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Corporal Punishment Is Uniquely Associated With a Greater Neural Response to Errors and Blunted Neural Response to Rewards in Adolescence

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ABSTRACT

BACKGROUND: Although corporal punishment is a common form of punishment with known negative impacts on health and behavior, how such punishment affects neurocognitive systems is relatively unknown.

METHODS: To address this issue, we examined how corporal punishment affected neural measures of error and reward processing in 149 adolescent boys and girls of ages 11 to 14 years (mean age [SD] = 11.02 [1.16]). Corporal punishment experienced over the lifetime was assessed using the Stress and Adversity Inventory. In addition, participants completed a flankers task and a reward task to measure the error-related negativity and reward positivity, respectively, as well as measures of anxiety and depressive symptoms.

RESULTS: As hypothesized, participants who experienced lifetime corporal punishment reported more anxiety and depressive symptoms. Experiencing corporal punishment was also related to a larger error-related negativity and blunted reward positivity. Importantly, corporal punishment was independently related to a larger error-related negativity and a more blunted reward positivity beyond the impact of harsh parenting and lifetime stressors.

CONCLUSIONS: Corporal punishment appears to potentiate neural response to errors and decrease neural response to rewards, which could increase risk for anxiety and depressive symptoms.

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Corporal punishment, defined as physical force that involves inflicting physical pain on another person, is a common form of discipline in the United States, with close to 50% of parents reporting use of corporal punishment over the course of a year (1). Research has demonstrated that corporal punishment is associated with increases in anxiety and depressive symptoms in children (2,3) in addition to other poor cognitive and behavioral outcomes that include greater aggression and antisocial behavior and less inhibitory control and working memory capacity (4–9). Despite an abundance of research documenting the negative consequences of corporal punishment, the effect of corporal punishment on neurocognitive systems is relatively unknown.

A growing body of research indicates that harsh parenting, characterized by high levels of control and low levels of warmth—which can include corporal punishment—may shape how children's brains respond to mistakes (10,11). This research has focused on the error-related negativity (ERN), an event-related brain potential (ERP) that is elicited when participants make errors in speeded reaction time tasks (12). Several within-subject studies have found that the ERN is sensitive to error salience: The ERN is increased when accuracy is emphasized over speed (13), when performance is evaluated (14), and when errors are punished in the laboratory (15,16). In addition, one study found that children had a larger ERN response when making mistakes in the presence of a controlling parent than when an experimenter was present (17). Similarly, punitive parenting styles have been related to a larger ERN in children and adults (18–20). Furthermore, in a sample of 280 parents and children, observed and self-reported harsh parenting at age 3 predicted a larger ERN at age 6 (11). Overall, this evidence indicates that harsh parenting may sensitize children to their mistakes, which may in turn shape how the brain responds to errors, similar to the lasting impact punishment in the laboratory has on the ERN (21).

A separate line of research indicates that children exposed to harsh parenting or corporal punishment are more likely to show reduced activity in reward-related brain regions such as the ventral striatum (22). Given links between harsh parenting and greater depressive symptoms in children (23), corporal punishment could affect reward-related neural pathways that are implicated in depression (24). ERP research has identified the reward positivity (RewP), an ERP component that is evident 250 ms to 350 ms following the onset of feedback, as an index of reward circuit function (25). A larger RewP has been associated with greater self-reported reward responsiveness, ventral striatum activation, and behavioral measures of reward sensitivity (26–28), suggesting that the RewP has good construct and convergent validity. Furthermore, children and adults with increased depressive symptoms and major depressive disorder have been shown to exhibit a reduced RewP (29–35). Moreover, research has found that a reduced RewP is observable prior to the onset of depression, suggesting that it may be a preclinical risk factor for major depressive disorder (36,37).

