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Personality, adrenal steroid hormones, and resilience in maltreated children: A multi-level perspective

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Abstract

In this multi-level investigation, resilience in adaptive functioning among maltreated and nonmaltreated low-income children (N = 677) was examined in relation to the regulation of two stress-responsive adrenal steroid hormones, cortisol and dehydroepiandosterone (DHEA), as well as the personality constructs of ego resiliency and ego control. Maltreatment status was not related to differences in average levels of morning or afternoon cortisol or DHEA. However, lower morning cortisol was related to higher resilient functioning, but only in nonmaltreated children. In contrast, among physically abused children, high morning cortisol was related to higher resilient functioning. Morning and afternoon DHEA was negatively related to resilient functioning. Although diurnal change in cortisol was not related to resilience, for DHEA, maltreated children with high resilience showed an atypical rise in DHEA from morning to afternoon. Morning and afternoon cortisol/DHEA ratios were positively related to resilient functioning, but did not interact with maltreatment status. Ego resiliency and ego control strongly differentiated maltreated and nonmaltreated children, and the personality variables were substantially predictive of resilience. When considered together, demonstrated effects of personality, cortisol, and DHEA maintained independent contributions in predicting resilience among high-risk youth.

Research conducted within a developmental psychopathology perspective (Cicchetti, 1984, 1993; Sroufe & Rutter, 1984) demonstrates that there is multifinality in developmental processes such that the manner in which the individual constructs, responds to, and interacts with vulnerability and protective forces at each level of the ecology allows for diversity of outcomes (Cicchetti & Lynch, 1993; Cicchetti & Rogosch, 1996; Sroufe, 1989). Accordingly, developmental psychopathologists stress that it is equally informative to comprehend the mechanisms that promote resilient functioning as it is to investigate developmental pathways to normality and psychopathology (Cicchetti, 1993; Cicchetti & Garmezy, 1993; Cicchetti & Toth, 1991; Luthar, 2003, 2006; Masten, 1989, 2001). Furthermore, discovering the processes underlying resilient functioning offers considerable promise for affirming, challenging, and expanding upon extant developmental theories, as well as for translating these findings to inform prevention, intervention, and social policy initiatives (Cicchetti, 1993; Cicchetti & Hinshaw, 2002; Cicchetti, Rogosch, & Toth, 2006; Luthar & Cicchetti, 2000; Masten, 2007; Toth, Rogosch, Manly, & Cicchetti, 2006).

Resilience has been conceptualized as the individual's capacity for adapting successfully and functioning competently, despite experiencing chronic stress or adversity following exposure to prolonged or severe trauma (Luthar, Cicchetti, & Becker, 2000; Masten, Best, &

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Garmezy, 1990). Resilience is a dynamic developmental process, not a static or trait-like condition (Egeland, Carlson, & Sroufe, 1993). Moreover, resilience is multi-dimensional in nature, exemplified by findings that high-risk individuals may manifest competence in some domains and contexts, whereas they may exhibit problems in others (Luthar, 2006; Luthar et al., 2000; Masten, Burt, & Coatsworth, 2006; Masten & Coatsworth, 1998; Masten & Curtis, 2000).

Child maltreatment is a pathogenic relational experience that represents one of the most adverse and stressful challenges that confront children (Cicchetti & Lynch, 1995). Child maltreatment ushers in motion a probabilistic path of epigenesis for abused and neglected children that is marked by an increased likelihood of failure and disruption in the successful resolution of salient developmental tasks, resulting in a profile of relatively enduring vulnerability factors that increase the probability of the emergence of maladaptation and psychopathology (Cicchetti & Lynch, 1993; for a review, see Cicchetti & Valentino, 2006). Because the vast majority of children are adversely affected by their experiences, child abuse and neglect may exemplify the greatest failure of the caregiving environment to provide opportunities for normal biological and psychological development (Cicchetti, 2002; Cicchetti & Lynch, 1995; DeBellis, 2001; Teicher, 2002).

Importantly, however, not all maltreated children develop in a maladaptive fashion (Cicchetti, 1989; Cicchetti & Rizley, 1981). Indeed, some abused and neglected youngsters function in a competent fashion despite the pernicious experiences they have encountered and the ignominious treatment they have received (Haskett, Nears, Ward, & McPherson, 2006). Consequently, the investigation of pathways to resilience among children who have been maltreated seeks to uncover the dynamic processes that influence how the various aspects of children's ecologies, in concert with children's intraorganismic forces, eventuate in multiplicity in child developmental outcomes –adaptive, maladaptive, or resilient. Among the array of protective factors that have been identified to promote resilient functioning in maltreated children are children's academic engagement, social competencies, average or above-average intellectual performance, and the presence of a secure relationship with an adult caregiver (Haskett et al., 2006; Herrenkohl, Herrenkohl, & Egolf, 1994; Shonk & Cicchetti, 2001).

Personality characteristics such as internal locus of control for positive events and higher self-esteem provide further examples of individual characteristics that serve a protective function for maltreated children, mitigating the risk for maladaptive outcomes (Kim & Cicchetti, 2004; Moran & Eckenrode, 1992). In a cross-sectional investigation, Cicchetti, Rogosch, Lynch, and Holt (1993) found that the personality constructs of ego resiliency and ego overcontrol and positive self-esteem emerged as correlates of resilient adaptation for maltreated children. In contrast, only ego resiliency and positive self-esteem were associated with resilient functioning among nonmaltreated children.

Similarly, in a three-year longitudinal investigation of maltreated and nonmaltreated children, differential predictors of resilience emerged (Cicchetti & Rogosch, 1997). Notably, for maltreated children, positive self-esteem, ego resilience, and ego overcontrol predicted resilient functioning, whereas relationship features were more influential in predicting resilience in nonmaltreated children (Cicchetti & Rogosch, 1997). These findings suggest that, in the face of unfulfilling relationships, maltreated children who demonstrate resilient functioning have developed an adaptive coping mechanism toward less reliance on relatedness in their everyday functioning. Rather, consistent with findings among highly stressed, disadvantaged youngsters in which positive future expectations for the self are a predictor of resilient functioning (Wyman, Cowen, Work, & Kerley, 1993), self-confidence

and self-reliance, in concert with interpersonal reserve, bode well for the development of resilient adaptation in maltreated children (Cicchetti & Rogosch, 1997).

Flores, Cicchetti, and Rogosch (2005) conducted a study of pathways to resilient functioning in maltreated and nonmaltreated Latino children. In contrast to prior investigations, the personality variables of ego resiliency and ego overcontrol did not differentially predict resilience for maltreated and nonmaltreated Latino children. For both maltreated and nonmaltreated Latino children, higher ego resiliency and moderate ego control were associated with higher resilient functioning. Congruent with previous findings, however, the predictive impact of relationship variables on resilience was more significant for nonmaltreated than maltreated Latino children (Flores, et al., 2005). These results suggest that among maltreated Latino children, personal strengths such as ego resiliency and ego overcontrol may be more essential than relationship features in determining resilient outcomes.

In a four-year longitudinal study of emergent personality organization in maltreated and nonmaltreated children, Rogosch and Cicchetti (2004) discovered five personality clusters: gregarious, reserved, overcontroller, undercontroller, and dysphoric. Although the maltreated children were more frequently represented in the less adaptive personality clusters (i.e., overcontroller, undercontroller, and dysphoric) than were nonmaltreated children, some maltreated children were members of the reserved and gregarious clusters. Taken together, the adaptive reserved and gregarious clusters closely resemble the resilient personality organization described in previous studies (e.g., Robins, John, Caspi, Moffitt, & Stouthamer-Loever, 1996). Moreover, Rogosch and Cicchetti (2004) found that maltreatment and personality clusters were related to individual differences that were perceived by peers. Furthermore, continuity and stability of children's personality organization and personality liabilities were found such that personality clusters from age 6 were maintained at age 9. The substantial variability in the personality features of maltreated children suggests that this domain of development has valuable potential to continue to contribute to our understanding of differential vulnerability and resilience processes among maltreated youth

Despite the increased attention paid to discovering the processes through which maltreated children develop in a competent fashion, the empirical study of resilience in maltreated children has focused predominantly on detecting the extraorganismic and individual-level psychosocial determinants of the phenomenon (Charney, 2004; Curtis & Cicchetti, 2003). Molecular genetic research has begun to reveal the genetic elements that may serve a protective function for individuals who have experienced child maltreatment (Caspi et al. 2002; Caspi et al., 2003; Cicchetti & Blender, 2004; Kaufman et al., 2006; Kaufman et al., 2004; Kim-Cohen et al., 2006). In order for our understanding of the pathways to competent functioning in maltreated children to grow in ways that are commensurate with the complexity of the construct, the incorporation of a multiple-levels-of-analysis perspective must increasingly be included in the design and implementation of investigations on the determinants of resilient adaptation (Cicchetti & Blender, 2004; Curtis & Cicchetti, 2003).

