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Childhood Abuse is Associated with Increased Startle Reactivity in Adulthood

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Abstract

Understanding the neurobiological correlates of childhood maltreatment is critical to delineating stress-related psychopathology. The acoustic startle response (ASR) is a subcortical reflex modulated by neural systems implicated in posttraumatic stress disorder (PTSD). ASR is conserved across species and is increased in rodent models of developmental stress. We measured acoustic startle response to a 40ms noise probe as well as fear-potentiated startle using electromyographic (EMG) recordings of the eyeblink in a primarily African-American sample (N=60) from a highly traumatized civilian population. We assessed self-reported history of abuse with the Childhood Trauma Questionnaire and current symptoms with the PTSD Symptom Scale and the Beck Depression Inventory.

We found that subjects reporting a history of high levels of physical or sexual abuse had increased startle on all trial types relative to those with low abuse ($p < .01$). This effect remained significant after co-varying for the subjects' age and sex, as well as PTSD and depression symptoms. Perceived childhood sexual abuse was the greatest predictor of increased startle response. Notably, emotional abuse in childhood did not affect baseline startle, and all groups demonstrated equivalent levels of fear-potentiated startle.

The long-lasting effects of early life trauma result in increased risk for adult psychopathology. These new data demonstrate that a self-report history of child abuse is related to altered baseline startle response that is not accounted for by PTSD or depression symptoms. Increased startle may be a biomarker of stress responsiveness that can be a persevering consequence of early trauma exposure during childhood.

Keywords

Child Abuse; Childhood Maltreatment; Trauma; Physiology; Biomarker; Startle; Anxiety

Introduction

Several studies have suggested that early adverse experiences are highly correlated with the development of adult mood and anxiety disorders including post-traumatic stress disorder (PTSD) and major depressive disorder (MDD). A growing number of studies [1,2] indicate

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that inner-city, low income, African Americans are at especially high risk for both exposure to traumatic events and PTSD. For example, our recent examination of 617 primary care patients (96% of whom were African American) found a 65% rate of lifetime trauma exposure and a 33% rate of PTSD [1], with many of the traumatic experiences beginning early in life.

The impact of early adverse events on mental health has been established for more than a decade: early-life stress (ELS) is a predictor of adult MDD, while ELS and adult trauma are both predictors of PTSD [3]. A rodent model of ELS in which neonates were repeatedly separated from their mothers found long-term effects on the hypothalamic-pituitary-adrenal (HPA) axis [4]. Similarly, women who were abused in childhood show increased HPA reactivity to a psychosocial stressor [5]. The hormones of the HPA axis, including corticotrophin releasing hormone (CRH), can have anxiogenic effects, such as increased startle reactivity [6]. The acoustic startle response (ASR) is characterized by an integrative, reflex contraction of the skeletal musculature in response to a sudden intense stimulus [7]. It is mediated by a simple subcortical three-neuron circuit [8], but is modulated by limbic brain structures such as the amygdala [8] and is enhanced by the release of CRH [6]. Exaggerated startle has been demonstrated with PTSD [9] and is included in the Diagnostic and Statistical Manual IV as a cardinal symptom of the disorder [10]. Prior work indicates that this effect may be an acute effect of the trauma [11].

While startle has been studied in PTSD patients with equivocal results [12], to our knowledge, there have been very few articles examining startle in adult patients with a history of childhood abuse [13]. In one study, women with a history of childhood abuse with and without lifetime PTSD were examined with a 500ms startle tone [13]. No effect of PTSD diagnosis was found, but since all subjects had a history of childhood abuse, it was not possible to detect whether abuse history by itself altered adult baseline startle. In another study, women with chronic physical punishment during childhood who had PTSD symptoms had a decreased startle response compared to controls [14]. These results are surprising given the literature on child abuse effects on HPA function and increased levels of CRH. Notably, elevated startle response has been proposed as a potential vulnerability factor for the development of PTSD in prospective studies of traumatized adults [15]. This is quite interesting given the above data that child abuse is also a vulnerability factor for PTSD risk in adults.

