Associations Between Childhood Trauma and Emotion-Modulated Psychophysiological Responses to Startling Sounds: A Study of Police Cadets

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Childhood trauma may confer risk for adult psychopathology by altering emotional and physiological responses to subsequent stressors. Few studies have distinguished effects of childhood trauma from effects of current Axis I psychopathology on adult psychophysiological reactivity. The authors exposed 90 psychiatrically healthy police cadets to startling sounds under increasing threat of shock while assessing their eyeblink electromyogram (EMG), skin conductance (SC), and heart rate responses. When compared with those who did not endorse early trauma (n = 65), cadets reporting childhood trauma (n = 25) reported less positive emotion and showed greater SC responses across all threat levels. They also showed threat-dependent elevations in reported negative emotions and EMG responses. Results suggest that childhood trauma may lead to long-lasting alterations in emotional and psychophysiological reactivity even in the absence of current Axis I psychopathology.

Keywords: childhood trauma, startle, police stress, psychophysiology

Adverse experiences during childhood can have long-lasting effects. For example, childhood trauma is a well-established risk factor for adult psychopathology (Brewin, Andrews, & Valentine, 2000; Kendler, Neale, Kessler, Heath, & Eaves, 1992; Kessler, Davis, & Kendler, 1997). Furthermore, accumulating evidence based on studies of nonhuman animals (Coplan et al., 1998; Hall, Huang, & Fong, 1997; Ladd, Owens, & Nemeroff, 1996; Liu et al., 1997; Meaney et al., 1996; Plotsky & Meaney, 1993; Rosenblum et al., 1994; Rosenblum & Paully, 1984; van Oers, de Kloet, & Levine, 1998), human children (Cicchetti & Rogosch, 2001a, 2001b; DeBellis, Chrousos, et al., 1994; De Bellis, Bear, Trickett, & Putnam, 1994; Galvin et al., 1995; Hart, Gunnar, & Cicchetti, 1995; Scheeringa, Zeanah, Myers, & Putnam, 2004), and human adults who were exposed to early-life adversities (Heim et al., 2000; Metzger et al., 1999; Orr et al., 1998) suggests that exposure to severe early-life stressors can permanently alter psychobiological systems involved in subsequent threat appraisal and reactivity. Although one might speculate that observed psychobiological aberrations among adults exposed to childhood trauma are due to trauma exposure, most human research bearing on this question has examined adults with concurrent Axis I disorders. Thus, it is unclear whether the observed abnormal reactivity to adult stressors is a consequence of early trauma, current psychopathology, or both.

We undertook the present study to determine whether childhood trauma history in the absence of current Axis I psychopathology alters adult emotional and psychophysiological reactivity under threat. If so, then individuals with a history of childhood trauma may be more sensitive to later traumatic stress exposure than those without a history of childhood trauma and consequently more vulnerable to developing posttraumatic stress disorder (PTSD), depression, and related psychopathology. Further understanding of the effects of childhood trauma on responses to adult stressors could be important for society as a whole and especially important for subgroups who are at high risk for exposure to adult trauma, such as soldiers, firefighters, and police officers.

Previous Studies of the Psychobiology of Childhood Trauma

Most of the literature on the psychobiological effects of childhood trauma has focused on hypothalamic–pituitary–adrenal axis dysfunction, such as hypersecretion of corticotropin-releasing factor, adrenocorticotropic hormone, or cortisol in nonhuman animals or human children (e.g., Ladd et al., 1996; Liu et al., 1997; Plotsky & Meaney, 1993; Putnam & Trickett, 1997). One of the few
studies involving human adults examined both adrenocorticotropic hormone and cortisol reactivity in women with and without self-reported childhood abuse and with and without current major depression (Heim et al., 2000). The women were biologically assessed before, during, and after public speaking and mental arithmetic stress tasks. Results showed that both depressed and nondepressed women with prior childhood abuse had increased adrenocorticotropic hormone reactivity as compared with the other groups. Although these findings are consistent with the theory that childhood abuse alone elevates adult physiological reactivity to stress, this conclusion must be tempered by the fact that more than one third (5 out of 14) of the women in the childhood abuse/no current depression group had current PTSD. Because PTSD has been associated with hypothalamic–pituitary–adrenal axis dysregulation (e.g., Neylan et al., 2005) and childhood abuse (Rodriguez, Ryan, Kemp, & Foy, 1997), it is difficult to disentangle the contribution of childhood abuse from that of current psychopathology.

In addition to the problem of confounding childhood trauma with current psychopathology, prior studies of the effects of childhood trauma on adult stress reactivity have emphasized neuroendocrine measures, such as cortisol, over psychophysiological measures, such as heart rate (HR), skin conductance (SC), and electromyogram (EMG) activity. Psychophysiological measures have the advantage over neuroendocrine measures of being able to capture nearly instantaneous reactions to acute stressors, which may better approximate responses to sudden traumatic stressors. Psychophysiological measures also have the advantage of being able to tap relevant domains of possible dysfunction that have been relatively neglected in the literature to date, such as abnormal emotional reactivity and sympathetic nervous system (SNS) hyperactivity, both of which may be examined in emotion-modulated startle paradigms.

