



# Childhood trauma predicts blunted error monitoring in adulthood: An event-related potential study

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## Abstract

Abuse and neglect have detrimental consequences on emotional and cognitive functioning during childhood and adolescence, including error monitoring, which is a critical aspect of cognition that has been implicated in certain internalizing and externalizing psychopathologies. It is unclear, however, whether (a) childhood trauma has effects on error monitoring and, furthermore whether, (b) error monitoring mediates the relation between childhood trauma and psychopathology in adulthood. To this end, in a large sample of young adults (ages 18–30) who were oversampled for psychopathology ( $N = 390$ ), the present study assessed relations between childhood trauma and error-related negativity (ERN), which is a widely used neurophysiological indicator of error monitoring. Cumulative childhood trauma predicted ERN blunting, as did two specific types of traumas: sexual abuse and emotional neglect. Furthermore, the ERN partially mediated the effects of cumulative childhood trauma and emotional neglect on externalizing-related symptoms. Future studies should further examine the relations between childhood trauma and error monitoring in adulthood, which can help to inform intervention approaches.

**Keywords** Cognitive control · ERP · Error monitoring · Error-related negativity, Childhood trauma

## Introduction

A history of adverse childhood experiences, including childhood trauma, predicts a broad range of negative outcomes, including the onset and recurrence of mental health disorders (Anda et al., 2006; Arnow, 2004; Springer et al., 2007; Wegman & Stetler, 2009). Increasingly, research has focused on identifying processes through which childhood trauma confers risk for psychopathology in an effort to identify potential treatment targets. One aspect of cognitive functioning that is important to examine further in relation to a history childhood trauma is error monitoring, or the ability to identify one's mistakes (Ridderinkhof et al., 2004; Taylor et al., 2007). Critically, impaired error monitoring is a

well-established correlate of and risk factor for psychopathology (for a review, see Pasion & Barbosa, 2019).

Error monitoring is commonly assessed by the error-related negativity (ERN; Lackner et al., 2018; Meyer et al., 2015). The ERN is a negative-going event-related potential (ERP) that occurs around 50 ms following the commission of an error (Luck, 2014). There are several theories regarding the ERN. The ERN is purported to index an aspect of cognitive control that supports the acquisition of goals by signaling the need for individuals to adjust their behavior in the context of heightened response conflict (i.e., to slow down responses following mistakes; Tamnes et al., 2013). Indeed, a larger (more negative) ERN relates to better executive function (e.g., inhibition, attentional control; Grammer et al., 2018; Larson & Clayson, 2011) and greater working memory capacity (Miller et al., 2012). The ERN is also purported to reflect individual differences in motivated attention to endogenous threat (i.e., the extent to which mistakes are perceived as threatening; Weinberg et al., 2012; Weinberg, Meyer, et al., 2016b). In other words, individuals who perceive mistakes as potentially threatening are more motivated to attend to potential mistakes, and ERN amplitude following mistakes may signal greater need for goal-directed adjustments.

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With regard to childhood trauma, aberrant error monitoring is evident in youth (children and adolescents) with a history of physical and emotional abuse, as well as broader stressful life events (e.g., Chong et al., 2020; Lackner et al., 2018; Lim et al., 2015; Mehra et al., 2022; Meyer et al., 2015). For example, children and adolescents whose parents exhibit an emotionally abusive, punitive, or controlling parenting style have been found to exhibit heightened (i.e., more negative) ERN amplitude (Chong et al., 2020; Meyer et al., 2015). Similarly, among children and adolescents, ERN was found to be larger in those with a history of more adverse experiences (Lackner et al., 2018), as well as among those who reported more interpersonal stress (Mehra et al., 2022). It has been proposed that physical and/or emotional abuse is related to heightened ERN as a result of children's increased need to pay attention to potential threats or errors that could lead to punishment (Banica et al., 2019; Meyer et al., 2015). Not only does childhood trauma relate to error monitoring in children, the ERN has been found to mediate the relation between harsh parenting and anxiety (Chong et al., 2020; Meyer et al., 2015). This suggests that the impact of childhood adverse experiences on error monitoring contributes to psychopathology-related outcomes.

Not all studies have found evidence of enhanced error monitoring in relation to childhood trauma, however, as some have identified blunted ERN and reduced error monitoring (Buzzell et al., 2020; Fava et al., 2019; Loman et al., 2013; Tabachnick et al., 2018; Troller-Renfree et al., 2016). In contrast with emotional and physical abuse, ERN blunting has typically emerged for children and adolescents who have experienced neglect and deprivation (particularly for prolonged neglect). For example, children and adolescents reared in an institution were found to exhibit evidence of reduced response and conflict monitoring (Buzzell et al., 2020). The effects of neglect and deprivation have been found to extend beyond error monitoring to other domains of cognitive control, however, including inhibitory control and cognitive flexibility, indicating that effects of these types of trauma may have broader effects on cognition. For example, emotional neglect and deprivation predicted impairment in executive function in adolescents and adults, above and beyond other forms of trauma (Buzzell et al., 2020; Letkiewicz et al., 2021).