In an effort to redress this significant gap in the literature, in this study we adopt a multiple-levels perspective on resilience in maltreated children. We chose to examine how the functioning of two adrenal steroid hormones that are released in response to stress, cortisol and dehydroepiandrosterone (DHEA), in concert with the personality variables of ego resiliency and ego control, contribute independently and interactively to the development of resilient functioning in maltreated children.

The role of biological factors in resilience is suggested by evidence on neuroendocrine system function in relation to stress. Consequently, in this investigation we chose to examine how the regulation of two adrenal steroid hormones, cortisol and DHEA, would contribute to maltreated children traversing along a resilient developmental pathway.

Stress has been conceptualized as a perceived threat to an organism's homeostasis and as a situation that causes increases in autonomic nervous system activity or hormone secretion (Cicchetti & Walker, 2001; Levine, 2005). Stressful or threatening experiences such as child abuse and neglect create adaptational challenges for the organism. There are multiple, converging pathways that determine the neural response to different stressors, including not only the neural circuits that are activated by physical, psychological, and immunological stressors, but also the influence of genetics, early experience, and ongoing life events (McEwen, 1998; Meaney et al., 1996; Sapolsky, 1994).

The hypothalamic-pituitary-adrenal (HPA) axis is one of the physiological systems that has evolved in mammals to help direct and sustain cognitive, emotional, behavioral, and metabolic activity in response to threat (Gunnar & Vazquez, 2006). The steroid hormones cortisol and DHEA are the two primary adrenocortical products of secretory activity occurring in the HPA axis (Hucklebridge, Hussain, Evans, & Clow, 2005).

Basal activity of cortisol follows a circadian rhythm, with high levels around the time of awakening, declining to low levels as the day proceeds (Kirschbaum & Hellhammer, 1989). Basal levels of cortisol are critical for normal brain development and for the support of the metabolic activity necessary to sustain overall functioning (Gunnar & Vazquez, 2006, McEwen, 1998). In addition, the capacity of individuals to elevate cortisol levels in response to exposure to acute trauma is important for survival (Gunnar & Vazquez, 2006; Levine, 1994).

In contrast, the secretory diurnal pattern of DHEA appears to be very stable across the course of the day (Hucklebridge et al., 2005). Thus, it seems that cortisol secretion is more variable and that DHEA secretory levels are a more consistent and stable index of underlying adrenal steroidogenic capacity (cf. Hucklebridge et al., 2005). DHEA, a precursor of the steroid hormones androstenedione, testosterone, and estradiol, exerts an impact upon a diverse array of biologic actions, including effects on the immune, cardiovascular, endocrine, metabolic, and central nervous systems (Majewska, 1995). Furthermore, as is true for cortisol, circulating levels of DHEA have been shown to be associated with individual differences in emotionality, cognitive functioning, health, and behavior (Granger, Schwartz, Booth, Curran, & Zakaria, 1999).

Alterations in the diurnal rhythms of both cortisol and DHEA have been found to be associated with disorders of affect, including child, adolescent, and adult depression (Goodyer et al., 1996; Goodyer, Herbert, & Tamplin, 2003; Young, Gallagher, & Porter, 2002). Likewise, dysregulation in the diurnal rhythms of cortisol and DHEA have been shown to be associated with high anxiety, negative mood, and cognitive deficits (van Nierkerk, Huppert, & Herbert, 2001).

Although a number of investigations of the effects of child maltreatment on cortisol regulation have been conducted, to date there have been no studies on DHEA regulation in abused and neglected children. The studies of maltreated and nonmaltreated children have revealed divergent patterns of cortisol regulation, both between-and-within groups. For example, Cicchetti and Rogosch (2001a) found that children who experienced an early onset of maltreatment, and multiple subtypes of abuse and neglect across a range of developmental periods expressed elevated levels of cortisol concentrations across the week in both the morning and late afternoon (a pattern resembling that of hypercortisolism). In

contrast, physically abused children exhibited lower levels of cortisol and less diurnal variation in cortisol levels from morning to afternoon over the course of a week than did nonmaltreated children (a pattern akin to hypocortisolism). Finally, no differences were obtained between the neglected and emotionally maltreated groups of children and the comparison group of nonmaltreated children (see Cicchetti & Rogosch, 2001a).

These findings mirror those obtained in other investigations of cortisol regulation in maltreated children (e.g., Cicchetti & Rogosch, 2001b; Hart, Gunnar, & Cicchetti, 1996; Kaufman, 1991). Specifically, not all maltreated children manifest cortisol dysregulation, nor do they exhibit the same pattern of cortisol dysregulation. Given the variability in cortisol regulation shown by maltreated children, we decided to examine the relation between cortisol regulation and resilience. Additionally, because no research has been conducted on diurnal variation in DHEA in maltreated children, we chose to investigate DHEA regulation in maltreated children. Furthermore, because of the multiplicity of effects that DHEA exerts on biological systems, as well as its intimate link with cortisol as the two major adrenal steroid hormones, we explored the relation between DHEA regulation and resilient functioning. In addition, because cortisol and DHEA are both released during stress and because incidents of child maltreatment engender massive stress in these vulnerable children, we also explored the relation between the cortisol/DHEA ratio and the development of resilience.

Hypotheses

This investigation was guided by the following hypotheses and research questions:

1. Nonmaltreated children will have higher mean levels of resilience than maltreated children and a higher percentage of children in the high resilient group. Nonetheless, high resilient maltreated children will exist.
2. Ego resiliency and ego control will predict resilience in both maltreated and nonmaltreated children.
3. Higher cortisol will predict poorer resilience levels in nonmaltreated children. In maltreated children, who often display reduced adrenocortical secretion (Gunnar & Donzella, 2002), we hypothesize that cortisol regulation will have a reduced association with resilient functioning.
4. We will examine the role of DHEA, the cortisol/DHEA ratio, and diurnal variation in cortisol in relation to resilient functioning.
5. We will examine the independent and potential interactive effects among personality, cortisol, and DHEA, in predicting resilience among maltreated and nonmaltreated comparison children.

METHOD

Participants

The participants in this investigation included 677 children aged six to twelve (M age = 9.54, sd = 2.26) who attended a summer camp research program designed for school-aged low-income children during the years 1999 to 2004. Some children attended the camp for multiple years, and the data from their first year of attendance during the indicated span of years were selected for inclusion in the current study. The sample included both maltreated children (n = 347) and nonmaltreated children (n = 330). Among the participants, 54.8 % were boys. The maltreated and nonmaltreated children were comparable in terms of racial/ethnic diversity and family characteristics; 61.9% of the sample was African American,

19.1% was white, 17.0% was Hispanic, and 2.1% was from other racial/ethnic groups. The families of the children were low income, with 94.8% of the families having a history of receiving welfare benefits. Single mothers headed 62.9% of the families.

Parents of all maltreated and nonmaltreated children provided informed consent for their child's participation, as well as consent for examination of any Department of Human Services (DHS) records pertaining to the family. Children in the maltreated group had been identified by the county DHS as having experienced child abuse and/or neglect, and the sample was representative of the children in families receiving services from the DHS. Comprehensive searches of DHS records were completed, and maltreatment information was coded utilizing operational criteria from maltreatment nosology specified in the *Maltreatment Classification System* (MCS: Barnett, Manly, & Cicchetti, 1993).

The MCS utilizes DHS records detailing investigations and findings involving maltreatment in identified families over time. Rather than relying on official designations and case dispositions, the MCS codes all available information from DHS records, making independent determinations of maltreatment experiences. Based on operational criteria, the MCS designates all of the subtypes of maltreatment children have experienced (i.e., neglect, emotional maltreatment, physical abuse, sexual abuse). Coding of the DHS records was conducted by trained research assistants, doctoral students, and clinical psychologists. Adequate reliability has been obtained (weighted kappas ranging from .86 to .98) (Manly, Kim, Rogosch, & Cicchetti, 2001). Other investigators have demonstrated that the MCS is reliable and valid in classifying maltreatment (Bolger & Patterson, 2001; Bolger, Patterson, & Kupersmidt, 1998; English et al., 2005; Manly, Cicchetti, & Barnett, 1994; Manly et al., 2001; Smith & Thornberry, 1995; Stouthamer-Loeber, Loeber, Homish, & Wei, 2001).

In terms of the subtypes of maltreatment, *neglect* involves failure to provide for the child's basic physical needs for adequate food, clothing, shelter, and medical treatment. In addition to inadequate attention to physical needs, forms of this subtype include lack of supervision, moral-legal neglect, and education neglect. *Emotional maltreatment* involves extreme thwarting of children's basic emotional needs for psychological safety and security, acceptance and self-esteem, and age-appropriate autonomy. Examples of emotional maltreatment of increasing severity include belittling and ridiculing the child, extreme negativity and hostility, exposure to severe marital violence, abandoning the child, and suicidal or homicidal threats. *Physical abuse* involves the non-accidental infliction of physical injury on the child (e.g., bruises, welts, burns, choking, broken bones). Injuries range from minor and temporary to permanently disfiguring. Finally, *sexual abuse* involves attempted or actual sexual contact between the child and caregiver for purposes of the caregiver's sexual satisfaction or financial benefit. Events range from exposure to pornography or adult sexual activity, to sexual touching and fondling, to forced intercourse with the child.