Emotional Modulation of Psychophysiological Responses to Startling Sounds

The startle reflex is a rapid muscular response to sudden, intense stimuli. This basic reflex is observed in all mammals and is usually assessed in humans via measurement of eyeblink EMG immediately following a loud sound. The startle reflex itself, which occurs within milliseconds of a sudden, intense stimulus, is generated by a simple brain stem circuit (Davis, Gendelman, Tischler, & Gendelman, 1982). It is also typically followed by well-characterized, secondary, “defensive” changes in autonomic parameters, such as SC and HR, that occur within seconds of the startling stimulus (Orr & Roth, 2000). These psychophysiological components of the startle response may also provide important information about the emotional state of the individual. As one of the earliest and most basic parts of our psychobiological defense against environmental threats, the startle reflex is keenly sensitive to environmental context as interpreted through our emotions. In most people, the eyeblink component of startle is reliably augmented by environmental cues that activate negative emotions (Lang, Bradley, & Cuthbert, 1990). Analogous augmentation of SC responses to startling sounds has also been observed (e.g., Vrana, 1995), but evidence of emotion modulation of HR responses has been more elusive (e.g., Perez, Fernandez, Vila, & Turpin, 2000; Vrana, 1995). Nonetheless, one study reported that individuals who were high in trait fearfulness showed emotion-modulated HR acceleration, which was absent in their low-fear counterparts (Cook, Davis, Hawk, Spence, & Gautier, 1992). Thus, examining eyeblink EMG, SC, and HR responses to startling sounds while manipulating contextual threat has the potential to reveal abnormalities in the central nervous system, autonomic nervous system, and/or emotional response systems.

The Present Study

In sum, there is suggestive evidence that exposure to early-life traumatic stressors is associated with alterations in psychobiological threat responding in nonhuman animals, human children, and human adults. However, the literature lacks studies of adults who were exposed to childhood trauma but who do not currently meet criteria for an Axis I psychiatric disorder. To determine whether childhood trauma in the absence of current Axis I psychopathology predicts exaggerated psychobiological reactivity, we assessed reported emotional (positive, negative) and psychophysiological (EMG, SC, and HR) reactions to startling sounds under three levels of threat (low, medium, and high) in psychopathologically healthy, urban police cadets with and without a reported history of childhood trauma. Our manipulation of threat was based on a paradigm developed by Grillon and his colleagues (e.g., Grillon, Morgan, Davis, & Southwick, 1998) and modified by our research group (e.g., Pole, Neylan, Best, Orr, & Marmar, 2003) in which participants are threatened with exposure to electrical shock. We hypothesized that cadets who reported childhood trauma would show more negative emotions and greater psychophysiological reactivity to the startling sounds, thereby supporting the view that even in the absence of Axis I pathology, childhood trauma is associated with increased threat reactivity in adulthood.

Method

Participants

The sample consisted of 90 cadets (84.4% male, 42.2% Caucasian, 24.4% Asian American, 14.4% Latino, 4.4% African American, 1.1% Native American, 13.3% other or mixed ethnicity) recruited from San Francisco Bay Area police academies to participate in an ongoing, institutional review board–approved, prospective study of risk and resilience factors for PTSD in police. Over the last several years, all members of each incoming academy class were invited to participate, and approximately 30% accepted our invitation. Using demographic data furnished by the police academies, we were able to determine that our sample did not

1 The sample originally included 101 participants. However, because of significant missing data on one or more of the main dependent measures, we excluded 11 potential participants. Self-report data were missing because participants left some items blank. Eyeblink EMG responses were typically rejected because of prestimulus noise or spontaneous blinking. HR responses were typically rejected because of pre- or poststimulus movement artifact. SC responses from 1 participant were rejected because of a defective electrode. The 11 excluded participants were compared with the 90 included participants on age, gender, education, social desirability reporting, trait anxiety, positive and negative affect, general psychiatric distress, amount of childhood and adulthood trauma exposure, and resting psychophysiological levels. No differences were observed on any of these variables.
differ significantly from the full academy classes in terms of age, gender, and ethnicity. Cadets who were combat veterans or who had prior experience in law enforcement or emergency services were excluded. On average, the sample was 28.5 (SD = 5.8) years old with 15.2 (SD = 1.4) years of education. Each cadet provided written informed consent and was compensated $275 for his or her participation.

