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Increased alpha-Amylase Response to an Acute Psychosocial Stress Challenge in Healthy Adults with Childhood Adversity

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Abstract

Childhood adversity is highly prevalent and linked to lasting psychological and physiological consequences. A potential mechanism for negative health outcomes is altered stress reactivity. While previous research has addressed associations of childhood adversity with stress system reactivity, sympathetic nervous system (SNS) stress reactivity is understudied. We therefore set out here to examine salivary alpha-amylase (sAA) reactivity in relation with childhood adversity. Forty-one healthy adult subjects ($n=24$ male; $n=17$ female) aged 18–34 years underwent the Trier Social Stress Test (TSST) and completed the Childhood Trauma Questionnaire (CTQ). Saliva for measurement of sAA was collected at three time points; before the TSST, immediately after, and 10 minutes post-TSST. We found that those with childhood trauma had a higher overall sAA response to the TSST, as seen in a repeated measures ANOVA (CTQ by time interaction: $F(1.8, 71.5)=6.46$, $p=.01$) and an independent samples t-test indicating higher sAA baseline to peak response ($t=3.22$, $p=.003$). There was also a positive correlation between sAA reactivity and the CTQ subscales of childhood physical abuse ($r=.46$, $p=.005$) and emotional abuse ($r=.37$, $p=.024$). Healthy adults with low-to-moderate childhood adversity had a heightened sAA response immediately following the stressor. Higher SNS reactivity could be a link to negative health outcomes in adults with early adversity. Future research should address whether altered sAA reactivity is predictive of negative health outcomes in those with childhood adversity.

Introduction

Adversity in childhood is staggeringly prevalent (U.S. Department of Health and Human Services, 2007) and is linked to lasting psychological and physiological consequences in adulthood (Heim, Shugart, Craighead, & Nemeroff, 2010). According to the most recent National Survey of Children's Health, 47.9% of U.S. children have experienced one or more types of serious childhood trauma (Child and Adolescent Health Initiative, 2011). Adverse

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experiences in childhood are associated with adult deficiencies in cardiovascular and immune health, metabolic control, learning, behavioral and psychological functioning, as well as an increased propensity toward unhealthy lifestyles, and an increased prevalence of chronic illnesses (Shonkoff et al., 2012). One potential mechanism for this multitude of negative health outcomes in those with a history of childhood adversity is altered stress reactivity (Cicchetti & Toth, 2005).

A suggested pathway for altered stress reactivity in adulthood is through a series of changes in brain development that occur in childhood (Weaver, 2009). Early childhood is a critical period for brain development and therefore the brain is especially sensitive to stress during this time (Lupien, McEwen, Gunnar, & Heim, 2009). These authors further suggest that the hypothalamic-pituitary-adrenal (HPA) axis, a major neuroendocrine stress system, is labile during infancy, and its functioning can be influenced by parenting styles. For example, sensitive parenting has been associated with smaller increases and less prolonged activation of the HPA axis during stressful experiences (Lupien et al., 2009). Altered HPA axis reactivity has been observed in individuals reporting childhood trauma or adversity, but different studies have reported both hypo- and hyper-reactivity in cortisol responses to stress (Champagne & Meaney, 2001; Engert et al., 2010; Tarullo & Gunnar, 2006). Previous research has addressed childhood adversity alongside HPA axis stress reactivity, but there has been markedly less exploration into sympathetic nervous system (SNS) stress reactivity in this context.

Similar to the HPA axis, the SNS has been theorized to be highly influenced by childhood experiences (Miller & Chen, 2010). It is thought that a hyper-reactive phenotype arises partly as a result of stressful early experiences, which lead to desensitization of the glucocorticoid receptor. This desensitization is then hypothesized to enable greater outflow from both the HPA axis and the SNS (Miller & Chen, 2010). Just as with the HPA, heightened and prolonged SNS responses, which may occur in response to childhood adverse events, can confer risk for a range of physical and mental health morbidities (Alkon, Boyce, Davis, & Eskenazi, 2011). While these risks are present throughout the lifespan, they are believed to be profoundly influenced by heightened responses that begin in early childhood, when the stress systems are still developing and calibrating to environmental demands (Alkon et al., 2011).