One study examined the association between parenting and the RewP. Levinson *et al.* (38) found that parents with greater authoritarian (i.e., harsh) parenting styles had a blunted neural response to their child's rewards. Although this study did not directly examine how harsh parenting affects children's RewP, the results suggest that harsh parenting styles are associated with less reactivity to a child's success. It is possible that parenting styles focused more on punishment than reward could model behaviors in which children learn to downplay their own success (39); however, the relation between corporal punishment and child's neural response to rewards has not been examined directly.

To address these gaps in the literature, we examined both error- and reward-related neural activity in children who reported corporal punishment over their lifespan. We sought to determine whether corporal punishment would be related to a potentiated ERN and a reduced RewP. Furthermore, we investigated whether these associations could be accounted for by authoritarian parenting more broadly or, specifically, whether the experience of corporal punishment was uniquely associated with a larger ERN and a blunted RewP.

To address these questions, we recruited participants between ages 11 and 14 years and had them complete the Stress and Adversity Inventory (STRAIN) (40) to identify exposure to corporal punishment at any point during their lifetime. They also completed an arrow version of the flankers task and the doors task and measures of anxiety and depressive symptoms. Parents completed an assessment of parenting styles. Based on prior research (18–20), we hypothesized that children who experienced corporal punishment during their life would exhibit a larger ERN and a more blunted RewP. Next, we conducted exploratory analyses to investigate whether a larger ERN and a blunted RewP were uniquely associated with corporal punishment (i.e., whether the effect of corporal punishment on error-related neural activity explained the effect of corporal punishment on reward-related neural activity). We also examined whether the severity, exposure timing, frequency, or duration of corporal punishment was associated with a more blunted RewP and an increased ERN.

METHODS AND MATERIALS

Participants and Procedure

This study is part of a multisite longitudinal study examining the impact of computerized adaptive attentional bias modification training on the ERN. Here, we focused on the ERN and RewP at baseline and on self-report questionnaires at the 2-year follow-up visit. Participants between the ages of 11 and 14 years, who were recruited from Tallahassee, FL area, completed a baseline visit and a follow-up visit 2 years later. Families were recruited using a registration list, word of mouth, and online advertisements.

At the baseline visit, participants included in this study (mean age [SD] = 11.02 [1.16] years) completed an arrow version of the flankers task and the doors task to measure the ERN and the RewP, respectively. At the follow-up visit, participants (mean age [SD] = 13.02 [1.16] years) completed the STRAIN, Children's Depression Inventory (CDI), and Screen for Child Anxiety Related Disorders (SCARED). In addition, at this visit, parents completed the Parenting Styles and Dimensions Questionnaire (PSDQ). Notably, because of the COVID-19 pandemic, the follow-up visits were mainly conducted virtually, and therefore, electroencephalography (EEG) data were not collected. The sample (N = 149) identified predominantly as White (71%), with the remaining participants identifying as African American (13%), Asian (3%), or mixed race (10%), and Hispanic ethnicity (3%). The average household income was $92,826 (SD = $57,281). The study was preapproved by the institutional review board; all parents provided consent, and children provided assent prior to participation. Families were compensated $20 per hour for their time.

Participants were excluded on an individual level based on their ERN and/or RewP data. For the ERN data, 1 participant was excluded due to poor EEG data and 4 participants were excluded for making more than 100 errors, indicating that participants may have not understood the task or were not paying attention to the task. One participant had an extreme ERN score that was $>$3 SDs beyond the mean; therefore, this participant's ERN was winsorized using 3 times the interquartile range. The final sample for the ERN analyses thus included 144 participants. For the RewP data, 1 participant was excluded because of poor EEG data, and another participant completed only 4 trials of the task. The final sample for the RewP analyses thus included 147 participants.

Screen for Child Anxiety Related Disorders

The SCARED asseses the presence of anxiety symptoms over the last 3 months with a total of 41 items rated on a 3-point Likert scale from 0 to 2 (41). Higher scores on the SCARED indicate greater anxiety symptom severity. In this study, 148 adolescents completed the SCARED (α = 0.93). The SCARED was completed at the follow-up assessment.