**Interview**

Cadets individually completed a structured interview within 1 week prior to participating in the laboratory procedure, which was conducted by one of a team of doctoral-level clinical psychologists. Part of the interview consisted of the Life Stressor Checklist—Revised (Wolfe, Kimerling, Brown, Chresman, & Levin, 1996), which assessed whether and at what age the cadet had experienced each of 21 traumatic events (e.g., serious accidents, disasters, physical and/or sexual assault). Participants were assigned to either a childhood trauma (CT; n = 25) or a no childhood trauma (NCT; n = 65) group on the basis of their responses to this interview. Those in the former group reported experiencing a life-threatening event before the age of 14 in which they believed that they could be “killed or seriously harmed” and in which they experienced intense helplessness, horror, or fear. Events that were merely witnessed or that happened to someone else and were not associated with intense peritraumatic distress were not counted as traumatic.

Age of first childhood trauma ranged from 4 to 13 years, but the average was 10 (SD = 2.5) years old. Disaster was the most commonly endorsed childhood trauma in the CT group (60%), followed by physical assault (20%), serious illness (8%), serious accident (8%), serious abuse (8%), serious neglect (4%), and sexual assault (4%). Most cadets in the CT group (84%) reported that only one event had happened to them in childhood, but 4 cadets (16%) had experienced two of these events. Most of the CT group (76%) reported a single exposure to their selected traumatic events, but 5 cadets (20%) reported experiencing a single type of event more than once, and 1 cadet (4%) reported experiencing two event types more than once. Of the 4 cadets who were exposed to two childhood trauma events, 1 reported experiencing two event more than once, 1 reported experiencing one event more than once, and the remainder reported experiencing their event only once.

The cadets also participated in a Structured Clinical Interview for DSM–IV Axis I Disorders (First, Spitzer, Gibbon, & Williams, 1997), which assessed past and current Diagnostic and Statistical Manual of Mental Disorders (4th ed., text rev.; American Psychiatric Association, 2000) Axis I disorders. Interviewers met biweekly to calibrate their diagnoses. Examination of the interview data revealed no current Axis I disorders in either the CT group or the NCT group, which was not surprising given that all cadets were psychologically evaluated prior to acceptance into the academy. Five cadets (20%) in the CT group and 1 cadet (1.5%) in the NCT group met criteria for past major depression, which was a significant difference (p = .006, Fisher’s exact test). Although there were no other past Axis I disorders in the CT group, the NCT group included 1 (1.6%) participant with past specific phobia. This difference was not statistically significant. Only 1 of the 4 cadets who had experienced more than one childhood trauma and 2 of the 6 who reported repeated exposure to childhood trauma also had a past Axis I disorder.

**Preexperiment Self-Report Measures**

**Social Desirability Scale** (Reynolds, 1982). To assess social desirability reporting bias, which could compromise the validity of self-report data, we administered the Social Desirability Scale, a widely used measure of the tendency to endorse self-report items in ways that avoid controversy and elicit the approval of others. The measure consists of 13 items that were answered in a true–false format with an internal consistency of .67 by our sample. Higher scores on the sum of item responses reflect greater social desirability.

**State–Trait Anxiety Inventory** (Spielberger, Gorsuch, & Lushene, 1990). To assess group differences in trait anxiety, which could explain group differences in physiological reactivity, we administered the Trait Form Y-2 of the State–Trait Anxiety Inventory. Respondents were asked to indicate how they “generally feel” with respect to 20 items pertaining to enduring anxiety symptoms. Each item was rated on a 4-point Likert scale ranging from 1 (almost never) to 4 (almost always). Item ratings showed internal consistency of .72 in our sample and were summed to index total trait anxiety. Higher scores indicate greater trait anxiety.

**Positive and Negative Affect Schedule** (Watson, Clark, & Tellegen, 1988). To assess positive and negative affect within the last month, which could also explain group differences in physiological reactivity, we administered the Positive and Negative Affect Schedule. Respondents rated each item with respect to how much they had felt each of 20 affects within the past month using a 5-point Likert scale ranging from 1 (very slightly or not at all) to 5 (extremely). We scored these ratings in terms of items referring to positive affect (attentive, interested, alert, excited, enthusiastic, inspired, proud, determined, strong, and active) and items referring to negative affect (distressed, upset, hostile, irritable, scared, afraid, ashamed, guilty, nervous, and jittery) by summing the ratings given to items. The internal consistency in our sample was .90 for positive affect and .79 for negative affect. Higher scores indicate more of each kind of affect in the last month.

**Symptom Checklist 90—Revised** (Derogatis & Savitz, 2000). To assess group differences in current general psychiatric distress, which could explain group differences in emotional or psychophysiological reactivity, we administered the Symptom Checklist 90—Revised. Each respondent rated how much he or she had “been distressed” by each of 90 common psychiatric symptoms within the past 7 days on a 5-point Likert-type scale ranging from 0 (not at all) to 4 (extremely). The global severity index, which is the mean rating across all 90 items, was used to index general psychiatric distress in the last week, with internal consistency of .97 in our sample. Higher scores indicate more psychiatric distress.