Children in the maltreatment group all had documented histories of abuse and/or neglect occurring in their families according to DHS records. However, DHS record information was not complete enough to code maltreatment subtype information for 50 (14.4%) of the maltreated children. Among the remaining maltreated children, 76.4% had experienced neglect, 68.0% had experienced emotional maltreatment, 32.7% had experienced physical abuse, and 9.1% had experienced sexual abuse. As is typical in maltreated populations (Bolger et al., 1998; Manly et al., 1994; 2001), the majority of children had experienced multiple subtypes of maltreatment. Specifically, 63.9% of the maltreated children had experienced two or more maltreatment subtypes, and 13 of the 15 possible combinations of presence/absence for the four maltreatment subtypes were observed in the sample.

In order to consolidate subtype groups for comparison purposes, a hierarchical classification system was used, based on the degree to which the subtype violates cultural standards and the relative frequency of the different forms of maltreatment, as indicated above. Accordingly, any child who had experienced sexual abuse was categorized as sexually abused ($n = 27$). Children who had been physically abused, but not sexually abused were included in a physical abuse group ($n = 87$). Children experiencing neglect but not physical or sexual abuse were classified as neglected ($n = 144$), whereas children who had experienced emotional maltreated alone were included in an emotional maltreatment group ($n = 39$).

Because maltreated children are predominantly from low socioeconomic status families, demographically comparable nonmaltreated children were recruited from families receiving Temporary Assistance for Needy Families (TANF). DHS record searches were completed for these families to verify the absence of any record of child maltreatment. Trained research assistants also interviewed mothers of children recruited for the nonmaltreatment group to confirm a lack of DHS involvement and prior maltreatment experiences. Subsequently, record searches were conducted in the year following camp attendance to verify that all available information had been accessed. Only children from families without any history of documented abuse and/or neglect were retained in the nonmaltreatment group. In addition, families who had received preventive services through DHS due to concerns over risk for maltreatment also were excluded from the nonmaltreated comparison group to reduce the potential for unidentified maltreatment existing within this group.

Procedure

Children attended a week-long day camp program and participated in research assessments. At the camp, children were assigned to groups of eight same-age and same-sex peers; half of the children assigned to each group were maltreated. Each group was conducted by three trained camp counselors, who were unaware of the maltreatment status of children and the hypotheses of the study. Each day of camp lasted for seven hours, providing 35 hours of interaction between children and counselors. In addition to the recreational activities, after providing assent, children participated in various research assessments (see Cicchetti & Manly, 1990, for detailed descriptions of camp procedures) and provided morning and afternoon saliva samples. Trained research assistants, who also were unaware of research hypotheses and maltreatment status, conducted individual research sessions with children, in which questionnaires and other research measures were administered. Clinical consultation and intervention occurred if any concerns over danger to self or others emerged during research sessions. At the end of the week, children in each group completed sociometric ratings of their peers. The counselors, who had been trained extensively for two weeks prior to the camp, also completed assessment measures on individual children, based on their observations and interactions with children in their respective groups. Counselors also were unaware of the research hypotheses and children's maltreatment status.

Measures

The measures described below constitute a subset of assessments conducted during the research camp. The camp context and associated measurement battery provide a multi-informant, multi-perspective view of child adaptive and personality functioning. Measures include child self-report, peer evaluations, counselor observations, and counselor-report assessments of individual children, as well as school record data obtained from children's school districts. Assay determinations also were made to determine children's cortisol and DHEA levels during the morning and afternoon across the days of the camp.

Saliva Collection and Preparation

The camp context allowed for a setting where a consistent collection of saliva samples could occur at uniform times across the camp week. Each day upon arrival to the camp at 9:00 a.m., trained research assistants obtained saliva samples from each child. Samples also were obtained each day prior to the children's departure from the camp at 4:00 p.m. Cortisol was assayed from the saliva samples for each day and time across the week. Larger saliva samples were obtained from children on Tuesday and Thursday mornings and afternoons so that DHEA also could be assayed.

The children had not consumed food or drink for at least 30 minutes before each saliva sample was obtained. Samples were collected following Granger et al. (1999). The children were asked to chew Trident® sugarless original flavor gum to stimulate saliva flow, and then passively drool though a short drinking straw into a 20 ml plastic vial. The samples were immediately frozen and stored at −40° C. Each week, the samples were shipped overnight on dry ice for next day delivery to Salimetrics Laboratories (State College, PA) for assay. Each sample was thawed, 4–5 1 mL aliquots were placed into 1.8 ml cryogenic storage vials and all aliquots were then frozen at −80°C until assayed. On the day of testing, samples were brought to room temperature, centrifuged at 3,000 RPM for 15 minutes, and the clear top-phase of the sample was pipetted into appropriate test tubes/wells.

Salivary Hormone Determination

Salivary cortisol was assayed using a commercially available enzyme immunoassay kit (Salimetrics, State College, PA). The test uses 25 μl of saliva, has a lower limit of sensitivity of 0.007 μg/dl (range up to 1.8 μg/dl), and average intra-and inter-assay coefficients of variation less than 5.0% and 10.0%, respectively. There is no detectable cross-reactivity of the antibody used in this assay with DHEA. Units of cortisol are expressed in μg/dl (micrograms per deciliter). The distributions of cortisol values for each day and time period were substantially skewed. Thus, prior to analyses all values were log transformed. The log transformed cortisol values for the morning samples were averaged to obtain a mean morning cortisol measurement. Similarly, the log transformed late afternoon samples values were averaged across days to derive an afternoon cortisol measure for analysis.

Salivary dehydroepiandrosterone determinations were made using an enzyme immunoassay kit (Salimetrics, State College, PA). The test uses 50 μl of saliva and has a minimum detection limit of 10.0 pg/mL (range up to 1000 pg/ml). Average intra-and inter-assay coefficients of variation were less than 5.0% and 15.0%, respectively. There is no cross-reactivity of the antibody used in this assay with cortisol. Units of DHEA are expressed as pg/ml (picograms per milliliter). The distributions of DHEA values also were found to be highly skewed, and all values were log transformed for analyses. DHEA log-transformed values for the Tuesday and Thursday morning samples were averaged to obtain a mean morning DHEA measurement. Similarly, the log-transformed later afternoon sample values on Tuesday and Thursday were averaged to obtain a mean afternoon DHEA value.

The cortisol to DHEA ratio also was calculated. Cortisol values in μg/dl units and DHEA values in pg/mL units were respectively transformed into moles per liter (nmol/L) values. This transformation was done for the Tuesday and Thursday, morning and afternoon, cortisol and DHEA values, and ratios were calculated for each day and time. As with the cortisol and DHEA distributions, the cortisol/DHEA ratio distributions evinced high skew. For analytic purposes, the ratios were log transformed prior to analysis. The two log transformed morning values were averaged, as were the two log transformed afternoon values to yield morning and afternoon cortisol/DHEA ratio measurements.

Child self-report measures

Children's Depression Inventory (CDI; Kovacs, 1982, 1992)—The CDI is a widely used self-report questionnaire to assess depressive symptomatology in school-age children. For each item, children chose from among three option statements, depicting increasing levels of depressive symptoms, in order characterize their experiences in the past two weeks. Kovacs (1992) reports that internal consistency for the total scale has ranged from .71 to .89, and validity has been well established. In addition to total scores, one critical item involving suicidal ideation was of particular interest in this study.

Peer measures

Peer Nominations—After children had interacted with each other during the week of summer camp, children evaluated the characteristics of their peers in their respective camp groups using a peer nomination method on the last day of camp (cf., Coie & Dodge, 1983). Counselors conducted the peer rating assessment with individual children. For each peer in the camp group, children were given five brief behavioral descriptors characterizing different types of social behavior and asked to select one peer from the group who best file the behavioral description, as well as select the one child who he/she liked most and liked least. The behavioral descriptors included a child who was: cooperative, a leader, shy, disruptive, and a fighter. The total number of nominations that each individual child received from peers in each category was determined, and these totals were converted to proportions of the possible nominations in each category, and these scores in each category were standardized within each year of camp.

Counselor Measures

Behavior ratings—Observations of individual children's social behavior were made based on the methodology of Wright (1983). Camp counselors rated the behavior of individual children on nine items tapping three aspects of interpersonal functioning, including prosocial behavior, aggressiveness, and social withdrawal. Seven-point ratings were completed each day based on 45-min observations of children in structured and unstructured camp settings (e.g., sports, lunch, art, free play, awards). Inter-rater reliabilities based on average intraclass correlations among pairs of raters across the years of assessment ranged from .68 to .80 (M = .76) for prosocial, .70 to .84 (M = .77) for aggression, and .61 to .77 (M = .71) for withdrawal. Individual counselor assessments for each of the three scales across measurement occasions were averaged to generate individual child scores.

