitude scales in children and adolescents. *Psychological Assessment*, 23(2), 311–324. <https://doi.org/10.1037/a0021590>
- Frost, R., Louison Vang, M., Karatzias, T., Hyland, P., & Shevlin, M. (2019). The distribution of psychosis, ICD-11 PTSD and complex PTSD symptoms among a trauma-exposed UK general population sample. *Psychosis*, 11(3), 187–198. <https://doi.org/10.1080/17522439.2019.1626472>
- Fung, H. W., Wong, E. N. M., Lam, S. K. K., Chien, W. T., Hung, S. L., Ross, C. A., & Cloitre, M. (2023). Prevalence and sociocultural correlates of post-traumatic stress disorder and complex PTSD among Chinese community health service users in Hong Kong. *International Journal of Social Psychiatry*, 69(4), 895–905. <https://doi.org/10.1177/00207640221141018>
- Fusar-Poli, P., Tantardini, M., De Simone, S., Ramella-Cravaro, V., Oliver, D., Kingdon, J., Kotlicka-Antczak, M., Valmaggia, L., Lee, J., Milian, M. J., Galderisi, S., Balottin, U., Ricca, V., & McGuire, P. (2017). Deconstructing vulnerability for psychosis: Meta-analysis of environmental risk factors for psychosis in subjects at ultra high-risk. *European Psychiatry*, 40, 65–75. <https://doi.org/10.1016/j.eurpsy.2016.09.003>
- Gallagher, A. R., Moreland, M. L., Watters, K. N., & Yalch, M. M. (2023). Relative effects of childhood trauma, intimate partner violence, and other traumatic life events on complex posttraumatic stress disorder symptoms. *Traumatology*, 29(1), 57–64. <https://doi.org/10.1037/trm0000379>
- Grasso, D. J., Dierkhising, C. B., Branson, C. E., Ford, J. D., & Lee, R. (2016). Developmental patterns of adverse childhood experiences and current symptoms and impairment in youth referred for trauma-specific services. *Journal of Abnormal Child Psychology*, 44(5), 871–886. <https://doi.org/10.1007/s10802-015-0086-8>
- Haselgruber, A., Knefel, M., Sölva, K., & Lueger-Schuster, B. (2021). Foster children's complex psychopathology in the context of cumulative childhood trauma: The interplay of ICD-11 complex PTSD, dissociation, depression, and emotion regulation. *Journal of Affective Disorders*, 282, 372–380. <https://doi.org/10.1016/j.jad.2020.12.116>
- Haselgruber, A., Solva, K., & Lueger-Schuster, B. (2020a). Symptom structure of ICD-11 Complex Posttraumatic Stress Disorder (CPTSD) in trauma-exposed foster children: Examining the International Trauma Questionnaire - Child and Adolescent Version (ITQ-CA). *European Journal of Psychotraumatology*, 11(1), 1818974. <https://doi.org/10.1080/20008198.2020.1818974>
- Haselgruber, A., Sölva, K., & Lueger-Schuster, B. (2020b). Validation of ICD-11 PTSD and complex PTSD in foster children using the International Trauma Questionnaire. *Acta Psychiatrica Scandinavica*, 141(1), 60–73. <https://doi.org/10.1111/acps.13100>
- Ho, G. W. K., Hyland, P., Shevlin, M., Chien, W. T., Inoue, S., Yang, P. J., Cheng, F. H., Chan, A. C. Y., & Karatzias, T. (2020). The validity of ICD-11 PTSD and Complex PTSD in East Asian cultures: Findings with young adults from China, Hong Kong, Japan, and Taiwan. *European Journal of Psychotraumatology*, 11(1), 1717826. <https://doi.org/10.1080/20008198.2020.1717826>
- Ho, G. W. K., Liu, H., Karatzias, T., Hyland, P., Cloitre, M., Lueger-Schuster, B., Brewin, C. R., Guo, C., Wang, X., & Shevlin, M. (2022). Validation of the International Trauma Questionnaire-Child and Adolescent Version (ITQ-CA) in a Chinese mental health service seeking adolescent sample. *Child and Adolescent Psychiatry and Mental Health*, 16(1), 66. <https://doi.org/10.1186/s13034-022-00497-4>
- Hobfoll, S. E. (2001). The influence of culture, community, and the nested-self in the stress process: Advancing conservation of resources theory. *Applied Psychology*, 50(3), 337–421. <https://doi.org/10.1111/1464-0597.00062>
