# Alterations in Fear Learning as a Mechanism linking Childhood Exposure to Violence with PTSD Symptoms: A Longitudinal Study

**Supplemental Methods**

**Preregistration**

The preregistration included an analytic plan for supplementary analyses to examine the physiological response to the unconditioned stimulus and the timing of childhood trauma as a predictor. These analyses were not possible due to the lack of timestamps for the unconditioned stimulus and missing data on the timing of childhood trauma (<10% of data available).

**Participants**

The participants were recruited at age three years in 2009 to 2010 from a university hospital birth register, daycares, preschools, health clinics, and charitable agencies. Families received information about the study and indicated their interest in participating. Families were recruited to obtain diversity in income at the start of the study. Exclusion criteria included children with developmental disabilities and lack of English proficiency. Additionally, participants from the parent study were excluded from the current assessment based on: moving out-of-area, IQ < 80, active substance dependence, psychosis, or the presence of a pervasive developmental disorder.

Of the initial sample (*n* = 215), 47.9% identified as female (*n* = 103). 88.8% of the sample identified as White, 12.6% of the sample identified as Black, 12.1% of the sample identified as Hispanic/Latino, 9.3% of the sample identified as Asian, 9.8% of the sample identified as American Indian or Alaskan native, 1.4% of the sample identified as Native Hawaiian or Pacific Islander, and 1.9% of the sample identified as biracial or other. The racial/ethnic composition of the sample is similar to the broader Seattle population (Peverill et al., 2023). Within the final sample, 37 youth had a clinically elevated overall score on the SCARED using the established cut-off score of >=25 indicating that 21.8% of the sample had significant levels of anxiety (Birmaher et al., 1999). 11 youth in the sample have clinically elevated externalizing scores using the cut-off score of >65 indicating that 6.5% of the sample had significant levels of externalizing psychopathology (Achenbach & Rescorla, 2001). Using the PSTD-RI, 4 youth in the sample met full criteria for PTSD at the initial visit (Kaplow et al., 2020). There were no significant differences in biological sex, race/ethnicity, age, psychopathology symptoms, or trauma or deprivation experiences between the initial sample (*n* = 215) and the final sample with usable data in fear acquisition or extinction.

**Childhood Trauma**

The childhood trauma composite is preregistered, and more information is available in (Weissman et al., 2022). The goal for the childhood trauma composite is to take a multimethod approach using multiple measures of violence exposure into a single score that reflects the severity and frequency of violence that youth have experienced. One consideration within this approach is that the CTQ only included physical and sexual abuse, and the VEX-R is the only measure to include witnessing violence. Therefore, physical and sexual abuse received higher weight in the overall scale. These experiences are more severe and their relatively greater weight is consistent with the Dimensional Model of Adversity (McLaughlin, Sheridan, Humphreys, Belsky, & Ellis, 2021; Weissman et al., 2022).

Child Experiences of Care and Abuse. The CECA interview assesses caregiving experiences, including physical abuse, sexual abuse, and emotional abuse (Bifulco, Brown, & Harris, 1994). We modified the interview to ask parallel questions about domestic violence as completed in prior research (Weissman et al., 2019). There is evidence of high inter-rater reliability on the CECA (Bifulco et al., 1994). The CECA was also used to assess emotional deprivation, one component of the deprivation composite (Bifulco, Bernazzani, Moran, & Jacobs, 2005).

Childhood Trauma Questionnaire. The CTQ is a 28-item scale that assesses the frequency of maltreatment during childhood, including physical and sexual abuse (Bernstein, Ahluvalia, Pogge, & Handelsman, 1997; Scher, Stein, Asmundson, McCreary, & Forde, 2001). Within the childhood trauma composite, we used the sum of the Childhood Trauma Questionnaire (CTQ) physical and sexual abuse subscales (Min = 10, Max = 35, *M* = 10.53, SD = 2.07). The CTQ neglect subscale was also used to assess physical deprivation as a component of the deprivation exposure composite. The CTQ has high internal consistency and test-retest reliability (Bernstein et al., 1997) (Cronbach’s alpha = 0.82 in the current study).

UCLA PTSD Reaction Index. The PTSD-RI includes a trauma screener that assesses exposure to 13 traumatic events, including physical abuse, sexual abuse, domestic violence, and associated PTSD symptoms (Elhai et al., 2013). The trauma screener is used to measure physical abuse, sexual abuse, or exposure to domestic violence. The UCLA PTSD-RI has high internal consistency and convergent validity (Steinberg et al., 2013) (Cronbach’s alpha = 0.92 – 0.97).

Violence Exposure Scale for Children-Revised. The VEX-R is a parent and child interview measure that assesses exposure to violence including abuse, domestic violence, and community violence using a 21-item, cartoon-based interview (Fox & Leavitt, 1995). Participants report on how frequently they have witnessed or experienced that violence on a Likert scale ranging from 0 (never) to 3 (lots of times) (Min = 0, Max = 27, *M* = 4.97, SD = 5.37). VEX-R has good internal consistency and convergent validity (Shahinfar, Fox, & Leavitt, 2000) (Cronbach’s alpha = 0.78 – 0.83).

