Published in final edited form as:
Dev Cogn Neurosci. 2014 July ; 9: 148–159. doi:10.1016/j.dcn.2014.03.001.

Harsh Parenting and Fearfulness in Toddlerhood Interact to Predict Amplitudes of Preschool Error-Related Negativity

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Abstract

Temperamentally fearful children are at increased risk for the development of anxiety problems relative to less-fearful children. This risk is even greater when early environments include high levels of harsh parenting behaviors. However, the mechanisms by which harsh parenting may impact fearful children's risk for anxiety problems are largely unknown. Recent neuroscience work has suggested that punishment is associated with exaggerated error-related negativity (ERN), an event-related potential linked to performance monitoring, even after the threat of punishment is removed. In the current study, we examined the possibility that harsh parenting interacts with fearfulness, impacting anxiety risk via neural processes of performance monitoring. We found that greater fearfulness and harsher parenting at 2 years of age predicted greater fearfulness and greater ERN amplitudes at age 4. Supporting the role of cognitive processes in this association, greater fearfulness and harsher parenting also predicted less efficient neural processing during preschool. This study provides initial evidence that performance monitoring may be a candidate process by which early parenting interacts with fearfulness to predict risk for anxiety problems.

Keywords

Fearful temperament; ERN; Harsh Parenting; Anxiety Risk

1. Introduction

Extremely fearful infants show more anxiety symptoms by adolescence than do typically-developing children (Hirshfeld-Becker et al., 2002). However, because only about one-third of fearful children develop anxiety disorders (Biederman et al., 2001), numerous exogenous factors may moderate the association between early fearfulness and anxiety problems. One such moderator is parental harshness, which contributes to increasing levels of anxiety in children (Feng, Shaw, & Silk, 2008). Yet, the mechanism by which harshness exacerbates anxiety symptoms for fearful children is unclear. Research recently revealed that punishment, an aspect of harsh parenting, can have long-term effects on neural processes of self monitoring (Riesel, Weinberg, Endrass, Kathmann, & Hajcak, 2012). Thus, it is possible

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that, over time, fearful children of harsh parents learn to anticipate the potential for punitive, critical behaviors from parents. This learned association may, in turn, lead to hyper-monitoring of one's own behavior in an effort to avoid negative interactions with parents. If this hypothesized process is accurate, hypervigilance, in the form of heightened self-monitoring, becomes a pathway by which risk for anxiety is exacerbated for fearful children. Testing this possibility was the aim of the current study.

As previously stated, heightened fearfulness is an established risk factor for the development of anxiety problems (Clauss & Blackford, 2012). Stable fearfulness over time increases one's likelihood of receiving an anxiety diagnosis (Chronis-Tuscano et al., 2009) and quantifications of extreme fearfulness in minimally-threatening contexts appear to strengthen the ability to predict the development of anxiety symptoms (Buss, 2011; Buss et al., 2013). Namely, children who are highly fearful, stable high in fear over time, or show high levels of fear in low-threat contexts appear to be at greatest risk for anxiety problems. Of course, all current methods for quantifying risk imperfectly predict anxiety problems. Thus, intermediate processes impacting early risk for anxiety problems remains important for advancing this area of research.

Some aspects of parenting (e.g., negative affect, intrusiveness) are relatively ubiquitous risk factors for maladaptive child outcomes. However, harsh parenting, typically defined as high levels of control, coercion, punitive behaviors, and/or punishment by parents, has been identified as a risk factor specific to the development of anxiety problems (Shanahan et al., 2008), multiplying risk by a factor of 2–4, depending on the diagnosis. Greater harsh parenting appears to be particularly detrimental for fearful children (Degnan, Almas, & Fox, 2010a; Leve, Kim, & Pears, 2005). The processes by which harsh parenting is linked to risk for anxiety problems have been understudied. A subset of work implicates cognitive processes as putative mechanisms of early fearfulness, but has not examined these factors in relation to parenting behaviors (e.g., Pérez-Edgar et al., 2011). Theories of moral development posit that consistent and predominant use of harsh parenting strategies is associated with an increasing fear of punishment in children (Hoffman, 1983). An increasing fear of punishment may lead to heightened self-monitoring in an effort to avoid harsh, punitive behaviors from parents. This possibility is supported by empirical research; children at risk for internalizing problems display overcontrolled behaviors (Eisenberg et al., 2001; Santesso, Segalowitz, & Schmidt, 2006). These behaviors, including heightened monitoring and reflection on performance (Messer, 1970), are associated with an increased risk for internalizing problems in children. Therefore, it is possible that harsh parenting may come to augment anxiety risk in children via its influence on the performance monitoring system.

The error-related negativity (ERN) is an event-related potential (ERP) believed to index performance monitoring at the neural level. The ERN is visible as a negative deflection in the response-locked EEG peaking 50 to 100 ms following incorrect behavioral responses. ERN is believed to capture aspects of error detection (Falkenstein, Hohnsbein, Hoormann, & Blanke, 1991), conflict detection (Botvinick, Braver, Barch, & Carter, 2001) reinforcement learning (Holroyd & Coles, 2002), emotion processing (Luu & Pederson, 2004), and motivation (Gehring & Willoughby, 2004). In general, the ERN does not appear to be dependent on conscious error-recognition; in fact, an ERN is detectable on correct trials for which participants are uncertain about their performance (Coles, Scheffers, & Holroyd, 2001). Thus, the ERN likely reflects a general process of performance monitoring (Falkenstein, Hoormann, Christ, & Hohnsbein, 2000), one aspect of which is error detection.