Our laboratory has recently developed a startle paradigm, based on an animal model that measures baseline startle response as well as fear-potentiated startle and the inhibition of fear-potentiated startle [16,17]. Using this paradigm, we found that PTSD subjects with higher current symptoms showed impairment in transferring inhibition of fear to a test stimulus that paired the danger and safety cues [18]. The rationale for the present study stems from our previous evidence that PTSD symptom severity is associated with deficient fear inhibition. The purpose of the present study was to assess the association between self-reported child abuse and fear-potentiated startle in a large sample of highly traumatized civilians. To specifically address the role of perceived child abuse independently of PTSD phenotype on fear inhibition, we utilized our conditional discrimination protocol. Based on our prior work in PTSD, we hypothesized that child abuse would be associated with impaired inhibition of fear-potentiated startle.

Methods

Study Subjects

Sixty subjects were included in this study. Participants were recruited as part of a larger study investigating the genetic and environmental factors that contribute to PTSD in a

primarily African-American, low socioeconomic, inner-city population. The rates of trauma exposure are very high in this sample (see Table 2 for description of trauma exposure in the study sample). Exclusion criteria for participation in the study included active psychosis and major medical illnesses as assessed by physical examinations by medical personnel. Medication use was not an exclusion criterion for the study. Prior to their participation, all participants signed informed consent forms approved by the Emory University Institutional Review Board.

Psychological Assessment

The Structured Clinical Interview for DSM IV [19] was administered to all subjects. In addition to the diagnostic interview, all participants completed the Childhood Trauma Questionnaire, the PTSD Symptom Scale, and the Beck Depression Inventory.

Childhood Trauma Questionnaire

The Childhood Trauma Questionnaire (CTQ) is a self-report inventory assessing perceived childhood physical, sexual, and emotional abuse. Bernstein and Fink [20] established scores for none, mild, moderate, and severe for each type of abuse. The data from the CTQ were used to classify participants into 2 categories for each type of abuse (physical, sexual, and emotional): (1) Low abuse included those with CTQ scale scores in the “none to mild” range, and (2) High abuse included those with CTQ scores in the “moderate to severe” range. We included the subjects with mild levels of abuse in the same category as those with no abuse due to the high prevalence of childhood trauma in this population.

Modified PTSD Symptom Scale

The modified PTSD Symptom Scale (PSS) is a psychometrically valid 17-item self-report scale assessing PTSD symptomatology over the two weeks prior to rating [21]. The PSS interview has been validated with the more widely used measure of PTSD, the Clinician Administered PTSD Scale (CAPS; [22,23]. Furthermore, within this population, we have previously validated the PSS with the CAPS. Consistent with prior literature, we summed the PSS frequency items (0 indicates “not at all” to 3 indicates “>5 times a week”) to obtain a continuous measure of PTSD symptom severity.

Beck Depression Inventory

(BDI) was administered to measure depression symptoms. The BDI consists of a 21-item questionnaire [24]. Each of the items measures the presence and severity of depressive symptoms which are rated on a scale from 0 to 3. This instrument provides a well-validated, commonly used, continuous score of depressive symptoms.

Startle Response Measurements

The psychophysiological data were acquired using Biopac MP150 for Windows (Biopac Systems, Inc., Aero Camino, CA). All data were sampled at 1000 Hz and amplified with a gain of 5000 using the electromyography (EMG) module of the Biopac system. The acquired data were filtered, rectified, and smoothed using MindWare software (MindWare Technologies, Ltd., Gahanna, OH) and exported for statistical analyses. The EMG signal was filtered with low- and high- frequency cutoffs at 28 and 500 Hz, respectively. As previously described in Jovanovic et al. [16–18], the eyeblink component of the acoustic startle response was measured by EMG recordings of the right *orbicularis oculi* muscle with two 5-mm Ag/AgCl electrodes filled with electrolyte gel. One electrode was positioned 1cm below the pupil of the right eye and the other was 1cm below the lateral canthus. We used disposable electrodes from Biopac (EL504) pre-coated with electrolyte gel. Impedance levels were less than 6 kilo-ohms for each participant. A background white noise of 70-dB

(A) SPL was presented continuously throughout the session; startle probe delivery was superimposed on the background noise. The startle probe was a 108-dB (A)SPL, 40ms burst of broadband noise with 0 rise time, delivered binaurally through headphones (Maico, TDH-39-P). The maximum amplitude of the eyeblink muscle contraction 20–200 ms after presentation of the startle probe was used as a measure of startle magnitude.