Children's Depression Inventory

The CDI assesses depressive symptoms over the past 2 weeks and has been well validated in children between the ages of 7 and 17 years (42). It consists of 27 items rated on a 3-point Likert scale from 0 to 2, with 0 indicating an absence of a symptom and 2 indicating the definite presence of the symptom. Total scores range from 0 to 54, with higher scores indicating greater depressive symptom severity. In this study, 148 adolescents completed the CDI (α = 0.90). The CDI was completed at the follow-up assessment.

Parenting Styles and Dimensions Questionnaire

The PSDQ is a 32-item questionnaire designed to measure authoritative, authoritarian, and permissive parenting styles (43). In addition, 5 items were added to assess overprotective parenting style. The authoritarian parenting subscale was of interest in this study (12 items; α = 0.76). Examples of items in this subscale include "I yell or shout when my child misbehaves," "I punish by taking privileges away from my child with little if any explanation," "I scold and criticize to make my child improve," or "I use physical punishment as a way of disciplining my child." The PSDQ was completed at the follow-up assessment.

Stress and Adversity Inventory for Adolescents

The STRAIN was used to assess participants' cumulative lifetime stressor exposure (40) (see https://www.strainsetup.com). Participants reported on a number of different life stressors, including corporal punishment. The corporal punishment question asked as follows: "Was there ever a period of time when you experienced harsh discipline from your parents (or caregivers)? This could include being spanked, hit, or otherwise hurt." When endorsed, these questions were followed by additional questions to assess the severity, frequency, exposure timing, and duration of corporal punishment. To assess severity, participants were asked, "At its worst, how stressful/threatening was it for you?" Participants responded using a scale from 1 (very slightly) to 5 (extremely). Frequency was assessed on a scale of 1 (once or twice in your life) to 6 (every day or almost every day). Participants were asked how old they were when the corporal punishment started, which was used to assess exposure timing. For duration, participants were asked to report how long (in years and months) the corporal punishment had persisted.

Overall, the STRAIN produces separate total scores for lifetime stressor count and severity in addition to other more fine-grained variables. Responses from 149 participants were collected, with 97 adolescents reporting that they had experienced no corporal punishment during their lifetime (i.e., coded as 0) and 52 adolescents reporting having experienced corporal punishment over their lifetime (i.e., coded as 1). Among the 52 participants who experienced corporal punishment, the average age of first exposure was 5.06 years (SD = 2.89), indicating that on average, participants experienced corporal punishment prior to the baseline visit. They also reported that on average, the corporal punishment occurred every few years (mean = 2.48 years, SD = 1.39) and lasted for 4.71 years (SD = 4.59). Finally, participants reported a mean perceived severity of 2.13 (SD = 1.25) for the corporal punishment stressor, indicating low to moderate severity. The total lifetime stressor count and severity variables include the corporal punishment item. The STRAIN has been well validated against numerous clinical, cognitive, and behavioral outcomes (40,44–46). In addition, the STRAIN has demonstrated high test-retest reliability over both 2-week (rs > 0.87) and 1-month (lifetime stressor count: $r = 0.94$ and lifetime stressor severity: $r = 0.95$) intervals (44,45).

EEG Tasks

The flankers and doors tasks were programmed and delivered using Presentation software version 17.0 (Neurobehavioral Systems, Inc.). Specific details regarding the task parameters are provided below.

Flankers Task. Each trial consisted of 5 horizontally aligned arrows in the middle of the screen presented for 200 ms. Half of the trials were compatible ("<<<<<" or ">>>>>"), and half were incompatible ("<<><<" or ">><>>"). Participants were instructed to respond as quickly and as accurately as possible by clicking the right mouse button if the center arrow was pointing to the right and the left mouse button if the center arrow was pointing to the left. Participants completed 10 practice trials. The task consisted of 11 blocks of 30 trials for a total of 330 trials. Incompatible and compatible trials were presented randomly. Performance feedback was given at the end of each block. When accuracy was at or below 75%, the message "Please try to be more accurate" was displayed. When accuracy fell at or above 90%, the message "Please try to respond faster" was displayed; otherwise, the message "You're doing a great job" was displayed.