Traditionally, children were not believed to show reliable ERN until adolescence, when the ERN takes adult-like form (Davies, Segalowitz, & Gavin, 2004; Ladouceur, Dahl, & Carter, 2007). However, recent work suggests that the ERN can be elicited in the young children with the use of developmentally appropriate tasks (Torpey, Hajcak, & Klein, 2009) and ERN has now been demonstrated in children as young as age 4 (Brooker & Buss, 2014). Though the number of studies of ERN in young children is limited, this work has demonstrated smaller (i.e., less negative) and more variable ERN amplitudes (Kim, Iwaki, Imashioya, Uno, & Fujita, 2007; Santesso et al., 2006; Wiersema, van der Meere, & Roeyers, 2007) and more broadly distributed ERN (Brooker & Buss, 2014; Hogan, Vargha-Khadem, Kirkham, & Baldeweg, 2005) in young children relative to adolescents and adults. These developmental differences are reasonable considering that the Anterior Cingulate Cortex, a putative source of ERN (Dehane, Posner, & Tucker, 1994), is not fully developed during in early childhood.

In most cases, performance monitoring is an adaptive process in that it signals the need for behavioral changes in order to enhance subsequent performance (Van Veen & Carter, 2006). However, extreme levels performance monitoring may reflect excessive, persistent concern about negative evaluation, which are hallmark symptoms of Social Anxiety Disorder (*DSM-5*, 2013). Indeed, adolescents who meet diagnostic criteria for an anxiety disorder show enhanced ERN amplitudes relative to healthy controls (Ladouceur, Dahl, Birmaher, Axelson, & Ryan, 2006). Greater ERN in adolescents is also related to histories of childhood fearfulness (McDermott et al., 2009). We recently showed that greater fearfulness at age 2 predicted the presence of an ERN at 4.5 years of age; ERN was not observed in low-fear children (Brooker & Buss, 2014). In young adults, enhanced ERN has also been linked to experience of punishment, an association that persisted after punishment was removed (Riesel et al., 2012). Additionally, trait-anxious participants were particularly sensitive to punishment. This pattern of results supports the notion that enhanced performance monitoring may be a pathway by which harsh parenting is associated with anxiety risk in fearful children. Namely, harsher parenting may increase concern or worry about the threat of punishment in the future, enhancing performance monitoring in children who are fearful early in life. Such a pathway is supported by adult work suggesting close associations between anxious apprehension/worry and performance monitoring (Moser, Moran, Schroder, Donnellan, & Yeung, 2013).

In the current study, we tested links among early fearfulness, harsh parenting, and performance monitoring. We conducted this work in a sample of preschoolers, as this is a time of rapid cognitive development. Moreover, given recent evidence, we focused on early risk for anxiety problems based on fearfulness in a low-threat context. Our first aim was to replicate previous findings that ERN is present in preschool children and that harsh parenting predicts the maintenance or increase of fear behaviors for children who were high in fearfulness early in life. Both of these examinations were done longitudinally, such that fearfulness and parenting were measured prior to the measurement of ERN. We then tested whether, across the same time period, high levels of fearfulness would be associated with enhanced performance monitoring (ERN) when children experienced greater harsh parenting as toddlers. Consistent with previous research, we predicted that high levels of fearfulness and greater harsh parenting during toddlerhood would predict more fearfulness and greater ERN during preschool.

2. Method

2.1 Participants

Participants were drawn from a larger study of toddler temperament. As a part of the parent project, a group of toddlers (*N* = 125) that had been oversampled for high levels of fear and wariness early in life participated in a laboratory assessment when children 2 years old (*M* = 2.04, *SD* = 0.04).

Sixty-six families from the parent project were invited to participate in the current study when children were 4.5 years old (*M* = 4.59, *SD* = 0.13, median = 4.50). Selection criteria for the current study were based on observed fearfulness during six laboratory episodes at age 2 and were intended to maximize the likelihood of recruiting a sample representing the full spectrum of fearfulness. Criteria for families to receive an invitation required that: (1) children be 4.5 years of age by the time of the current study and (2) children either scored 3 or greater (5-point scale) on observer-rated fearfulness in at least half of the episodes of the age 2 laboratory visit (i.e., were high in fearfulness) or scored less than 3 in at least half of the episodes of the age 2 laboratory visit (i.e., were low in fearfulness). Notably, this broadly-defined measure of fearfulness was intended only to ensure that an ample number of high-fear toddlers would be recruited for the current study. The quantification of early fearfulness (high fear in a low-threat context) was based on a more detailed microcoding scheme described later. Eligible families were contacted by telephone. Those who expressed interest in participating verified that children were free of any known developmental delays and not taking any psychostimulant medications. Parents also verified an absence of neurological impairment in the medical history of all members of the child's immediate family.

Of the 66 families contacted, 1 family withdrew from the parent project; 7 families did not return phone calls or respond to recruitment mailings; 3 families had moved away from the area; 13 families declined to participate based on time constraints, driving distance, or because they did not believe that their child would tolerate the procedures; and 1 family failed show for their laboratory visit. Thus, the final sample included 41 preschoolers (20 girls).

The subsample of participants in the current study was representative of the parent project and the area from which families were recruited with respect to socioeconomic status and racial and ethnic diversity. Parents identified the majority of children (87.5%) as Non-Hispanic Caucasian, 5.0% as African-American, 5.0% as Asian American, and 2.5% as of Hispanic ethnicity. Families reported annual incomes ranging from less than $15,000 to over

$60,000. The highest proportion of families (47.5%) reported annual incomes of more than $60,000.

2.2 Procedure

2.2.1 Toddler laboratory visit—Similar to previous procedures (Buss, 2011), episodes from the laboratory visit at 2 years were drawn from the toddler and preschool versions of the Laboratory Temperament Assessment Battery (Lab-TAB: Goldsmith, Reilly, Lemery, Longley, & Prescott, 1994; Buss & Goldsmith, 2000). Given evidence regarding the importance of high fear in low threat contexts, early risk for anxiety problems was focused on a composite measure of children's microcoded fearful behaviors in a highly novel but minimally threatening episode in which children watched 2-minute Puppet Show. Prior to the laboratory visit, parents were mailed a packet of questionnaires to be completed and returned upon arrival to the lab.