Research on childhood adversity and SNS reactivity has been markedly more limited than that of the HPA axis, likely because measuring the SNS response requires more invasive or costly sample collection using blood. In response to these difficulties, the enzyme salivary alpha amylase (sAA) has been suggested as a marker for SNS reactivity (Granger, Kivlighan, el-Sheikh, Gordis, & Stroud, 2007; Rohleder & Nater, 2009). Acute stress activates a biological fight-or-flight response that includes the activation of the SNS, which leads to increased heart rate and blood pressure, as well as the release of the catecholamines epinephrine and norepinephrine (Frankenhaeuser, 1978). It has been suggested that sAA is a measure of overall peripheral nervous system (PNS) activation (Bosch, Veerman, de Geus, & Proctor, 2011); however, previous research has linked sAA reactivity to stress with other markers of sympathetic reactivity, such as plasma norepinephrine (e.g., (Rohleder, Nater, Wolf, Ehlert, & Kirschbaum, 2004; Thoma, Kirschbaum, Wolf, & Rohleder, 2012)),

suggesting that sAA may be alternative way to measure SNS reactivity less invasively. Although there is some ambiguity regarding whether sAA can be used as an indicator of SNS responses, or if it is better described as reflecting autonomic balance, this is true for many proxies of SNS (or PNS) activation. Given that this is a common issue in psychophysiology research, but also considering that sAA increases can be suppressed by beta-blockers (van Stegeren, Rohleder, Everaerd, & Wolf, 2006), and elicited by SNS activators (Ehlert, Erni, Hebisch, & Nater, 2006), we are using sAA here as an indicator for autonomic balance, with cautious interpretation of sAA increases reflecting SNS responses.

To date, sAA reactivity has not been used in many studies examining stress responses in those with childhood adversity. One previous study has examined sAA reactivity in the context of pre-natal adversity. Quesada et al. (2014) found that children who were born pre-term had elevated levels of sAA in response to a psychosocial stressor designed for children. While the results of this study may indicate differences in SNS functioning in response to stress in those with one type of childhood adversity, the exclusion of children with other types of adversity limits generalizability. Additionally, another study found that children who report being victimized by peers have higher levels of sAA in response to a peer-oriented social challenge (Rudolph, Troop-Gordon, & Granger, 2010). While it is important to note that these differences in sAA response are present well into childhood, it is essential to establish whether or not this altered SNS reactivity extends into adulthood.

One previous study, which employed a psychosocial stress challenge, has found that adults with a history of low care in childhood have an increased ratio of sAA to cortisol, compared to those with high care (Ali & Pruessner, 2012). Similarly, another study has found that adult women with a history of childhood abuse had a heightened heart rate response, a measure of the SNS, as well as an increased cortisol response, to a psychosocial stress challenge (Heim et al., 2000). Alternatively, other studies have found that in healthy adults, reports of adversity in childhood are linked to a blunted response of both cortisol and heart rate reactivity to a psychosocial stress challenge (Lavallo, Farag, Sorocco, Cohoon, & Vincent, 2012; Voellmin et al., 2015). This research, while contradictory in explaining the precise direction of the altered reactivity, provides support for stress response dysregulation among both the HPA and the SNS. Although limited research has been conducted to address sAA response to stress in adults with a history of childhood adversity, there is other evidence that suggests possible mechanisms for stress dysregulation in this marker. One study has found that those with a negative psychological profile, i.e. lower self-compassion, had an increased sAA response to a psychosocial stressor (Breines et al., 2015). Further, it has been found that maltreated children display lower-self compassion than non-maltreated children (Tanaka, Wekerle, Schmuck, Paglia-Boak, & Team, 2011). It is therefore conceivable that those with a history of childhood adversity are more prone to negative psychological states, and in turn, altered SNS reactivity to stress.

Understanding the relationship between childhood adversity and altered stress reactivity is critical because both the HPA axis and SNS feed into inflammation, with glucocorticoids from the HPA axis down-regulating inflammation, and catecholamines from the SNS up-regulating inflammation (Rohleder, 2012). While there are other components that exert their effects on the inflammatory system, the HPA axis and SNS are two major systems

influencing inflammation (Slavich, 2015). Establishing what factors underlie dysregulated responses in these systems, and what factors may counteract this damage is imperative, as increased levels of inflammatory cytokines have been linked to a variety of diseases such as cancer, stroke, myocardial infarctions, and Alzheimer's disease (Danesh et al., 2008; Ershler & Keller, 2000; Yudkin, Kumari, Humphries, & Mohamed-Ali, 2000), as well as age related cognitive declines and mood disturbances (Weaver et al., 2002), potentially through repeated activation of these stress systems (McEwen, 2013).