Experimental Design

The startle data were collected in a conditional discrimination paradigm referred to as AX+/BX− [16]. Each session consisted of a startle habituation phase followed by three blocks of conditioning that occurred without any breaks. The conditioning phase was seamlessly followed by a testing block for fear inhibition. Each conditioned stimulus (CS) was a compound of two shapes presented on a computer monitor. The AX+ compound served as the reinforced stimulus (CS+), and the BX− compound served as the non-reinforced stimulus (CS−). The AX+ and BX− cues consisted of a set of 2 blue, black or purple shapes (star, triangle or square) presented centrally on a monitor (with counterbalanced shape assignment across the CSs). Each compound CS had one novel cue (A or B) and one common cue 'X'. The fear inhibition test stimulus was a compound of the previously conditioned A and B cues that was used to determine transfer of inhibition (by B) to the fear response to A [16,25]. For each compound stimulus, the shapes were presented simultaneously and in one of two pseudorandom sequences. The aversive stimulus (US) was a 250 ms airblast with an intensity of 140 psi directed to the larynx. This US has been used in our prior studies [16,26] and produces robust fear-potentiated startle.

The habituation phase of the startle session consisted of six startle probes presented alone (noise-alone trials, NA). Immediately following habituation, participants underwent the conditioning phase consisting of three blocks, with four trials of each CS type and four noise-alone trials for a total of 12 trials per block. A block of four NA trials was presented after the conditioning phase. Three conditioned inhibition test trials were presented during this block. All CS+ trials were reinforced with the US, while the CS− and test trials were not reinforced. Both conditioned stimuli were 6 sec in duration. During CS+ trials, the 250 ms air blast co-terminated with the stimulus, and the 40ms startle probe preceded the US (airblast) by 500 ms. The CS− trials terminated immediately after the presentation of the startle probe. In all phases of the experiment, inter-trial intervals ranged from 9 to 22 seconds.

Response Keypad

A response keypad unit (SuperLab, Cedrus, Corp.) was incorporated into the startle session in order to assess trial-by-trial US expectancy and to facilitate elemental processing of the compound cues [17]. Subjects were instructed to respond on each CS trial by pressing one of three buttons: one when they expected the US, a second button when they did not expect the US, and a third button when they were uncertain of the contingency. The exact instructions given to the subjects were: "During this experiment you will hear some sudden tones and noises in addition to seeing several colored lights turn on. The tones are there to elicit startle and occur every time something happens. However, some of the lights will be followed by the blast of air while other lights will not. Throughout the experiment please press the button on the keypad to tell us whether you think a light will be followed by air (the plus sign), or will not be followed by air (the minus sign). If you do not know, press the 0 sign. You should press a button for each light."

Data Analysis

The group variables in the analyses were derived from the severity categories on the CTQ. For each of the three types of abuse (physical, sexual, and emotional), subjects were divided

into low and high abuse groups. If a subject reported high levels of abuse on more than one type of abuse, they were included in the high abuse group for each category of abuse.

Startle reactivity was assessed for the noise-alone trials (NA) by averaging the startle response to the probe in the absence of the CSs. This resulted in five NA blocks: habituation, 3 conditioning blocks, and a post-conditioning block. A repeated measures analysis of variance (ANOVA) with the within-subjects variable of block (5 levels) and the between-group variable of child abuse group (2 levels: high, low) was performed for each type of abuse. Additionally, in order to assess initial startle reactivity, we examined startle response to each of the six trials in the habituation phase. In these analyses the linear contrast of the block or trial variable was used to determine habituation to the startle probe.

Fear acquisition for these experiments is defined as the difference between CS+ and NA, as we have published previously. Fear acquisition was tested using a mixed ANOVA model with a within-subject factor of trial type (2 levels: NA, AX+) with the between groups factor of child abuse group (2 levels: high, low). The dependent variable for these analyses was startle magnitude.