Pupil Evaluation Inventory (PEI; Pekarik, Prinz, Liebert, Weintraub, & Neale, 1976)—The PEI was completed by camp counselors for children in their respective groups at the end of each camp week. The PEI consists of 35 items assessing social behavior, yielding three homogeneous and stable factors, including likeability, aggression, and withdrawal. Similar to peer nomination procedures, counselors were asked to select no more than two children who were best characterized by each individual item. Inter-rater reliabilities based intraclass correlations across the years of camp ranged from .72 to .85 (M = .78) for likeability, .85 to .90 (M = .88) for aggression, and .72 to .84 (M = .78) for withdrawal.

Teacher Report Form (TRF; Achenbach, 1991)—Behavioral symptomatology was evaluated at the end of each week by counselors' completion of the TRF. The TRF is a widely used and validated instrument to assess behavioral disturbance from the perspective of teachers, and the measure was used in the present study, because camp counselors are able to observe similar behaviors to that of teachers. The TRF, containing 118 items rated for frequency, assesses two broadband dimensions of child symptomatology, externalizing

and internalizing, as well as total behavior problems. Subscales scores are also computed for the following factors: withdrawn, somatic problems, anxiety/depression, social problems, thought problems, attention problems, delinquent behavior, and aggressive behavior. In the present study, interrater reliability for the internalizing and externalizing scales based on average intraclass correlations among pairs of raters. Across the years, reliabilities ranged from .56 to .84 (M = .68) for internalizing, and from .78 to .88 (M = .83) for externalizing. The counselors' scores for each child were averaged to obtain individual child scores for the broadband dimensions.

California Child Q-Set (CCQ; Block & Block, 1969/1980)—At the end of each week of camp after extensive observation and interaction, two counselors independently completed the CCQ (Block & Block, 1969/1980) on children in their group. The CCQ consists of 100 diverse items about children's personality, and cognitive and social characteristics. Raters sort the individual items printed on cards into a fixed distribution of piles depicting nine categories, ranging from most to least characteristic of the individual child. Thus, individual profiles of the 100 items are generated for each child. Inter-rater agreement (average intraclass correlations among pairs of raters) across the years of the study ranged from .68 to .85 (M = .80).

Dimensional scores were derived from the Q-set data to obtain to personality scores, ego resiliency and ego control. Based on criterion scores for prototypical levels of ego resiliency and ego control, each Q-set item was assigned a criterion score, and each child's individual Q-set data was correlated with the criterion sorts. The resulting correlations for each child's profile with the prototypical ego resiliency and ego control criterion sorts represented how similar or different the individual child was, in comparison to the prototypical profiles. For example, a high positive correlation with the ego resiliency criterion sort would indicate that a child had high levels of ego resiliency. In contrasts, a negative correlation would indicate low ego resiliency or ego brittleness. The ego control dimension is organized such that a high score indicates high ego undercontrol. The correlation of the counselor-rated profiles for each individual child with the criterion sorts were averaged across counselors to yield an ego resiliency and ego control score for each child.

School Record Data

School risk index—Each year, information from school districts on children's adaptation to school was obtained for the academic year prior to camp. Annual evaluations of each child were used by the school districts to determine broad indicators of deficient school functioning. The school risk index is a total of five possible risk indicators, including the following: a. attendance problems in the form of excessive absences or tardiness, b. poor performance on standardized achievement tests, c. suspension from school, d. failing school grades, and e. being two or more years below age level for grade placement. Meeting criteria for any of these five indicators was considered substantial risk in adapting successfully to school.

Composite of Resilient Functioning

Consistent with prior work examining resilience in maltreated and nonmaltreated children (Cicchetti & Rogosch, 1997; Cicchetti et al., 1993), a composite of resilient functioning was derived from indicators of children functioning well in domains of particular developmental importance for school-aged children. Initially, three composite indicators of social competence, combining the perspectives of peers and adults, were generated. First, a prosocial composite combined peer nomination scores for leader and cooperative with counselor behavior rating scores for prosocial behavior and counselor PEI scores for likeability. Internal consistencies of this composite were internally consistent with alphas

ranging from .66 to .75 (M = .70). Second, a disruptive-aggressive composite was comprised of peer nominations of disruptive and fights, and counselor behavior ratings of aggressive and counselor PEI scores for aggressiveness. The internal consistencies for this composite across the years ranged from .80 to .87 (M = .85). Third, a withdrawn composite included peer nomination scores for shy, counselor behavior ratings for withdrawn, and counselor PEI scores for the withdrawn subscale. Alphas ranged from .68 to .78 (M = .69). For each of these internally consistent composites, component variables were standardized within each hear of camp, and the standardized variables were averaged to generate the composite scores for each child.

In addition to these three indicators of social competence, the child's self-report of depressive symptoms on the CDI, counselor assessment of internalizing and externalizing behavior problems from the TRF, and the school risk index were other components of the resilience composite. For each of the seven indicators, criteria for the most competent functioning was established. More specifically, children were considered as demonstrating competent functioning if they had scores in the top third of the distribution for the prosocial composite, scored in the lowest one third of the distribution for the aggressive composite, the withdrawn composite, the CDI score, and TRF internalizing and externalizing scores, and had no school risk indicator. Children meeting the criterion on a given dimension were given a score of 1; all other children were given a score of 0 for that dimension. Summing across the seven indicators produced a composite index of resilient functioning with a possible range of scores ranging from 0 to 7.

Results

Plan of analysis

Initially, differences between maltreated children in average levels of resilient functions scores are examined, as well as differences in the rate of high and low resilience. In subsequent analyses, we begin to build a multi-level model of influences on resilient functioning, incorporating the effects of maltreatment, cortisol, and DHEA. The relations among these domains are examined in two ways. First, each of the hormones and maltreatment are examined as predictors of mean level differences in resilient functioning. Second, at a more person-centered level, groups of maltreated and nonmaltreated children with varying levels of resilient functioning are examined to determine if there are systematic differences in hormone levels for different types of children. The joint effects of cortisol and DHEA on resilient functioning also are examined. Then, the influences of the personality variables, ego resiliency and ego control, are examined as predictors of resilient functioning. Finally, from a multi-level perspective, the multiple influences of maltreatment, cortisol, DHEA, and the personality variables are examined together to investigate potential overlap of influence versus independence of their contributions.

Maltreatment and Resilience

As expected, maltreated (n = 347) and nonmaltreated children (n = 330) differed significantly on the composite of resilient functioning, t (675) = 6.02, p < .001. Maltreated children (M = 1.76, sd = 1.51) had lower average resilience scores than nonmaltreated children (M = 2.48, sd = 1.60). Maltreatment subtype groups also demonstrated significant differences, F (4,622) = 9.92, p < .001. Tukey post hoc comparisons indicated that physical abused children (M = 1.51, sd = 1.40) and sexually abused children (M = 1.59, sd = 1.31) had significantly lower resilient functioning scores than nonmaltreated children. Emotionally maltreated children (M = 1.90, sd = 1.76) and neglected children (M = 1.85, sd = 1.53) had intermediate scores between the nonmaltreated children and the two abuse

groups, did not differ significantly from either the physically or sexually abused group or from the nonmaltreated group.

Resilience groups were defined as low (scores of 0 or 1), medium (scores of 2, 3 or 4), and high (scores of 5 or more) based on resilient functioning scores. The maltreated and nonmaltreated children differed in terms of their distribution across these resilience groups. A greater proportion of nonmaltreated children (11.8%) were in the high resilience group as compared to the maltreated children (6.1%). In contrast, a greater proportion of maltreated children (49.9%) than nonmaltreated children (29.4%) were in the low resilience group. Among the maltreated children, subtype groups did not differ in the rates of low, medium, or high resilience, χ^2 (6, N = 297) = 4.63, ns.

Cortisol and maltreatment in relation to resilient functioning scores

Morning cortisol—A hierarchical multiple regression analysis was conducted with maltreatment status and morning cortisol as predictors of the resilient functioning scores. Age and gender were included as covariates. In this and all subsequent regression analyses, continuous predictors were centered. The overall regression equation was significant, adjusted R^2 = .064, p < .001. Age was a significant covariate (β = .11, p = .003). In terms of main effects, a significant effect of maltreatment was found (β = −.22, p < .001) indicating that maltreatment was negatively related to resilience functioning scores, whereas the main effect of morning cortisol was not significant (β = −.03, ns). However, these results were clarified by a significant maltreatment by morning cortisol interaction (β = −.14, p = .02). Separate regression analyses were conducted for the maltreatment and nonmaltreatment groups, controlling for age and gender. In the nonmaltreatment group, higher morning cortisol was related to lower resilient functioning scores (β = −.11, p = .05), whereas no association was found among maltreated children (β = .03, ns).

To examine this interaction effect further, morning cortisol was categorized into three levels: low (≤−1 sd); medium (between ± 1sd); and high (≥ + 1 sd). An ANCOVA with age and gender as covariates, again indicated a significant interaction effect of maltreatment and morning cortisol level, F (2,675) = 4.46, p = .012. This interaction is depicted in Figure 1. Low and medium levels of morning cortisol were related to significantly higher resilient functioning scores among nonmaltreated children as compared to maltreated children. At high morning cortisol levels, nonmaltreated children showed their lowest level of resilient functioning scores, at a level commensurate with maltreated children. Overall, differences among maltreated children in resilient functioning were not related to morning cortisol level.