In order to examine the association between childhood adversity and the response of SNS reactivity to an acute psychosocial stressor in healthy adults, sAA reactivity was measured prior to- and following- stress in healthy young adults with and without a history of childhood adversity. Based on previous research indicating both a heightened and blunted SNS response post-acute stress, we hypothesized that those with a history of childhood trauma would have an altered sAA response to a psychosocial stress challenge.

Method

Sample

Young adults (age 18–35 years) were recruited from Brandeis University and the surrounding towns via newspaper and magazine advertisements. The participants in this sample were $n=41$ healthy adults (24 male, 17 female), with a mean age of 21.1 years ($SD=4.02$), and a mean BMI of 24.61 kg/m^2 ($SD=3.42$). All participants underwent a brief medical and psychological screening by telephone before testing and were invited to participate only if they met following selection criteria: (a) body mass index (BMI) within the reference range between 18 and 35 kg/m^2 ; (b) luteal phase of menstrual cycle at time of participation, for females; (c) absence of psychiatric, endocrine, or cardiovascular diseases, or other specific chronic diseases; (d) no intake of psychoactive drugs, beta-blockers, gonadal steroids (hormonal contraceptives), GCs; (e) non-smoker; (f) no previous experience with the stress protocol, and (g) not under any extraordinary stress at the current time, such as bereavement, the ending of a relationship, or great difficulty with school or work. Individuals were paid for their participation. Weight and body fat measurements were taken using a Seca Supra Plus 720 column scale (Hamburg, Germany), via a bioelectrical impedance analysis.

Procedure

Eligible participants were scheduled for an afternoon (13:30-18:30 h) laboratory session to control for circadian variation of sAA (Rohleder & Nater, 2009). Participants were instructed to refrain from exercising 24 hours prior to the session, and from eating or drinking anything but water for one hour before the session. Written informed consent was obtained prior to participation. The Brandeis University Institutional Review Board approved all procedures.

The laboratory session lasted approximately three hours and included a 30-minute resting period followed by exposure to the Trier Social Stress Test (TSST; (Kirschbaum, Pirke, & Hellhammer, 1993)). In addition to the TSST, participants were asked to fill out

questionnaires regarding their early life experiences and psychological well-being. This was done immediately prior to the conclusion of the study day. Saliva samples for measurement of sAA were collected using Salivette collection devices (Sarstedt, Newton, NC) at baseline, as well as immediately after-, and 10 minutes after- TSST. Salivettes were then centrifuged, and saliva was stored at -20 °C until processing.

Stress Induction Paradigm

Acute psychosocial stress was induced using the TSST (Kirschbaum et al., 1993), a widely used standardized laboratory stress paradigm. The TSST used in the present study consisted of a five-minute preparatory period, followed by a five-minute mock job interview, and a five-minute mental arithmetic task, all in front of an audience of two judges wearing lab coats and maintaining a neutral evaluative facial expression. Participants were informed that the judges were trained in analyzing verbal and non-verbal behavior and that their performance would be videotaped. The TSST has been demonstrated as a good paradigm to test reactivity to uncontrollable socio-evaluative threat, producing strong biological responses (Dickerson & Kemeny, 2004).

Measures

Childhood adversity—Childhood adversity was assessed using the Childhood Trauma Questionnaire (CTQ, (Bernstein, Fink et al. 1994)), a 28-item, 5 point likert-scale measure. The CTQ is a widely used tool to assess childhood adversity, and has been cited in related research more than 1,000 times (MacDonald et al., 2016). The CTQ asks respondents to report on childhood experience across five types of childhood maltreatment; physical abuse (“I got hit so hard by someone in my family that I had to see a doctor or go to the hospital”), sexual abuse (“Someone tried to touch me in a sexual way, or tried to make me touch them”), emotional abuse (“People in my family called me things like “stupid,” “lazy,” or “ugly”), physical neglect (“I had to wear dirty clothes”), and emotional neglect (“My parents were too drunk or high to take care of the family”). Scoring of the CTQ produces a composite CTQ score encompassing all five subtypes, as well as scores for each subtype of maltreatment. This scale showed good reliability ($\alpha = 0.81$) in this sample.