**Emotion-Modulated Startle Procedure**

Research technicians, who were blind as to the participants’ childhood trauma status, collected the data on self-reported emotion and psychophysiology. Participants were instructed to refrain from exercise, cigarettes, and coffee on the day of the lab experiment and from eating for 1 hr prior to the experiment. Detailed reports were obtained of substances ingested within 24 hr of the experiment. There were no significant between-groups differences (CT vs. NCT) in the percentage of participants who used caffeine, cigarettes, alcohol, over-the-counter medications, or prescription
medications. Two participants (both in the NCT group) were taking antihistamine or antihypertensive medications that could have confounded physiological results.

Sensors were attached to the participants to monitor psychophysiological responses (described in detail below). After a 2-min resting period, during which baseline psychophysiological measures were obtained, participants were told that they would hear potentially startling sounds. They were fitted with headphones and asked to sit upright in a chair, facing a large, black X on a computer monitor a few feet in front of them. They were instructed to keep their eyes open except when blinking, to focus their attention on the X, and to listen to the sounds generated by a Coulbourn Instruments (Allentown, PA) Lablinc V Modular System. The sounds were 106-dB(A), 40-ms white noise bursts with 0-ms rise and fall times separated by intertrial intervals of between 30 s and 50 s and presented binaurally through headphones under low, medium, and high threat conditions, as in our previous work (Pole et al., 2003). In particular, participants were told that they would receive shocks later in the study but that the shocks could not occur until the participants were fitted with a Coulbourn Instruments E13-22 Transcutaneous Aversive Finger Stimulator. They were then exposed to 10 startling sounds.

In keeping with a common procedure (Blumenthal et al., 2005), responses to the first 5 sounds were used to establish a stable response and then discarded. The remaining 5 responses were retained to index the reaction to the low threat condition. Under the medium threat condition, the participants were fitted with the finger stimulator, and the X on the computer monitor was replaced with the words No Shock, indicating that the participants would not be shocked. The participants were then exposed to 5 additional startling sounds. Even though participants were shown a No Shock signal, we designated this condition medium threat on the basis of previous work (Grillon et al., 1998; Pole et al., 2003) indicating that the mere placement of the finger stimulator leads to more intense negative emotions than the low threat condition. Under the high threat condition, the cadets continued to wear the finger stimulator, but the computer monitor now displayed the sign Shock Coming, indicating that a shock was imminent. They were then presented with 5 startling sounds followed by one 2.5-mA shock, which was annoying but not painful. We designated this condition high threat because we anticipated that the additional threat of imminent shock would elevate negative emotions above levels observed in both the low and the medium threat conditions. Each condition lasted approximately 4 min, and there was less than 1 min between conditions. The no shock and shock coming signals acted as long lead stimuli, lasting the length of the intertrial intervals. All participants were exposed to all three threat conditions. The order of medium and high threat conditions was counterbalanced.

Psychometric and Physiological Response Measures

**Psychometric.** Following the resting baseline and each of the threat conditions, respondents completed an Emotional Response Scale, which was composed of seven negative emotion words (anxiety, danger, fear, anger, stress, annoyance, helplessness) and five positive emotion words (safety, pleasure, calm, contentment, amusement). Each word was rated on a 5-point Likert-type scale from 1 (not at all) to 5 (quite a lot) with respect to the participant’s emotional state during each experimental condition. Items were averaged into scales indexing reported negative (average α = .88) and reported positive emotions (average α = .81).

**Psychophysiology.** Three physiological parameters—eyeblink EMG, SC, and HR—were assessed during the resting baseline and following each startling sound. All three physiological signals were sampled at 2 Hz during the resting baseline and 1000 Hz during the stimulus presentations, digitized by a Coulbourn Instruments LabLinc V Analog to Digital Converter, and stored for offline analysis. Eyeblink EMG, the primary index of the startle reflex, was measured in microvolts, by means of three 4-mm (sensor diameter) InVivo Metrics Ag/AgCl surface electrodes filled with electrolyte paste. Two electrodes were placed on the left orbicularis oculi according to published specifications (Blumenthal et al., 2005), and the ground electrode was placed on the center of the forehead. Impedance levels were kept below 10 KOhms, as verified by a UFI (Morro Bay, CA) Checktrode Model 1089 mkIII electrode tester. The EMG signal was amplified (by 10,000), rectified, filtered to retain the 13 Hz to 1000 Hz range, and notch filtered at 60 Hz by a Coulbourn Instruments V75-04 Isolated Bioamplifier. A Coulbourn Instruments V76-23A Contour Following Integrator smoothed the EMG data by applying a 5-ms time constant.