Doors Task. The doors task is a monetary guessing task in which participants are presented with 2 doors displayed side by side on each trial and are instructed to select the door they believe will yield a prize (i.e., money) using the left or right mouse button. Once participants decide, a fixation cross is presented for 1500 ms followed by feedback indicating whether they won (i.e., a green arrow pointing upward signifies +\$0.50) or lost (i.e., a red arrow pointing downward signifies −\$0.25); this feedback was presented for 2000 ms. Following each trial, text on the screen instructed participants to "Click for next round," followed by a fixation cross presented for 1000 ms. There was a total of 30 gain and 30 loss trials, which were presented pseudorandomly. Participants were told that they had a chance to earn up to \$15; all participants were given \$8 at the end of the task.

EEG Data Collection and Processing

Continuous EEG data were recorded while participants completed the flankers and doors tasks using an active electrode system (ActiCHamp; Brain Products GmbH) with 32 scalp electrodes placed in accordance with an extended 10–20 system (ActiCAP; Brain Products GmbH). Facial electrodes were placed above and below the left eye and near the outer canthi of the left and right eyes to monitor horizontal and vertical electro-oculographic activity. TP9 and TP10 electrodes were placed on the mastoids. Electrode Cz was used as the online reference, and a ground electrode was placed on the forehead. Continuous EEG signals were recorded at a sampling rate of 1000 Hz using a bandpass recording filter of 0.01 to 100 Hz.

EEG data were processed using Brain Vision Analyzer, version 2.2 (Brain Products GmbH). Data were re-referenced offline to the average of TP9 and TP10 and filtered with a high-pass filter of 0.01 Hz and a low-pass filter of 30 Hz. For the flankers task, the data were segmented from −500 ms prior to the response and up to 1000 ms after the response. Eye movement artifacts were removed using an algorithm developed by Gratton *et al.* (47). Segments containing voltage steps >50 μV between sample points, a voltage difference of 175 μV within a 400-ms interval, or a maximum voltage difference of <0.5 μV within 100-ms intervals were identified as artifacts and were automatically removed. Baseline correction was applied using a −500 ms to 300-ms interval. Response-locked epochs were averaged separately for correct (split-half Spearman-Brown–corrected $r = 0.96$) and error (split-half Spearman-Brown–corrected $r = 0.80$) trials. The ERN was scored as the mean activity within a 50-ms time window around the most negative peak of the error minus correct difference waveform extracted from a 50-ms to 150-ms time window at Fz for each participant (split-half Spearman-Brown–corrected $r = 0.78$).

For the doors task, data were segmented from −200 ms prior to the feedback and up to 800 ms after feedback. Artifact rejection and ocular correction methods were similar to the ERN data. Feedback-locked epochs were averaged separately for win (split-half Spearman-Brown–corrected $r = 0.89$) and loss (split-half Spearman-Brown–corrected $r = 0.84$) trials. The −200-ms prefeedback interval served as the time window for baseline correction. The RewP was scored as the mean activity within a 100-ms time window around the most positive peak of the gain minus loss difference waveform extracted from a 200-ms to 400-ms time window at FCz for each participant (split-half Spearman-Brown–corrected $r = 0.45$).

Data Analysis. All analyses were conducted using SPSS version 26.0 (IBM Corp.) with a critical α of 0.05. Bivariate correlations were conducted to examine associations between the study variables. Correlations were also conducted within the corporal punishment group to examine whether corporal punishment severity, frequency, exposure timing, or duration was associated with other study variables. Independent-samples *t* tests were conducted to examine whether youths who reported corporal punishment differed on demographic variables such as age and sex, as well as the SCARED total score, the CDI total score, and authoritarian parenting style from the PSDQ. Given that we had a directional hypothesis regarding anxiety and depressive symptoms, we used one-tailed independent-samples *t* tests to examine differences in anxiety and depressive symptoms.