Whether a history of childhood trauma relates to error monitoring in adulthood has been studied to a lesser extent than in children and adolescents. Although available evidence indicates that error monitoring in adulthood is affected by lifetime stress and early maladaptive experiences (Banica et al., 2019; Banica et al., 2022), it is unclear whether the ERN accounts for associations between childhood trauma and mental health outcomes in adulthood. As previously stated, the ERN is a well-established correlate of psychopathology (Pasion & Barbosa, 2019); however, this varies by

type of psychopathology. Whereas the ERN has generally been shown to be enhanced in response to errors for some anxiety-related disorders and symptom dimensions, such as generalized anxiety disorder (GAD), trait worry, social phobia/social anxiety disorder (SAD), and obsessive-compulsive disorder (OCD; Cavanagh et al., 2017; Riesel, 2019; Weinberg et al., 2010), results are more mixed for other internalizing disorders, including specific phobia, panic disorder, and depression (Hajcak et al., 2003; Lieberman et al., 2017; Rabinak et al., 2013; Swick et al., 2015; for review, see Weinberg et al., 2015). For externalizing-related behaviors and traits, including drug abuse, antisocial behavior, hostility, and impulsivity, an opposite association has been reported with the ERN being blunted for these mental health outcomes (Gorka et al., 2019; Hall et al., 2007; Heritage & Benning, 2013; Pasion & Barbosa, 2019). Given that the association between error monitoring and psychopathology varies by psychopathology, aberrant error monitoring may be a mechanism through which childhood trauma leads to psychopathology that varies by psychopathology type as well.

Thus, the present study sought to assess whether childhood trauma predicts error monitoring in adulthood, and, furthermore, whether error monitoring accounts for the relation between childhood trauma and psychopathology in adulthood. Specifically, we assessed whether (1) cumulative childhood trauma and/or (2) specific subtypes of childhood trauma (sexual abuse, physical abuse, emotional abuse, physical neglect, and/or emotional neglect) predict ERN magnitude. Furthermore, we formally tested whether error monitoring mediates the relations between cumulative childhood trauma and/or specific subtypes of trauma and psychopathology. We examined the potential role of cumulative trauma *and* specific types of trauma because there is evidence that an accumulation of trauma/stressful life events broadly affects error monitoring (Mehra et al., 2022), as well as evidence that specific trauma types and dimensions of trauma (e.g., threat-related abuse versus neglect/deprivation) differentially predict outcomes in adulthood (Gibb et al., 2007; Gould et al., 2012; Letkiewicz et al., 2021; for a review, see McLaughlin et al., 2014).

Because personality traits and dimensions predict a significant portion of variance in psychopathology and related impairment (Conway et al., 2019), and taxometric studies indicate that psychopathology is well-characterized by higher-order dimensional models (Krueger et al., 2021; Watson et al., 2022), personality traits were used to measure specific internalizing symptoms that have previously been found to relate to heightened error monitoring (trait anxiety and OCD related) and externalizing dimensions. Notably, personality traits and trait domains have previously been found to relate to childhood trauma and clinical diagnoses in adults (Bach et al., 2022; Veith et al., 2017), as well as error-related

negativity (Ladouceur et al., 2010). Importantly, personality trait measures can index persistent tendencies to experience elevated, clinically relevant symptoms that do not meet full diagnostic criteria, yet nonetheless affect functioning (Shankman et al., 2009), and have better prognostic utility than psychiatric diagnoses (Waszczuk et al., 2022).

Given that the majority of available child and adolescent research indicates that trauma/stressors, and particularly cumulative stressors, criticism, and punitive parenting styles, relate to heightened error monitoring (e.g., through heightened salience of potential mistakes), it was anticipated that cumulative trauma and trauma subtypes reflective of more critical and punitive experiences in childhood (emotional and physical abuse) would predict greater anxiety and OCD-related symptoms. Furthermore, based on the results of studies with children and adolescents, it was anticipated that the heightened ERN would mediate relations between childhood trauma and these internalizing symptoms.

Because there is evidence of *reduced* error monitoring in some child and adolescent studies (i.e., blunted rather than heightened ERN; Fava et al., 2019; Frenkel et al., 2020; Loman et al., 2013; Tabachnick et al., 2018; Troller-Renfree et al., 2016), and that some aspects of childhood trauma (e.g., neglect and deprivation) predict impairment in cognitive control (Letkiewicz et al., 2021; McDermott et al., 2013), it was hypothesized that emotional or physical neglect would predict a blunted ERN. In contrast with GAD and OCD, the ERN is commonly blunted for externalizing-related traits and disorders such as drug abuse, antisocial behavior, hostility, impulsivity, and attention deficit hyperactivity disorder (Gorka et al., 2019; Hall et al., 2007; Heritage & Benning, 2013; Pasion & Barbosa, 2019). Hence, it was anticipated that blunted ERN would mediate relations between emotional and/or physical neglect and externalizing-related traits.

## Methods

### Participants

Participants included in the present study came from a large study of transdiagnostic mechanisms of psychopathology (Correa et al., 2019; Weinberg & Shankman, 2017; see Table 1 for demographic and clinical characteristics). For the large study, individuals were recruited from the local community and mental health clinics in Chicago, IL. Individuals were eligible to participate if they were 18–30 years old and had a biological sibling in the same age range who was interested in participating.