These relations were probed further by examining maltreatment subtype differences. A similar ANCOVA was conducted, substituting maltreatment subtype group for maltreatment status. Consistent with the previous analyses, a significant subtype by morning cortisol level interaction was obtained, F (8,625) = 2.22, p = .024. Examination of the patterning of subtype differences indicated that the physically abused and sexually abused groups showed the most distinctive patterns. The ANCOVA was rerun, with only the nonmaltreated children and the physically abused and the sexually abused groups. The interaction effect was significant, F (4, 443) = 3.96, p = .004. Figure 2 illustrates the interaction effect. The physically abused group stands out with a distinctive pattern. For both nonmaltreated and sexually abused children, there appears to be a relative decline in resilient functioning scores at higher levels of morning cortisol. However, the physically abused children show an increase in resilient functioning scores only at high morning cortisol levels. Significant interaction effects were found in analyses comparing physically abused with nonmaltreated children, F (2,416) = 7.59, p = .001, and with sexually abused children, F (2, 114) = 4.02, p = .021.

Afternoon cortisol—Variation in afternoon cortisol also was examined in relation to resilient functioning. As previously, a hierarchical multiple regression analysis was conducted with maltreatment status and afternoon cortisol and their interaction to predict resilient functioning scores. Age and gender were included as covariates. The main effect of afternoon cortisol and the interaction of maltreatment status and afternoon cortisol were both nonsignificant.

Resilience groups and maltreatment in relation to cortisol

Whether maltreated and nonmaltreated children with different levels of resilient functioning (low, medium, and high) differed in their average level of morning and afternoon cortisol was examined. An ANCOVA, with age and gender as covariates, was conducted with maltreatment status and resilience group as main effects to examine relations with morning cortisol. Maltreatment status, resilience group, and their interaction were all nonsignificant. The same ANCOVA was again conducted with afternoon cortisol as the dependent variable, and the main and interaction effects were nonsignificant. Finally, diurnal variation in cortisol in relation to maltreatment or resilience groups also was examined. A repeated measures ANCOVA was conducted with morning and afternoon cortisol levels as the within-subjects dependent variables, maltreatment status and resilience group as the main effects, and age and gender as covariates. The main effects and interaction of maltreatment and resilience group were not significant. Thus, resilience groups in the maltreated and nonmaltreated groups were not distinguished based on their levels of morning or afternoon cortisol, or diurnal variation in cortisol from morning to afternoon.

DHEA and maltreatment in relation to resilient functioning scores

Hierarchical regression analyses were conducted to determine if maltreatment, morning and afternoon DHEA, and their interaction were related to resilient functioning scores. In these analyses, age and gender were included as covariates. For morning DHEA levels, significant effects were obtained for maltreatment status, $\beta = -.21$, $p < .001$, and morning DHEA level, $\beta = -.13$, $p = .001$, adjusted $R^2 = .068$, $p < .001$. Nonmaltreatment status and lower morning DHEA were independently related to higher resilient functioning scores. The interaction of maltreatment and morning DHEA was not significant.

Similar effects were found for afternoon DHEA levels. In the hierarchical regression analysis, maltreatment status, $\beta = -.21$, $p < .001$, and afternoon DHEA levels, $\beta = -.13$, $p = .001$, were both significant predictors of resilient functioning scores, adjusted $R^2 = .067$, $p < .001$. The interaction of maltreatment status and afternoon DHEA levels was not significant. Thus, in addition to maltreatment status, both lower morning DHEA levels and lower afternoon DHEA levels were found to relate to higher resilient functioning scores, and this did not differ by maltreatment status.

Resilience groups and maltreatment status in relation to morning and afternoon DHEA

Maltreated and nonmaltreated children in the low, medium, and high resilience groups also were examined to determine if there were differences related to variation in average levels of morning and afternoon DHEA. For morning DHEA, an ANCOVA was conducted with maltreatment status and resilience group as main effects, and age and gender as covariates. The resilience group effect was significant, $F(2,667) = 5.30$, $p = .005$, whereas the effect of maltreatment and the maltreatment by resilience group interaction were not significant. An analogous ANCOVA was conducted for afternoon cortisol, and similar results were obtained. The main effect for resilience group was significant, $F(2, 662) = 5.52$, $p = .004$. However, maltreatment status and the interaction of maltreatment status and resilience group were not significant. Based on Tukey post hoc tests on covariate-adjusted means, for both morning DHEA and afternoon DHEA, the high resilience group had significantly lower

morning and afternoon DHEA than the low resilience group. The medium resilience group did not differ from the low or high resilience groups.

A more elaborate picture emerged when diurnal variation in DHEA was examined for the maltreatment and resilience groups. A repeated measures ANCOVA was conducted, with morning and afternoon DHEA as the within-subjects factor, and maltreatment status and resilience group as between subjects factors. Age and gender were included as covariates. Significant within-subjects effects were obtained for resilience groups, F (2,651) = 3.06, p = .048, but this effect was clarified by a significant maltreatment by resilience group interaction, F (2, 651) = 4.07, p = .018. The pattern of this interaction effect is depicted in Figure 3. Among nonmaltreated children only, a repeated measures ANCOVA for resilience group did not result in a significant within-subjects effect for morning to afternoon DHEA, F (3,318) = .68, *ns*. In the figure, there is a relative stability in DHEA from morning to afternoon with a subtle decline in DHEA for the medium and high resilience groups. Among the maltreated children, the within subjects effect was significant, F (2,331) = 5.03, p = .007. As shown in Figure 3, the low and medium resilience groups show a similar pattern of decreasing DHEA from morning to afternoon and a decrease in DHEA level with higher levels of resilience. However, the high resilience maltreated children exhibited a distinctive pattern of diurnal variation. Rather than showing a decrease in DHEA from morning to afternoon, the high resilience maltreated children had a notable increase in afternoon DHEA.

In addition to mean level differences, another perspective on this diurnal variation was examined. In particular, whether children demonstrated a higher level of DHEA in the afternoon was determined. Among nonmaltreated children, the percentage of children in the three resilience groups who had a higher level of DHEA in the afternoon was not significantly different, χ^2 (2, n = 323) = .05, ns., with 45.4%, 45.5%, and 43.6% of children exhibiting an increase, for the low, medium, and high resilience groups, respectively. In contrast, among the maltreated children, the group difference was significant, χ^2 (2, n = 336) = 7.49, p = .024. Whereas 42.4% of the low and 40.0 % of the medium resilience group maltreated children had an increase in DHEA in the afternoon, among the high resilience maltreated children, this increase was found among 71.4% of the children. Thus, the high resilience group maltreated children stands out in terms of greater mean level DHEA levels in the afternoon and a higher proportion of the group exhibiting a morning to afternoon rise in DHEA levels.

Cortisol/DHEA ratio, maltreatment, and resilient functioning

The dual contributions of cortisol and DHEA to resilient functioning were examined with the cortisol/DHEA ratio. A hierarchical multiple regression analysis to predict resilient functioning was conducted with maltreatment status and the morning cortisol/DHEA ratio as main effects; age and gender were included as covariates. Significant main effects for maltreatment, β = −.20, p < .001, and for the morning cortisol/DHEA ratio, β = .11, p = .007, were obtained, adjusted R^2 = .063, p < .001. The interaction of maltreatment and morning cortisol/DHEA ration was not significant. Thus, in addition to the contribution of maltreatment, higher cortisol/DHEA ratios were related to higher levels of resilient functioning. Comparable findings were found for the afternoon cortisol/DHEA ratio. In a hierarchical multiple regression analysis, significant main effects for maltreatment, β = −.21, p < .001, and for the afternoon cortisol/DHEA ratio, β = .11, p = .008, were found, R^2 = .064, p < .001, whereas the interaction of maltreatment and the afternoon cortisol/DHEA ratio was not significant. As with the morning cortisol/DHEA ratio, higher values of the afternoon cortisol/DHEA ratio were related to higher levels of resilient functioning.

Independent effects of maltreatment, cortisol, and DHEA on resilient functioning

Given the previous findings, particularly for morning cortisol and DHEA, the independent and potentially interactive effects of these hormones on resilient functioning, in addition to maltreatment status were examined. In a hierarchical regression analysis, the covariates of age and gender were entered first, followed by the main effects of maltreatment, morning cortisol, and morning DHEA. In step three, terms for the two-way interactions among maltreatment, morning cortisol, and morning DHEA were added, followed by the three-way interaction in step four. See Table 1.

In step one, age was a significant covariate, $\beta = .12$, p =. 003. The main effects were added in step two, and consistent with prior analyses, maltreatment status, $\beta = -.21$, $p < .001$, and morning DHEA, $\beta = -.13$, $p = .002$, were significant main effects. Among the two-way interactions entered in step three, only the maltreatment by morning cortisol interaction was significant, $\beta = -.15$, $p = .01$. The three-way interaction of maltreatment, cortisol, and DHEA entered in step 4 was not significant. Thus, previously demonstrated relations of maltreatment, morning DHEA, and the interaction of maltreatment and cortisol in predicting resilient functioning each maintained significant effects when examined together. Additional interactive effects between cortisol and DHEA were not observed.

