Available online at www.sciencedirect.com
ScienceDirect
Hormones and Behavior 53 (2008) 96–103
Hormones and Behavior
www.elsevier.com/locate/yhbeh

Salivary alpha amylase–cortisol asymmetry in maltreated youth

Elana B. Gordis [a,*], Douglas A. Granger [b], Elizabeth J. Susman [b], Penelope K. Trickett [c]

[a] Department of Psychology, University at Albany, SUNY, Social Sciences 369, 1400 Washington Ave, Albany, NY 12222, USA
[b] Department of Biobehavioral Health, Penn State University, USA
[c] School of Social Work, University of Southern California, USA

Received 21 May 2007; revised 27 August 2007; accepted 4 September 2007
Available online 12 September 2007

Abstract

Background: Maltreatment represents a major stressor in the lives of many youth. Given the known effects of stress exposure on subsequent functioning of biological stress response systems, researchers have been interested in the effects of maltreatment on the functioning of these systems. Experimental studies reveal that previous exposure to stress affects the symmetry between components of the physiological stress response to subsequent stress. The present study examined asymmetry between salivary alpha amylase (sAA), a sympathetic indicator, and cortisol reactivity to a social stressor among maltreated and comparison youth age 9 to 14 years. Consistent with earlier studies suggesting that stress leads to asymmetry between hypothalamic–pituitary–adrenal axis and sympathetic nervous system activity, we expected that maltreated youth would exhibit greater sAA–cortisol asymmetry than would comparison youth.
Methods: Forty-seven maltreated and 37 comparison youth visited the laboratory and engaged in a social stress protocol. We collected 2 saliva samples before the stressor and 4 after, at 0 min post-stress and every 10 min for 30 min.
Results: Maltreatment status moderated the relation between sAA and cortisol activity in response to the stressor. Comparison youth showed significant links between the sAA and cortisol responses; maltreated youth had no significant associations between responses in the two biomarkers.
Conclusion: The data were consistent with sAA–cortisol asymmetry among maltreated youth. Further research should seek to replicate this finding and investigate its implication for developmental trajectories.

Keywords: Cortisol; Salivary alpha-amylase; Child maltreatment; Adolescence; Social stress

The present study examined the relation between child maltreatment and asymmetry between salivary alpha amylase (sAA) and cortisol responses to stress. Given connections between the HPA axis and the SNS, one would anticipate symmetry between these systems, meaning that relatively strong responses in one system should correspond with relatively strong responses in the other. Recently researchers have suggested that the degree of asymmetry between biological stress systems may have implications for developmental outcomes (Bauer et al., 2002). Factors affecting degree of asymmetry between these biological stress systems remain poorly understood.

The biological stress response consists primarily of two systems: the locus cereleus–norepinephrine/sympathetic nervous system (LC–NE/SNS) and the hypothalamic–pituitary–adrenal (HPA) axis (Chrousos and Gold, 1992). The LC–NE/SNS is responsible for effects often referred to as the "fight or flight" response, which include increased cardiovascular tone, faster breathing rate, and increased blood flow to muscles (Cannon, 1914). The HPA axis involves multiple steps, including the release of corticotropin releasing hormone (CRH) from the hypothalamus, triggering the release of adrenocorticotropic hormone (ACTH) from the anterior pituitary, causing the release of the steroid hormone cortisol from the adrenal glands.

The negative impact of maltreatment on psychological/behavioral development may be at least partially due to an altered stress response. Childhood trauma in general and maltreatment

* Corresponding author.
E-mail addresses: egordis@albany.edu (E.B. Gordis), dag11@psu.edu (D.A. Granger), esusman@psu.edu (E.J. Susman), pennyt@usc.edu (P.K. Trickett).

0018-506X/$ - see front matter © 2007 Elsevier Inc. All rights reserved.
doi:10.1016/j.yhbeh.2007.09.002

in particular are linked with alterations in both the HPA axis and in the LC–NE/SNS. Maltreated youth have demonstrated reduced stress reactivity in the HPA axis (Hart et al., 1995). One theory is that chronic stress leads to attenuation of the stress response (Goldstein and McEwen, 2002; Susman, 2006). Though few studies have examined the effect of maltreatment on the functioning of the LC–NE/SNS among children, some researchers report elevated urinary catecholamine levels among maltreated and traumatized children (De Bellis et al., 1999, 1994). Thus, some research links maltreatment to alterations of both the HPA axis and the LC–NE/SNS, though the specific nature of the impact of maltreatment on stress reactivity remains unclear.

The HPA axis and the SNS are connected at multiple neural levels, and thus activity in these two systems should demonstrate some degree of symmetry (Chrousos and Gold, 1992; Lovallo and Thomas, 2000; Young et al., 2005). Factors leading to individual differences in the degree of symmetry between these systems remain unclear. One possible factor may be different habituation rates of these systems given previous exposure to stress. Some evidence suggests faster habituation rates in the HPA axis (Gerra et al., 2001; Schommer et al., 2003). Schommer et al. (2003) and Gerra et al. (2001) both found decreased ACTH and cortisol responses over successive repetitions of the Trier Social Stress Test (TSST; Kirschbaum et al., 1993), but unchanged responses in level of epinephrine and NE. Animal research also suggests that prolonged stress may lead to asymmetry between these systems (Britton et al., 1992).