SC level, an index of secondary defensive responding to startling sounds, was measured in microsiemens via a Coulbourn Instruments V71-23 Isolated Skin Conductance Coupler sending a constant 0.5 V through 9-mm (sensor diameter) InVivo Metrics Ag/AgCl electrodes filled with isotonic paste and placed on the hypothenar surface of the medial phalanges of the middle and index fingers of the nondominant hand. HR, also an index of secondary defensive responding to startling sounds, was measured in beats per minute and recorded via 3-Dot brand 3M Corporation (Maplewood, MN) electrocardiogram (EKG) electrodes attached in a Type I EKG configuration. The EKG signal was filtered for 8 Hz to 13 Hz activity and amplified (by 10,000) by a Coulbourn Instruments V75-04 Isolated High Gain Bioamplifier. Interbeat intervals were calculated by software (described below) from the R-peaks of the digital EKG signal and converted to HR.

Psychophysiological response scores were calculated according to conventions established by Scott Orr and his colleagues (e.g., Orr, Lasko, Shalev, & Pitman, 1995). Human Startle Software (Coulbourn Instruments) automatically generated measures of the mean physiological level during the 1 s prior to each stimulus onset for all three measures and the maximum poststimulus level within 21 ms to 200 ms for eyelink EMG and within 1 s to 4 s for SC and HR.2 We inspected these measures carefully for potential artifact. Excessively high prestimulus EMG values (e.g., values greater than 100 microvolts), which were usually indicative of noise or spontaneous blinking, rendered approximately 2% of the co-occurring EMG blink responses to be rejected. All automati-

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2 Although this method of calculating HR response is consistent with the majority of studies examining reactivity to loud tones in PTSD and consistent with Turpin’s (1986) formulation of the typical HR response to intense auditory stimuli, it does not permit detailed examination of the full range of poststimulus phasic responses (accelerations and decelerations) that have been observed by investigators who collect poststimulus data for 80 s or more (e.g., Perez et al., 2000).
cally calculated HR values were corroborated against the digital EKG signal by visual inspection via Windaq software (DATAQ Instruments, 1998). When movement artifact resulted in excessively high or uninterpretable pre- or poststimulus HR values (e.g., values greater than 140 beats per minute), the response was rejected. Approximately 5% of HR responses were rejected for this reason. SC responses from 1 participant were unusable because of a defective electrode. We calculated response scores by subtracting prestimulus mean values from poststimulus peak values. No minimum response threshold was designated for any physiological measure. Therefore, all scorable responses that were not contaminated by artifact (including those that might be traditionally designated as nonresponses) were accepted as valid. Participants needed at least four (of five possible) valid responses for each condition and for all three physiological measures to be included in the present study. Participants who did not meet these criteria were among the 11 excluded from the study (see Footnote 1). Mean response scores were calculated for each physiological measure within each threat condition with the following average internal consistency across threat conditions: EMG (α = .97), SC (α = .89), and HR (α = .70).

Data Analysis

The CT and NCT groups were compared on background and baseline variables by means of t tests and chi-square tests. Main hypotheses were tested with separate linear mixed-effects models for each dependent measure (reported positive and negative emotions; mean eyelink EMG, SC, and HR responses) fitting childhood trauma group (CT, NCT) as a between-groups fixed effect and threat level (low, medium, high) as a within-subject repeated fixed effect. We also included Group × Threat Level interactions in each model. This mixed-effects analysis has several advantages over traditional mixed analysis of variance for analyzing repeated measures data, including freedom from normal assumptions of homogeneity of variance (Gueorguieva & Krystal, 2004). We examined the possibility of order effects by treating order of presentation of the medium or high threat condition as an additional between-groups fixed effect. When we observed significant effects on the composite reported affect or emotion variables, we recomputed analyses at the item level to identify the source of the finding. When we found significant CT group differences in a baseline or background variable, we entered that variable as a fixed covariate in subsequent analyses. Finally, we examined the influence of gender, potentially confounding medication, and past depression by reanalyzing the data with each of these groups excluded. We used an alpha level of .05 for comparisons of background and baseline variables and for omnibus tests of the main hypotheses. However, we applied Bonferroni corrections to alpha (i.e., .05/3 = .017) for pairwise post hoc tests. Analyses were conducted with SPSS 14.0.

Results

Demographic and Psychometric Comparisons

Table 1 shows that there were no differences between the CT and NCT groups in gender composition, age, or years of education. By definition, the two groups were significantly different in the number of traumatic events that they reported experiencing during
childhood. Notably, however, they were not different in the number of traumatic events that they reported experiencing as adults. There were also no group differences in social desirability reporting bias, trait anxiety, or current general psychiatric distress. The CT group reported marginally higher scores on the Positive and Negative Affect Schedule negative affect items (p = .06). Further decomposition revealed that this trend was due to greater reported jitteriness (p = .04). We next compared the two groups in their resting self-reported emotion and physiological levels. The CT group reported marginally fewer positive emotions (p < .10) during the resting baseline, but they were not different in reported resting negative emotions. The groups were also not significantly different in resting eyeblink EMG or HR, but the CT group showed significantly higher resting SC levels than the NCT group (p = .03).