Psychological health and well-being—Depressive symptoms were assessed using the 20-item Center for Epidemiologic Studies Depression Scale (CES-D; (Radloff 1977)) by which respondents are asked to indicate how often they have felt or behaved in the stated manner over the past week, including statements such as “I felt depressed.” Ratings are made on a 4-point scale (0 = Rarely or none of the time; 3 = Most or all of the time) and final scores are computed by summing scores on all items after reverse scoring four items. The CES-D has demonstrated reliability and validity (Radloff 1977). In the present study, the CES-D showed good reliability ($\alpha = 0.93$) and average scores fell below the clinical cut-off of 16 ($M = 11.6$; $SD = 10.3$, Range 0-46) (Anderson, Freedland et al. 2001).

Perceived stress over the past month was assessed using the Perceived Stress Scale (PSS, (Cohen, Kamarck, & Mermelstein, 1983)). The PSS is designed to measure how stressful one interprets their life to be. Respondents are asked how often they have experienced certain situations, and how stressful the situations were. Ratings are made on a 5-point scale

(0 = Never; 4 = Very Often) and final scores are computed by summing scores on all items after reverse scoring four items. In the present study, the PSS showed good reliability ($\alpha = 0.906$), $M=15.71$, $SD=7.35$.

Measurement of Salivary alpha-Amylase

Salivary alpha-amylase was measured with an in-house enzyme kinetic assay using reagents from Roche Diagnostics (Mannheim, Germany). Before assaying saliva was centrifuged at 2000 g for 5 min. Measurement of sAA was completed using an enzyme kinetic method as described previously (Bosch et al., 2003; Rohleder & Nater, 2009). Saliva was diluted at 1:625 with ultrapure water, and diluted saliva was incubated with substrate reagent (alpha-amylase EPS Sys; Roche Diagnostics) at 37°C for 3 min before a first absorbance reading was taken at 405 nm with a Tecan Sunrise ELISA reader (Tecan, Morrisville, NC). A second reading was taken after 5 min incubation at 37°C, and increase in absorbance was transformed to sAA concentration (U/ml) using a standard curve prepared using “Calibrator f.a.s.” solution (Roche Diagnostics). Inter- and intra-assay coefficients of variation were below 10%. Cortisol was also measured in this study, but preliminary analyses did not indicate any significant effects, and are therefore not reported here.

Statistical Analyses

All statistical analyses were performed using SPSS (21) software packages (IBM, Chicago, IL, USA). Kolmogorov–Smirnov tests were computed prior to statistical analyses to test for normal distribution as well as homogeneity of variance of all dependent variables. To test for stress-induced changes in sAA, we used a repeated measure analysis of variance (ANOVA), with the within-subject factor “time” (three time points for sAA levels before and after TSST). In all ANOVA tests, Greenhouse–Geisser corrections were applied if the sphericity assumption was violated (Vasey and Thayer 1987, Greenhouse and Junker 1992). The CTQ was used as a continuous variable for Pearson correlations and as a covariate in repeated measures ANCOVAs. For independent samples t-tests and ANOVAs between groups, the CTQ was also used as a discrete measure, to subdivide the sample into no exposure to childhood adversity ($n=23$), and low-moderate childhood adversity ($n=18$), based on previously established CTQ cut-off scores for each of the CTQ subscales. The cut off scores for physical abuse, physical neglect, and sexual abuse are 8, for emotional neglect the cutoff is 15, and for emotional abuse it is 10, allowing for a minimum above-threshold score of 49 (Walker et al., 1999). In the no childhood adversity exposure group, there were 15 males and 7 females. In the low-moderate group, there were 9 males and 10 females. For a breakdown of subscale scores by sex, see Table 1. Four participants were excluded from overall analysis, due to CTQ scores more than 3 standard deviations above the mean. Results including these four outliers are reported alongside overall results. To test for group differences between those with and without childhood adversity, independent samples t-tests were used to analyze sAA response to TSST. ANOVA was used to find specific pattern differences between the two groups. Linear regressions and Pearson correlations were used to test the continuous relationship between childhood adversity, specific CTQ subscales, and sAA reactivity. We also computed an increase measure, which indicates the change from baseline sAA to peak sAA following TSST (time point 2).