**Deprivation**

Cognitive Deprivation. Cognitive deprivation was quantified using the Home Observation Measurement of the Environment – Short Form (HOME-SF). The HOME-SF is a parent questionnaire used to measure of the amount of cognitive stimulation in the home based on the Home Observation for the Measurement of the Environment, an observational measure for use in children’s home to assess cognitive stimulation (Bradley, Caldwell, & Corwyn, 2003; Mott, 2004). The HOME-SF has adequate reliability of the cognitive stimulation subscale (0.71) and similar psychometric properties to the HOME observational measure (Sugland et al., 1995). The measure assesses cognitive stimulation, including the presence of learning materials in the home, the child’s engagement in activities outside the home, parent-child interaction, and parental scaffolding of child learning. Due to interest in cognitive deprivation, the HOME items were reverse scored. Each item is scored dichotomously. To create a dimensional measure of cognitive deprivation, we summed the cognitive stimulation items and then z-scored the variable to standardize the cognitive deprivation variable.

Emotional Deprivation. Emotional deprivation was quantified using a composite of variables assessing emotional neglect including the neglect items from the CECA Interview and the emotional neglect subscale of the Multidimensional Neglectful Behavior Scale (MNBS). The MNBS is a child interview measure used to assess neglect using cartoon-based items tailored to the child’s gender and the gender of their primary caregiver (Kantor et al., 2004). The reliability of the neglect items ranges from 0.66 to 0.94 depending on the sample (Kantor et al., 2004) (Cronbach’s alpha = 0.74). From the CECA Interview and MNBS, we created a total sum score for each scale, standardized each scale, and averaged them together to create a final score for emotional deprivation.

Physical Deprivation. Physical Deprivation was quantified using the physical deprivation subscale of the MNBS, the four-item scale from the Household Food Insecurity Scale, and the physical neglect subscale of the CTQ. The Household Food Security Scale SF is a parent questionnaire used to measure food insecurity experiences that correctly identifies food-insecurity compared to the longer form for 98% of all households (Blumberg, Bialostosky, Hamilton, & Briefel, 1999). Because each of these items are on similar scales and had a similar range, we took the mean of the three scales and then created a z-score to create a composite of physical deprivation.

**Psychopathology**

 Child Behavior Checklist and Youth Self Report. The CBCL and YSR scales are among the most widely used measures of parent and youth-reported emotional and behavioral problems and use extensive normative data to generate age-standardized estimates of symptoms of psychopathology using a 3-point scale from 0 or “Not True” to 2 or “Very True or Often True”. (Achenbach, 1991). The present study used the combined parent and child report externalizing subscale, which includes rule-breaking and aggressive behavior (Cronbach’s alpha CBCL = 0.94, YSR = 0.92) .

 Screen for Child Anxiety Related Emotional Disorders. The SCARED Self-Report assesses child report of anxiety symptoms across five domains: panic/somatic, generalized anxiety, separation anxiety, social phobia, and school phobia using a 3-point scale from 0 or “Not True or Hardly Ever True” to 2 or “Very True or Often True”. The SCARED is widely used and has good psychometric properties (Birmaher et al., 1997). The SCARED total score was used as a measure of anxiety in the study (Cronbach’s alpha = 0.89).

UCLA PTSD Reaction Index. The PTSD-RI assess the frequency of PTSD symptoms in the past month included in the DSM-5 criteria for PTSD using a 5-point scale from 0 “None” to 4 “Most”. The PTSD severity score from the combined parent and child report was used as a measure of psychopathology in the current study (Cronbach’s alpha child report = 0.97, parent report = 0.92).

**Fear Conditioning Task**

The US was an air blast directed to the larynx at 80 psi 500 ms after a startle probe. After all stimuli (CS+, CS-), a startle probe was played consisting of a 106-dB 40 ms burst of noise delivered through headphones. Youth were seated and asked to remain still and look at a computer screen. The experimental protocol consisted of two phases: fear acquisition and extinction. The phases were separated by 10 minutes. The acquisition phase consisted of 3 blocks, each with 3 CS+ trials, 3 CS− trials, and 3 noise alone (NA) trials. Both CSs were colored shapes presented on a computer for 6 seconds. After all stimuli, the startle stimulus occurred. In fear acquisition, the CS+ co-terminated with the US (air blast). The CS+ was reinforced with the air blast 100% of the time. The CSs were the same as above, except that the CS+ was no longer paired with the air blast. In all phases of the experiment, inter-trial intervals were randomized between 9 and 22 seconds.