**Comparisons of Reported Emotional and Psychophysiological Responses to Emotion-Modulated Startling Sounds**

Table 2 presents descriptive statistics (means and standard deviations) of mean reported emotional responses (positive and negative) and mean psychophysiological responses (eyeblink EMG, SC, and HR) to the startling sounds under the three threat conditions (low, medium, and high) for both the CT and the NCT groups. This table also shows the results of the omnibus mixed model tests examining the effects of CT group, threat level, and their interaction on these responses. Prior to conducting these mixed model analyses, we added order of presentation of the medium and high threat conditions as a between-subjects fixed effect. We found a marginal main effect of order, F(1, 84.3) = 2.94, p = .09, on the mean EMG response (cadets who received medium threat first had a trend toward larger overall EMG responses) and a marginal three-way interaction of order, CT group, and threat level, F(4, 93.1) = 2.08, p = .09, on mean HR response (members of the CT group who received medium threat first showed greater HR responses under medium threat than under low threat). Otherwise, we found no main effects of order or two- or three-way interactions among order, CT group, and threat level on any other reported emotion or psychophysiological response variable.

**Reported positive emotional response.** We found a main effect of CT group on reported positive emotions in which the CT group reported marginally fewer positive emotions than the NCT group. An examination of individual emotion items revealed that this main effect was held for reported safety (p = .005), pleasure (p < .001), calm (p < .001), and contentment (p < .001) but not amusement (p = .37). We also found a within-subject effect of threat condition. The significant main effect of threat condition held for reported safety (p < .001) but not for the other positive emotions. Although the overall trend was for reported positive emotions to decrease with increasing threat level, after a post hoc Bonferroni adjustment, only the reduction in positive emotions between the low and high threat conditions was significant (members of the CT group who received medium threat first showed greater HR responses under medium threat than under low threat).

**Note.** Reported positive emotions (safety, pleasure, calm, contentment, and amusement) and reported negative emotions (anxiety, danger, fear, anger, stress, annoyance, and helplessness) are expressed in subjective units (1 = none, 2 = a bit, 3 = some, 4 = a lot, 5 = quite a lot). Eyeblink electromyogram (EMG) response is expressed in microvolts. Skin conductance response is expressed in microsiemens. Heart rate response is expressed in beats per minute. *p < .05. **p < .01. ***p < .001.

### Table 2

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<th>Variable</th>
<th>Childhood trauma</th>
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<th>Threat level main effect</th>
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</tr>
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<td>High threat</td>
<td>5.57</td>
<td>7.07</td>
<td>5.54</td>
<td>6.85</td>
<td></td>
</tr>
</tbody>
</table>

3 We also compared the CT and NCT groups on all of the standard Symptom Checklist-90—Revised subscales (e.g., Depression, Anxiety, Somatization, Obsessive Compulsive, Interpersonal Sensitivity, Hostility, Phobic Anxiety, Paranoia, and Psychoticism) and found no significant group differences on any subscale.
threat conditions was significant \( (p = .01) \). We found no significant CT Group \( \times \) Threat Condition interaction on positive emotions.

Reported negative emotional response. With regard to negative emotions, we found a significant main effect of CT group in which the CT group reported more negative emotions than the NCT group. An examination of the individual emotion items revealed that the CT group main effect was due to elevated reported anxiety \( (p = .002) \), danger \( (p < .001) \), fear \( (p = .001) \), stress \( (p < .001) \), annoyance \( (p = .002) \), and helplessness \( (p < .001) \) but not anger. We also found a significant within-subject effect of threat condition, which applied to reported anxiety \( (p < .001) \), danger \( (p = .001) \), fear \( (p < .001) \), stress \( (p < .001) \), annoyance \( (p = .02) \), and helplessness \( (p = .03) \) but not anger. After post hoc Bonferroni adjustments, the within-subject effect of threat was shown to be driven by more reported negative emotions in the high threat condition as compared with the medium threat condition \( (p < .001) \). Finally, we found a significant CT Group \( \times \) Threat Condition interaction, which was specific to reported danger \( (p = .02) \), fear \( (p < .001) \), and helplessness \( (p = .01) \) but not reported anxiety, anger, annoyance, or stress. After post hoc Bonferroni adjustments, the interaction was shown to be driven by the fact that whereas the CT group reported increases in negative emotion both from low to medium threat \( (p = .005) \) and from medium to high threat \( (p < .001) \), the NCT group only reported increases in negative emotion from medium to high threat \( (p < .001) \).