To test our primary hypotheses, independent-samples *t* tests were conducted to examine whether youths who reported corporal punishment had a blunted RewP and a potentiated ERN as compared with youths who did not experience corporal punishment. If the equality of variances assumption was violated as indicated by a significant Levene's test, the Satterthwaite-adjusted degrees of freedom were reported. For our exploratory analysis, a logistic regression was conducted to predict corporal punishment group status (1 = youth experiencing corporal punishment; 0 = youth not experiencing corporal punishment) from the ERN, the RewP, and authoritarian parenting while controlling for lifetime stressor exposure (minus the corporal punishment item), age, and sex (0 = female; 1 = male).

RESULTS

The means and standard deviations for all study variables are presented in Table 1 along with the results of independent-samples *t* tests. Bivariate correlations among all study variables are presented in Table 2. Of note, youth who did versus those who did not experience corporal punishment did not differ in age or sex; however, youth who reported experiencing corporal punishment did report more severe anxiety symptoms and depressive symptoms.

Within the corporal punishment group, corporal punishment severity was not related to age at follow-up ($r = -0.10$, $p = .498$), sex ($r = 0.01$, $p = .960$), authoritarian parenting ($r = -0.04$, $p = .774$), depressive symptoms ($r = 0.18$, $p = .225$), the RewP ($r = 0.16$, $p = .264$), or the ERN ($r = -0.16$, $p = .267$). However, corporal punishment severity was related to marginally greater anxiety symptoms ($r = 0.26$, $p = .07$). Moreover, corporal punishment frequency, duration, and age of first exposure did not relate to any of the study variables (*p*s $> .15$).

Corporal Punishment, RewP, and ERN

Consistent with our primary hypothesis, youth who experienced corporal punishment exhibited a larger ERN[1] (Figure 1) and a more blunted RewP[2] (Figure 2). To determine whether a larger ERN and a blunted RewP were uniquely associated with corporal punishment, we conducted an exploratory logistic regression. The overall logistic regression with the ERN and the RewP as simultaneous predictors while controlling for authoritarian parenting, lifetime stressor exposure (minus the corporal punishment item), sex, and age at follow-up was significant. Corporal punishment was uniquely associated with both a larger ERN and a blunted RewP. In addition, adolescents who reported experiencing a more authoritarian parenting style and greater lifetime stressor exposure were more likely to have experienced corporal punishment (Table 3).[3]

DISCUSSION

Although research suggests that harsh parenting and corporal punishment have adverse effects on a child's psychological well-being, few studies have examined the effect of harsh parenting and corporal punishment on neural activity linked to psychopathology. To address this gap, we examined how experiencing corporal punishment was related to youths' neural responses to errors and rewards, measures that have been robustly related to anxiety and depression, respectively. We further examined whether authoritarian parenting style accounted for associations between corporal punishment and neural measures. As hypothesized, we found that youth who had experienced corporal punishment exhibited greater anxiety and depressive symptoms, were more likely to have a parent who reported a more authoritarian parenting style, and had a larger delta ERN and a blunted RewP than youth who did not experience corporal punishment. Moreover, a blunted RewP and a larger ERN were independently associated with corporal punishment, even when considering the broader constructs of authoritarian parenting style and lifetime stressor exposure.

[1]The ERN peak latency did not differ between the no corporal punishment group (mean [SD] = 34.81 [47.50]) and the corporal punishment group (mean [SD] = 43.64 [44.39]).

[2]The RewP peak latency did not differ between the no corporal punishment group (mean [SD] = 287.79 [38.21]) and the corporal punishment group (mean [SD] = 286.75 [43.95]).