2.2.2 Preschool laboratory visit—Families were invited to return to the laboratory when children reached 4.5 years of age. An experimenter reviewed the consent form and explained all experimental procedures to the parent(s) and their child upon their arrival. Children were told that they would receive a sticker to add to a cartoon "treasure map" for each task they completed. All children were rewarded with a small prize at the end of the laboratory visit. Children were fitted with a 128-channel Hydrocel Geodesic Sensor Net (Electrical Geodesics, Inc.) for EEG collection. The child then completed three laboratory episodes: a resting baseline, a modified version of the Attention Network Test (ANT; Rueda et al., 2004), and a second resting baseline. Baseline episodes are not considered in the current analyses.

2.3 Measures

2.3.1 Parenting during toddlerhood—When children were 2 years old, parenting was assessed via responses made by the primary caregiver to two questionnaires. The Coping with Children's Negative Emotions Scale (CCNES; Fabes, Poulin, Eisenberg, & Madden-Derdich, 2002), modified for use with toddlers (Spinrad, Eisenberg, Kupfer, Gaertner, & Michalik, 2004), was designed to assess parental responses to negative emotions in young children. Parents rated, using a 7-point scale, their likelihood of responding in each of six possible ways to 12 hypothetical scenarios. Individual items were composited to form six 12-item scales: distress reactions (α = 0.74), expressive encouragement (α = 0.92), emotion-focused reactions (α = 0.79), problem-focused reactions (α = 0.82), punitive/minimizing reactions (α = 0.87), and granting wish reactions (α = 0.72). Parents also completed the New Friends Vignettes, a 36-item measure on which they used a 3-point scale to rate the likelihood of their responses to two hypothetical situations (McShane & Hastings, 2009). Individual items were composited into 3 subscales of maternal behavior: critical control (α = 0.72), appropriate support (α = 0.79), and overprotection (α = 0.73).

Scale scores from both measures were subjected to a principal components analysis (PCA) with oblique rotation. This analysis returned a 3-factor solution accounting for 69.09% of the variance of the original variables. The first and second factors appeared to reflect responsive and overprotective parenting, respectively. These factors were not pertinent to the hypotheses of the current study and so were not considered further. The third factor reflected harsh parenting, with high positive loadings for punitive/minimizing reactions and critical control (mean factor loading = 0.81). Thus, this factor reflected a harsh parenting style that stressed punishment, a lack of child-orientation (e.g., minimizing rather than comforting negative emotions in children), and high levels of criticism and control. Individual factor scores were extracted for each child as a score of harsh parenting experienced during toddlerhood.

2.3.2 Fearfulness during toddlerhood—Fearfulness at age 2 was defined for each child as a factor score of the following behaviors during the novel, but low-threat puppet show: latency to freeze (reverse scored), duration of facial fear, duration of bodily fear, duration of freezing, and duration of proximity to mother (across behaviors, range $r = 0.30 – 0.93$; mean $r = 0.62$). Fifteen percent of episodes were double coded for reliability (agreement: 86 – 91% across behaviors[1]). Factor scores of fearfulness were identical to those in previous research (Buss, 2011).

2.3.3. Fearfulness during preschool—During the laboratory at age 4.5, the primary experimenter provided online ratings of child affect and behavior at the beginning (prior to first baseline), middle (following ANT), and end (after EEG cap was removed) of the laboratory visit using a version of the Behavioral Rating Scale (BRS), modified from the Infant Behavior Record (Stifter & Corey, 2001). These points of data collection were selected as putative baseline, reactive, and recovery assessments. The experimenter completed 11 items, which asked about children's positivity, negativity, reactivity to people and objects, and persistence with laboratory tasks. Each item required the examiner to rate, on a five-point scale, the degree to which children were high or low in each behavior. Anchors for items differed in order to fit the rated behavior. For example, children's responsiveness to the examiner could be rated from avoiding/withdrawn (1) to inviting/initiating/demanding (5) while happiness could range from child seemed unhappy throughout the laboratory episode (1) to child radiated happiness/was animated during episode (5).

In addition to experimenter ratings, videotapes of laboratory visits were coded by an undergraduate research assistant who was trained by a master coder. Independent ratings were assigned for levels of fearful behaviors, including fearful distress and shyness/withdrawal, observed for each child. Fearful distress was defined as facial, bodily, or vocal displays of negative affect during novelty episodes; withdrawal was defined as intentional retreat from the stimulus. Ratings ranged from 1 (behavior is absent) to 4 (behavior lasts entire episode). Separate ratings were made for the beginning, middle, and end of the laboratory visit based on a five-point interval scale ranging from an absence of the behavior to behavior of the highest intensity and duration. All coding was completed by a single research assistant, eliminating the need for inter-rater reliabilities; however, 30% of episodes

[1]As reported in Buss, 2011, because coding used second-by-second ratings of behavior, most coding epochs contained scores of zero, which resulted in unbalanced marginal totals and artificially low κ (Lantz & Nebenzahl, 1996). Therefore, inter-coder reliability was calculated as percent agreement on 15% of cases for each episode.

were double coded in order to protect against coding drift (*ICC*s: fearful distress = 0.98, shyness = 0.91).

Experimenter ratings were positively correlated (mean $r = 0.35$) across the laboratory visit. Observational ratings of shyness/withdrawal were also positively correlated (mean $r = 0.66$) across the laboratory visit. Therefore, ratings made at the beginning, middle, and end of the laboratory visit were mean composited (experimenter and observational ratings were composited separately). Standardized scores for experimenter ratings and observational coding were submitted to a PCA and confirmatory factor analysis. Items ($n = 3$) that failed to return a communality or factor loading greater than 0.50 were removed and the analysis was rerun. The confirmatory factor analysis returned a two-factor solution that accounted for 69.03% of the variance in the original factors. The first was an engagement factor that is not used in the current study. The second factor reflected fearfulness and included high negative loadings for happiness and responsiveness to the examiner along with high positive loadings for shyness and reactivity to the new/strange (absolute value of mean loading = 0.76).