- Hobfoll, S. E., Halbesleben, J., Neveu, J. P., & Westman, M. (2018). Conservation of resources in the organizational context: The reality of resources and their consequences. *Annual Review of Organizational Psychology and Organizational Behavior*, 5(1), 103–128. <https://doi.org/10.1146/annurev-orgpsych-032117-104640>
- Howard, M. C., & Hoffman, M. E. (2018). Variable-Centered, person-centered, and person-specific approaches: Where theory meets the method. *Organizational Research Methods*, 21(4), 846–876. <https://doi.org/10.1177/1094428117744021>
- Huang, C., Yang, M., Geng, Y., Chen, Y., Cheung, S. P., Deng, G., Dong, Q., Hu, H., Hua, K., Liao, J., Tan, Y., Tu, B., Wang, E., Yu, Z., Zhang, C., Zhang, S., & Zhuo, G. (2021). Adverse childhood experiences and mindfulness in Chinese college students during the COVID-19 pandemic. *Frontiers in Psychiatry*, 12, 619128. <https://doi.org/10.3389/fpsy.2021.619128>
- Huang, L., Chi, P., Wang, E., Bu, H., & Chi, X. (2024). Trajectories of complex posttraumatic stress symptoms among Chinese college students with childhood adversities: The role of self-compassion. *Child Abuse & Neglect*, 150, 106138. <https://doi.org/10.1016/j.chiabu.2023.106138>
- Huang, L., Qu, D., Liang, K., Ren, Y., & Chi, X. (2023). Longitudinal measurement invariance, validity, and reliability analysis of the self-compassion scale-short form among Chinese college students. *Chinese Journal of Clinical Psychology*, 31(1), 107–111+115. <https://doi.org/10.16128/j.cnki.1005-3611.2023.01.019>
- Humphreys, K. L., LeMoult, J., Wear, J. G., Piersiak, H. A., Lee, A., & Gotlib, I. H. (2020). Child maltreatment and depression: A meta-analysis of studies using the

- childhood trauma questionnaire. *Child Abuse & Neglect*, 102, 104361. <https://doi.org/10.1016/j.chiabu.2020.104361>
- Hyland, P., Shevlin, M., Fyvie, C., & Karatzias, T. (2018). Posttraumatic stress disorder and complex posttraumatic stress disorder in DSM-5 and ICD-11: Clinical and behavioral correlates. *Journal of Traumatic Stress*, 31(2), 174–180. <https://doi.org/10.1002/jts.22272>
- Injadat, M., Moubayed, A., Nassif, A. B., & Shami, A. (2021). Machine learning towards intelligent systems: Applications, challenges, and opportunities. *Artificial Intelligence Review*, 54(5), 3299–3348. <https://doi.org/10.1007/s10462-020-09948-w>
- Jannini, T. B., Longo, L., Rossi, R., Niolu, C., Siracusano, A., & Di Lorenzo, G. (2023). Complex post-traumatic stress disorder (cPTSD) and suicide risk: A multigroup mediation analysis exploring the role of post-traumatic symptomatology on hopelessness. *Journal of Psychiatric Research*, 165, 165–169. <https://doi.org/10.1016/j.jpsychires.2023.07.032>
- Kalmakis, K. A., Meyer, J. S., Chiodo, L., & Leung, K. (2015). Adverse childhood experiences and chronic hypothalamic-pituitary-adrenal activity. *Stress (Amsterdam, Netherlands)*, 18(4), 446–450. <https://doi.org/10.3109/10253890.2015.1023791>
- Karatzias, T., Cloitre, M., Maercker, A., Kazlauskas, E., Shevlin, M., Hyland, P., Bisson, J. I., Roberts, N. P., & Brewin, C. R. (2017a). PTSD and complex PTSD: ICD-11 updates on concept and measurement in the UK, USA, Germany and Lithuania. *European Journal of Psychotraumatology*, 8(sup7), 1418103. <https://doi.org/10.1080/20008198.2017.1418103>
- Karatzias, T., Hyland, P., Bradley, A., Cloitre, M., Roberts, N. P., Bisson, J. I., & Shevlin, M. (2019a). Risk factors and comorbidity of ICD-11 PTSD and complex PTSD: Findings from a trauma-exposed population based sample of adults in the United Kingdom. *Depression and Anxiety*, 36(9), 887–894. <https://doi.org/10.1002/da.22934>
- Karatzias, T., Hyland, P., Bradley, A., Fyvie, C., Logan, K., Easton, P., Thomas, J., Philips, S., Bisson, J. I., Roberts, N. P., Cloitre, M., & Shevlin, M. (2019b). Is self-compassion a worthwhile therapeutic target for ICD-11 Complex PTSD (CPTSD)? *Behavioural and Cognitive Psychotherapy*, 47(3), 257–269. <https://doi.org/10.1017/S1352465818000577>