Differential conditioning and conditioned inhibition were tested by calculating using a repeated-measures (RM) ANOVA with 3 levels (AX+, BX-, and AB) and the between-group factor of abuse (2 levels: high, low) for each abuse category. Two within-subject contrasts were tested: AX+ vs. BX- to evaluate differential conditioning between the CS+ and CS-, and AB vs. AX+ to evaluate inhibition of fear. The dependent variable for these analyses was percent potentiation from baseline for each trial type, in order to account for individual differences in startle reactivity. This value was derived as follows: Percent Startle Potentiation = $100 \times (\text{startle amplitude during CS trials} - \text{NA startle}) / (\text{NA startle})$. We then averaged the trials across the conditioning blocks for AX+, BX- and AB.

In order to account for the effects of demographics and clinical symptoms, we followed-up significant between groups effects with an analysis of covariance (ANCOVA). Demographic variables of sex and age, and clinical variables of BDI and PTSD symptoms were included as covariates in the ANCOVA. Finally, in order to examine the contributions of each type of abuse to the increase in startle magnitude, we performed a stepwise regression analysis in which emotional, physical, and sexual abuse variables were added at each step to predict average startle magnitude.

In addition to startle, we also examined US expectancy on the response keypad across the abuse groups. A response on the plus sign was given a value of 1, the minus sign a value of -1, and a response of 0 was given a value of 0. Average US expectancy to CS+ and CS- trials were compared using a mixed model ANOVA with abuse group as between-groups factor. We also used the keypad to categorize individuals as either aware or unaware of the reinforcement contingencies in the experiment. In order to be classified as aware, the subjects needed to have two consecutive correct responses to the training trials [17]. We operationally defined correct responses to CS+ trials as expectations of airblast, and the correct responses to CS- were expectations of no airblast. The distribution of aware and unaware individuals across the abuse groups was compared using a Chi-square analysis.

In the repeated measures ANOVAs with 3 levels we used the Huynh-Feldt statistic to correct for violations of the sphericity assumption. All analyses were performed in SPSS 15.0 for Windows (SPSS, Inc) with an alpha level of 0.05.

Results

Subject Characteristics

A total of 60 subjects were included in the analyses. The subjects' ages ranged from 18–63 years old and 47.1% were female. Table 1 shows the breakdown of the subjects across the different types of child abuse, as well as demographic information, and PTSD and depression symptoms. Table 2 shows the rates of traumatic events experienced by the subjects in the study sample. The PSS and BDI scores were significantly correlated, $r(57)=0.37$, $p<0.01$; the association remained significant after co-varying for childhood trauma, sex and age.

Startle Reactivity

Startle reactivity was assessed during noise-alone (NA) trials and in the presence of conditioned stimuli. The first set of results describes baseline startle magnitude, i.e. data for the NA trials across the session, as well as to the trials of the habituation phase. The second set of results focuses on fear-potentiated startle during the presentations of the CSs. These data were evaluated for fear acquisition, differential conditioning between danger and safety signals, and conditioned inhibition of fear.

Startle Magnitude to Noise Alone

A two-way mixed-model ANOVA with block and group showed a significant between groups effect for self-reported physical ($F(1,58)=4.08$, $p<0.05$) and sexual ($F(1,58)=6.98$, $p=0.01$) abuse, with high abuse subjects exhibiting greater startle magnitude (Figure 1A and 1B). On the other hand, self-reported emotional abuse did not show a between groups effect (Figure 1C). In all three types of child abuse, the severity of abuse did not affect the degree of habituation to the startle probe throughout the session. The linear trend for block was significant in physical ($F(1,58)=14.48$, $p<0.01$), sexual ($F(1,58)=14.96$, $p<0.01$), and emotional abuse ($F(1,58)=10.26$, $p<0.01$). There were no block-by-group interactions.

In order to examine initial startle reactivity in more detail, we compared abuse groups on startle magnitude to the first six trials of the pre-conditioning habituation block. Here we also found a significant effect of perceived physical abuse ($F(1,57)=4.97$, $p<0.05$) and perceived sexual abuse ($F(1,57)=7.28$, $p<0.01$) on startle magnitude. Even in these early trials, there was no effect of perceived emotional abuse. However, startle magnitude in all three types of abuse decreased over the 6 trials (physical abuse linear $F(1,57)=7.91$, $p<0.01$; sexual abuse linear $F(1,57)=6.50$, $p=0.01$; emotional abuse linear $F(1,57)=9.76$, $p<0.01$), again showing habituation. There were no trial-by-group interactions.