Participants were not recruited on the basis of *DSM* disorders, but to enroll a sample that was enriched for internalizing and externalizing symptoms, various advertisements

**Table 1** Demographic and clinical characteristics

<i>N</i> = 390	Mean (SD)
Age	22.2 (2.1)
Gender	63% female
Ethnicity	White: 42% Black/African American: 15% Hispanic: 21% Asian: 12% Middle Eastern: 3% Mixed: 6% Other: 0.4% No Response: 0.6%
PID-5	Mean (SD)
Anxiousness (Internalizing)	1.09 (.73)
OCD-related traits (Internalizing)	
Rigid Perfectionism	.82 (.65)
Perseveration	.65 (.58)
Composite	1.47 (1.08)
Antagonism (Externalizing)	.53 (.40)
Disinhibition (Externalizing)	1.18 (.33)
Diagnosis of an Anxiety-Related Disorder (DSM-5) - Current	%
Social Anxiety Disorder	11.8% ( <i>n</i> = 46)
Generalized Anxiety Disorder	3.8% ( <i>n</i> = 15)
Panic Disorder	2.8% ( <i>n</i> = 11)
<i>Any Anxiety-Related Disorder</i>	17.4% ( <i>n</i> = 68)
Diagnosis of an Externalizing Disorder (DSM-5) - Current	%
Alcohol Use Disorder	6.2% ( <i>n</i> = 24)
Substance Use Disorder	6.7% ( <i>n</i> = 26)
<i>Any Externalizing Disorder</i>	10.8% ( <i>n</i> = 42)

*PID-5* Personality Inventory for DSM-5

were used that targeted anxiety, depression, and alcohol use disorder. Additionally, participants were oversampled for psychopathology using the Depression, Anxiety, and Stress Scale (DASS; Lovibond & Lovibond, 1995) during an initial phone screen. The sample had normally distributed DASS scores, but also had a higher average number of symptoms than the general population ( $M = 23.6$ ,  $SD = 20.5$  versus  $M = 8.3$ ,  $SD = 9.8$ ; Crawford et al., 2011).

### Measures

#### Childhood trauma

Participants' history of childhood trauma was assessed using the Childhood Trauma Questionnaire (CTQ), which has exhibited excellent psychometric properties in clinical

and nonclinical samples (Bernstein et al., 2003; Bernstein & Fink, 1998). The CTQ is a self-report questionnaire that assesses sexual abuse, physical abuse, emotional abuse, physical neglect, and emotional neglect. Each subscale includes five items that are scored on a scale of 1 (*never*) to 5 (*very often*). Observed internal consistencies for the CTQ subscales ranged from .60 to .88 and was .87 for the full scale. The observed internal consistency for the physical neglect subscale (.60) fell below the commonly accepted cutoff of .70 (Nunnally, 1978), which is in line with a previous large study of community participants (Scher et al., 2001).

#### Personality Inventory for the DSM-5 (PID-5-Adults)

The PID-5 was used to assess anxiety-related internalizing personality traits and broader externalizing-related personality domains. Internalizing traits related to heightened attention to endogenous threat and worry were captured by (1a) Anxiousness and facets that relate to OCD (De Caluwé et al., 2014) were indexed by (1b) a composite of Rigid Perfectionism and Perseveration, which were strongly correlated in the present study ( $r = .55$ ). Externalizing was captured by (2a) Antagonism (Manipulativeness, Deceitfulness, Grandiosity) and (2b) Disinhibition (Irresponsibility, Impulsivity, Distractibility).

#### Structured Clinical Interview for DSM-5 Disorders (SCID-NP)

Current clinical diagnostic status (which was not an inclusion criterion for the larger study) was not used as a primary outcome measure in the present study; diagnostic data were included to confirm that psychopathology-related traits were related to clinical diagnostic status (i.e., to clarify clinical relevance of the personality trait domains for the sample). Current psychopathology was assessed using the Structured Clinical Interview for DSM-5 (SCID-NP; First et al., 2015). A code of 1 was given to individuals if they met diagnostic criteria for particular anxiety or OCD-related internalizing disorders or an externalizing disorder, and 0 if they did not. Specifically, anxiety and OCD-related psychopathology that has been found to relate to enhanced error monitoring/heightened attention to endogenous threat (i.e., current generalized anxiety disorder, social anxiety disorder, and obsessive-compulsive disorder) were included. Externalizing psychopathology included alcohol use and substance use disorders (which included all *DSM-5* classes of substances except tobacco and caffeine).

#### Flanker task to elicit ERN

A modified, arrowhead version of the Erickson flanker task was completed by participants during electroencephalograph

(EEG) data collection (Eriksen & Eriksen, 1974; Kopp et al., 1996). Error-related negativity elicited by the Flanker Task has been shown to exhibit high within-session consistency and evidence of convergent validity with the ERN elicited by other error-related tasks (Meyer et al., 2013; Riesel et al., 2013). The task consisted of 330 total trials, which were completed in 11 blocks of 30 trials (see the Supplement for task description, and for full method details, also see Weinberg, Liu, & Shankman, 2016a, and Gorka et al., 2019).