Results

Salivary alpha-Amylase Stress Response

The TSST significantly induced a stress response in participants, as evidenced by a significant time effect ($F(1.6,66.4)=20.10$, $p<.001$). Post-hoc analyses indicate that there was a significant difference between time-points 1 and 2 ($t=7.14$, $p<.001$), and 2 and 3 ($t=-6.29$, $p<.001$), but not between 1 and 3 ($t=1.4$, $p=.172$), indicating a difference in the time-point immediately following the TSST. See Figure 1. There were no significant differences in sAA response based upon age, sex, or body fat (all $p>.05$). Adding age, sex, or body fat as covariates to the repeated measures ANOVA revealed no significant effect of any of these variables on the stress response (all $p>.05$). sAA baseline levels were unrelated to age ($r=-.18$, $p=.27$), body fat ($r=.10$, $p=.53$), or BMI ($r=-.07$, $p=.68$), and did not differ between the sexes ($t(40)=-.96$, $p=.34$). Further, sAA delta scores were also unrelated to age ($r=-.05$, $p=.76$), body fat ($r=.10$, $p=.53$), or BMI ($r=.12$, $p=.44$), and did not differ between the sexes ($t(40)=-.61$, $p=.54$).

Association of Childhood Adversity with sAA stress responses

Total CTQ score—Based on our binary grouping, ANOVA indicated that the adversity group had higher sAA values in response to the TSST (CTQ by time interaction: $F(1.68,59.94)=5.01$, $p=.014$). A comparison of increase measures (delta scores from baseline to peak) between the two groups further revealed significantly higher stress-induced sAA increase in the childhood adversity group ($t(39)=-3.10$, $p=.004$) (Figure 1). In the analysis containing the four outliers, based on our binary grouping, ANOVA indicated that the adversity group had higher sAA values in response to the TSST (time effect: $F(1.72,66.91)=6.46$, $p=.004$). In the analysis including the four outliers, a comparison of the increase measure revealed that there was a significant difference in level of sAA stress-induced change from baseline to peak between those with and without childhood adversity ($t(39)=-3.10$, $p=.004$), adversity. Further examination of childhood adversity as a continuous variable revealed a positive correlation between CTQ total score and the magnitude of sAA response to TSST, based on the increase measure ($r=.45$, $p=.005$) (Figure 2). In the analysis containing the four outliers with CTQ scores above 55, this linear relationship continued to be significant ($r=.33$, $p=.034$).

Trauma score subscales—Using Pearson correlation, we found a significant relationship between increase score of sAA response to TSST and physical abuse ($r=.456$, $p=.005$) and emotional abuse ($r=.37$, $p=.024$; see Table 2). In the analysis containing the four outliers with overall CTQ scores above 55, we continued to find a significant correlation between the emotional abuse subscale score and increase score of sAA response to TSST ($r=.34$, $p=.028$), as well as with emotional neglect ($r=.33$, $p=.036$).

Potential confounds—Using linear regressions, we tested other potential covariates that may be associated with our main findings, such as health and perceived stress. CTQ remained a significant predictor of sAA change in response to TSST (CTQ $\beta=.44$, $p=.011$, $R^2=.21$) when controlling for age, sex, and BMI (age $\beta=-.06$, sex $\beta=-.03$, BMI $\beta=.01$). CTQ remained a significant predictor of sAA change in response to TSST (CTQ $\beta=.46$, $p=.009$,

$R^2 = .20$) when controlling for perceived stress (Perceived Stress Scale; $\beta = -.03$) and depression (CTQ $\beta = .50$, $p = .004$, $R^2 = .25$, CESD $\beta = -.022$). In the analysis containing the four outliers, we again tested other potential covariates that may be associated with our main findings. CTQ remained the strongest predictor of sAA change in response to TSST (CTQ $\beta = .31$, $p = .052$, $R^2 = .14$) when controlling for age, sex, and BMI (age $\beta = -.06$, sex $\beta = .05$, BMI $\beta = .14$). CTQ remained a marginally significant predictor of sAA change in response to TSST (CTQ $\beta = .35$, $p = .071$, $R^2 = .11$) when controlling for perceived stress (Perceived Stress Scale $\beta = -.04$), and the strongest predictor for sAA change when controlling for depression (CTQ $\beta = .31$, $p = .16$, $R^2 = .08$, CESD $\beta = -.028$).