[3]A logistic regression with the constituent ERP waveforms in place of the difference scores, controlling for age, sex, and authoritarian parenting (Nagelkerke $R^2 = 0.371$, $\chi^2 = 43.98$, $p < .001$), suggested that an increased ERN (odds ratio = 0.898, $p < .006$), a blunted ERP to wins (odds ratio = 0.904, $p < .014$), and a blunted ERP to losses (odds ratio = 1.13, $p < .004$) were related to corporal punishment.

Table 1. Demographic and Clinical Characteristics of Participants Experiencing and Not Experiencing Corporal Punishment

Variable	Total Sample	Children Experiencing Corporal Punishment	Children Not Experiencing Corporal Punishment	Test Statistic
Age at Follow-up, Years	13.02 (1.15)	14.94 (1.08)	14.77 (1.18)	$t_{147} = -1.053$
Sex, Female, *n*	61	24	37	$\chi^2_2 = 0.898$
ΔERN	−6.30 (5.81)	−7.68 (5.81)	−5.56 (5.71)	$t_{142} = 2.11$[a]
RewP	6.93 (5.69)	5.06 (5.17)	7.92 (5.72)	$t_{145} = -2.98$[b]
Anxiety Symptoms (SCARED Total Score)	17.39 (12.27)	20.29 (13.89)	15.86 (11.09)	$t_{84.2} = 1.97$[a]
Depressive Symptoms (CDI Total Score)	7.54 (7.25)	9.42 (8.51)	6.55 (6.31)	$t_{79.7} = 2.12$[a]

Values are presented as mean (SD) unless indicated otherwise. For the CDI total score and the SCARED total score, one-tailed independent *t* tests and Satterthwaite-adjusted degrees of freedom are reported.

ΔERN, delta error-related negativity; CDI, Children's Depression Inventory; RewP, reward positivity; SCARED, Screen for Child Anxiety Related Disorders.

[a]$p < .05$.

[b]$p < .01$.

Prior research has found that harsh parenting is associated with a larger ERN in children (10,11,19). In turn, a larger ERN has been associated with both cross-sectional and prospective increases in anxiety symptoms and disorders (48–51). In this context, to our knowledge, our study is the first to demonstrate that corporal punishment is uniquely associated with a larger ERN beyond the effect of experiencing harsh parenting more generally. These results are consistent with functional magnetic resonance imaging research suggesting that corporal punishment is associated with atypical development of multiple brain regions (5,21,51–53). Specifically, Cuartas *et al.* (52) found that corporal punishment was related to elevated threat processing in children (51). Children who reported corporal punishment showed greater dorsal anterior cingulate cortex activation, a brain region speculated to be a generator of the ERN (12,54), than children who did not report corporal punishment. Taken together, these data suggest that corporal punishment adversely affects the development of brain regions implicated in threat and error processing. More specifically, corporal punishment may sensitize children to their mistakes, which may increase the risk of developing anxiety disorders (19).

To our knowledge, this is also the first study to examine the association between parenting style and children's RewP response. In this context, the results of this study indicate that children who experienced corporal punishment had a blunted RewP as compared with children who did not experience corporal punishment and that this association was evident above and beyond the more general impact of authoritarian parenting and lifetime stressor exposure. Overall, the results are consistent with prior functional magnetic resonance imaging research suggesting abnormalities in reward-related brain regions among individuals who experienced harsh parenting (55). Specifically, punitive parenting has been associated with reduced striatal volume and ventral striatum connectivity (56,57). Given that reductions in the RewP are linked to increases in depressive symptoms and onset of depressive disorders in children (29,31,37), corporal punishment may increase the risk for depressive symptoms and disorders by reducing reward-related brain activity.