2.3.4 Preschool ERN—ERN was elicited during the ANT at the preschool laboratory visit. The ANT was selected given that flanker tasks have been shown to successfully elicit an ample number of errors for creating an ERN. Each child completed the ANT on a Dell PC using E-Prime 1.1 (Psychology Software Tools, Inc: Pittsburg, PA). Participants were told that a row of cartoon fish would appear on the computer screen, were instructed to attend only to the middle fish (i.e., the target fish), and to “feed that fish” using a response box. The rightmost button on the response box “fed” target fish depicted as facing rightward; the leftmost button on the response box “fed” target fish depicted as facing leftward. When it was clear that participants understood the instructions, they began a set of computerized practice trials.

A session of the ANT consisted of a total of 16 practice trials and two experimental blocks of 64 trials each. Participants were allowed to take a short break between experimental blocks. Each trial began with the presentation of a fixation cross for 400 ms. On some trials, a warning cue was subsequently presented for 150 ms and represented one of three conditions relevant to different dimensions of attention. The target array appeared 450 ms after the offset of the warning cue and remained on the screen for 1700 ms or until a response was detected. Target arrays were either congruent, with the target fish facing the same direction from the flanking fish, or incongruent, with the target fish facing the opposite direction from the flanking fish. A picture of a happy or a sad face indicated to children whether their previous answer had been correct or incorrect, respectively. Children’s ability to distinguish between congruent and incongruent trials was not central to questions of the current study. Thus, ANT data were collapsed across all presentation conditions (Figure 1). Accuracy and reaction time were recorded for each trial.

EEG was recorded using NetStation acquisition software version 4.3.1 (Electrical Geodesic, Inc.: Eugene, OR). The sampling rate for data collection was 500 Hz. Prior to beginning data acquisition, all impedances were reduced to less than 80 kΩ as recommended by the manufacturer. EEG was recorded using a 0.1 Hz highpass filter and a 100 Hz lowpass filter. All channels were referenced to Cz (129) during data collection and rereferenced offline to an average of the two mastoid channels (57 and 100). Data from each participant were submitted to an Independent Components Analysis in EEGLab Version 8.0.3b (Delorme & Makeig, 2004) in order to extract eye blink and eye movement artifacts prior to quantifying ERPs.

Offline, all data processing was completed using Brain Vision Analyzer (Brain Products: Gilching, Germany). EEG data were high-pass filtered at 0.10 Hz (12 dB rolloff) and low-pass filtered at 20 Hz (12 dB rolloff). From the continuous EEG, 1600 ms segments were extracted beginning 600 ms prior to participant responses. Segments were baseline corrected by subtracting from each data point the average activity in the 600 ms time window preceding the response (Pailing et al., 2002; Segalowitz et al., 2010). Remaining trials were rejected when any of the following criteria were met: a voltage step of more than 75 μV between data points, a voltage difference of 150 μV within a single segment, amplitudes exceeded ±200 μV within a single trial, or amplitudes dropped below 0.5μV during any 50 ms period. Each trial was also visually inspected for artifacts following this procedure. Based on these criteria, an average of 6.17 (SD = 3.46) trials per person were rejected across all trial types. Grand averages were created for artifact-free segments during correct and error trials. Trials were not included in the average if the reaction time occurred outside of a 200–1600 ms time window.

Based on previous work with children, the ERN was defined as the mean voltage across the +/−20 ms surrounding the greatest negative deflection in the time window from 100 ms before to 100 ms after the response. ERN was evaluated along the midline (Fz, Cz, Pz) electrodes. Note that scored in this way, greater ERN corresponds to greater negative amplitudes (i.e., more negative numbers) during error trials.

2.3.6 Missing Data—ERP averages were not created for participants with fewer than 6 trials of usable data (Olvet & Hajcak, 2009; Pailing et al., 2002). This resulted in the exclusion of data from 5 children because there were not enough error trials to create an average. Some level of transient noise appeared in the data sets of 5 additional children, who were also excluded[2]. Six children were missing either the CNES or NFV measure, precluding the calculation of scores on the parenting scales. Given that data were missing completely at random (Little's MCAR: $\chi^2[15] = 4.86$, $p > 0.10$), we used a complete-case analysis strategy to handle missing data (n = 25).

3. Results

3.1 Preliminary Analyses

Independent sample t-tests indicated that parents of males reported greater harsh parenting than did parents of females (d = 0.96); therefore, sex was used as a covariate in all subsequent analyses. Descriptive statistics, including t-test results, are provided in Table 1. Bivariate associations that controlled for sex of child were largely nonsignficiant, save for a link between greater ERN and greater fearfulness at age 4.5 (Table 2). Analyses of response time data are reported elsewhere[3] (Brooker & Buss, 2014); generally, these analyses showed

[2]Analyses are equivalent with or without these participants.

that although mean response times were faster for error relative to correct trials, as is typical, this difference was not significant.