Eyeblink EMG response. We found a significant main effect for the CT group in which the CT group showed larger eyeblink responses than the NCT counterparts. We also found a significant within-subject effect of threat condition, which, on further decomposition with post hoc Bonferroni adjustment, revealed a significant increase in mean eyeblink EMG magnitude between the low and medium threat conditions \( (p = .004) \) and between the medium and high threat conditions \( (p < .001) \). Moreover, we found a significant CT Group \( \times \) Threat Condition interaction. Further post hoc decomposition revealed that the source of the interaction was that whereas the CT and NCT groups only differed marginally under the low threat condition \( (p = .032) \), the CT group showed a significantly larger eyeblink response under both medium \( (p = .01) \) and high threat \( (p = .002) \).

SC response. We found a significant main effect for the CT group in which the CT group showed larger SC responses than the NCT group. We found a significant within-subject effect of threat level, which, on further post hoc decomposition, was shown to be driven by larger mean SC response in the high threat condition than the medium threat condition \( (p = .01) \). We found no CT Group \( \times \) Threat Condition interaction on this measure.

HR response. Although we found no significant main effect of CT group and no significant CT Group \( \times \) Threat Condition interaction on mean HR response, we found a significant within-subject effect of threat condition. Post hoc analyses showed that this effect was due to significantly larger HR responses under medium threat than under low threat \( (p = .007) \).

Examining the Potential Influences of Resting SC Levels, Gender, Past Major Depression, and Autonomically Active Medications

Because we found initial CT group differences in resting SC level, we recomputed the above analyses with resting SC as a covariate. We found that adjusting for resting SC did not alter our findings with respect to reported emotion, eyeblink EMG, or HR, but it did eliminate the main effect of CT group on SC response \( (p = .32) \). We also recomputed these analyses after excluding cadets who were female, had past major depression, or were taking autonomically active medications. Neither the exclusion of individuals on potentially confounding medications nor the exclusion of those with past major depression altered any of our findings. However, after we excluded female cadets, the interaction effect on eyeblink EMG was now only marginal, \( F(2, 89.6) = 2.71, p = .072 \). Thus, we added gender to the mixed model to determine whether gender interacted with CT status and threat level in influencing eyeblink EMG response. We found that this interaction was not significant, \( F(2, 103.7) = 1.94, p = .15 \).

Discussion

We found that police academy cadets who were free of current Axis I disorders but who reported experiencing a life-threatening trauma before the age of 14 responded to the combination of increasing threat of shock and startling sounds with subjective emotions and psychophysiological activation that differed significantly from their counterparts without reported childhood trauma. In particular, those who reported childhood trauma showed larger eyeblink responses and rated themselves as experiencing more negative emotions as the level of threat increased in the experiment. They also reported experiencing less positive emotion and showed larger SC responses throughout the experiment. In general, the findings are consistent with our hypothesis that, even in the absence of current Axis I psychopathology, the experience of childhood trauma can be associated with long-lasting aberrations in psychobiological processes that mediate the response to environmental threat. The results also have a number of other implications that are described below and considered in light of the study’s shortcomings.

First, we note that our finding that reported negative and positive emotions were altered by increasing threat level implies that our threat manipulation was a valid means of augmenting negative emotions and reducing positive emotions. An examination of the specific emotion items composing these effects suggests that the task had some specificity in reducing “safety” among the positive emotions, but it appears to have elicited a wide range of negative emotions, including (but not limited to) fear and anxiety. As other investigators have shown (e.g., Lang et al., 1990; Vrana, 1995), these subjective emotional conditions were accompanied by elevated eyeblink EMG and SC responses. Consistent with our previous work (Pole et al., 2003), we found that eyeblink EMG was more sensitive than SC to the subtle increase in threat implied by the medium threat condition. We even found some evidence of emotion modulation of HR, although this effect marginally depended on both CT group status and order of threat presentation.

A few main effects of CT group were not significantly modified by threat condition, such as reduced positive emotions and augmented SC responding. In fact, the CT group showed significantly greater SC levels and a trend toward fewer positive emotions even before being exposed to any startling sounds or increasing threat. We interpret the elevated resting SC levels in the CT group as indicative of chronic hyperactivity of the SNS, which is consistent with similar findings in studies of nonhuman animals (e.g., Coplan
et al., 1998) and human children (e.g., DeBellis et al., 1994) as well as our own study of these same cadets while they watched a video depicting real officers experiencing traumatic stress (Otte et al., 2005). In that study, we found that cadets with childhood trauma showed elevations in a major SNS metabolite. The fact that the baseline difference in resting SC levels specifically accounted for greater SC responses to startling sounds in the CT group implies that these SC response elevations were also due to hyperactivity of the SNS.