Discussion

We found that healthy adults with a history of childhood adversity showed higher overall sAA responses to acute psychosocial stress. Specifically, those with low-to-moderate childhood adversity have a heightened stress-induced sAA response immediately following acute stress, more so than those without childhood adversity. We also found that each point increase in overall childhood trauma, and childhood emotional abuse and physical abuse was incrementally predictive of an increased sAA response.

Our results are in line with previous research that has found altered stress system reactivity to acute stress (Engert et al., 2010; Tarullo & Gunnar, 2006). There is a wealth of research indicating that experiencing a negative or neglectful early life environment is linked to mental illness and substance abuse, partially through neurobiological pathways within the HPA (for a review, see (Weaver, 2009)). Additionally, research has provided evidence for alterations in the SNS in those with childhood adversity (McLaughlin et al., 2015). While many studies have measured HPA stress reactivity in those with childhood trauma, we have replicated this altered stress reactivity with sAA, a possible marker of SNS reactivity. Previous research on this topic using sAA has been somewhat limited, however; one study has found that adults who reported low care during childhood had an increased sAA response and a decreased cortisol response, when compared to a high care group (Ali & Pruessner, 2012). This fits well with the findings of the current study, and provides additional support for SNS dysregulation in those with childhood adversity.

In general, sAA is expected to increase in response to acute stress, due to SNS activation. Acute stress begins a cascade of physiological responses, resulting in increased heart rate and blood pressure, as well as the release of the catecholamines epinephrine and norepinephrine (Frankenhaeuser, 1978). In addition, acute stress inhibits the peripheral nervous system (PNS), leading to PNS withdrawal (Bosch et al., 2011). While this reflects a healthy response to acute stress, hyper-reactivity is considered maladaptive because of the regulatory influence of the SNS on inflammation (Slavich, 2015).

During infancy and childhood, chronic stress and adverse events may program the stress systems for a hyper reactive response (Lupien et al., 2009). During the early life period, when physiological stress systems are adjusting to the environment, heightened and prolonged HPA and SNS responses may lead to a hyper-reactive phenotype, resulting in desensitization of the glucocorticoid receptor (Miller & Chen, 2010). This altered stress

system functioning may explain our finding of higher sAA among those with childhood adversity.

Another potential explanation for our findings is the association between childhood adversity and negative psychological profiles. Those with childhood trauma report lower-self compassion (Tanaka et al., 2011), a psychological profile that has been associated with increased sAA response to psychosocial stress (Breines et al., 2015). Further, those with a history of childhood trauma have been found to have a higher degree of threat perception (Dannlowski et al., 2012). It is conceivable that this hyper-reactive psychological response has an impact at the physiological level. In addition, it may be that both physiological stress system alterations, as well as negative psychological programming occur in response to childhood adversity, influencing the assessment of a novel stress situation, along with the physiological reactivity to the stressor in adulthood.

Higher sAA may reflect an increased SNS response to stress. SNS hyper-reactivity is related to elevated levels of inflammation mediators (Rohleder, 2012), as well as higher blood pressure (Singh, Chapleau, Harwani, & Abboud, 2014). This increase in inflammation may lead to a multitude of negative health outcomes, such as cancer, stroke, myocardial infarctions, and Alzheimer's disease (Danesh et al., 2008; Ershler & Keller, 2000; Yudkin et al., 2000) due to wear and tear on the body, conceptualized as allostatic load (McEwen, 2013). It is important to note that the participants in the current study were healthy adults, without any indication of current inflammation-related disease. It is possible that because the sample is relatively young, this increased disease risk may be too early to present, but the relationship between childhood adversity and sAA stress reactivity in those with more severe trauma, or with poorer adult health should be further investigated.