#### Electrophysiological recordings and data reduction

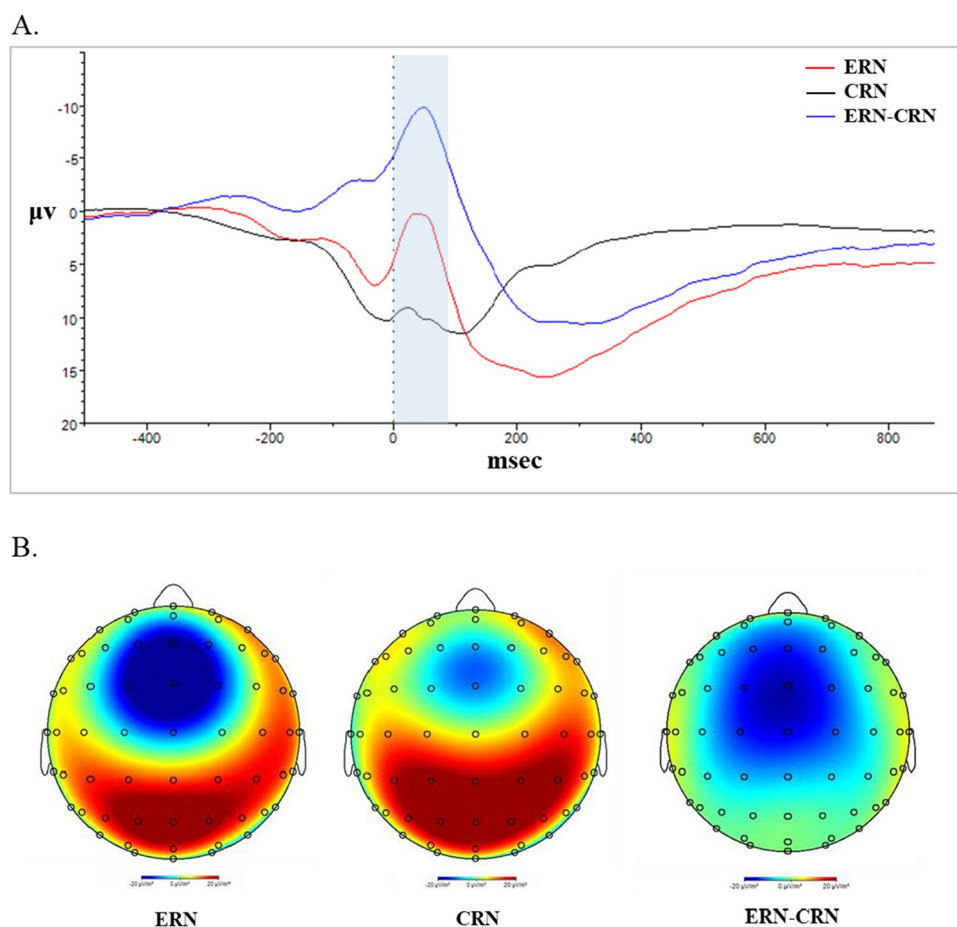
During the flanker task, continuous EEG was recorded with the ActiveTwo BioSemi System (Biosemi, Amsterdam, Netherlands) using a 64-channel elastic electrode cap. The electrode array was based on the 10/20 system, with two additional electrodes placed on the left and right mastoids. Continuous EEG data were processed off-line using Brain Vision Analyzer 2 software (Brain Products, Gilching, Germany; see Supplement for data reduction details).

Response-locked ERPs were averaged separately for error trials (i.e., ERN) and correct trials (i.e., correct response negativity; CRN). Based on the maximal ERN across participants and on previous research (e.g., Weinberg et al., 2015), amplitudes for the ERN and CRN were averaged between 0 to 80 ms postresponse at the Cz electrode (see Fig. 1). To isolate ERP activities specific to error monitoring, we regressed ERN onto CRN and used the resulting standardized ERN residual scores in the analyses (Meyer et al., 2017). A more negative ERN residual score reflects heightened error monitoring.

Several behavioral measures were also computed for each participant, including total number of error trials, response omissions (i.e., not responding to a Flanker arrowhead during the task), accuracy, average reaction times (RTs) on error and correct trials (calculated separately), and posterror slowing (average of  $[RT(E_{t+1}) - RT(E_{t-1})]$  for all errors  $E$ , where  $t$  = error trial; Dutilh et al., 2012).

#### Data analysis

The final sample included 390 participants. To identify whether aberrant error monitoring accounts for the relationship between childhood trauma (cumulative and/or specific subtypes) and psychopathology-related traits in adulthood, we formally tested mediation using the lavaan package in R (Rosseel, 2012). Prior to a formal test of mediation, we tested associations with psychopathology-related traits and trauma subtypes. Specifically, using regression analyses, we assessed relations between childhood trauma and the ERN (i.e., the “a path”), as well as associations with anxiety-related and/or OCD-related traits (Anxiousness and Rigid Perfectionism/Perseveration) and



**Fig. 1** **a** Grand-average waveforms. The rectangle indicates the scoring interval for the ERN and CRN. Time course is depicted on the x-axis. **b** Current source density plots illustrating areas of maximal voltage for ERN, CRN, and ERN-CRN ( $\Delta$ ERN)

externalizing traits (Antagonism and Disinhibition; i.e., the “c path”), and the relations between the ERN and psychopathology-related traits covarying for childhood trauma (i.e., “b path”; b and c path results are provided in the Supplement).