Whereas experimental manipulations suggest that repeated stressors may lead to asymmetry between the HPA axis and the SNS, we know little about the effects of real life stressors on the symmetry between activity in these two systems in response to subsequent stress. If previous exposure to stress leads to asymmetry between the systems, we might expect individuals with a history of significant stress to show more asymmetry. This asymmetry may be important for understanding the impact of stress on atypical development. Recently, researchers have argued that examination of each stress system alone limits what we know about the role of the stress response in atypical development (Bauer et al., 2002). Each system independently has been linked to developmental trajectories in psychological and behavioral characteristics. Activity in the HPA axis covaries with aggression, disruptive behavior, depression, and inhibited behavior (e.g., De Souza, 1995; Duval et al., 2006; Shirtcliff et al., 2005; Shoal et al., 2003). Autonomic arousal has been associated with aggression, delinquency, and antisocial behavior (Lorber, 2004; Ortiz and Raine, 2004). Bauer et al. suggest that, beyond relations with each system independently, we will learn more about the role of the biological stress response in mediating developmental outcomes if we consider the functioning of these systems together and examine the relations between them.

Examination of the HPA axis is long-established through salivary cortisol (Kirschbaum et al., 1992). Recently, a marker of autonomic activity has been possible via salivary alpha amylase (sAA), an enzyme released by the parotid gland (Granger et al., 2007). Protein release into the saliva is primarily controlled by sympathetic arousal and in particular by beta adrenergic activity (Bosch et al., 2003). In addition, parasympathetic activity appears to augment release of salivary proteins, including sAA, due to the effect of parasympathetic activity on salivary flow rate (Bosch et al., 2003; Gjörstrup, 1979). Animal studies have demonstrated that stimulation of the sympathetic system leads to increased secretion of sAA in the saliva in the presence of parasympathetic activity (Gjörstrup, 1979). In humans, sAA increases in response to stress (Bosch et al., 2003; Nater et al., 2005; Rohleder et al., 2004). Some research shows that sAA correlates with plasma NE (Chatterton et al., 1996), though this link has not been completely consistent (Nater et al., 2006). Stress-dependent release of sAA correlates with cardiovascular autonomic measures (Bosch et al., 2003). The beta adrenergic antagonist propranolol leads to lower levels of sAA at rest and in response to a stressor (van Stegeren et al., 2006). Thus, saliva can provide indices of both SNS and HPA axis activity.

The present study examined the symmetry between HPA and SNS activity in maltreated and comparison adolescents. We expected that indices of HPA and SNS activity in response to stress would correlate positively among youth with no history of maltreatment. Consistent with the idea that stress may cause asymmetry between the systems, we expected that maltreated youth would demonstrate lower correlations between cortisol and sAA indices and that maltreatment status would moderate the link between cortisol and sAA response to stress.

Materials and methods

Participants

Eighty-four adolescents were selected from a larger, longitudinal study of the effects of maltreatment on adolescent development. Youth visited the laboratory with a parent or guardian for the first or second of three yearly interviews. Maltreated youth were recruited from select zip codes in a large urban area on the basis of recent (within the previous 2 months) referrals to the Department of Children and Family Services (DCFS) for child maltreatment (physical or sexual abuse or neglect). Comparison youth were recruited from the same or comparable census blocks. We excluded youth who used medications that would interfere with cortisol or sAA measures (e.g., synthetic corticosteroids or beta adrenergic agonists) or who reported smoking. In addition, based on parents'/guardians' reports, no child had a history of cancer, diabetes, or thyroid problems. In the final sample of 84 adolescents, the mean age was 12.1 years (SD=1.2, range=9.1–14.5). The maltreated group included 47 youth (26 male), and the comparison group included 37 youth (18 male). Demographic information regarding the sample appears in Table 1. Ethnic composition did not differ by maltreatment status. Among the maltreated youth, 50% had been referred to DCFS for physical abuse, 34.2 for sexual abuse, 31.5 for emotional abuse, and 63.2 for neglect. Consistent with these percentages, most youth (78.9%) had more than one referral to DCFS (mean number of referrals=3.8, SD=2.7, range=1–12, median=3).

Procedures

All procedures were approved by the university institutional review board and were carried out with the written understanding and assent of the adolescent participants and consent of their parents or guardians. Each adolescent and a parent or guardian attended a laboratory session lasting approximately 4 h. As part of the procedures, adolescents engaged in a modified version of the TSST (Kirschbaum et al., 1993). During this procedure, the interviewer and a panel of 2 judges entered the room. The interviewer told the participant that he or she would read the beginning of a story, and the participant would have 5 min to