Ego resiliency, ego control, and maltreatment in relations to resilient functioning

Next, the influences of the personality variables, ego resiliency and ego control, in conjunction with maltreatment, were examined for their role in predicting individual differences in resilient functioning. Maltreated and nonmaltreated children differed significantly on both personality variables, ego resiliency: $t(675) = 6.82$, $p < .001$; ego control: $t(670) = 4.36$, $p < .001$. Maltreated children had lower ego resiliency, $M = .23$, $sd = .31$, and higher ego undercontrol, $M = .06$, $sd = .25$, than nonmaltreated children, ego resiliency: $M = .39$, $sd = .29$, ego control: $M = -.02$, $sd = .22$.

To investigate the joint influences, a hierarchical regression was conducted, with age and gender as covariates. In step two, maltreatment was added, whereas the personality variables of ego resiliency and ego control were added in step three. The two-way interaction terms were included in step four, and the three-way interaction term in step five. See Table 2.

As in prior analyses, in step 2, maltreatment had an independent effect in predicting resilient functioning, $\beta = -.22$, $p < .001$. However, with the entry of ego resiliency and ego control, in step 3, the independent effect of maltreatment status was no longer significant, indicating that the personality variables served to mediate the relation between maltreatment status and resilient functioning. Ego resiliency, $\beta = .64$, $p < .001$, and ego (under)control, $\beta = -.08$, $p = .009$, each made independent contributions to prediction, increasing the R^2 substantially. In the next step, only the two-way interaction of ego resiliency and ego control, $\beta = -.28$, $p < .001$, was found to be significant. The three-way interaction among maltreatment and the two personality variables was not significant. Thus, the personality variables, notably high ego resiliency and greater undercontrol were shown to have strong predictive power in relating to individual differences in children's resilience striving.

Maltreatment, hormones, and personality in relation to resilient functioning

Based on the prior analyses, a final hierarchical multiple regression analysis to predict resilient functioning was conducted to examine the extent to which the influences of maltreatment, cortisol, DHEA, and the personality variables were maintained when the already demonstrated effects of these domains were considered within one analysis. Accordingly, age and gender were entered in step one, followed by maltreatment status in step two. In step three, morning cortisol, morning DHEA, as well as ego resiliency and ego

control were entered. In the final step, the two-way interactions of maltreatment and cortisol and of ego resiliency and ego control were included. See Table 3.

As shown in prior analyses, age was a significant covariate, β = .12, $p = .003$. When maltreatment was entered in step 2, it also had a significant effect, β = −.21, $p < .001$; however, the impact of maltreatment was mediated by the personality variables, as they were entered in step 3. In this step, significant effects were found for DHEA, β = −.07, $p = .033$, ego resiliency, β = .64, $p < .001$, and ego (under)control, β = −.09, $p = .003$. Finally, both two-way interaction terms were found to be significant in step 4, including, maltreatment by morning cortisol, β = .11, $p = .015$, and ego resiliency by ego control, β = −.26, $p < .001$. Thus, the effects of the personality variables, morning DHEA, and the interaction of maltreatment and morning cortisol were maintained when examined in conjunction. Although not presented here, additional terms were considered for incorporation into these analyses. These terms included interactions between the personality and hormone variables, as well as higher order interactions. However, none of the interactions was found to be significant. Thus, from a multi-level perspective, the relations demonstrated for cortisol, DHEA, and ego resiliency and ego control constituted distinct and independent contributions to understanding individual differences in resilient functioning in high risk maltreated and nonmaltreated children.

Discussion

In this investigation of the developmental pathways to resilience in maltreated and nonmaltreated children, we adopted a multiple-levels-of-analysis perspective and examined the unique and interactive contributions that personality features and adrenal steroid stress hormone regulation make to the achievement of competent functioning in the face of significant stress and adversity. Utilizing a large, representative sample of maltreated children and a well-matched group of nonmaltreated children, we embarked on one of the first empirical studies of biological and psychological contributors to resilience in abused and neglected children (see also Curtis & Cicchetti, 2007).

Personality Features

The personality features, ego resiliency and ego control, and the adrenal steroid hormones associated with stress, cortisol and DHEA, made independent contributions to resilience. Although operating at different levels of analysis, behavioral/psychological and biological factors each made unique contributions to resilience.

Consistent with the results of previous investigations (Cicchetti et al., 1993; Cicchetti & Rogosch, 1997; Flores et al., 2005; Rogosch & Cicchetti, 2004), ego resiliency and ego (over)control were significant predictors of resilience. Moreover, ego resiliency and ego (over)control operated as mediators of the relation between maltreatment and resilient functioning. However, contrary to findings obtained in prior studies of the determinants of resilience in maltreated children, the interaction of ego (over)control and maltreatment status was not significant, indicating that ego control was not operating differentially in the maltreated and comparison groups of children.

Despite the fact that these personality features did not differentially predict resilient functioning in maltreated and nonmaltreated children, the finding that ego resiliency and ego (over)control were predictive of resilience in both maltreated and nonmaltreated children is noteworthy. The resilient maltreated and nonmaltreated children, through adopting a more reserved, controlled, and rational way of interacting and relating with their peers and the adults camp counselors, may be more attuned to behave in ways that are critical for adapting successfully to their stress-laden environments.

Stress Regulation

Masten (2001) has theorized that resilience is a "common phenomenon that results…from the operation of basic human adaptational systems" (p. 227) that work together optimally when confronted with stress, adversity, or trauma. Another aspect of resilience is the ability to recover positive function by bouncing back from negative experiences through adapting flexibly to life's ongoing vicissitudes (Cicchetti & Rogosch, 1997; Luthar et al., 2000; Masten, Best, & Garmezy, 1990). When neurobiological systems are operating in an optimal fashion, organisms are able to confront and adapt to the stressors and adversity they are facing and respond while continuing to maintain homeostasis (Gunnar, 2007; Gunnar & Vazquez, 2006; Levine, 2005).

Allostasis has been conceptualized as "maintaining stability (or homeostasis) through change" (McEwen, 1998, p. 32). In the process of allostasis, biological homeostatic "set points" are modified to generate the physiological resources necessary to promote successful adaptation in response to environmental challenges (Davies, Sturge-Apple, Cicchetti, & Cummings, in press; Korte, Koolhaas, Wingfield, & McEwen, 2005; Lupien, Ouellet-Morin, Hupbach, Tu, & Buss, et al., 2006; McEwen, 1998). The concept of allostatic load (McEwen & Stellar, 1993) has been invoked to describe the wear-and-tear that the body experiences due to repeated cycles of allostasis that are inefficiently handled. Allostatic load refers to cumulative physiological dysregulation across multiple biological systems (Cooper, Feder, Southwick, & Charney, 2007; Davies et al., in press; McEwen, 1998). Whenever biological systems become activated or overstimulated too frequently, when these systems do not return to baseline following exposure to stressors, or when interconnected biological systems do not respond to one another in an appropriate fashion, then physiological dysregulation eventuates (Cooper et al., 2007; Lupien et al., 2006; McEwen, 1998; Miller, Chen, & Zhou, 2007). Prolonged stress, as is often the case in child maltreatment, can lead to allostatic load through a cascade of causes and sequelae that can damage the brain, organ systems, and the neurochemical balance that undergirds cognition, emotion, mood, personality, and behavior (Cicchetti & Rogosch, 2001a; 2001b; Cooper et al., 2007; Lupien et al., 2006). Interacting genetic, developmental, and experiential factors, including child maltreatment, play prominent roles in the wide array of individual differences among individuals in coping with challenges throughout their lives (Gunnar, 2007; Heim & Nemeroff, 2002; McEwen, 1998).

To date, the vast majority of research on the developmental sequelae of severe psychological stress in humans has focused on discovering the pathways to maladaptation and psychopathology. This investigation is one of the first studies to examine the role that neurobiological responses to stress play in the development of resilient adaptation in maltreated and nonmaltreated children.

In addition to personality features, which operate at the behavioral level, the adrenal steroid hormones, cortisol and DHEA, were found to have associations with resilient functioning at the biological level. On the one hand, some broad general relations of these hormones were demonstrated. On the other hand, evidence for some atypical relations also was found when particular subgroups of children were examined, suggesting complex associations between experience, biology, and striving for competence.

In terms of the broader findings obtained when examining the continuum of resilient functioning, cortisol and maltreatment were found to interact in predicting resilience. For the nonmaltreated comparison children, as cortisol increased, resilience was shown to decrease. In contrast, for the maltreated children, basal levels of cortisol in the morning were generally not found to be related to increasing levels of resilience. Among nonmaltreated children, high basal cortisol may be indicative of children who are undergoing greater stress exposure

and as a consequence are constrained in their capacity to adapt competently. This association appears to be attenuated among maltreated children.