Next, we formally tested whether the ERN mediates the relationship between cumulative childhood trauma and psychopathology-related traits, and/or particular trauma subtypes and psychopathology-related traits. To test for indirect effects, the bootstrapping method was used (2,000 samples, 95% CI). Age and sex were included as covariates in all models. Sex was assessed using a binary approach (male or female) based on an item from the SCID. Follow-up analyses examined whether the relations between childhood trauma, error monitoring, and psychopathology-related traits were moderated by sex (i.e., moderated-mediation). The latter was explored given that previous research has identified sex differences for the ERN, including its relationship with anxiety (Moser, 2017; Moser et al., 2016).

## Results

### Demographics and psychopathology-related traits

The average age of participants was 22.2 years ( $SD = 3.1$ ) and over half of the sample self-identified as female (63%; see Table 1). Means and standard deviations for the childhood trauma and psychopathology measures are reported in Table 1 (see Table 2 for zero-order correlations between the CTQ and PID-5 domains). Compared to previous studies with community samples, scores on the CTQ were slightly higher in the present study (Majer et al., 2010; Scher et al., 2004; Scher et al., 2001; see Table 3), though participants in the present study were not specifically included on the basis of endorsing trauma history.

### Psychopathology-related traits' associations with clinical diagnoses

Approximately 17% of participants met criteria for a current anxiety or OCD-related disorder and 12% of participants met



**Table 2** Zero-Order correlations between the Childhood Trauma Questionnaire (CTQ) total score CTQ subscales, and Personality Inventory for DSM-5 (PID-5) trait domains.

<i>N</i> = 390	CTQ SA	CTQ PA	CTQ EA	CTQ PN	CTQ EN	PID-5 Anx	PID-5 Rig & Psv	PID-5 Antagonism	PID-5 Disinhibition
CTQ Total	.47**	.63**	.79**	.65**	.81**	.22**	.30**	.21**	.20**
CTQ SA	-	.31**	.19**	.28**	.16**	.02	.11*	-.01	-.01
CTQ PA	-	-	.49**	.33**	.28*	.13*	.15*	.13*	.18*
CTQ EA	-	-	-	.31**	.55**	.25**	.32**	.24**	.22**
CTQ PN	-	-	-	-	.48*	.08	.07	.12*	.14*
CTQ EN	-	-	-	-	-	.19*	.22*	.15*	.13*
PID-5 Anx	-	-	-	-	-	-	.62**	.03	.24**
PID-5 Rig & Psv	-	-	-	-	-	-	-	-.04	.33**
PID-5 Antagonism	-	-	-	-	-	-	-	-	.42**

\*\* $p < .01$ , \* $p < .05$

*PA* Physical Abuse, *EA* Emotional Abuse, *PN* Physical Neglect, *EN* Emotional Neglect, *NA* Negative Affect; *Anx* Anxiousness, *Rig* Rigid Perfectionism, *Psv* Perseveration

criteria for a current externalizing disorder (see Table 1). Including all psychopathology-related trait domains in a regression model predicting current diagnostic status revealed that both anxiety-related trait domains predicted a unique portion of variance in current anxiety/OCD-related disorder status (Anxiousness:  $B = .28$ ,  $p < .001$  and OCD:  $B = .20$ ,  $p = .003$ ). By contrast, the Disinhibition trait domain was negatively related to diagnostic status ( $B = -.15$ ,  $p = .010$ ), while Antagonism was not significantly related ( $B = .08$ ,  $p = ns$ ). With regard to specific anxiety and OCD-related diagnoses, Anxiousness predicted a unique portion of variance in current GAD ( $B = .30$ ,  $p < .001$ ) and SAD ( $B = .29$ ,  $p < .001$ ), whereas OCD predicted a unique portion of variance in current OCD ( $B = .19$ ,  $p = .013$ ). Both externalizing trait domains predicted a unique portion of variance in current externalizing disorder status (Antagonism:  $B = .16$ ,  $p = .005$  and Disinhibition:  $B = .13$ ,  $p = .045$ ), whereas the anxiety-related trait domains did not (Anxiousness:  $B = .06$ ,  $p = ns$  and OCD:  $B = .03$ ,  $p = ns$ ). These results highlight the validity of personality traits as indicators of anxiety-related versus externalizing psychopathologies.

## Behavior

### Cumulative trauma

Cumulative childhood trauma did not predict the number of errors that were made during the task,  $B = -.03$ ,  $p = .536$ , response omissions,  $B = .07$ ,  $p = .185$ , accuracy,  $B = .00$ ,  $p = .969$ , average RT on correct trials,  $B = .04$ ,  $p = .417$ , average RT on error trials  $B = .05$ ,  $p = .345$ , or posterror slowing,  $B = -.01$ ,  $p = .856$ .

### Trauma subtypes

There was a significant unique effect of emotional neglect on omissions,  $B = .16$ ,  $p = .015$ . No other significant effects emerged.

## Childhood trauma and ERN

### Cumulative trauma

Greater cumulative trauma during childhood was related to less negative (i.e., blunted) ERN amplitude,  $B = .13$ ,  $p = .013$  (see Supplemental Fig. S1).

### Trauma subtypes

When all of the CTQ subscales were included in a multivariate regression model, sexual abuse and emotional neglect uniquely predicted variance in ERN,  $B = .10$ ,  $p = .045$  and  $B = .16$ ,  $p = .013$ , respectively (for full results, see Table 4).