ANCOVAs of startle reactivity with demographic and clinical covariates did not eliminate the effect of abuse. Subjects reporting high levels of physical abuse had higher startle than those with low abuse after co-varying for sex, age, PTSD and depression ($F(1,47)=4.33$, $p<0.05$). Furthermore, subjects reporting high levels of sexual abuse had higher levels of startle than those with low abuse after co-varying for sex, age, PTSD and depression ($F(1,47)=4.04$, $p<0.05$).

A hierarchical regression analysis was performed by entering emotional, physical, and sexual abuse as independent variables in a stepwise procedure. The dependent variable was the average startle magnitude to all the noise alone trials in the session. The overall final model was significant, $F(3,59)=3.39$, $p<0.05$, accounting for 15.4% of the variance in startle magnitude, see Table 3. Adding physical abuse resulted in an R^2 change of 0.058, $p=0.07$. Adding sexual abuse resulted in a significant R^2 change of 0.081, $p=0.02$.

Fear-Potentiated Startle

Fear acquisition (see Figure 2) was tested comparing startle magnitude trial types (2 levels: NA, CS+) on the last block of conditioning with the between groups factor of child abuse group (2 levels: high, low) for each of the three types of abuse. There was a significant effect of group for perceived physical abuse ($F(1,58)=4.58, p<0.05$) and perceived sexual abuse ($F(1,58)=6.78, p<0.05$), but not for physical or emotional abuse (Figures 2 A–C).

In all three types of child abuse there was an overall significant main effect of trial type. Startle magnitude to the CS+ trials was significantly higher than NA for physical ($F(1,58)=24.39, p<0.001$), sexual ($F(1,58)=22.60, p<0.001$), and emotional abuse ($F(1,58)=17.24, p<0.001$), see Figure 2. However, there were no trial-type-by-group interactions.

Differential conditioning to CS+ and CS–, and fear inhibition on transfer trials was assessed with a RM ANOVA comparing the groups on percent startle potentiation to AX+, BX–, and AB (see Figure 3). There were no significant between-groups effects. However, this analysis showed a significant within-subjects main effect of trial type in all three abuse categories: physical abuse, $F(2,116)=4.78, p<0.05$, sexual abuse, $F(2,116)=3.63, p<0.05$, and emotional abuse, $F(2,116)=3.73, p<0.05$, see Figures 3 A–C. Within-subjects contrasts showed that fear-potentiated startle was greater on the AX+ trials than the BX– trials in all three categories: physical abuse, $F(1,58)=11.36, p<0.01$, sexual abuse, $F(1,58)=7.02, p<0.01$, and emotional abuse, $F(1,58)=8.30, p<0.01$. Finally, fear-potentiated startle was inhibited on the AB transfer test relative to AX+ in all three categories: physical abuse, $F(1,58)=7.09, p<0.01$, sexual abuse, $F(1,58)=5.42, p<0.01$, and emotional abuse, $F(1,58)=5.58, p<0.05$. There were no significant trial-type-by-group interactions on either the main effects or either of the two contrasts.

US Expectancy

The results of the response keypad data showed that, across all three abuse types, subjects reporting high and low levels of abuse understood the experimental contingencies. There was a main effect of CS type, with higher US expectancy for the AX+ than the BX–: physical abuse ($F(1, 57)=25.82, p<0.001$), sexual abuse ($F(1, 57)=22.25, p<0.001$), and emotional abuse ($F(1, 57)=25.25, p<0.001$). There was no main effect of group; as in the startle analyses, there were no trial-type-by-group interactions. We used the response keypad data to categorize individuals as to their awareness of the reinforcement contingencies in the experiment using criteria described in our previous study [17]. The distribution of aware and unaware subjects did not vary in the high and low abuse groups for physical abuse (high abuse: 15 aware and 5 unaware, low abuse: 24 aware and 13 unaware, $\chi^2(57)=0.62, p>0.1$), sexual abuse (high abuse: 9 aware and 6 unaware, low abuse: 30 aware and 12 unaware, $\chi^2(57)=0.67, p>0.1$), or emotional abuse (high abuse: 9 aware and 4 unaware, low abuse: 30 aware and 14 unaware, $\chi^2(57)=0.01, p>0.1$).