- Karatzias, T., Shevlin, M., Fyvie, C., Hyland, P., Efthymiadou, E., Wilson, D., Roberts, N., Bisson, J. I., Brewin, C. R., & Cloitre, M. (2017b). Evidence of distinct profiles of Posttraumatic Stress Disorder (PTSD) and Complex Posttraumatic Stress Disorder (CPTSD) based on the new ICD-11 Trauma Questionnaire (ICD-TQ). *Journal of Affective Disorders*, 207, 181–187. <https://doi.org/10.1016/j.jad.2016.09.032>
- Kazlauskas, E., Jovarauskaite, L., Abe, K., Brewin, C. R., Cloitre, M., Daniunaite, I., Haramaki, Y., Hihara, S., Kairyte, A., Kamite, Y., Sugimura, K., Thoresen, S., Zelviene, P., & Truskauskaitė-Kuneviciene, I. (2022). Trauma exposure and factors associated with ICD-11 PTSD and complex PTSD in adolescence: A cross-cultural study in Japan and Lithuania. *Epidemiology and Psychiatric Sciences*, 31, e49. <https://doi.org/10.1017/S2045796022000336>
- Kazlauskas, E., Zelviene, P., Daniunaite, I., Hyland, P., Kvedaraitė, M., Shevlin, M., & Cloitre, M. (2020). The structure of ICD-11 PTSD and complex PTSD in adolescents exposed to potentially traumatic experiences. *Journal of Affective Disorders*, 265, 169–174. <https://doi.org/10.1016/j.jad.2020.01.061>
- Kemp, A. H., Koenig, J., & Thayer, J. F. (2017). From psychological moments to mortality: A multidisciplinary synthesis on heart rate variability spanning the continuum of time. *Neuroscience and Biobehavioral Reviews*, 83, 547–567. <https://doi.org/10.1016/j.neubiorev.2017.09.006>
- Kerker, B. D., Zhang, J., Nadeem, E., Stein, R. E., Hurlburt, M. S., Heneghan, A., Landsverk, J., & McCue Horwitz, S. (2015). Adverse childhood experiences and mental health, chronic medical conditions, and development in young children. *Academic Pediatrics*, 15(5), 510–517. <https://doi.org/10.1016/j.acap.2015.05.005>
- Kim, H., & Drake, B. (2023). Has the relationship between community poverty and child maltreatment report rates become stronger or weaker over time? *Child Abuse & Neglect*, 143, 106333. <https://doi.org/10.1016/j.chiabu.2023.106333>
- Kira, I. A., Aljakoub, J., Al Ibraheem, B., Shuwiekh, H. A., & Ashby, J. S. (2022). The etiology of complex PTSD in the COVID-19 and continuous traumatic stressors era: A test of competing and allied models. *Journal of Loss and Trauma*, 27(7), 608–628. <https://doi.org/10.1080/15325024.2022.2028094>
- Kumar, S. A., Jaffe, A. E., Brock, R. L., & DiLillo, D. (2022). Resilience to suicidal ideation among college sexual assault survivors: The protective role of optimism and gratitude in the context of posttraumatic stress. *Psychological Trauma: Theory, Research, Practice and Policy*, 14(S1), S91–S100. <https://doi.org/10.1037/tra0001141>
- Lassri, D., Gewirtz-Meydan, A., & Zamir, O. (2023). The mediating role of self-compassion between childhood maltreatment and satisfaction with intimate relationships. *Mindfulness*, 14(4), 970–978. <https://doi.org/10.1007/s12671-023-02107-6>
- Lavelock, C. R., Griffin, B. J., Worthington, E. L., Jr., Benotsch, E. G., Lin, Y., Greer, C. L., Garthe, R. C., Coleman, J. A., Hughes, C. M., Davis, D. E., & Hook, J. N. (2016). A qualitative review and integrative model of gratitude and physical health. *Journal of Psychology and Theology*, 44(1), 55–86. <https://doi.org/10.1177/009164711604400105>
- Li, X., Wang, Z., Hou, Y., Wang, Y., Liu, J., & Wang, C. (2014). Effects of childhood trauma on personality in a sample of Chinese adolescents. *Child Abuse & Neglect*, 38(4), 788–796. <https://doi.org/10.1016/j.chiabu.2013.09.002>
- Lortye, S. A., Will, J. P., Rameckers, S. A., Marquenie, L. A., Goudriaan, A. E., Arntz, A., & de Waal, M. M. (2024). Types of childhood maltreatment as predictors of post-traumatic stress disorder severity and complex posttraumatic stress disorder in patients with substance use disorders. *European Journal of Psychotraumatology*, 15(1), 2367179. <https://doi.org/10.1080/20008066.2024.2367179>