## Childhood trauma and psychopathology-related traits: Mediation by ERN

### Cumulative trauma

A mediation model was used to formally tested to identify whether the ERN mediates the relationship between cumulative trauma and anxiety or OCD-related traits and/or externalizing domains (for the results of the individual b and c mediation model paths, see Supplemental Table S1 and Fig. S2). As shown in Fig. 2A, the ERN partially mediated

**Table 3** Childhood trauma characteristics

<i>N</i> = 390	Mean (SD)	Range	% Mild	% Moderate-to-Severe
<b>CTQ Total</b>				
(Full sample)	35.0 (9.5)	25-75	-	-
Males	35.2 (9.0)	25-73	-	-
Females	34.9 (10.0)	25-75	-	-
<b>CTQ SA</b>				
(Full sample)	5.6 (2.9)	5-24	5	7
Males	5.2 (0.9)	5-13	5	3
Females	5.9 (2.8)	5-24	6	9
<b>CTQ PA</b>				
(Full sample)	6.6 (2.3)	5-25	16	8
Males	6.5 (1.9)	5-14	14	8
Females	6.6 (2.5)	5-25	18	8
<b>CTQ EA</b>				
(Full sample)	8.1 (3.6)	5-24	22	12
Males	8.0 (3.3)	5-22	22	10
Females	8.1 (3.7)	5-24	22	14
<b>CTQ PN</b>				
(Full sample)	6.4 (2.2)	5-16	13	9
Males	6.6 (2.3)	5-16	12	10
Females	6.3 (2.2)	5-21	13	9
<b>CTQ EN</b>				
(Full sample)	8.4 (3.8)	5-25	20	9
Males	8.9 (4.1)	5-25	21	10
Females	8.2 (3.6)	5-21	20	8

CTQ = Childhood Trauma Questionnaire, SA Sexual Abuse; PA Physical Abuse, EA Emotional Abuse, PN Physical Neglect, EN Emotional Neglect. Mild SA cutoff:  $\geq 6$  &  $< 8$ , Moderate-to-Severe SA cutoff:  $\geq 8$ ; Mild PA cutoff:  $\geq 8$  &  $< 10$ , Moderate-to-Severe PA cutoff:  $\geq 10$ ; Mild EA cutoff:  $\geq 9$  &  $< 13$ , Moderate-to-Severe EA cutoff:  $\geq 13$ ; Mild PN cutoff:  $\geq 8$  &  $< 10$ , Moderate-to-Severe PN cutoff:  $\geq 10$ ; Mild EN cutoff:  $\geq 10$  &  $< 15$ , Moderate-to-Severe EN cutoff:  $\geq 15$

the relationship between cumulative childhood trauma and Disinhibition. There was a significant indirect effect of cumulative trauma on Disinhibition through the ERN and the direct effect of childhood trauma on Disinhibition was reduced with the ERN included in the model; however, the direct effect of childhood trauma on Disinhibition remained significant. The ERN did not mediate the relationship

between cumulative childhood trauma and any of the other traits or domains (see Table 5).

**Trauma subtypes**

As shown in Fig. 2B, there was a significant effect of emotional neglect on the ERN and significant effect of the ERN on Disinhibition. Although there was not a direct effect of emotional neglect on Disinhibition, there was a significant indirect effect of emotional neglect on Disinhibition through the ERN. The ERN did not mediate the relationship between any of the other CTQ trauma types and personality-related traits or domains (see Table 5).

**Follow-up analyses**

**Childhood trauma and psychopathology-related traits: Moderated-mediation (mediation by ERN, moderation by sex)**

Sex moderated the relationship between the ERN and Anxiousness ( $B = -.09, p = .020$ ), such that a more negative ERN was related to more anxiety-related symptoms among females ( $B = -.12, p = .021$ ), but not males ( $B = .07, p = .199$ ). However, there was no evidence of moderated mediation for any psychopathology-related traits or domains.