When we examined the effect of awareness on baseline startle magnitude to NA, fear acquisition, differential conditioning and conditioned inhibition we found no significant differences between aware and unaware subjects. However, due to the small number of unaware subjects there was not enough power to compare aware and unaware individuals in each group. Given the possibility that unaware subjects were occluding the results of the conditioning trials, we ran additional analyses of the fear-potentiated startle data by restricting the dataset to aware subjects. These analyses replicated the first set of analyses which included all subjects, in that there were no significant between-group differences on the AX+, BX–, or AB trials: physical abuse $F(1, 37)=0.01, p>0.1$, sexual abuse, $F(1, 37)=2.09, p>0.1$, or emotional abuse, $F(1, 37)=0.01, p>0.1$. Furthermore, there were no

significant interactions between group and trial type: physical abuse $F(2, 74)=1.17, p>0.1$, sexual abuse, $F(2, 74)=0.28, p>0.1$, or emotional abuse, $F(2, 74)=0.98, p>0.1$.

Discussion

To our knowledge, this is the first study to examine startle reactivity during fear acquisition in patients with a self-report history of childhood abuse in an urban traumatized population. The study has yielded two important findings. First, our data suggest that perceived childhood physical and sexual abuse is associated with increased startle reactivity. In contrast, the study by Medina and colleagues [14] found decreased startle reactivity in women who had experienced corporal punishment in childhood. One reason for the discrepancy between their study and the current study may be the levels of abuse experienced by the study participants. While corporal punishment can qualify as physical abuse, the average ratings for the participants in the study conducted by Medina and colleagues indicated that they had been hit by their parents 5–10 times during their childhood. This degree of abuse would qualify as low levels of abuse in our study. The Medina et al. study did not use standardized inventories for child abuse, but had subject ratings of corporal punishment on the single item described above. In addition, a hierarchical regression analysis of the effects of different types of abuse on startle magnitude indicated that sexual abuse accounted for the greatest amount of variance.

The present study also found the effects of perceived child abuse to be specific to baseline startle, i.e., child abuse did not affect the degree of fear-potentiated startle, differential conditioning, or fear inhibition. Given our previous findings in PTSD of impaired conditioned inhibition, we had hypothesized that high levels of child abuse would be associated with impaired inhibition. However, as shown in Figure 3, the subjects reporting high abuse had intact inhibition on the transfer test (AB). This finding suggests that the effects of perceived abuse do not parallel the effects of PTSD, but rather have unique effect on physiology; namely an across-the-board increase in startle magnitude observed on all trial types. Importantly, when we co-varied for age, sex and Axis I disorders (PTSD and depression), the group differences between individuals with high and low levels of early sexual and physical trauma remained significant.

These results suggest that early life trauma has long-lasting neurobiological effects. While this has been shown in studies of cortisol regulation [5], this is the first study that has examined startle response in a large sample of highly traumatized individuals, while controlling for other comorbidities. While increased startle is one of the hallmark symptoms of PTSD as defined by the Diagnostic and Statistical Manual [10], the psychophysiological evaluation of startle in PTSD patients has not yielded consistent results, with the suggestion that trauma history is an important mediator [12]. Studies of Gulf War veterans with PTSD found exaggerated startle compared to non-PTSD veterans [9], while Vietnam veterans with PTSD did not show increased startle [27] unless they were subjected to a threatening context [28]. Grillon and Baas [11] concluded that increased baseline startle may be related to recency of combat exposure and may decline after a few years. On the other hand, all veterans may be more sensitive to anxiety or fear-potentiated startle. Our studies with combat veterans show that fear-potentiated startle, but not baseline startle reactivity, is associated with the level of PTSD symptoms [18].

The findings of the current study however, were unexpected, novel, and interesting. Specifically, that independent of any possible effects of child abuse history on fear conditioning, we find this apparent robust effect on baseline startle measured across all conditioning and habituation trials. The startle response provides an ideal translational tool because its neurobiology is well defined and it can be measured in many different species

[8,29,30]. Such phenotypes that serve as intermediate biomarkers of mental disorder are necessary to examine the cascade of effects between trauma and illness.