3.2 ERN in Preschool

A 3 (Electrode: Fz, Cz, and Pz) X 2 (Trial Type: Correct and Error) repeated measures ANOVA confirmed that errors were associated with greater negative amplitudes than correct trials ($F(1, 32) = 9.94$, $p < 0.01$, $\eta^2_p = 0.24$). Both error and correct trials showed heightened negativity at anterior (Fz) and posterior (Pz) electrode sites ($F_{quad}(1, 32) = 9.26$, $p < 0.01$, $\eta^2_p = 0.22$). Importantly, a significant interaction between electrode site and trial type suggested that the difference between error negativity and correct trial negativity varied as a function of electrode site ($F_{Lin}(1, 32) = 4.24$, $p < 0.05$, $\eta^2_p = 0.12$). Follow-up tests showed that negative amplitudes for error trials were significantly greater than negative amplitudes for correct trials at Fz ($t(1,35) = -2.43$, $p < 0.05$, $d = 0.54$) but not at Cz ($t(1,34) = -0.61$, $p > 0.10$) or Pz ($t(1,33) = -1.24$, $p > 0.10$). Therefore, subsequent analyses focused only on ERN at Fz, which is illustrated in Figure 2.

3.2 Harsh Parenting as a Moderator of the link between Toddler Fearfulness and Age 4 Fear

Harsh parenting was tested as a moderator of the link between fearfulness during toddlerhood and observed fear at age 4 in a hierarchical regression analysis. Sex was entered as a covariate in Step 1 along with main effects for age 2 harsh parenting and age 2 fearfulness. The interaction between age 2 harsh parenting and age 2 fearfulness was entered in Step 2. Continuous predictor variables were centered prior to creating the interaction term.

As shown in Table 3, an association emerged between the interaction of fearfulness and harsh parenting at age 2 and observed fearfulness at age 4. In order to prevent the creation of arbitrary low/high groups and retain power given our small sample, this interaction was probed by examining the continuous simple slopes of age 2 fearfulness recentered at low (−1 *SD*) and high (+1 *SD*) levels of early harsh parenting (Aiken & West, 1991). Probing the interaction in this manner revealed that when harsh parenting was high at age 2, greater fearfulness at age 2 was marginally associated with greater fearfulness at age 4 ($B = 0.03$, $SE(B) = 0.01$, $\beta = 0.64$, $p < 0.10$). In contrast, at low levels of harsh parenting, age 2 fearfulness was unrelated to fearfulness at age 4 ($B = -0.03$, $SE(B) = 0.02$, $\beta = -0.66$, $p > 0.10$).

3.2 Early Fearfulness Moderates the Link between Early Harsh Parenting and ERN

Early harsh parenting was then tested as a moderator of the association between age 2 fearfulness and age 4 ERN using the hierarchical regression procedure previously described. As shown in Table 4, a significant interaction emerged between the interaction of age 2 fearfulness and harsh parenting and ERN at age 4. Probing the simple slopes of age 2 fearfulness at low and high levels of early harsh parenting revealed that at high levels of

[3]Previous findings with this sample focused on the association between early fearfulness and the presence of an ERN during preschool. None of the analyses included in the current study have been conducted or presented in prior work.

harsh parenting during toddlerhood, greater age 2 fearfulness predicted greater (i.e., more negative) ERN at age 4 ($B = -0.50$, $SE(B) = 0.23$, $\beta = -0.83$, $p < 0.05$). In contrast, at low levels of harsh parenting during toddlerhood, greater age 2 fearfulness marginally predicted smaller (i.e., less negative) ERN at age 4 ($B = 0.64$, $SE(B) = 0.31$, $\beta = 1.05$, $p < 0.10$).

3.4 Post-Hoc Analysis

Because increased ERN has been interpreted as both maladaptive (i.e., indicative of anxiety risk; less efficiency) and as reflecting adaptive development (i.e., better performance monitoring across development; more efficiency), we wanted to further validate our assertion that heightened ERN reflects disruptions in cognitive processing efficiency for high fear children. If greater harsh parenting and greater fearfulness during toddlerhood predicted diminished cognitive efficiency, the association that we found between these measures and increased ERN would be more likely to be maladaptive. In contrast, if greater harsh parenting and greater fearfulness during toddlerhood predicted increased cognitive efficiency, the association that we found between these measures and increased ERN would more likely reflect adaptive cognitive development (e.g., developing ERN).

To test whether differences in fearfulness and harsh parenting were suggestive of low or high cognitive efficiency, we reran our hierarchical regression model predicting cognitive efficiency as indexed by response times for correct trials of the ANT. Limited to correct trials only, greater efficiency is suggested by faster response times (i.e., smaller values) while less efficiency is suggested by longer response times (larger values). An interaction emerged between age 2 fearfulness and harsh parenting predicting response times at age 4 (Table 5). Probing the simple slopes of harsh parenting at low and high levels of age 2 fearfulness revealed that at high levels of fearfulness at age 2 greater harsh parenting was associated with slower response times, indicating less efficiency ($B = 3.80$, $SE(B) = 1.62$, $\beta = 0.73$, $p < 0.05$). In contrast, at low levels of age 2 fearfulness, harsh parenting was unrelated to response times ($B = -3.14$, $SE(B) = 2.35$, $\beta = -0.60$, $p > 0.10$).

4. Discussion

Our results were largely consistent with study hypotheses. First, using longitudinal data, we replicated previous research showing that when levels of toddlerhood fearfulness were high, harsher parenting was associated with more observed fear at age 4. Second, we showed that high levels of performance monitoring measured at the level of neural activity accompany increases in fearfulness across a two-year period. Namely, when fearfulness and levels of harsh parenting were high at age 2, children showed both greater fear and amplified ERN at age 4. Importantly, our results were obtained in a longitudinal multi-trait, multi-method, multi-rater design that, while complex, reduces rater bias, measurement error, and potential context effects relative to studies that include only single measures, raters, or assessment methods.