**Trauma subtypes and psychopathology-related traits: Moderated-mediation (mediation by ERN, moderation by sex)**

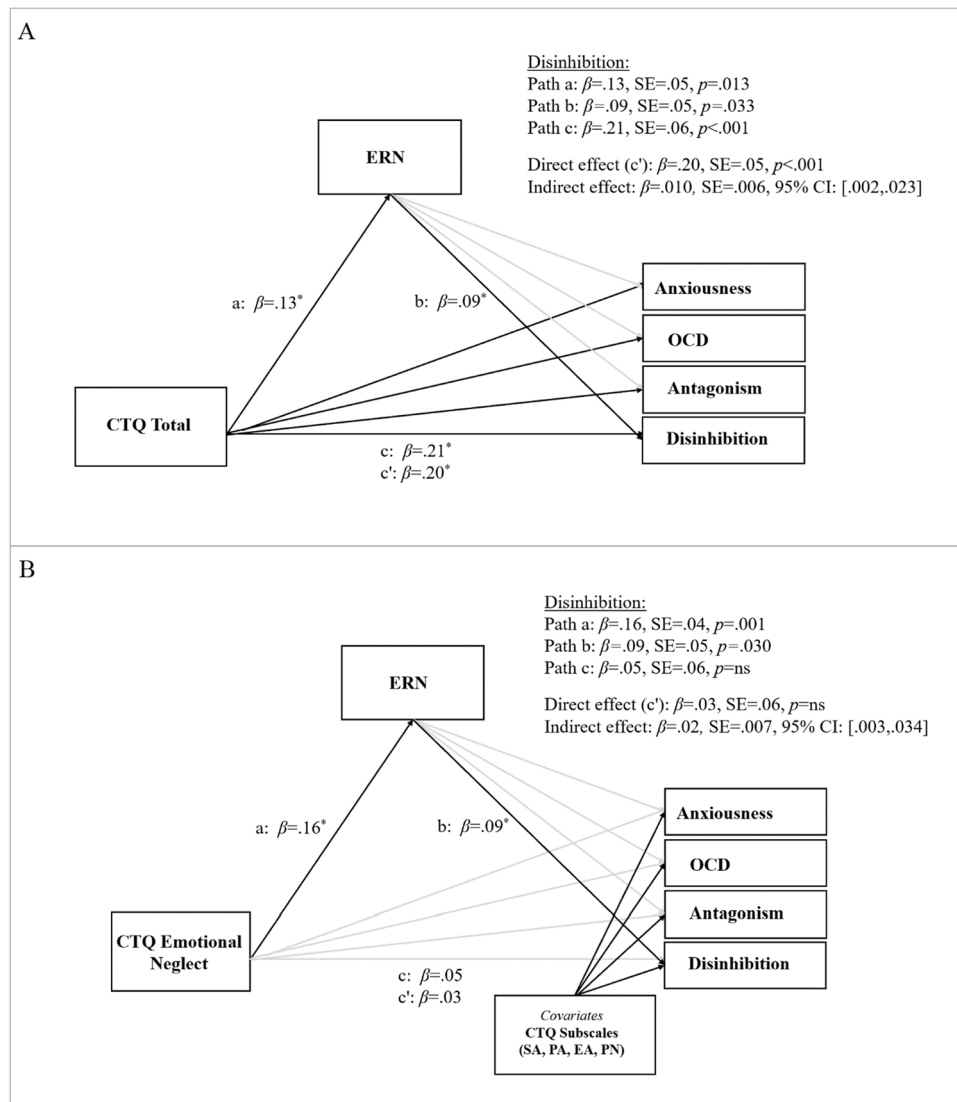
There was no evidence that sex moderated the mediation models for any psychopathology-related traits or domains.

**Discussion**

The present study identified that cumulative childhood trauma predicted reduced error monitoring (as indicated by blunted error-related negativity) in adulthood. Furthermore, there was evidence of an indirect effect of cumulative childhood trauma on Disinhibition through error monitoring. Although the direct effect of cumulative childhood trauma remained after accounting for error monitoring (i.e., there

**Table 4** Path A. The model tested whether childhood trauma subtypes (included in the same model) predict ERN amplitude

Trauma Subtypes	CTQ SA	CTQ PA	CTQ EA	CTQ PN	CTQ EN
IVs:					
DV: ERN	$B = .10, p = .045$	$B = -.05, p = .382$	$B = .004, p = .947$	$B = -.06, p = .253$	$B = .16, p = .013$



**Fig. 2** Depiction of the mediation models testing whether Error-Related Negativity mediates relations between (a) CTQ Total Trauma and/or (b) CTQ Trauma Subtypes and PID-5 Anxiousness, Rigid Perfectionism & Perseveration (OCD), Antagonism, and Disinhibition

was no evidence of full mediation), error monitoring was found to partially mediate the relationship between cumulative childhood trauma and Disinhibition. Taken together, results indicate that aberrant error monitoring is one route through which childhood trauma contributes to certain dimensions of psychopathology in adulthood.

Although several previous studies found that childhood trauma, harsh parenting styles, and adverse experiences related to heightened ERN in children and adolescents (e.g., Chong et al., 2020; Lackner et al., 2018; Meyer et al., 2015), cumulative childhood trauma was related to *blunted* error monitoring in our sample of young adults. This finding is, however, in line with some studies with children and adolescents that have linked childhood trauma with blunted error monitoring—particularly among samples with a history of

neglect. For example, children raised in an institution (an environment characterized by physical and emotional deprivation) were found to exhibit a smaller ERN during the Flanker task relative to children who were either born to and raised by their biological parents (i.e., nonadopted/never institutionalized) or raised in an institution for only a short duration (Loman et al., 2013).

In addition to an effect for cumulative trauma, both sexual abuse and emotional neglect were forms of childhood trauma that uniquely predicted blunted error monitoring (i.e., covarying for other specific forms of childhood trauma). For sexual abuse and emotional neglect, ERN results may, in part, reflect stress-related neurocognitive changes within brain regions that support error monitoring (e.g., due to inefficient development of emotion regulation resulting from



**Table 5** Indirect effects results. The models tested whether ERN amplitude mediated relationships between (A) cumulative childhood trauma and psychopathology-related traits or (B) trauma subtypes and psychopathology-related traits