A limitation of this study is its post-hoc nature: our data cannot determine whether heightened startle preceded the abuse. While it is unlikely that higher startle reactivity would increase the frequency of abuse, it is possible that other personality factors contribute both to startle reactivity and likelihood of abuse. However, the data from the animal models of early life stress in which stressors produce neurobiological sequelae such as increased CRH [4]; [3], strongly suggest that early abuse has a causal relationship with increased startle. Another alternative explanation is that higher startle reactivity, or underlying personality traits associated with greater startle, resulted in an increase in the reporting of abuse. It is possible that a general trait such as hypersensitivity could cause heightened startle reactivity and the likelihood that an individual may perceive oneself as abused.

This explanation points out another study limitation: the use of a retrospective self-report measure of child abuse. While this instrument has been validated in previous studies [2,31], there may be inherent reporting bias in adult assessments of childhood trauma history. Given that we do not have longitudinal, objective measures of child abuse we are relying on the subjects' perception of their abuse history. However, given the high rates of trauma exposure, substance abuse, and history of incarceration in this low income population, it is likely that the reported abuse is accurate. The CTQ has shown very good convergence with other measures of child abuse, indicating that it is a valid instrument [32]. Furthermore, this subjective perception may in fact be related to individual sensitivity, which in itself may be a risk factor for psychopathology. Therefore it is possible that perceived abuse contributes to mental disorders to a greater extent than actual abuse. Future studies should include measures that aim to assess history of abuse with objective measures; as well as instruments that describe personality traits that could lead to heightened startle.

Conclusion

In summary, this study found that high levels of reported history of child abuse are associated with increased startle reactivity in adulthood. Furthermore, these effects appear to be independent of sex, age, as well as the level of symptoms of PTSD or depression. Thus baseline startle magnitude may serve as an important and robust neurophysiological correlate of perceived history of abuse regardless of whether the individual meets criteria for a disorder. This approach of finding intermediate phenotypes or endophenotypes, for mental health disorders, is of utmost importance for progress in this field.

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A. Physical Abuse **B. Sexual Abuse** **C. Emotional Abuse** **Figure 1. Baseline Acoustic Startle Response During the Experimental Session**

A. Mean±SE startle magnitude to noise alone trials (NA) during habituation, 3 blocks of conditioning, and post-conditioning blocks in subjects reporting high and low levels of childhood physical abuse. Main effect of group $p<0.05$; linear contrast for block $p<0.05$.

B. Mean±SE startle magnitude to noise alone trials (NA) during habituation, 3 blocks of conditioning, and post-conditioning blocks in subjects reporting high and low levels of childhood sexual abuse. Main effect of group $p<0.05$; linear contrast for block $p<0.05$.

C. Mean±SE startle magnitude to noise alone trials (NA) during habituation, 3 blocks of conditioning, and post-conditioning blocks in subjects reporting high and low levels of

childhood emotional abuse. There were no group differences. No effect of group; linear contrast for block $p < 0.05$.

Figure 2. Acoustic Startle Response During Fear Acquisition

A. Mean+SE startle magnitude to noise alone trials (NA) and the reinforced conditioned stimulus (AX+) during the last conditioning block in subjects reporting low and high levels of childhood physical abuse. Main effect of group $p < 0.05$; main effect of trial type $p < 0.001$.
B. Mean+SE startle magnitude to noise alone trials (NA) and the reinforced conditioned stimulus (AX+) during the last conditioning block in subjects reporting low and high levels of childhood sexual abuse. Main effect of group $p < 0.05$; main effect of trial type $p < 0.001$.
C. Mean+SE startle magnitude to noise alone trials (NA) and the reinforced conditioned stimulus (AX+) during the last conditioning block in subjects reporting low and high levels of childhood emotional abuse. No effect of group; main effect of trial type $p < 0.001$.