As expected, greater fearfulness at age 2 predicted greater ERN at age 4 at high levels of early harsh parenting. Parallel analyses indicating greater age 4 fearfulness early fear and harsh parenting were high at age 2 are consistent with the notion that ERN may be a process linking harsh parenting with augmented anxiety risk in young children over time. That is, this work is consistent with a conceptual rationale suggesting that harsh parenting exacerbates fear of punishment in fearful children and catalyzes coping efforts that include heightened self-monitoring. Importantly, temperament theory and work from developmental neuroscience suggests that punishment may actually diminish fearful children's ability to cope and/or self-regulate, providing an explanation as to why the typically-adaptive ERN is associated with risk rather than resilient outcomes for fearful children (Degnan, Almas, & Fox, 2010b; Tomoda et al., 2009). Similarly, our post-hoc analysis of cognitive processing contributes to the notion of diminished neural efficiency over time in fearful children who experience harsh parenting. Thus, convergent behavioral, psychophysiological, and cognitive data support performance monitoring as plausible mechanism of the link between harsh parenting and anxiety risk. This interpretation is additionally supported by evidence that performance monitoring is robustly related to the anxious apprehension/worry domain of anxiety symptoms (Moser et al., 2013). To the extent, then, that temperamental fear may encompass fear or worry about potential punishment, this work underscores the idea that the experience of punishment may enhance concern about future punishment from parents and enhance performance monitoring as observed in ERN.

The pattern of slopes in the current findings also suggests that lower levels of harsh parenting were associated with smaller (i.e., less negative) ERN amplitudes when age 2 fear was high. Research has shown that optimal development for fearful children includes appropriate levels of encouragement from caregivers to interact with novelty and gain practice self-regulating distress responses (Arcus, 2001; Kiel & Buss, 2012). Understandably, this push for children to approach novel people or situations, which they find threatening, may appear as harsh attempts to minimize or control the child's affect. However, at appropriate levels, gentle encouragement leads to declines in fearfulness over time (Arcus, 2001) and is not considered harsh. Similarly, reviews of the literature have suggested that at later stages of processing following attentional capture, more trait-anxious individuals tend to shift attention away from putative sources of threat (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). If excessive worry about error commission (Borkovec, 1994) leads some high-fear children to disengage from performance monitoring, one might expect to see smaller ERN. Such disengagement would notably be easier for children whose parents put less effort into pushing children to approach and attend to contexts or situations that may feel threatening to the child. Because ERN has not previously been examined in tandem with parenting behaviors, such a possibility has not been empirically evaluated. Nonetheless, it may reflect an alternative developmental pathway for fearful children in the context of parent behaviors.

That a trend for greater ERN was seen when both harsh parenting and fearfulness at age 2 were low was unexpected. This is visible, however, within the negative association between age 2 fearfulness and ERN amplitude at low levels of harsh parenting. While we do not believe that this link detracts from the significance of the effects seen in high fear children, it may be important to consider in future work. There are at least two ways to view this unanticipated association. The first is the possibility that, given the small size of the current data set, this association is the product of a subset of extreme scores. Although outliers were removed prior to analyses and a search for multivariate outliers suggested that no overly influential data points remained, ERP data in children are known to be highly variable relative to data in adults (Brooker, Buss, & Dennis, 2011; Torpey et al., 2009; Wiersema, Van Der Meere, Roeyers, Van, & Baeyens, 2006), which may make the detection of outliers more difficult.

The second, and we feel more likely, possibility is that the link between harsh parenting and ERN for low fear children represents normative development of the ERN in low fear children. Given that a diminished ERN has been associated with the presence of externalizing behavior problems, such as Attention Deficit-Hyperactivity Disorder (Jonkman, van Melis, Kemner, & Markus, 2007; Stieben et al., 2007), it would be logical that the relation of ERN to optimal adjustment in children would be nonlinear. We have previously suggested that the ERN may be differentially related to behaviors in low and high fear children (Brooker & Buss, 2014). Notably, this work showed that greater ERN amplitudes were related to more risk-related behaviors in high fear but not in low fear children, similar to the behavioral results presented here. Moreover, it is important to remember that while work with adults and adolescents has shown an exaggerated ERN in anxious individuals (Hajcak, McDonald, & Simons, 2003; Ladouceur et al., 2006), it does not report an *absence* of ERN in individuals who are not anxious. Thus, one would not expect that only those children at risk for anxiety would show in ERN. One possibility for future research will be to determine whether certain conditions, such as low temperamental fearfulness and low levels of harsh parenting, are optimal for the normative development of the ERN.

It will also be important to address possible associations between ERN and anxiety risk in the context of other parenting behaviors. Parent sensitivity, for example, maintains a complicated association with early fearfulness and risk for developing anxiety problems. Greater maternal sensitivity, for example, is frequently viewed as aiding in the development of adaptive behaviors and positive outcomes (Hane, Cheah, Rubin, & Fox, 2008). However high levels of sensitivity may also predict the maintenance of fearfulness in highly fearful children (Park, Belsky, Putnam, & Crnic, 1997), which would ultimately exacerbate risk for anxiety problems. Similarly, maternal protective behaviors frequently help to regulate distress in young children (Crockenberg & Leerkes, 2004); yet, more recent work suggests that positive effects may be limited to those instances when maternal involvement is solicited by the child (Buss & Kiel, 2011). We chose to focus on harsh parenting given its more direct association with anxiety risk and previously-established links with ERN. However, to the extent that other parenting behaviors may influence performance monitoring processes in similar ways, it may also be valuable to explore ERN process that may also impact risk in other contexts.

It is also worth noting that this work provides a replication of previous reports of ERN in children during the fifth year of life. These findings increase confidence that ERN is visible early in life. Previous ERN studies have, using cross-sectional designs, included 4–8 (Brooker et al., 2011), 5–7 (Torpey et al., 2009), and 7–13 (Wiersema et al., 2007) year-old children. While some of this work controlled for age, studies have not been conducted with only preschoolers. Narrowed age ranges are necessary to assure that effects are not driven by the inclusion of data from older children (Crone & Ridderinkhof, 2011).