Table 2. Correlations Between the Main Study Variables

	1	2	3	4	5	6	7	8
1 Age at Follow-up	–							
2 Sex	−0.09	–						
3 Authoritarian Parenting	−0.18[a]	0.04	–					
4 Anxiety Symptoms	0.07	−0.36[b]	0.11	–				
5 Depressive Symptoms	0.14	−0.26[b]	0.05	0.75[b]	–			
6 RewP	−0.12	0.15[c]	−0.15[c]	−0.08	−0.10	–		
7 ΔERN	−0.15[c]	−0.01	0.06	0.08	0.11	−0.10	–	
8 Corporal Punishment	0.06	−0.07	0.24[b]	0.15[a]	0.16[a]	−0.25[b]	−0.19[a]	–
9 Lifetime Stressor Exposure	0.17[a]	−0.08	0.11	0.47[b]	0.63[b]	−0.14	0.07	0.41[b]

Anxiety symptoms were measured using the Screen for Child Anxiety Related Disorders, and depressive symptoms were measured using the Children's Depression Inventory total score. One-tailed correlations are reported for anxiety symptoms and corporal punishment and for depressive symptoms and corporal punishment. $N = 141$. Sex (0 = female, 1 = male). Corporal punishment (0 = no, 1 = yes).

ΔERN, delta error-related negativity; RewP, reward positivity.

[a]$p < .05$.

[b]$p < .01$.

[c]$p < .10$.

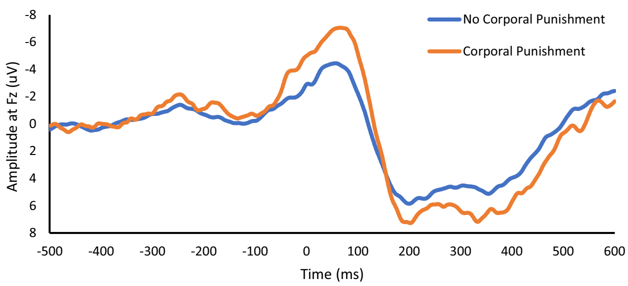

Figure 1. The response-locked event-related potential difference waveform (error − correct) to the flankers task averaged across all participants at electrode Fz for the no lifetime corporal punishment group (blue) and the lifetime corporal punishment group (orange). Participants who experienced corporal punishment over the lifespan had a larger error-related negativity, measured as the average activity between 0 ms and 100 ms after error commission than participants who did not experience corporal punishment.

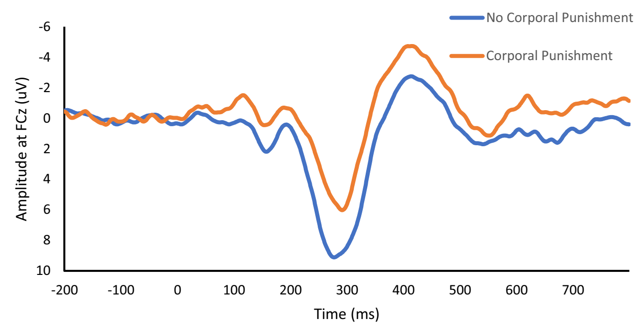

Figure 2. The reward positivity difference waveform (win − loss) to the doors task averaged across all participants at electrode FCz for the no lifetime corporal punishment group (blue) and the lifetime corporal punishment group (orange) scored at FCz. Participants who experienced corporal punishment over the lifespan had a more blunted RewP as compared with participants who did not experience corporal punishment.

Collectively, the results indicate that corporal punishment was related to both increased error processing and reduced reward processing in children. These results are consistent with the broader research on the effects of adverse childhood experiences indicating that experiencing more adverse childhood experiences is associated with increased threat/error processing and reduced reward processing (58–60). Specifically, adverse childhood experiences such as trauma and neglect have been shown to be related to and predict an increased ERN and a reduced RewP (61–64). Although the reasons for these results require speculation, one possibility is that corporal punishment represents a unique type of life stressor that both involves a physical attack and threatens the social safety of a child. Thus, these results are consistent with the Social Safety Theory in that increasing attention to one's errors and decreasing attention to rewards may serve as a protective mechanism that helps individuals anticipate social and physical threats in the environment and prioritize behaviors that would have had the greatest adaptive advantage over the course of evolutionary history (65).