A. Physical Abuse **B. Sexual Abuse** **C. Emotional Abuse** **Figure 3. Fear-Potentiated Startle**

A. Mean+SE percent potentiated startle on differential conditioning trials (AX+, BX-) and inhibition transfer test trials (AB) in subjects reporting low and high levels of childhood physical abuse. No effect of group; Trial type contrast effects: AX+ vs. BX- $p < 0.01$, AX+ vs. AB $p < 0.01$.

B. Mean+SE percent potentiated startle on differential conditioning trials (AX+, BX-) and inhibition transfer test trials (AB) in subjects reporting low and high levels of childhood sexual abuse. No effect of group; Trial type contrast effects: AX+ vs. BX- $p < 0.01$, AX+ vs. AB $p < 0.01$.

C. Mean+SE percent potentiated startle on differential conditioning trials (AX+, BX-) and inhibition transfer test trials (AB) in subjects reporting low and high levels of childhood emotional abuse. No effect of group; Trial type contrast effects: AX+ vs. BX- $p < 0.01$, AX+ vs. AB $p < 0.05$.

Table 1

The table displays the rates of three forms of reported child abuse within the total subject pool, as well as demographic information in addition to patients' scores of depressive and PTSD symptoms.

	PHYSICAL ABUSE		SEXUAL ABUSE		EMOTIONAL ABUSE	
	LOW	HIGH	LOW	HIGH	LOW	HIGH
TOTAL SAMPLE (N=60)	40	20	44	16	47	13
SEX (N, %):						
MALE	20 (50%)	9 (45%)	26 (59.1%)	3 (18.7%)	24 (51.1%)	5 (38.5%)
FEMALE	20 (50%)	11 (55%)	18 (40.9%)	13 (81.3%)**	23 (48.9%)	8 (61.5%)
RACE (N, %):						
AFRICAN AMERICAN	37 (92.5%)	19 (95%)	42 (95.5%)	14 (87.5%)	45 (95.7%)	11 (84.6%)
CAUCASION	3 (7.5%)	1 (5%)	2 (4.5%)	2 (12.5%)	2 (4.3%)	2 (15.4%)
INCOME (N, %):						
BELOW \$500/month	14 (35.9%)	10 (50.0%)	18 (41.9%)	6 (37.5%)	19 (41.3%)	5 (38.5%)
ABOVE \$500/month	25 (64.1%)	10 (50.0%)	25 (58.1%)	10 (62.5%)	27 (58.7%)	8 (61.5%)
AGE (MEAN, SD)	44.7 (13.0)	47 (8.0)	46.3 (12.0)	43.1 (10.0)	44.5 (12.3)	48.6 (8.2)
BDI SCORE (MEAN, SD)	11.7 (6.4)	18.1 (14.2)	12.8 (9.4)	17.3 (12.4)	11.7 (7.4)	21.5 (14.5)
PSS SCORE (MEAN, SD)	8.7 (8.5)	11.8 (10.5)	9.1 (8.6)	11.6 (10.9)	7.9 (8.0)	16.7 (10.7)

** p<0.01 compared to males with high levels of sexual abuse.

Table 2

The table displays the rates of traumatic events experienced by the subjects in the study sample.

TRAUMATIC EVENTS INVENTORY	Percent of Sample
Natural Disaster	20.69
Serious Accident or Injury	55.77
Sudden Life-Threatening Illness	38.60
Military Combat	9.26
Close Friend or Family Member Murdered	3.57
Close Friend or Family Member Committed Suicide	8.77
Attacked with Weapon	35.09
Attacked Without Weapon	34.55
Violence Between Parents or Caregivers	35.19
Beaten as a Child	35.71
Sexual Contact Before Age 13	21.43
Forced Sexual Contact Between 14 and 17	9.09
Forced Sexual Contact After Age 17	9.80

Table 3

The table displays the statistics for the hierarchical regression analyses examining the contributions of each abuse type on baseline startle.

MODEL	R ²	R ² Change	F Change	p
1. Emotional abuse only	0.13	0.02	1.04	0.31
2. Emotional + Physical abuse	0.27	0.06	3.41	0.07
3. Emotional + Physical + Sexual abuse	0.39	0.08	5.34	0.02
FINAL MODEL	Beta	t	p	
Emotional abuse	-0.11	-0.74	0.46	
Physical abuse	0.23	1.64	0.11	
Sexual abuse	0.31	2.31	0.02	