One final point for consideration is the degree to which the current work might advance current methods for identifying individuals who are at early risk for anxiety problems. While the current findings help to isolate basic scientific knowledge of one mechanism by which harsh parenting behaviors may exacerbate risk for the development of anxiety disorders, it is difficult to estimate their utility in predicting degree of risk for any individual. That is, without follow-up measures identifying those individuals who develop clinical levels of anxiety symptoms over time, it is unclear whether this work enhances our ability to identify early risk. This will be an important avenue for future research.

The current study is not without limitations that should be considered for the generalizability of findings. First, the current sample size is limited. Although we were able to replicate significant effects related to high fearfulness and harsh parenting across three separate outcome measures, a future replication in a larger sample of toddlers would increase our confidence in findings presented here and allow a comparative test of mediation. In addition, the current study does not include any measures of anxiety symptoms. Similarly, the ratings of fearfulness at age 4 may be less representative of risk than fearfulness during the age 2 visit. The laboratory episodes at age 4 were not designed to explicitly elicit fear and the full array of microcoded behaviors from the age 2 visit was not codable while EEG data were being collected. Our ability to replicate work showing harsh parenting as a moderator of fearfulness over time increases confidence in the utility of these measures for the current study. However, we acknowledge that identical measures of fear at ages 2 and 4 would be optimal. Finally, the literature suggests a number of ways to quantify harsh parenting. In this work we used a variable that maximized the role of mothers' punitive, minimizing reactions and critical control. However, we do not assume that matches all conceptualizations of harsh parenting. It will be important to keep this difference in mind when considering our results in the context of the broader literature.

In sum, the current study presents evidence that high temperamental fearfulness in combination with high levels of harsh parenting early in toddlerhood predict amplified ERN during the preschool years. Although there is still work to be done, this finding and parallel associations between harsh parenting and both greater fearfulness and less efficient neural processing in high fear children during preschool provide preliminary evidence for performance monitoring as a process by which harsh parenting may contribute to an profile of anxiety risk early in life.

Acknowledgments

Data collection for this project was supported by a RGSO dissertation support award from the Penn State College of the Liberal Arts (R.J. Brooker) and R01 MH075750 from the National Institute of Mental Health (PI: Buss). The preparation of this manuscript was partially supported by the first T32 MH018931 (PI: Davidson) and K01 MH100240 (PI: Brooker). All work was conducted with the ethical approval of all relevant bodies.

We thank the children and families who participated in this study and staff of the Emotion Development Lab and the Social, Life, and Engineering Sciences Imaging Center who provided assistance and resources for recruitment, data collection, and data analysis.

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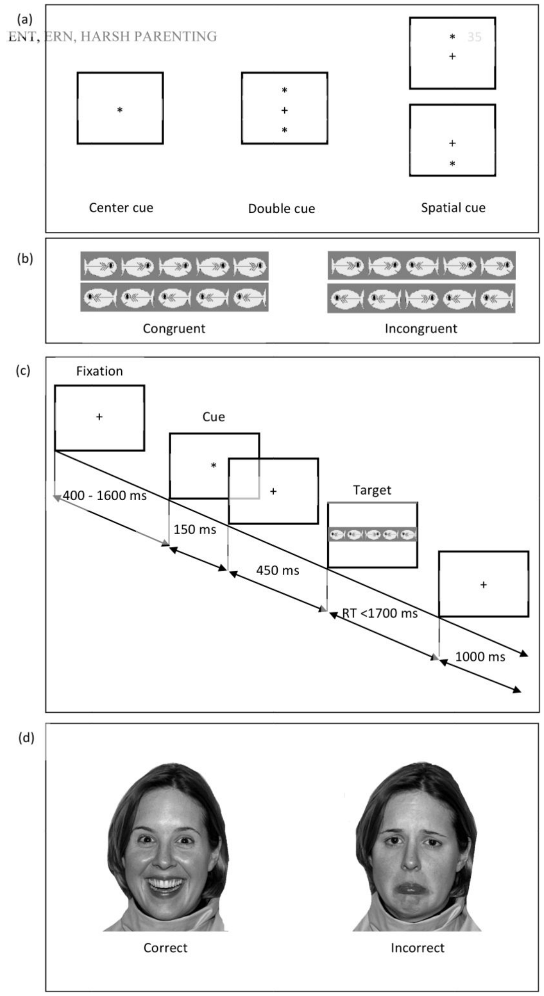

Figure 1.

Experimental procedure. FEARFUL (a) Cue presentation, (b) Stimulus presentation, (c) An overview of the procedure, and (d) Feedback presentation, which immediately followed response.