One could argue that the most interesting findings of the study are the interactions between CT group status and threat level. Such interactions reveal that the CT group was uniquely reactive to the medium threat condition in terms of negative emotion and that these participants showed particular elevations in eyelink magnitude under both medium and high threat. The apparent sensitivity of the CT group to the medium threat condition is interesting because this condition presented both danger cues (e.g., being fitted with a shock-eliciting device) and safety cues (e.g., being told that they would not be shocked). Individuals in the CT group appeared to preferentially respond to the danger cues rather than the safety cues. In this respect, they behaved similarly to individuals with PTSD (Grillon et al., 1998; Pole et al., 2003).

In fact, our results may have implications for the prediction of PTSD. Childhood trauma is a known risk factor for adult PTSD (Brewin et al., 2000). Yet the mechanism by which childhood trauma contributes to PTSD is largely unspecified. Our sample had no current or past PTSD, which was likely because of both police academy selection procedures and the fact that these individuals had relatively little trauma exposure. However, those with early-life trauma may be more sensitive to threat (as evidenced by our findings), so that when they are exposed to the high levels of life threat that typically accompany urban police work, they may be more likely to develop PTSD. Individuals with PTSD show exaggerated psychophysiological responses to startling sounds (e.g., Metzger et al., 1999; Orr et al., 1995; Pole, in press), especially when such sounds are delivered in threatening contexts (Grillon et al., 1998; Pole et al., 2003). Although it has commonly been assumed that exaggerated startle responses occur as a result of PTSD, it is possible that exaggerated startle is a preexisting vulnerability factor for PTSD, perhaps caused by early exposure to life-threatening stress. This would be consistent with Guthrie and Bryant’s (2005) finding that among firefighters, duty-related PTSD symptoms were prospectively predicted by eyelink EMG and SC responses to startling sounds.

Like all studies, ours has limitations that qualify any conclusions that may be drawn from it. First, we studied a convenience sample of predominantly male police cadets. It is not clear how well they represent other cadets and to what extent they represent the broader civilian population. Indeed, it is reasonable to presume that individuals who seek a high-risk career in law enforcement and who passed a screening process that excludes individuals with current psychopathology differ from average civilians in many ways relevant to the outcomes assessed in this study (e.g., personality, stress reactivity). A second generalizability issue is that the CT group in this study was small in size and predominantly exposed to either a single disaster or a physical assault. Although we have reason to believe that these events were bona fide traumatic events of the type specified by PTSD Criterion A (because they were only coded positive by the interviewer if the respondent believed at the time that death or serious injury was likely and that his or her emotional response was one of fear, helplessness, or horror), it is nonetheless unclear how the effects of exposure to such events would generalize to more commonly studied childhood trauma, such as repeated sexual or physical abuse.

Another limitation of the study is that our assessment of childhood trauma was based primarily on participant self-report, thereby raising questions about honesty and accuracy of reporting. Concerns about reporting bias are somewhat diminished by (a) the fact that the trauma history was gathered by experienced, doctoralevel trauma interviewers, (b) the fact that social desirability reporting bias scores were very low and not significantly different between childhood trauma groups, and (c) the fact that the groups did not differ in trait anxiety, thereby rendering implausible the suggestion that preexisting differences in trait anxiety left the CT group more likely to recall childhood trauma. It is still possible that marginally greater negative affect or unmeasured reporting biases (e.g., acquiescence) in the CT group influenced these participants’ reporting. Also, there remains the problem of unintentional retrospective reporting error, which could be systematically linked to physiological reactivity differences through genetic pathways (e.g., Krueger, Markon, & Bouchard, 2003). Although one could partly address such reporting errors by requiring corroborating evidence of childhood trauma, such a tactic would fail to ensure that participants who reported no childhood trauma in fact had none. Finally, we must note that participants in this study were not assessed for Axis II psychopathology. Thus, we cannot conclude that our sample was entirely free of current psychopathology. It is possible that unmeasured Axis II disorders account for some of our results.

Limitations notwithstanding, this study offers one of the few demonstrations of links between childhood trauma and greater psychophysiological reactivity. It also has implications for the cadets who participated in this study and other emergency services personnel like them. Populations such as these are understudied relative to combat veterans, sexual assault survivors, and motor vehicle accident victims, yet they will almost certainly encounter numerous threatening or traumatic situations in the course of their job duties. Our results imply that life-threatening experiences occurring during childhood can influence the developing nervous system as it attunes itself to the contingencies of the surrounding environment, altering its sensitivity to environmental threat. Early stresses may also establish effects that cascade through later development and limit the organism’s flexibility in adapting to new, challenging situations. Although a variety of limitations in the design and execution of the study leave open the possibility of alternative explanations, our results are consistent with the conclusion that exposure to childhood trauma leads to heightened emotional and psychophysiological reactivity. Future studies will determine the generalizability of these findings and their importance for emergency services work and emerging adult psychopathology.

References


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