Further evidence that different levels of analysis made unique contributions to resilience can be observed through examining the findings of the relation between DHEA and resilience. Regression analyses indicated that maltreatment and both morning and afternoon levels of DHEA were associated with the continuous resilient functioning dimension. Maltreatment status did not interact with morning or afternoon DHEA levels in predicting resilience. Thus, in general, lower DHEA in the morning and afternoon was associated with higher resilience scores for both maltreated and nonmaltreated children.

Finally, neither the morning nor afternoon cortisol/DHEA ratios were related to maltreatment. However, maltreatment and morning cortisol/DHEA levels, and maltreatment and afternoon cortisol/DHEA ratios contributed to prediction of resilient functioning scores, and maltreatment and cortisol/DHEA ratios did not interact. Thus, higher cortisol/DHEA ratios related to higher resilient functioning among both maltreated and nonmaltreated children. Given the associations demonstrated above for DHEA levels, higher ratio scores are obtained with lower DHEA levels, and as such these relations for cortisol/DHEA ratios may not be unique.

DHEA may generate effects that are associated with resilience. For example, DHEA counteracts the harmful effects of hypercortisolism, therein potentially conferring neuroprotection to the brain (Charney, 2004). In addition, several empirical investigations exist that provide suggestive evidence that DHEA may promote resilience. These include negative correlations between the cortisol/DHEA ratio and dissociation, between DHEA and depressive symptomatology, between DHEA and PTSD and the antidepressant effects of stress (Charney, 2004; Haglund, Nestadt, Cooper, Southwick, & Charney, 2007).

In addition to these broad findings for cortisol, DHEA, and the cortisol/DHEA ratio, more person-centered analyses revealed additional more complex relationships. Because adversity and trauma are typically associated with high risk for maladaptation and psychopathology, resilience in the face of extreme stressors runs counter to expectations. There may be evidence of atypical processes operating to promote positive adaptation in some children evincing resilience. In the current investigation, two examples of associations that stood out as unusual were noteworthy. First, in looking beyond overall maltreatment effects, the observation that physically abused children with high morning cortisol had higher resilient functioning than children with lower levels of cortisol was divergent from the more general pattern of higher cortisol being related to lower resilient functioning as was seen in nonmaltreated and sexually abused children.

Prior findings have indicated that physically abused children on the average tend to have lower morning cortisol (Cicchetti & Rogosch, 2001a). It may be that a subgroup of physically abused children who are still able to elevate cortisol to adapt to stressors in their lives are demonstrating greater striving for competence. The enhanced basal cortisol secretion may serve to mobilize and replenish energy stores and contribute to enhanced arousal and focused attention, each of which may be associated with the development of resilience (Charney, 2004). Cortisol exerts regulatory effects on the hippocampus, amygdala, and prefrontal cortex (Gold, Drevets, & Charney, 2002). Investigations of HPA axis regulation in maltreated children have revealed attenuated cortisol secretion (Gunnar & Donzella, 2002). This hyposecretion is akin to hypocortisolism, an indicator of allostatic load. The physically abused children with lower levels of morning cortisol may have developed hypocortisolism over time in response to chronic stress exposure. As a result, there may be a diminished capacity to mobilize the HPA axis to promote positive adaptation

under conditions of ongoing stress. In contrast to the physically abused children, the very low level of resilience among sexually abused children with high basal cortisol may be a product of their different traumatic experiences and the consequences of chronic excessive vigilance and preoccupation, with commensurate HPA axis hyperarousal.

The second noteworthy observation was the atypical pattern of a relative diurnal increase in DHEA seen in maltreated children with high resilience. What might promote this variation is unclear. However, the general trend for lower morning DHEA and lower afternoon DHEA to be related to higher resilient functioning, as shown in regression analyses, was not borne out when we looked in more detail at the subgroup of maltreated children with high resilience. In fact, the maltreated children with high resilience were unique compared to other groups of maltreated and nonmaltreated children in terms of the greater likelihood (71.4%) of showing an increase in DHEA from morning to afternoon. It may be that maltreated children who have the capacity to increase DHEA over the course of the day are better equipped to meet the demands of high chronic exposure to stress in their lives and to adapt competently. The nonmaltreated children with high resilience did not demonstrate this pattern of diurnal DHEA increase. Rather, the high resilient nonmaltreated children exhibited to lowest levels of DHEA across the day. It may be that a more typical pattern of DHEA diurnal regulation is sufficient to address the less toxic experiences in their lives and allow their successful adaptation to unfold.

What is unclear is the extent to which there is a contribution of innate individual differences in stress hormone levels that promotes alterations in adapting to stress versus the extent to which stress exposure differentially interacts with individuals' propensity for specific hormone levels and affects adaptation. Studying HPA regulation over the course of development is needed to differentiate the influences of innate individual differences in HPA regulation, the manner in which individuals with innate differences in HPA regulation respond differentially to stress, and the developmental course of HPA regulation under stress, particularly the potential conversion from early hypercortisolism to later hypocortisolism among individuals chronically exposed to stress. . Research has documented the role of stress hormones in the expression of genes that govern brain function (Watson & Gametchu, 1999). For example, glucocorticoid receptors in the nuclei of neurons are responsible for genomic effects, such that stress hormones influence gene expression, and affect neuronal growth, neurotransmitter synthesis, receptor density and sensitivity, and neurotransmitter reuptake. Because stress hormones can have such direct effects on genes that control brain structure and function (Watson & Gametchu, 1999), research on stress in developing organisms is crucially important. Therefore, understanding the transactions between the regulation of adrenal steroid hormones and brain processes over the course of development, particularly under conditions of stress, will be invaluable for providing insight into resilience promoting processes.

In summary, different levels of analysis contributed independently to resilience -- personality, cortisol x maltreatment interaction, and DHEA each demonstrated independent effects is explaining variation in resilient functioning in maltreated and nonmaltreated children. Moreover, evidence also was found for atypical relations between adrenal steroid hormone regulation and resilience for some subgroups of maltreated children. Despite these findings, even though ego-resiliency and ego (over)control, DHEA, and the cortisol by maltreatment interaction each made unique contributions to resilience, there were no personality x hormone interactions in the prediction of resilience.

In the future, additional research on the pathways to resilience in maltreated and nonmaltreated children should be conducted within a multiple-levels-of-analysis approach (Cicchetti & Blender, 2004). Such investigations should be longitudinal in nature and

incorporate a broader array of levels of analysis, both biological and psychological. The incorporation of such a perspective into the study of resilience will result in a more sophisticated and comprehensive portrayal of this phenomenon that will serve not only to advance the scientific knowledge of resilience, but also to inform efforts to translate research on positive adaptation in the face of adversity into the development of interventions to promote resilient functioning.

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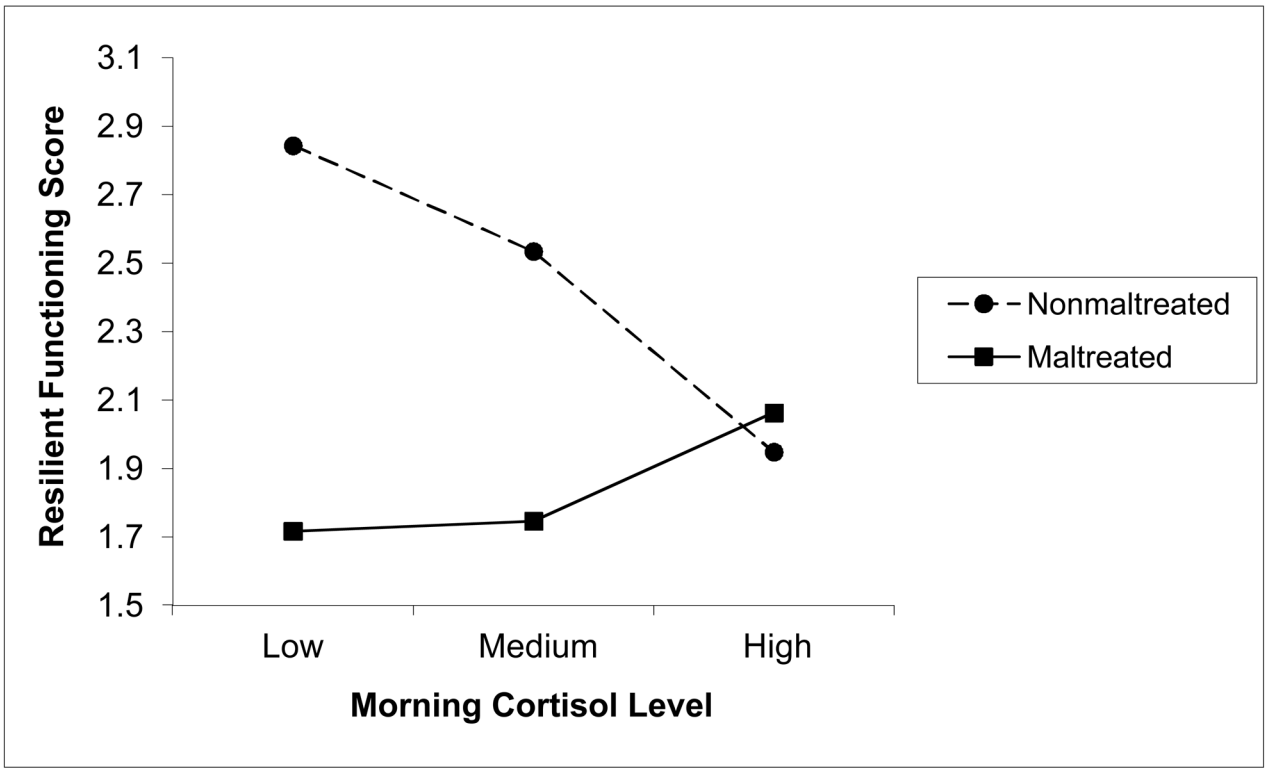


Figure 1.
Interaction of maltreatment status and morning cortisol levels in relation to resilient functioning scores.