- Lundberg, S. M., & Lee, S. I. (2017). A unified approach to interpreting model predictions. *Advances in Neural Information Processing Systems*, 30. <https://doi.org/10.48550/arXiv.1705.07874>
- Mandelli, L., Petrelli, C., & Serretti, A. (2015). The role of specific early trauma in adult depression: A meta-analysis of published literature. Childhood trauma and adult depression. *European Psychiatry*, 30(6), 665–680. <https://doi.org/10.1016/j.eurpsy.2015.04.007>
- Marques-Feixa, L., Moya-Higueras, J., Romero, S., Santamarina-Pérez, P., San Martín-Gonzalez, N., Mas, A., Rapado-Castro, M., Blasco-Fontecilla, H., Zorrilla, I., Forner-Puntonet, M., Anglada, E., Ramírez, M., Mayoral,

- M., Muñoz, M. J., Fañanás, L., EPI-Young Stress GROUP, Palma-Gudiel, H., Castro-Quintas, Á., Monteserín, J. L., ... Rios, G. (2023). Complex post-traumatic stress disorder (CPTSD) of ICD-11 in youths with childhood maltreatment: Associations with age of exposure and clinical outcomes. *Journal of Affective Disorders*, 332, 92–104. <https://doi.org/10.1016/j.jad.2023.03.088>
- McLaughlin, K. A., Sheridan, M. A., Alves, S., & Mendes, W. B. (2014). Child maltreatment and autonomic nervous system reactivity: Identifying dysregulated stress reactivity patterns by using the biopsychosocial model of challenge and threat. *Psychosomatic Medicine*, 76(7), 538–546. <https://doi.org/10.1097/PSY.000000000000098>
- McNaughton, N., & Gray, J. A. (2000). Anxiolytic action on the behavioural inhibition system implies multiple types of arousal contribute to anxiety. *Journal of Affective Disorders*, 61(3), 161–176. [https://doi.org/10.1016/S0165-0327\(00\)00344-X](https://doi.org/10.1016/S0165-0327(00)00344-X)
- McQuillan, K., Hyland, P., & Vallières, F. (2022). Prevalence, correlates, and the mitigation of ICD-11 CPTSD among homeless adults: The role of self-compassion. *Child Abuse & Neglect*, 127, 105569. <https://doi.org/10.1016/j.chiabu.2022.105569>
- Møller, L., Søgaard, U., Elklit, A., & Simonsen, E. (2021). Differences between ICD-11 PTSD and complex PTSD on DSM-5 section III personality traits. *European Journal of Psychotraumatology*, 12(1), 1894805. <https://doi.org/10.1080/20008198.2021.1894805>
- Neff, K. D. (2016). The self-compassion scale is a valid and theoretically coherent measure of self-compassion. *Mindfulness*, 7(1), 264–274. <https://doi.org/10.1007/s12671-015-0479-3>
- Neff, K. D. (2023). Self-compassion: Theory, method, research, and intervention. *Annual Review of Psychology*, 74(1), 193–218. <https://doi.org/10.1146/annurev-psych-032420-031047>
- Radua, J., Ramella-Cravaro, V., Ioannidis, J. P., Reichenberg, A., Phipphothasane, N., Amir, T., Thoo, H. Y., Oliver, D., Davies, C., Morgan, C., McGuire, P., Murray, R. M., & Fusar-Poli, P. (2018). What causes psychosis? An umbrella review of risk and protective factors. *World Psychiatry*, 17(1), 49–66. <https://doi.org/10.1002/wps.20490>
- Raes, F., Pommier, E., Neff, K. D., & Van Gucht, D. (2011). Construction and factorial validation of a short form of the self-compassion scale. *Clinical Psychology & Psychotherapy*, 18(3), 250–255. <https://doi.org/10.1002/cpp.702>
- Richardson, A. L., & Gallagher, M. W. (2021). Giving thanks is associated with lower PTSD severity: A meta-analytic review. *Journal of Happiness Studies*, 22(6), 2549–2562. <https://doi.org/10.1007/s10902-020-00322-9>
- Rink, J., & Lipinska, G. (2020). Evidence of distinct profiles of ICD-11 post-traumatic stress disorder (PTSD) and complex PTSD in a South African sample. *European Journal of Psychotraumatology*, 11(1), 1818965. <https://doi.org/10.1080/20008198.2020.1818965>