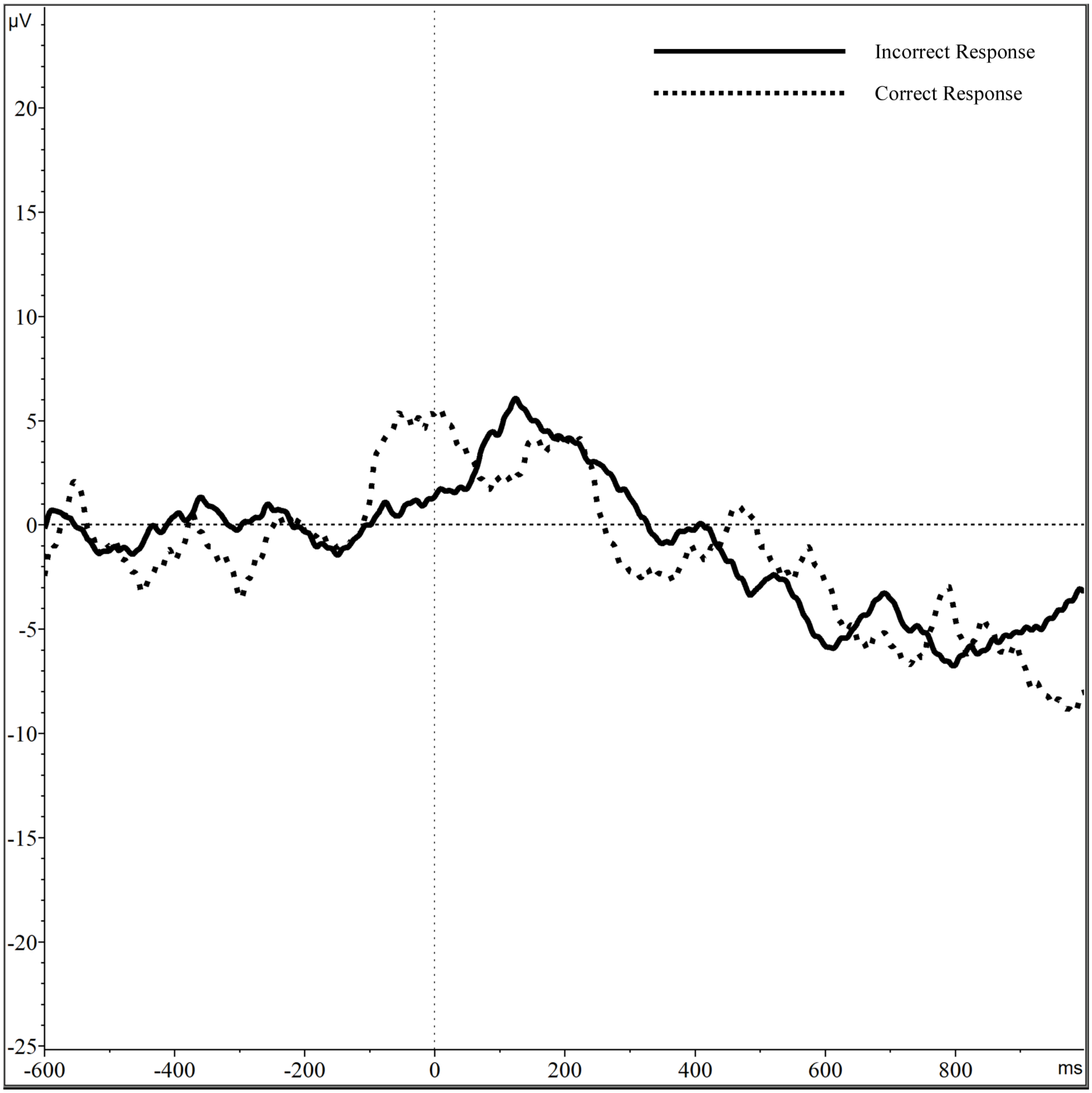

Figure 2.
Response-locked Grand-Average Waveform at Fz

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Table 1

Descriptive Statistics and *t*-tests

	n	Min	Max	*M*	*SD*	t^1
Age 4 ERN	25	−43.64	29.56	−6.02	14.27	−0.35
Age 2 Fearfulness	30	0.43	84.71	39.61	23.35	0.03
Age 4 Fearfulness	30	−1.63	2.16	0.17	1.01	0.64
Age 4 Mean Response Time	30	647.05	1184.50	953.75	121.63	−0.43
Age 2 Harsh Parenting	30	−2.24	1.89	0.04	1.05	2.29^*

[1] t-tests (two-tailed) compared males and females,

* $p<.05$

Table 2

Partial Correlations Controlling for Sex of Child

	1.	2.	3.	4.
1. Age 2 Harsh Parenting				
2. Age 2 Fearfulness	−0.18			
3. Age 4 Fearfulness	−0.04	0.15		
4. Age 4 ERN	0.07	−0.07	−0.46*	
5. Age 4 Mean Response Time	0.34	0.14	0.07	−0.08

* $p<.05$

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Table 3

Regressions Predicting Observed Age 4 Fearfulness

	B	***SE(B)***	**β**	***t***	**Δ*R*²**
Step 1.					0.05
Sex	−0.11	0.42	−0.05	−0.25	
Age 2 Fearfulness	0.01	0.01	0.15	0.74	
Age 2 Harsh Parenting	0.16	0.21	0.17	0.76	
Step 2.					0.12+
Sex	0.23	0.44	0.12	0.53	
Age 2 Fearfulness	−0.00	0.01	−0.03	−0.16	
Age 2 Harsh Parenting	0.55	0.29	0.57	1.90+	
Age 2 Fearfulness x Age 2 Harsh Parenting	0.03	0.02	0.57	1.86+	

+ $p < .10$

Table 4

Regression Predicting Age 4 ERN

	B	*SE(B)*	β	*t*	ΔR^2
Step 1.					0.01
Sex	3.05	6.78	0.11	0.45	
Age 2 Fearfulness	−0.04	0.13	−0.06	−0.27	
Age 2 Harsh Parenting	0.95	3.60	0.06	0.26	
Step 2.					0.22*
Sex	−0.84	6.35	−0.03	−0.13	
Age 2 Fearfulness	0.09	0.13	0.15	0.68	
Age 2 Harsh Parenting	−5.02	4.11	−0.34	−1.22	
Age 2 Fearfulness x Age 2 Harsh Parenting	−0.58	0.25	−0.66	−2.38*	

* $p < .05$

Table 5

Regression Predicting ANT Response Times at Age 4.

	B	*SE*(*B*)	β	*t*	ΔR^2
Step 1.					0.10
Sex	48.62	48.80	0.20	1.00	
Age 2 Fearfulness	1.17	1.00	0.22	1.17	
Age 2 Harsh Parenting	35.30	24.19	0.31	1.46	
Step 2.					0.12*
Sex	90.75	50.79	0.38	1.79+	
Age 2 Fearfulness	0.20	1.06	0.04	0.19	
Age 2 Harsh Parenting	83.80	33.36	0.73	2.51	
Age 2 Fearfulness x Age 2 Harsh Parenting	3.58	1.79	0.59	2.00*	

* $p = .05$