This study has several limitations. The number of participants in this sample was somewhat limited. In order to help correct this, we ran analyses both with and without four additional participants, whose CTQ scores were outliers. The limited sample size did not allow for separate sex-based analyses; however, analyses controlling for sex were used to combat this concern. Additionally, participants had either no childhood adversity, or low-to-moderate childhood adversity. Future research on SNS stress reactivity in adulthood should capture individuals with severe levels of childhood adversity; however, this study was able to demonstrate significant differences within a limited adversity sample. Related to this, the CTQ, while an excellent tool for briefly assessing childhood trauma, does not assess age of trauma. It is possible that neural development is differentially impacted by trauma, depending upon the age of the child. Additionally, we used sAA as one potential marker of SNS activity. These findings may not simply represent a direct relationship between childhood adversity and altered SNS reactivity, because peripheral nervous system deactivation may also be captured by sAA (Bosch et al., 2011); however, sAA stress responses have been found to be moderately correlated with catecholamine stress responses (Rohleder et al., 2004). Further, the differentiated autonomic response in those with childhood adversity remains important to understand. Future research should include additional measures of SNS activity.

The epigenetic mechanisms behind the precise way in which childhood adversity is translated and programmed to influence SNS reactivity and inflammation must be addressed. Additionally, the molecular link from this pre-programming to disease states later in life have not been explored. Further research into the predictive value of altered sAA reactivity to later health outcomes in those with early life adversity must be conducted, but this study provides evidence for altered stress functioning of the SNS, even in those with low levels of exposure to childhood adversity.

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Figure 1. sAA levels immediately pre-TSST, immediately post-TSST, and 10 minutes post-TSST in those with no history of childhood adversity, and those with a history of low-moderate childhood adversity.

Figure 2.

Solid line: Correlation between CTQ total score and magnitude of sAA response to TSST, peak response to baseline ($r=.33$, $p=.034$). Dotted line: Correlation between CTQ total score and magnitude of sAA response to TSST, peak response to baseline, excluding CTQ scores above 55 ($r=.45$, $p=.005$).

Figure 3.

A. Correlation between emotional neglect subscale score and magnitude of sAA response to TSST, peak response to baseline ($r=.34$, $p=.028$).

B. Correlation between emotional abuse subscale score and magnitude of sAA response to TSST, peak response to baseline ($r=.33$, $p=.036$).

Table 1

Descriptive breakdown of CTQ subscales by gender, as well as t-test examining difference between CTQ groups on each subscale.

Subscale	Cut- off Score	Participants above cut-off (male/female)	Participants below cut-off (male/female)	Subscale score (below cut-off)	Subscale score (above cut-off)	Difference (t-test)
Physical Abuse	8	34 (20/14)	7 (4/3)	5.41 ±.17	8.22 ±.97	t(18.05)= 2.81, p=0.01
Emotional Abuse	10	27 (19/8)	14 (5/9)	6.14 ±.27	11.94 ±.78	t(21.17)= 5.81, p<0.001
Sexual Abuse	8	41 (24/17)	0 (0/0)	5.05 ±.05	5.11 ±.076	t(28.34)= .74, p=0.47
Physical Neglect	8	33 (18/15)	8 (6/2)	5.32 ±.12	7.44 ±.69	t(18.04)= 2.13, p=0.007
Emotional Neglect	15	36 (21/15)	5 (3/2)	7.45 ±.53	12.5 ±.93	t(17.54)= 5.05, p<0.001

Table 2

Correlations between CTQ total and subscales with stress-induced increase in sAA, as computed with sAA increase measure.

	CTQ Total	Physical Abuse	Emotional Abuse	Sexual Abuse	Physical Neglect	Emotional Neglect
sAA increase (no outliers)	$r=.448$ $p=.005^*$	$r=.456$ $p=.005^*$	$r=.370$ $p=.024^*$	$r=.243$ $p=.147$	$r=.041$ $p=.808$	$r=.198$ $p=.240$
sAA increase (with outliers)	$r=.332$ $p=.034^*$	$r=.245$ $p=.122$	$r=.343$ $p=.028^*$	$r=.187$ $p=.243$	$r=.083$ $p=.604$	$r=.329$ $p=.036^*$

* Indicates relationship is significant at $\alpha < .05$ level