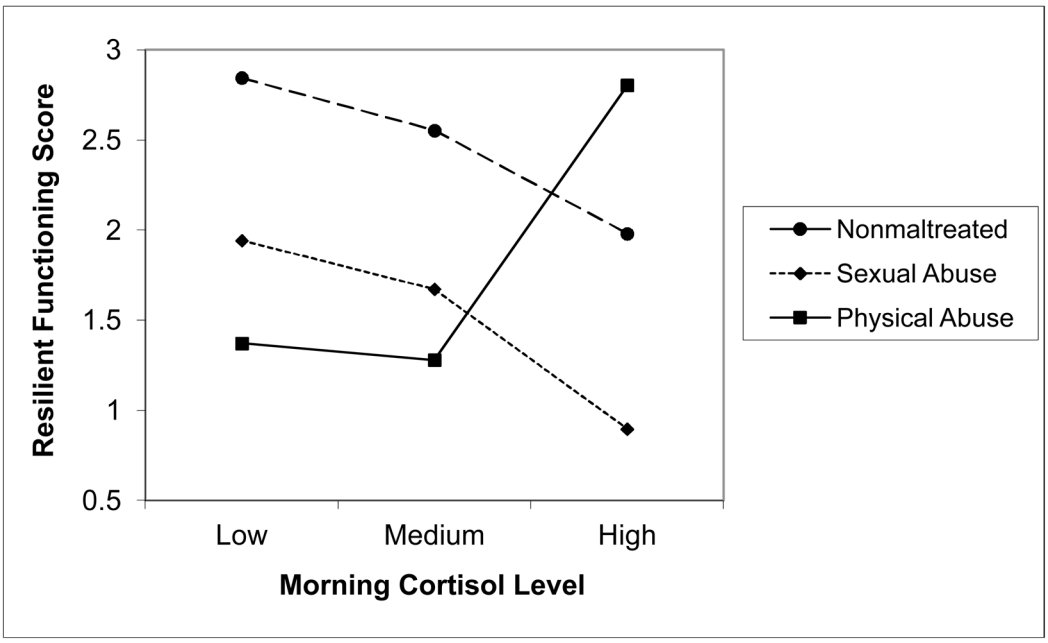
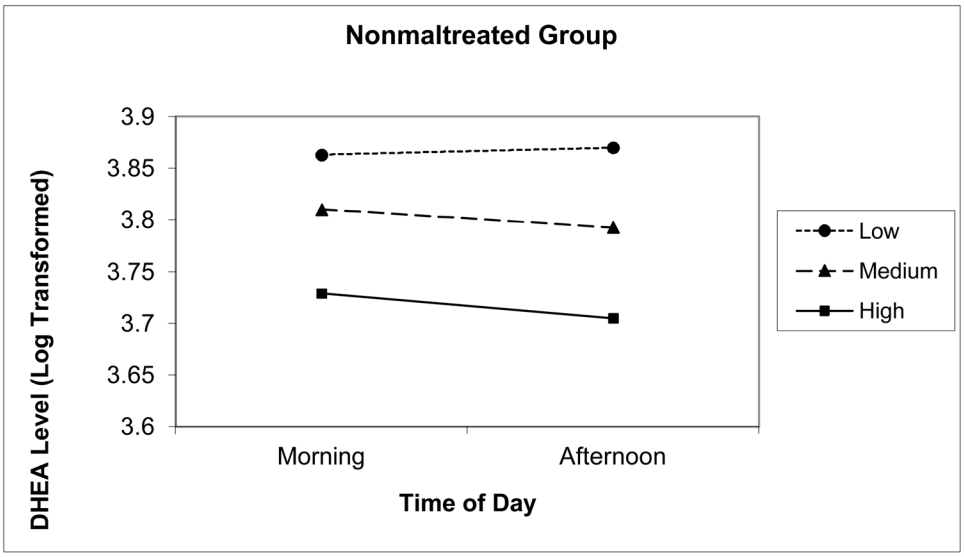


Figure 2.
Interaction of maltreatment subtype groups and morning cortisol levels in relation to resilient functioning scores.



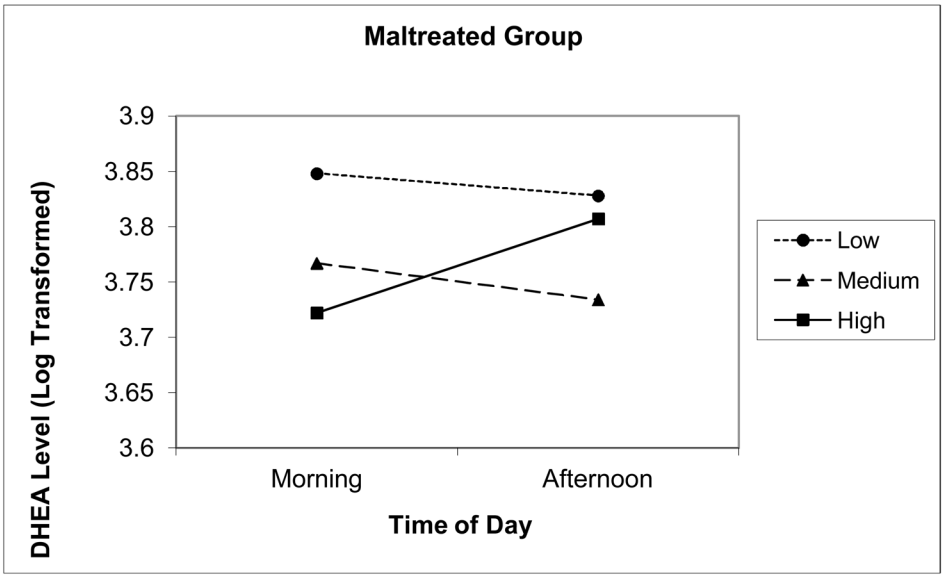


Figure 3.
Diurnal variation in DHEA for maltreated and nonmaltreated children in different resilience groups.

Table 1

Hierarchical regression analysis with maltreatment and morning cortisol and DHEA predicting resilient functioning scores.

			Adjusted	
Step	**Variable**	**β**	**R^2**	**Δ R^2**
1.	Sex	−.06		
	Age	.12**	.017	.014 **
2.	Maltreatment	−.21***		
	Cortisol (a.m.)	−.02		
	DHEA (a.m.)	−.13**	.067	.057 ***
3.	Cortisol X DHEA	−.03		
	Maltreatment X Cortisol	.15**		
	Maltreatment X DHEA	.03	.073	.01 +
4.	Maltreatment X Cortisol X DHEA	.03	.071	.00

+ p < .10

* p < .05

** p < .01

*** p < .001

Table 2

Hierarchical regression analysis with maltreatment, ego resiliency, and ego control predicting resilient functioning scores.

			Adjusted	
Step	**Variable**	**β**	**R^2**	**Δ R^2**
1.	Sex	−.06		
	Age	.12 **	.017	.014 **
2.	Maltreatment	−.21 ***	.059	.046 ***
3.	Ego resiliency	.65 ***		
	Ego control	−.08 **	.469	.410 ***
4.	Maltreatment X Ego Resiliency	−.04		
	Maltreatment X Ego Control	−.07		
	Ego Resiliency X Ego Control	−.28 ***	.490	.022 ***
5.	Maltreatment X Resiliency X Control	−.02	.489	.000

+ p < .10

* p < .05

** p < .01

*** p < .001

Table 3

Hierarchical regression analysis with maltreatment, morning cortisol and DHEA, and ego resiliency and ego control predicting resilient functioning scores.

			Adjusted	
Step	**Variable**	**β**	**R^2**	**Δ R^2**
1.	Sex	−.06		
	Age	.12 **	.017	.003 **
2.	Maltreatment	−.21 ***	.055	.042 ***
3.	Cortisol (a.m.)	−.027		
	DHEA (a.m.)	−.07 *		
	Ego resiliency	.64 ***		
	Ego control	−.09 **	.472	.418 ***
4.	Maltreatment X Cortisol	.11 *		
	Ego Resiliency X Ego Control	−.26 ***	.495	.024 ***

+ p < .10

* p < .05

** p < .01

*** p < .001