A. Indirect Effects of Cumulative Trauma on DVs through ERN					
IVs					
CTQ Total					
DVs					
Anxiousness	$B = -.006, p = .477$				
OCD	$B = .001, p = .869$				
Antagonism	$B = .009, p = .226$				
Disinhibition	$B = .010, p = .048$				
B. Indirect Effects of Trauma Subtypes on DVs through ERN					
IVs					
	CTQ SA	CTQ PA	CTQ EA	CTQ PN	CTQ EN
DVs					
Anxiousness	$B = -.005, p = .471$	$B = .003, p = .500$	$B = .00, p = .971$	$B = .003, p = .544$	$B = -.008, p = .462$
OCD	$B = .001, p = .837$	$B = .001, p = .847$	$B = .00, p = .990$	$B = .003, p = .507$	$B = -.002, p = .832$
Antagonism	$B = .01, p = .214$	$B = -.007, p = .346$	$B = .00, p = .964$	$B = -.006, p = .456$	$B = .013, p = .146$
Disinhibition	$B = .01, p = .268$	$B = -.006, p = .340$	$B = .00, p = .968$	$B = -.006, p = .365$	$B = .02, p = .044$

CTQ Childhood Trauma Questionnaire, SA Sexual Abuse, PA Physical Abuse, EA Emotional Abuse, PN Physical Neglect, EN Emotional Neglect

lack of caregiver responsiveness; McLaughlin et al., 2017). However, given that childhood trauma has broadly been linked with altered stress responses and stress-related brain changes (Wilson et al., 2011), this explanation alone does not readily account for the unique effects of sexual abuse and emotional neglect.

Although sexual abuse and emotional neglect are related to a similar outcome (i.e., blunted ERN), equifinality can be explained by different pathways. Sexual abuse is associated with greater experiential avoidance and emotional suppression than are other forms of trauma (for a discussion, see Noll, 2008, 2021). Having participants experimentally engage in emotional suppression has been found to (temporarily) decrease ERN magnitude (Wang et al., 2014), and hence (although speculative), the tendency to engage in emotional suppression may contribute to a blunted ERN. For emotional neglect, results may reflect the privation of early input that is critical for adaptive development of error monitoring (Buzzell et al., 2020; McDermott et al., 2013). Neglectful caregivers often ignore children's behavior and, as a result, emotionally neglected children may not learn to adequately monitor their own behavior and errors, leading to reduced error monitoring in adulthood. In contrast with sexual abuse, emotional neglect specifically was found to exert an effect on disinhibited behavior (e.g., risk-taking, impulsivity) through blunted error monitoring.

In addition to the potential role of neglect, there are several possible reasons why the present study primarily found evidence of ERN blunting, as opposed to ERN enhancement. First, although the CTQ questionnaire assesses types of childhood trauma that are related to early experiences that

have previously been found to predict enhanced ERN, the CTQ is a broader measure that does not specifically assess for criticism, punitive, and/or authoritarian parenting. Second, some studies have found that developmental timing of stressors is an important moderator of ERN effects. For example, Mehra et al. (2022) identified that a greater number of interpersonal stressors predicted a heightened ERN, but only among younger children (not adolescents). Because the CTQ measure does not assess the particular timing that the trauma occurred, future studies should include additional measures to identify whether trauma that occurs earlier in childhood predicts a heightened, as opposed to blunted, ERN in adults. Finally, although participants had higher rates of childhood trauma on average than community participants from other studies (e.g., Scher et al., 2001), participants were not specifically recruited for childhood trauma.

That results emerged for ERN blunting may reflect limitations of the present study; however, mixed findings across studies highlight the need to consider more complex pathways through which “cognitive” and “affective-motivational” processes are affected by childhood trauma (types and course), as well as how these affect attentional control and the ERN (for reviews, see Moser, 2017; Moser et al., 2013). For example, error monitoring performance and the ERN has been found to be significantly enhanced among individuals with better cognitive control combined with heightened motivated attention toward errors (Ladouceur et al., 2010). Thus, if individuals “don't care” about mistakes and have impaired cognitive control, they may have particular difficulty maintaining their attention on tasks. This may have been the case for emotional neglect,

which (a) was associated with a blunted ERN and response omissions and (b) has previously been linked with cognitive control impairments (Letkiewicz et al., 2021).

The results have several important clinical implications. The present study identified a role of blunted error monitoring in disinhibition, the latter of which has previously been found to predict substance and alcohol use disorders (Iacono et al., 1999; Mullins-Sweatt et al., 2019), as well as in the present study. Aberrant error monitoring following childhood trauma may reflect a latent vulnerability that should be considered clinically with regard to risk for the onset of mental health disorders in adults (McCrary et al., 2017). Enhancing attentional abilities, executive function, and/or emotional acceptance among individuals with childhood trauma (including emotional neglect), such as through mindfulness practice (Becerra et al., 2017; Cásedas et al., 2020; Jha et al., 2007; Teper & Inzlicht, 2013) or cognitive control interventions (Hoorelbeke et al., 2016; Koster et al., 2017) may improve future outcomes, though transfer of cognitive training to real-world cognitive functioning has generally been found to be limited. Given that the size of the partial mediation effect through the ERN was small in the present study, additional mechanisms and treatment targets should be considered.

Overall, results indicate that childhood trauma (cumulative trauma, sexual abuse, and emotional neglect) affects error monitoring in adulthood. Furthermore, cumulative childhood trauma and emotional neglect were found to indirectly relate to disinhibition (an externalizing domain) through blunted error monitoring. Given the importance of error monitoring for successful behavioral regulation and goal acquisition, future work is needed to further clarify dynamics between childhood trauma, error monitoring, and psychopathology.

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**Open practices statement** Data for the experiments reported here are available on the Research Domains of Criteria Database ([rdocdb](#)). None of the experiments was preregistered.

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