The results of this study also indicate that children who experienced corporal punishment reported higher levels of anxiety and depressive symptoms and had parents who were more likely to endorse a harsh parenting style. Boys and girls were equally likely to report corporal punishment, and reports of corporal punishment did not differ by age. Although we examined corporal punishment occurring across the lifetime, our analyses were cross-sectional. Therefore, future studies should examine whether corporal punishment prospectively predicts increases in anxiety and depressive symptoms that are mediated by changes in the ERN and the RewP, respectively.

This study has several strengths, including the fact that both the ERN and RewP were examined within the same sample and that separate assessments of harsh parenting and corporal punishment were collected. However, several limitations should also be noted. First, the sample consisted of boys and girls between the ages of 11 and 14 years old; therefore, it remains to be seen whether these results generalize to younger children and adults as well as gender nonbinary adolescents. Second, the measure of corporal punishment relied on child reporting. Although children may accurately report corporal punishment, it is also possible that some children may report no corporal punishment even if they experienced it or, alternatively, minimize its frequency (66). Therefore, it is important that future studies include multiple informant assessments. This study also did not find any evidence for an association between corporal punishment severity, frequency, exposure time, or duration and either the ERN or RewP. The lack of bivariate associations between corporal punishment features and the ERN/RewP may be due to a restricted range within each of the corporal punishment features (i.e., participants generally indicated minimal severity and frequency along with a short duration and early onset). However, this pattern of results would suggest that corporal punishment could affect neural functioning regardless of the intensity of its features.

Table 3. Results of the Logistic Regression Predicting Corporal Punishment From the ERN and RewP While Controlling for Authoritarian Parenting, Lifetime Stressor Exposure (Minus Corporal Punishment), Sex, and Age at Follow-up

Variable	R^2	χ^2	OR (95 % CI)	*p*
	0.373	44.30		<.001
ΔERN	–	–	0.889 (0.824–0.960)	.003
RewP	–	–	0.891 (0.819–0.969)	.007
Authoritarian Parenting	–	–	1.11 (1.003–1.227)	.043
Sex	–	–	0.929 (0.396–2.178)	.865
Age at Follow-up	–	–	0.914 (0.617–1.354)	.655
Lifetime Stressor Exposure (Minus Corporal Punishment)	–	–	1.075 (1.037–1.115)	<.001

Corporal punishment (no = 0, yes =1). Sex (0 = female, 1 = male). Nagelkerke R^2 is reported.
ΔERN, delta error-related negativity; RewP, reward positivity.

Using multiple informant and prospective assessments, future studies could further examine whether the impact of corporal punishment on the ERN and RewP varies by frequency, timing, duration, or severity.

Finally, the ERN and RewP were measured 2 years prior to the time that the self-report measures were collected. It is possible that a child's behaviors could affect parenting behaviors and elicit corporal punishment. Indeed, child behaviors that are perceived as cohesive and disruptive are associated with increased experience of corporal punishment (67). Although prior research has shown that an increased ERN and a reduced RewP are associated with harsh parenting, it is unknown whether variations in a child's ERN and RewP influence parenting behaviors. Therefore, future research should make use of more fine-grained assessments of both parenting measures, including corporal punishment, and ERPs to understand their relation.

Notwithstanding these limitations, these data provide novel evidence suggesting that corporal punishment experienced over the life span is uniquely related to both error- and reward-related neural responses that have previously been associated with increases in risk for psychopathology (35,36,48,59–61). Future research studies should examine the prospective impact of corporal punishment on neural systems to examine whether increases in ERN and decreases in RewP explain developmental associations between corporal punishment and the development of anxiety and depression, respectively.

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ARTICLE INFORMATION

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