EMG was recorded from two Ag-AgCl electrodes placed on the orbicularis oculi muscle 1 cm under the pupil. SCR was recorded from two Ag-AgCl electrodes attached to the index and middle finger of the non-dominant hand after the fingers were cleaned with rubbing alcohol and abraded. All data was analyzed using MindWare software. The EMG data was filtered with low and high frequency cutoffs at 28 and 500 Hz. Fear-potentiated startle magnitude was assessed as the peak amplitude of the EMG contraction 20 to 200 ms following the startle probe. The startle magnitude was compared across baseline startle and fear-potentiated startle for the CS+ and the CS- as the percent potentiation for each CS type to account for individual differences. The value was constructed as

$100 × \frac{\left(Startle magnitude during CS - Startle magnitude during baseline startle\right)}{\left(Startle magnitude during baseline startle\right)} $ during each session as done in prior work (Jovanovic et al., 2014). Initial analyses of the EMG data revealed substantially less usable data due to high levels of artifact for numerous children as compared to SCR. 139 participants had usable EMG data able to be analyzed compared to 170 usable SCR participants. Out of the 139 participants with usable data, there were 21 outliers with values greater than 3 SD from the mean within those participants. Due to the high level of missing data and number of outliers, we focus on SCR as our primary measure of fear conditioning in this sample.

**Final Sample**

Of the 215 participants, 3 refused to participate in fear conditioning and 5 discontinued the task. Data was lost or unable to be analyzed due to technological issues for 19 people in fear acquisition and 37 people in fear extinction. One person fell asleep during extinction and three individuals had > 4 extinction variables with outliers and were removed. Finally, 18 people were removed from analyses during fear acquisition (14 during fear extinction) due to inconsistent responding to questions during fear acquisition. Individuals were removed for responding to the same question with multiple different answers which served as an attention check across the task. This resulted in a final sample of 170 people in fear acquisition and 152 people in fear extinction with high-quality data (Table 1). Of the final 170 participants, 162 completed follow-up questionnaires on psychopathology symptoms and thus, were included in mediation models.

**Supplemental Results**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Predictor | Sum of Squares | *df* | Mean Square | F | *p*  |
| Time | 0.12 | 3 | 0.04 | 3.52 | 0.02\* |
| Time x Age | 0.10 | 3 | 0.04 | 3.01 | 0.03\* |
| Time x Trauma | 0.10 | 3 | 0.04 | 2.88 | 0.04\* |
| Time x Deprivation | 0.01 | 3 | 0.00 | 0.18 | 0.90 |
| Time x Sex | 0.04 | 3 | 0.02 | 1.18 | 0.31 |
| Stimulus | 0.01 | 1 | 0.01 | 0.90 | 0.35 |
| Stimulus x Age | 0.03 | 1 | 0.03 | 2.13 | 0.15 |
| Stimulus x Trauma | 0.02 | 1 | 0.02 | 1.35 | 0.25 |
| Stimulus x Deprivation | 0.01 | 1 | 0.01 | 0.58 | 0.45 |
| Stimulus x Sex | 0.03 | 1 | 0.03 | 2.13 | 0.15 |
| Time x Stimulus | 0.05 | 3 | 0.02 | 1.15 | 0.33 |
| Time x Stimulus x Age | 0.04 | 3 | 0.01 | 0.97 | 0.41 |
| Time x Stimulus x Trauma | 0.14 | 3 | 0.05 | 3.44 | 0.02\* |
| Time x Stimulus x Deprivation | 0.03 | 3 | 0.01 | 0.88 | 0.45 |
| Time x Stimulus x Sex | 0.07 | 3 | 0.02 | 1.70 | 0.17 |

Table S1.4 x 2Repeated-measures ANOVA of childhood trauma, deprivation and fear learning controlling for age and biological sex with Time (4 blocks) and Stimulus (CS+, CS-)

\* *p* < .05

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1. Childhood Trauma | – |  |  |  |  |  |  |  |
| 2. Deprivation | .26\*\* | – |  |  |  |  |  |  |
| 3. Age | -.11 | -.02 | – |  |  |  |  |  |
| 4. PTSD Symptoms | .54\*\* | .27\*\* | -.03 | – |  |  |  |  |
| 5. PTSD Symptoms at Follow-Up  | .24\*\* | .18\* | .05 | .28\*\* | – |  |  |  |
| 6. Anxiety Symptoms | .15 | .14 | .08 | .30\*\* | .08 | – |  |  |
| 7. Anxiety Symptoms at Follow-Up | -.04 | .02 | .05 | .06 | .14 | .38\*\* | – |  |
| 8. Externalizing Symptoms | .28\*\* | .32\*\* | .00 | .28\*\* | .27\*\* | .22\*\* | -.00 | – |
| 9. Externalizing Symptoms at Follow-Up | .44\*\* | .34\*\* | -.07 | .40\*\* | .37\*\* | .09 | .09 | .56\*\* |

Table S2. Correlations of variables of interest

\* *p* < .05. \*\* *p* < .01.

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Figure S1. Correlation between skin conductance response to the threat cue (CS+) during early fear learning and baseline PTSD symptoms

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