- Salvesen, K. T., Stige, S. H., Wästlund, M., & Vrabell, K. (2023). Change despite obstacles: A mixed-methods pilot study of a trauma-sensitive mindfulness and compassion intervention. *European Journal of Trauma & Dissociation*, 7(4), 100361. <https://doi.org/10.1016/j.ejtd.2023.100361>
- Sciaraffa, M. A., Zeanah, P. D., & Zeanah, C. H. (2018). Understanding and promoting resilience in the context of adverse childhood experiences. *Early Childhood Education Journal*, 46(3), 343–353. <https://doi.org/10.1007/s10643-017-0869-3>
- Shin, Y. J., Kim, S. M., Hong, J. S., & Han, D. H. (2021). Correlations between cognitive functions and clinical symptoms in adolescents with complex post-traumatic stress disorder. *Frontiers in Public Health*, 9, 586389. <https://doi.org/10.3389/fpubh.2021.586389>
- Shrestha, N. (2020). Detecting multicollinearity in regression analysis. *American Journal of Applied Mathematics and Statistics*, 8(2), 39–42. <https://doi.org/10.12691/ajams-8-2-1>
- Sölva, K., Haselgruber, A., & Lueger-Schuster, B. (2020). Latent classes of childhood maltreatment in children and adolescents in foster care: Associations with ICD-11 PTSD and complex PTSD. *European Journal of Psychotraumatology*, 11(1), 1832757. <https://doi.org/10.1080/20008198.2020.1832757>
- Tian, Y., Li, W., Wu, X., & Cheng, X. (2022). Complex PTSD in Chinese adolescents exposed to childhood trauma: A latent profile analysis. *Journal of Interpersonal Violence*, 37(21–22), NP20190–NP20211. <https://doi.org/10.1177/08862605211050111>
- Tian, Y., Wu, X., Wang, W., Zhang, D., Yu, Q., & Zhao, X. (2020). Complex posttraumatic stress disorder in Chinese young adults using the International Trauma Questionnaire (ITQ): A latent profile analysis. *Journal of Affective Disorders*, 267, 137–143. <https://doi.org/10.1016/j.jad.2020.02.017>
- van Harmelen, A. L., van Tol, M. J., van der Wee, N. J., Veltman, D. J., Aleman, A., Spinhoven, P., van Buchem, M. A., Zitman, F. G., Penninx, B. W., & Elzinga, B. M. (2010). Reduced medial prefrontal cortex volume in adults reporting childhood emotional maltreatment. *Biological Psychiatry*, 68(9), 832–838. <https://doi.org/10.1016/j.biopsych.2010.06.011>
- World Health Organization. (2019). *International classification of diseases* (11th ed.). <https://icd.who.int/en>
- Wu, Q., Cao, H., Lin, X., Zhou, N., & Chi, P. (2022). Child maltreatment and subjective well-being in Chinese emerging adults: A process model involving self-esteem and self-compassion. *Journal of Interpersonal Violence*, 37(15–16), NP13685–NP13706. <https://doi.org/10.1177/0886260521993924>
- Wu, Q., Chi, P., Lin, X., & Du, H. (2018). Child maltreatment and adult depressive symptoms: Roles of self-compassion and gratitude. *Child Abuse & Neglect*, 80, 62–69. <https://doi.org/10.1016/j.chiabu.2018.03.013>
- Xu, H., Li, M., Cai, J., Yuan, Y., He, L., Liu, J., Wang, L., & Wang, W. (2023). Comparison of ACE-IQ and CTQ-SF for child maltreatment assessment: Reliability, prevalence, and risk prediction. *Child Abuse & Neglect*, 146, 106529. <https://doi.org/10.1016/j.chiabu.2023.106529>
- Yarkoni, T., & Westfall, J. (2017). Choosing prediction over explanation in psychology: Lessons from machine learning. *Perspectives on Psychological Science*, 12(6), 1100–1122. <https://doi.org/10.1177/1745691617693393>
- Young, J. E., Klosko, J. S., & Weishaar, M. E. (2003). *Schema therapy: A practitioner's guide*. Guilford Press.
- Zhang, H., Li, J., Sun, B., & Wei, Q. (2023). Effects of childhood maltreatment on self-compassion: A systematic review and meta-analysis. *Trauma, Violence, & Abuse*, 24(2), 873–885. <https://doi.org/10.1177/15248380211043825>
- Zhang, H., Liu, M., & Long, H. (2021). Child maltreatment and suicide ideation in rural China: The roles of self-compassion and school belonging. *Child & Adolescent Social Work Journal*, 38(3), 325–335. <https://doi.org/10.1007/s10560-020-00679-z>